TRANSPORT DEPARTMENT

GOVERNMENT OF BIHAR

DETAILED PROJECT REPORT FOR DEVELOPMENT OF IWT ON RIVER KOSI IN BIHAR

FINAL REPORT

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RITES LTD

(A GOVERNMENT OF INDIA ENTERPRISE)

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DPR FOR DEVELOPMENT OF IWT ON RIVER KOSI

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CHAPTER - 1

INTRODUCTION

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INTRODUCTION

1.1 PREAMBLE

Rivers constitute an important means of transport in Eastern India comprising Bihar, Bengal and Assam. Post independence, the country embarked upon a large programme of agricultural production and industrialization, which was resulted in substantial increase in the movement of cargo traffic. Apart from the above, the change in economic policy and the rapid increase in the industrialization during the last decade made their impact on the existing traffic movement by various means. Due to the immense increase in road traffic, Government of India given due attention in widening and relaying of National Highways including the construction of time bound Golden Quadrilateral and North-South corridors. Similarly, the dedicated rail corridors for the movement of goods by rail are in the implementation stage by the Government. Thus, it is now well recognized that all modes of transport need to be developed and the vital role which rivers can play in meeting the ever increasing transport demands of a fast developing economy can not be ignored.

Inland Water Transport is the cheapest mode of transport for certain kind of traffic both over long and short distances especially between the places located on the waterfront. One of the crucial problems facing the country today is the inflation in which the transport cost of commodities is an important factor to be reckoned with. Inland Water Transport being more energy efficient than other modes of surface transport can help in reducing the transport cost and stabilizing the prices of commodities. A liter of fuel is known to move 24 kms by road, 85 kms by rail and 105 kms by water. IWT is thus the least energy consuming system of transport. Further it has many other inherent advantages. It generates more employment per unit of investment than any other mode. According to National Transport Policy Committee Report (1980), the employment potential per Rs.1 lakh

investment is 33.59 man-years by IWT, compared to 16.95 by road and 4.30 by railways. It requires lower capital investment on track as compared to rail and road since Waterways are a gift of nature and require lower capital expenditure on maintenance as well as on operation. It provides a relatively pollution free atmosphere and contributes towards preservation of environment.

Development of Waterways offers the least expensive means of expanding transportation. It is for this reason that the developed nations in Europe and the USA have improved their waterways for transportation. In the USA, 13 percent of all transportation is done by Inland waterways at a total cost of less than 2 percent. New roads and railways are expensive. They require land acquisition with consequent problem of rehabilitation and environment. Water Transport, on the other hand is relatively more economical with track being provided by nature. In fact, with scientific conservancy measures, it may in certain instances be possible to re-claim land from the rivers while undertaking channel improvement works.

The National Transport Policy Committee Report (1980) had observed that if the national economy grows at a rate consistent with national aspirations for balanced and orderly growth, the transport system is likely under stress all through and hence there is need to develop and encourage every mode of transport with in an integrated frame work. In such a framework, an over riding consideration in today's context will be to encourage modes requiring least energy consumption. Such energy considerations led the committee to suggest according encouragement to IWT.

More over, the inland waterways have played an important role in the Indian transport system since ancient times. Though inland water transport is comparatively a cheaper and efficient means of transportation in recent times the importance of this mode of transport has declined considerably with the expansion of road and rail transport. In addition diversion of river water for irrigation has also reduced the importance of inland water transport. The decline is also due to deforestation of hill range leading to

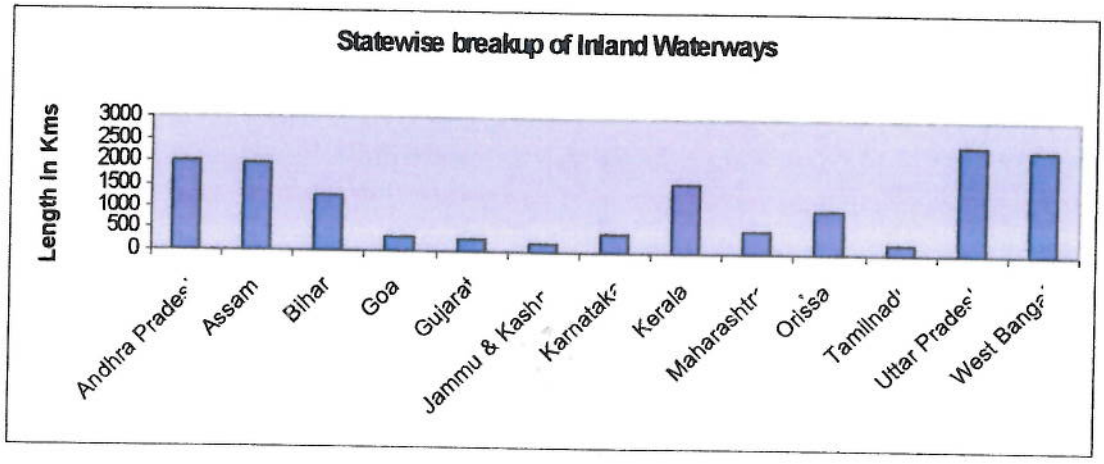
erosion, accumulation of silt in rivers and failure to modernize the fleet to suit local conditions. The transportation of goods in an organized form is confined to West Bengal, Assam, parts of North Eastern Region and Goa. The Seventh Plan was an important landmark in the development of inland water transport. The expenditure on this sector in the plan (at Rs. 131.85 crores) was more than expenditure incurred right up to the end of the sixth plan.

Three objectives were laid down in the Seventh Plan for development of inland water transport.

- Development of inland water transport in the regions where it enjoys natural advantage.
- Modernization of vessels and country crafts to suit local conditions.
- Improvement in the productivity of assets.

The Inland Waterway Authority has been set up which is a big step forward and should help in the accelerated development of inland water transport.

It can be seen from the following chart; around 1200 km length of waterway is available in the State of Bihar.



Since India has vast IWT potential, it could play a significant role in augmenting the country's transport infrastructure. India has about 14,500 km of inland waterways network comprising rivers, lakes and canals and the IWT sector has only recently received its due attention. Much more needs to be done to really take advantage of this sector.

With Global economy and the WTO regime, there would be greater movement of goods to and fro. This would create heavy pressures on the already burdened transport system of rail and road. There is limit for expansion of rail and road capacity on account of constraints of available land, exorbitant cost and environmental considerations. Inland Water Transport can play a supportive role for Rail and Road Transport. The cost effectiveness of IWT can be addressed from the fact that while the development of 1 km of highway costs Rs 6 crores, much less than this amount is enough to develop 100 km of waterways.

There are some hazardous commodities that should / cannot be allowed to be transported on road. In view of these constraints and considerations, the development of Inland Water Transport has been relevant in today's context.

IWT has advantages over railways and roadways both in terms of cost and energy consumption in cargo transportation. As per estimates, for every one rupee spent for IWT development, the corresponding cost for development of same length of roadways and railways would be Rs 2 and Rs 5, respectively. In case of energy consumption, the ratio would be between 1.5 and 4, respectively.

The major inherent advantages of IWT include doubling of load capacities for a small increase in depth thereby providing an aging flexibility and cost elasticity, which do not exist in other modes of transport.

Besides lower fuel consumption and construction costs, the IWT has the advantage of ensuring minimum human loss against very frequent accidents occurring in case of roads and railways.

Regional cargo transportation using riverine systems is confined to Goa, West Bengal, Assam and Kerala. If the inland waterways were developed with the necessary infrastructure such as fairway, terminals and navigational aids, the Inland Water Transport mode could become quite competitive and attract considerable cargo.

To give a thrust to Inland Water Transport mode, the following waterways have now taken up to study their viability by the State Transport Department, Government of Bihar.

- River Gandak
- River Kosi
- River Son and
- River Ganga at Patna

This report is dealt with the development of Inland Water Transport on river Kosi.

1.2 BACKGROUND

The Transport Department, Government of Bihar proposes to carry out Detailed Project Report (DPR) studies for develop Inland Water Transport on Rivers Kosi, Gandak, Sone and Ganga at Patna in Bihar under centrally sponsored schemes and accordingly floated tenders to appoint consultancy firm for the above studies.

RITES has responded to the above tender and offered its services to carry out DPR studies for the above identified waterways in Bihar state as per the scope of work and methodology given below. The transport department, Government of Bihar vide work order ***No.PR-1/WT-201/2006 PROJECT-6 DATE 21-02-2007*** has appointed RITES LTD for the above job.

1.3 SCOPE OF SERVICES

The scope of work is as follows:

1.3.1 Collection of Hydro-morphological Data

The consultants propose to collect and study the available reports and hydrographic survey charts of the identified waterways. The collection and study of the data shall include water level, depth, velocity, discharge, cross sections, bed and bank material, hydrographic, topographic data etc.

As per the notification of the transport department, Government of Bihar, the Detailed Project Reports are to be prepared based on collection of hydro-morphological data, hydrographic survey, model study, techno economic feasibility study and traffic survey. Since RITES has carried out hydrographic surveys / investigations on rivers Kosi and Gandak and also hydrographic surveys on river Ganga at Patna, the available data with us will be utilized for preparation of DPR. As such no field investigations will

be carried out on these three rivers (Gandak, Kosi and Ganga at Patna). Accordingly the consultants proposed to prepare the DPR's based on collection of data, from various organizations.

As far as Sone River is concerned the State Transport Department, Government of Bihar shall provide the available data or assist the consultants to collect the relevant data from Inland Waterways Authority of India. In case no hydrographic data is available, it is proposed to carry out a single line thalweg survey on river Sone from Dehri to Ganga confluence near Semariya (226km), to assess the available depths in the navigation channel. The other topographic features will be obtained from Survey of India Toposheets / Satellite Imageries.

The consultants proposed to ascertain the latest river features based on Satellite Imageries using the appropriate software in built model. As such no model study will be carried out.

1.3.2 Waterway design and navigation facilities

The consultants shall design navigational channel of the identified waterways and the works shall include, fixation of channel dimension for navigation, assessment of dredging requirement for design vessel, navigational aids, temporary channel marking, short term river conservancy works etc.

1.3.3 Terminal design and infrastructure facilities

The consultants shall select the site for terminal locations, plan and Conceptual design of terminals taking into consideration the site conditions and available construction material, cargo to be handled.

1.3.4 Advice on Vessel

The consultants shall advice suitable types of cargo vessels for the projected cargo, workout the details of the type of vessels their number and cost.

Estimation of scale of facilities and preliminary cost assessment

The consultants shall work out cost estimates for various facilities proposed to be provided viz, dredging, river conservancy, channel marking, loading / unloading terminals and vessels.

1.3.5 Traffic projections and Economic Evaluation.

The consultants shall review the traffic data and projections made by State Government departments for the identified waterways. If any limited data on traffic is required the same shall be collected from other agencies like IWAI to augment the above data. Based on the traffic data collected, traffic projections will be made.

1.4 REPORT

Based on the items described above, detailed project reports will be prepared for the four identified waterways viz, Gandak river, Kosi river, Sone river and Ganga river at Patna. The report shall be prepared in three stages.

- Interim Report
- Draft report
- Final report

1.5 RIVER KOSI

The Kosi River originates at an altitude of over 7000 m in the Himalayas and lies between 85^0 and 89^0 E longitude and $25^0 20'$ and 29^0 N latitude. The upper catchment of the river system (62620 km^2 or 85 percent of a total catchment area of 74030 km^2 in the hilly reaches of the great Himalayan range) lies in Nepal and Tibet. The highest peaks in the world, Mount Everest and the Kanchenjunga, are in the Kosi catchment. It has seven tributaries namely Arun Kosi, Sun Kosi, Tamur, Indrawati, Bhotia, Doodhi and Tamba. Its three major tributaries, Sun Kosi, Arun Kosi and Tamur join at Tribeni in Nepal to form Saptakosi. Saptakosi cuts its path through a 10 km long deep gorge in the Central Himalayan range and debauches into the plains near Chatra in the Saptari district of Nepal. The river enters into Indian Territory near Bhimnagar in the Supaul district of Bihar state. Lower down the Chatra, Kosi travels for about 276 km in an alluvial plain to meet the river Ganges near Kursela in Katihar district of Bihar. The river has a total length of 468 km of which 236 km from Hanumannagar to Kursela is in the Indian Territory **(Fig 1.1).**

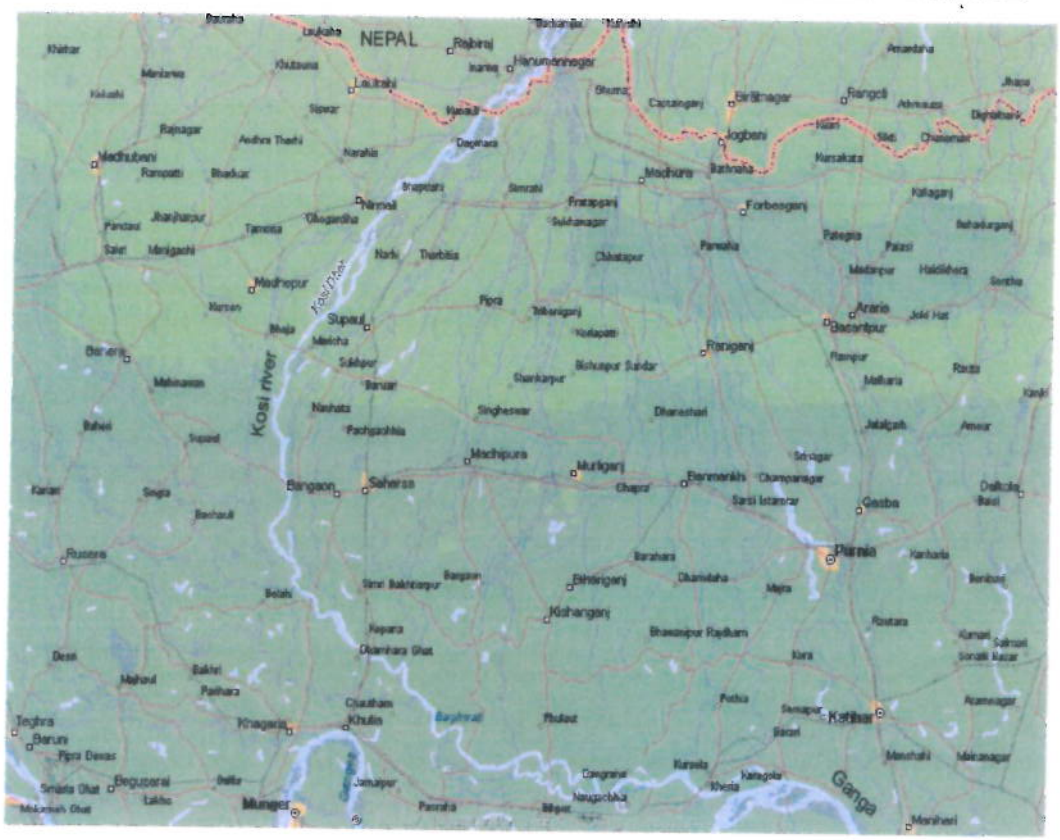


Fig. 1.1: River Kosi from Hanumannagar (India-Nepal border) to Kursela

The Kosi barrage was built at about 58 km downstream of Tribeni during the period 1956 – 1963 and 468 km length of flood embankments were constructed on either side of the river to arrest the river shifting and to control the flood ravages. Besides, a series of spurs were also constructed at vulnerable areas to prevent the breach in embankment by diverting the flow. But the river continued its shifting the course and flooding due to breaches of embankments. It is proposed to construct a high dam near Barakshetra (about 8 km down stream of the Tribeni) across the narrow gorge of river Kosi and a barrage in the plains near Chatra, to control the vagaries of the Kosi by stabilizing it in one or more defined channels and also to provide facilities for diverting the river supplies for power generation, irrigation and navigation.

Fig. 1.2: Kosi barrage at Hanumannagar

1.5.1 Salient features of Kosi River & Barrage

- **Catchment area (upto Barakshetra)** – 58849 km^2
- **Distance of barrage from Barakshetra** – 53 km
- **Design discharge** - 26900 cumec
- **Length of barrage** – 1149 m.
- **Looseness factor of barrage** – 1.45
- **Silt factor** – 1.3
- **Number of bays**
  - Left under sluice – 6 nos. each 18.288 m
  - Spillway - 46 nos. each 18.288 m
  - Right under sluice - 4 nos. each 18.288 m
- **Length of stilting basin with friction block** – 27.28 m
- **Lacey's scour depth**
  - Spillway – 11.77 m
  - Under Sluice – 12 .56 m
- **Intensity of discharge**
  - Under Sluice – 11.24 cumec
  - Spillway – 10.14 cumec
- **Present Pond level** – 74.69 m
- **Future pond level** – 77.74 m

- **Crest level**
  - Spillway – 71.64 m^2 (RL)
  - Under Sluice – 70.12 m^2 (RL)
- **Size of gates**
  - Under Sluice – 18.288 x 7.92 m
  - Spillway – 18.288 x 6.40 m
- **Piers width**
  - Main Pier – 2.134 m
  - Double Pier – 3.048 m
  - Dummy Pier – 1.829 m
- **Guide bund:**
  - Left – 1830 m
  - Right 1830 m
- **Eastern Kosi Main Canal:**
  - Discharge – 424.80 cumec
  - CCA – 6.13 lac Ha
- **Western Kosi Main Canal:**
  - Discharge – 240.72 cumec
  - CCA – 3.25 lac Ha
- **Kosi River Embankment:**
  - Western Afflux bund - 12 km
  - Eastern Afflux bund - 32 km
  - Eastern Embankment - 125 km
  - Western Embankment - 101 km (47 + 54)
- **Navigation Locks:**
  - Not Available

CHAPTER - 2

TRAFFIC CHARACTERSTICS AND TRAFFIC PROJECTIONS

CHAPTER-2

TRAFFIC CHARACTERSTICS AND TRAFFIC PROJECTIONS

2.1 CHARACTERSTICS OF THE STATE OF BIHAR

Bihar is located in the eastern part of the country and is an entirely land–locked state, although the outlet to the sea through the port of Kolkata is not far away. It is bounded by Nepal in the north and by Jharkhand in the south. The Bihar plain is divided into two unequal halves by the river Ganga which flows through the middle from west to east. The Bihar state has total area of 94163.0 sq km of which 1095 sqkm is urbanised area.

The state has extensive and well developed railway system providing vital links to mining industry and tourism with important cities and Ports in the country. The total rail length in the state is in excess of 5400 Kms. The State is serviced by 2118 Kms. of National Highways, 4192 Kms. of State Highways, 12526 Kms of district roads and over 69000 Kms. of other roads. South Bihar has extensive network of roads linking major industrial locations in the state. Patna in Bihar is connected with Delhi, Kolkata, Mumbai, Lucknow and Varansi by scheduled air services.

Bihar is richly endowed with water resources, both the ground water resource and the surface water resource. Not only by rainfall but it has considerable water supply from the rivers which flow within the territory of the State. Ganga is the main river which is joined by tributaries with their sources in the Himalayas. Some of them are Saryu (Ghaghra), Gandak, Budhi Gandak, Kosi, Bagmati, Kamla-Balan and Mahananda. There are some other rivers that start from the platue area and meet in Ganga or its associate rivers after flowing towards north. Some of them are Son, Uttari Koyal, Punpun, Panchane and Karmnasha.

The economy of the state is mainly based on agricultural and trading activities. The soil is extremely fertile which makes it ideal for agriculture. Bihar is the first largest producer of vegetables and second largest producer of fruits in the country. The major agro based industries of Bihar are of rice, sugar, edible oil.

The main large and small scale industries of the state can be categorized as follows:

- Agro based Industries such as rice mills, sugar mills and edible oil mills
- Power
- Oil refinery
- Textiles
- Engineering industries
- Tobacco and
- Information Technology

2.2 PROJECT INFLUENCE AREA

The study area comprises of the influence areas of Rivers Gandak, Sapt Kosi, Son and Ganga for providing inland water transport (IWT) services. The proposed IWT services would mainly serve the parts of Bihar and Jharkhand in India and parts of Nepal. The influence area of three rivers is summarized as follows:

1. Paschim Champaran –Patna stretch of Gandak river comprises of 8 districts of Bihar namely Paschim Champaran, Gopalganj, Purba Champaran, Siwan, Muzaffarpur, Saran, Vaishali and Patna.
2. Patna –Aurangabad stretch of Son river comprises of 4 district namely Bhojpur , Rohtas, Jahanabad and Aurangabad.
3. Supaul – Bhagalpur stretch of Sapt Kosi river primarily comprises of 5 districts namely Supaul, Madhepura, Saharsa, Khagaria and Bhagalpur.

For the purpose of traffic analysis, 42 traffic zones have been identified, 36 are internal zones comprising of various districts of Bihar, and 8 are external zones i.e. outside the boundary of Bihar. The name of the traffic zones is given in **Table 2.1** below and shown in the **Figure 2.1.**

Table 2.1 Traffic Zone List

Zone Number	Name of Traffic Zone
1	Paschim Champaran
2	Purba Champaran
3	Gopal Ganj
4	Siwan
5	Chapra (Saran)
6	Mujaffarpur
7	Sitamarhi & Sheohar
8	Vaishali
9	Patna
10	Bhojpur (Ara)
11	Buxar
12	Bhabhua
13	Rohtas (Sasaram)
14	Aurangabad
15	Gaya
16	Jahanabad
17	Nawada
18	Nalanda (Bihar Sharif)
19	Shekhpur
20	Jamui
21	Lucke Sarai

Zone Number	Name of Traffic Zone
22	Begusarai
23	Samastipur
24	Darbhanga
25	Madhubani
26	Supaul
27	Madhepura
28	Saharsa
29	Khagaria
30	Munger
31	Banka
32	Bhagalpur
33	Katihar
34	Purnia
35	Araria
36	Kishanganj
37	East U.P.
38	Delhi & Punjab
39	Jharkhand I
40	Jharkhand II
41	East India
42	Nepal

Figure 2.1 Traffic Zone Systems

2.3 DEMOGRAPHIC PROFILE

The area and population of districts of Bihar is given in **Table 2.2**. As per Census 2001 figures, total population of Bihar is 82, 878,796. While the decadal population growth rate for the state of Bihar is 28.43% for the period 1991-2001, it grows at the rate of 30-35% in some districts. It is evident from the table that the three top districts in Bihar are Patna, East Champaran and Muzaffarpur. Patna is the most populous district of the State. The average population of a district in Bihar works out to be 22.4 Lakh.

Table No.2.2 District Wise Population of Bihar State

Sl. No.	District	Population 1991	Population 2001	%age Decadal Growth Rate
1	Patna	3,618,211	4,709,851	30.17
2	Purba Champaran	3,043,061	3,933,636	29.27
3	Muzaffarpur	2,953,903	3,743,836	26.74
4	Madhubani	2,832,024	3,570,651	26.08
5	Gaya	2,664,803	3,464,983	30.03
6	Samastipur	2,716,929	3,413,413	25.63
7	Darbhanga	2,510,959	3,285,473	30.85
8	Saran	2,572,980	3,251,474	26.37
9	Pachim Champaran	2,333,666	3,043,044	30.40
10	Vaishali	2,146,065	2,712,389	26.39
11	Siwan	2,170,971	2,708,840	24.78
12	Sitamarhi	2,013,796	2,669,887	32.58
13	Purnia	1,878,885	2,540,788	35.23
14	Rohtas	1,917,416	2,448,762	27.71
15	Bhagalpur	1,909,967	2,430,331	27.24
16	Katihar	1,825,380	2,389,533	30.91
17	Nalanda	1,996,257	2,368,327	18.64
18	Begusarai	1,814,773	2,342,989	29.11
19	Bhojpur	1,792,771	2,233,415	24.58
20	Gopalganj	1,704,310	2,149,343	26.11
21	Araria	1,611,638	2,124,831	31.84

Sl. No.	District	Population 1991	Population 2001	%age Decadal Growth Rate
22	Aurangabad	1,539,988	2,004,960	30.19
23	Nawada	1,359,694	1,809,425	33.08
24	Supaul	1,342,841	1,745,069	29.95
25	Banka	1,292,504	1,608,778	24.47
26	Madhepura	1,177,706	1,524,596	29.45
27	Jehanabad	1,174,900	1,511,406	28.64
28	Saharsa	1,132,413	1,506,418	33.03
29	Buxar	1,087,676	1,403,462	29.03
30	Jamui	1,051,527	1,397,474	32.90
31	Kishanganj	984,107	1,294,063	31.50
32	Kaimur	983,269	1,284,575	30.64
33	Khagaria	987,227	1,276,677	29.32
34	Munger	943,583	1,135,499	20.34
35	Lakhisarai	646,395	801,173	23.94
36	Sheikhpura	420,260	525,137	24.96
37	Sheohar	377,699	514,288	36.16
	Total:-	**64,530,554**	**82,878,796**	**28.43**

2.4 PRIMARY TRAFFIC AND TRAVEL SURVEYS

The following traffic and travel surveys have been conducted as part of the study in order to determine commodity wise O-D flows in the project influence area:

- Classified traffic volume count survey (15 locations)
- Vehicle occupancy survey
- Road side origin-destination survey

These above surveys have been conducted day and night continuously for three days. In addition Industrial Surveys were also conducted in Bihar. About 100 medium and large scale industries were surveyed in the study area to determine the willingness of industry management to use inland water transport for the inbound shipment of raw materials as used by the industries

and outbound shipment of the finished product manufactured by the industries.

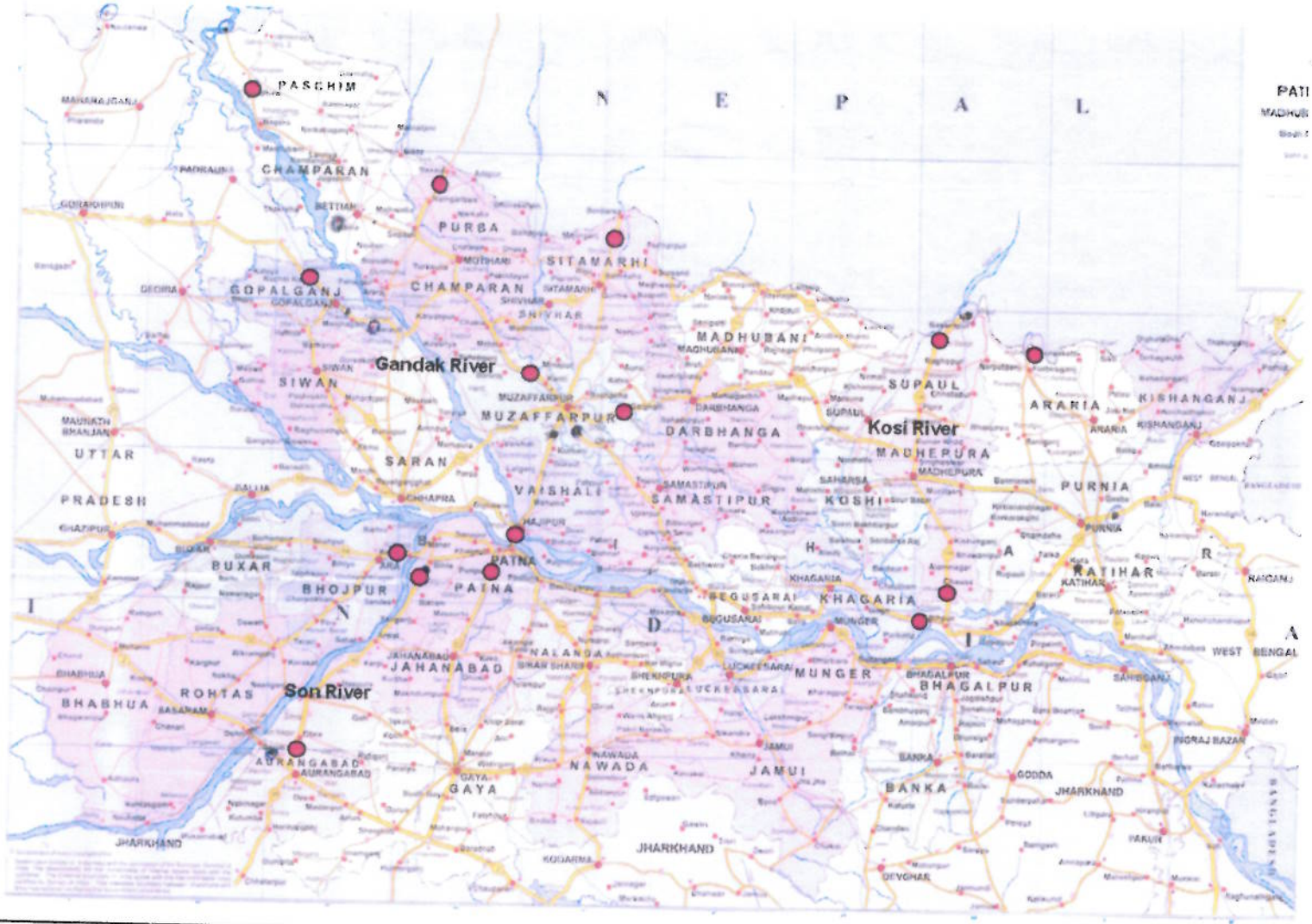
The survey performs for traffic and industrial surveys are given in **Annexure 2.1** to **2.3** The data collected through the above field surveys have been analysed to assess the present classified traffic volumes and movement pattern at various identified locations near the rivers influence area throughout the state of Bihar. The survey locations are listed in **Table 2.3** below and also shown in **Figure 2.2**.

Table 2.3 List of Traffic Surveys Locations

Location No.	Locations of Traffic Surveys
1	Hajipur Bridge
2	Ara Buxar Road (Near Undawant Nagar)
3	Muzaffarpur- Darbhanga Road (Near Galghatti)
4	Jahanabad Road (Near Bihta)
5	Jahanabad Road (Near Punpun)
6	Muzaffarpur Purvi Champaran Road (Near Kanti)
7	Aurangabad-Jahanabad Road (Near Obra)
8	Khagaria Bhagalpur Road (Near Bihpur)
9	Bhagalpur -Madhepura Road Near Chausa
10	Sonbarsa Nepal Border Road (Sitamarhi)
11	Raxaul -Nepal Border Road
12	Bagha-Nepal Border Road (Paschim Champaran)
13	Gopalganj Gorakhpur Road(Near Kuchal Kot)
14	Ararai- Nepal Bordar Near Forbes Ganj
15	Supaul Nepal Border Road Near Basant Pur

Source: Primary Survey September '2008

FIGURE 2.2. TRAFFIC SURVEY LOCATIONS



2.5 TRAFFIC VOLUME CHARACTERISTICS

Classified Traffic Volume Count

The classified traffic volume surveys have been conducted at 15 identified locations for 72 hours continuously i.e. three days. The quantum and temporal variation of total and daily traffic moving in the study area are presented in the following sections.

2.5.1 Traffic Volume (Average Daily Traffic – 24 hours)

The traffic count both in terms of number of vehicles and passenger car units (PCUs) have been computed for the total daily (24 hours) traffic continuously for three days at different identified locations which are presented in **Table 2.4**. It is observed that the daily traffic at different locations varies from 2513 PCU's (3159 vehicles) at Sonbarsa Nepal Border (Sitamarhi) to 41873 PCU's (28233 vehicles) at Hajipur Bridge Patna.

Table 2.4 Average Daily Traffic Volume (24 Hours) at Identified Locations

Sl No	Name of Location	DAILY TRAFFIC						AVERAGE DAILY TRAFFIC	
		Day-1		Day-2		Day-3			
		Vehicle	PCU's	Vehicle	PCU's	Vehicle	PCU's	Vehicle	PCU's
1	Hajipur Bridge	25693	38712	25944	37770	33062	49138	28233	41873
2	Ara Buxar Road (Near Undawant Nagar)	16761	26924	19904	31592	19878	31462	18848	29993
3	Muzaffarpur- Darbhanga Road (Near Galghati)	9218	12733	6111	8769	11351	16754	8893	12752
4	Jahanabd Road (Near Bhita)	3468	4316	2788	3434	3942	4724	3399	4158
5	Jahanabad Road (Near Punpun)	3983	4051	3057	2990	4260	4339	3767	3793
6	Muzaffarpur Puri Champuran Road (Near Kanti)	14187	21332	17623	25509	16246	25983	16019	24275
7	Aurangabad -Jahanabad Road (Near Obra)	4539	4778	4727	5418	5961	7086	5076	5760
8	Khagaria Bhagalpur Road (Near Bihpur)	3958	6798	4428	7567	3166	4911	3851	6425
9	Bhagal Pur MadhePura Road Near Chausa	5183	4295	7592	6898	7433	6651	6736	5948
10	Sonbasara Nepal Border Road (Sita Marhi)	2955	2259	3237	2801	3286	2481	3159	2513
11	Raxaul Nepal Border Road	16375	18535	18228	20466	20375	22580	18326	20527
12	Bagha NepaL Border Road (Paschim Chamarm)	7875	8456	4329	5475	8361	8738	6855	7556
13	Gopalganj Gorakhpur Road (Near Kuchkal Lot)	5653	6400	5984	7007	6281	6897	5973	6768
14	Ararai NepaL Border (Near Forbesganj)	3160	3846	3648	4686	4163	5658	3657	4730
15	Supaul Nepal Border Road (Near Basantpur)	5473	3917	5389	3714	5364	3680	5409	3770

Source: Primary Survey September '2008

2.5.2 Peak Hour Traffic

The peak hour traffic characteristics at the identified locations are presented in **Table 2.5**. The peak hour factor is the percentage of peak hour traffic to the total daily traffic. The peak hour factor varies from 5.53% at Ara Buxar Road (Near Undawant Nagar) to 9.15% at Supaul Nepal Border Road (Near Basant Pur). The averaging peak hour average in all the locations is about 7.07%.

Table 2.5 Peak Hour Characteristics at Identified Locations

S. No.	Name of Location	Average 24 Hr. Traffic (PCUs)	Average Peak Hr. Traffic (PCUs)	Average % Peak Hour Share/ Factor
1	Hajipur Bridge	41873	2319	5.54
2	Ara Buxar Road (Near Undawant Nagar)	29993	1658	5.53
3	Muzaffarpur- Darbhanga Road (Near Galghatti)	12752	733	5.75
4	Jahanabad Road (Near Bihta)	4158	246	5.92
5	Jahanabad Road (Near Punpun)	3793	254	6.70
6	Muzaffarpur Purvi Champaran Road (Near Kanti)	24275	1837	7.57
7	Aurangabad-Jahanabad Road (Near Obra)	5760	381	6.61
8	Khagaria Bhagalpur Road (Near Bihpur)	6425	486	7.56
9	Bhagalpur -Madhepura Road Near Chausa	5948	371	6.24
10	Sonbarsa Nepal Border Road (Sitamarhi)	2513	204	8.12
11	Raxaul -Nepal Border Road	20527	1861	9.07
12	Bagha-Nepal Border Road (Paschim Champaran)	7556	509	6.74
13	Gopalganj Gorakhpur Road(Near Kuchal Kot)	6768	568	8.39
14	Ararai- Nepal Bordar Near Forbes Ganj	4730	339	7.17
15	Supaul Nepal Border Road Basant Pur	3770	345	9.15

Source: Primary Survey September '2008

2.5.3 Composition of Traffic

The composition of traffic in terms of fast moving, goods and slow moving at various identified locations are presented in **Table 2.6.** The daily traffic

composition of fast moving passenger traffic is varying from 28.67% at Ara Buxar Road (near Undawant Nagar) to 54.13% at Hazipur Bridge (Patna). On an average the light fast moving passenger vehicles comprises 76% of total traffic. It is observed that the share of slow moving vehicles varies from 9.15% to 59.75% with an average of about 20%. The share of bus traffic is as low as 1.11% at Raxual (Nepal Border Road (maximum of about 10.26% at Aurangabad-Jahanabad Road (Near Obra) with an average of about 2.6% of total traffic. The fast passenger vehicles predominantly consist of two wheelers, cars and auto while the slow vehicles consist of cycles and cycle rickshaws. The share of goods traffic varies from 2.17% to 32.74% at various locations.

Table 2.6 Daily Traffic Composition (24 Hours) at Identified Locations

Sl. No.	Name of Location	Composition (%)			
		Bus	Fast Moving Passenger	Goods	Slow Moving Passenger
1	Hajipur Bridge	6.72	54.13	30.00	9.15
2	Ara Buxar Road (Near Undawant Nagar)	4.15	28.67	30.11	37.07
3	Muzaffarpur- Darbhanga Road (Near Galghatti)	9.33	43.52	27.32	19.84
4	Jahanabad Road (Near Bihta)	5.64	41.87	20.61	31.88
5	Jahanabad Road (Near Punpun)	4.76	63.12	8.42	23.69
6	Muzaffarpur Purvi Champaran Road (Near Kanti)	6.10	41.43	32.74	19.73
7	Aurangabad-Jahanabad Road (Near Obra)	10.26	52.01	17.69	20.03
8	Khagaria Bhagalpur Road (Near Bihpur)	4.03	36.98	30.48	28.51
9	Bhagalpur -Madhepura Road Near Chausa	4.06	35.05	5.28	55.62
10	Sonbarsa Nepal Border Road (Sitamarhi)	2.91	43.66	4.64	48.79
11	Raxaul -Nepal Border Road	1.11	33.42	5.71	59.75
12	Bagha-Nepal Border Road (Paschim Champaran)	1.32	37.94	19.89	40.84
13	Gopalganj Gorakhpur Road(Near Kuchal Kot)	1.40	46.28	19.97	32.35
14	Ararai- Nepal Bordar Near Forbes Ganj	6.37	33.42	2.52	57.68
15	Supaul Nepal Border Road Basant Pur	1.94	42.68	2.17	53.21

Source: Primary Survey September '2008

2.5.4 Occupancy of Vehicles and Passenger Trips

The average occupancy of various modes is presented in **Table 2.7**. The average Bus occupancy varies from 15 to 54 at different locations and averaging occupancy is 41. Averaging occupancy for cars, two wheelers and auto rickshaws is about 3.9, 1.7, and 4.2 respectively. The mini buses have an averaging occupancy of 11.

Table 2.7 Occupancy of Fast Passenger Vehicles at Identified Locations

S. N.	Name of Locations	Average Occupancy				
		Car	2 Wh.	Auto	Bus	Mini Bus
1	Hajipur Bridge	3.39	1.70	4.86	52.42	9.06
2	Ara Buxar Road (Near Undawant Nagar)	2.94	1.44	3.66	54.25	15.1
3	Muzaffarpur- Darbhanga Road (Near Galghatti)	4.13	1.65	3.2	41.08	12.38
4	Jahanabad Road (Near Bihta)	4.21	1.64	4.32	46.06	12.01
5	Jahanabad Road (Near Punpun)	4.00	1.67	3.6	14.34	11.4
6	Muzaffarpur Purvi Champaran Road (Near Kanti)	3.89	1.64	4.65	49.17	12.77
7	Aurangabad-Jahanabad Road (Near Obra)	3.61	1.70	4.22	41.99	11.43
8	Khagaria Bhagalpur Road (Near Bihpur)	4.25	1.90	3.86	49.68	9.5
9	Bhagalpur -Madhepura Road Near Chausa	2.36	1.93	4.2	35.72	6.51
10	Sonbarsa Nepal Border Road (Sitamarhi)	5.10	1.64	3.66	36.11	6.13
11	Raxaul -Nepal Border Road	3.83	1.66	5.16	48.75	11.37
12	Bagha-Nepal Border Road (Paschim Champaran)	2.61	1.60	5.12	43.75	12.17
13	Gopalganj Gorakhpur Road(Near Kuchal Kot)	4.17	1.64	4.38	23.75	12.44
14	Ararai- Nepal Bordar Near Forbes Ganj	5.20	1.93	4.75	48.75	11.25
15	Supaul Nepal Border Road Near Basant Pur	5.40	1.80	3.72	34.44	11.67

Source: Primary Survey September '2008

Total daily passenger trips are presented in **Table 2.8.** It is observed that the passenger trips at different locations vary from 7,466 trips at Supaul Nepal Border Road near Basant Pur to 1,35,260 trips at Hajipur Bridge. Another major location is Muzaffarpur - Purvi Champaran Road (Near Kanti) which is handling 54,433 trips per day.

Table 2.8 Daily Passenger Trips at Identified Locations

S. No.	Location	Fast Moving Passenger Trips					Total Trips
		Car Jeep Van	2-Wh	Auto	Bus		
					Bus	Mini Bus	
1	Hajipur Bridge	17782	11417	16140	87926	1996	135260
2	Ara Buxar Road (Near Undawant Nagar)	5193	4284	2425	21573	5803	39279
3	Muzaffarpur- Darbhanga Road (Near Galghatti)	4733	3452	2022	20882	3978	35068
4	Jahanabad Road (Near Bihta)	2400	1105	775	5742	805	10827
5	Jahanabad Road (Near Punpun)	2100	2207	1913	750	1448	8418
6	Muzaffarpur Purvi Champaran Road (Near Kanti)	9619	4950	5330	29797	4738	54433
7	Aurangabad-Jahanabad Road (Near Obra)	2049	2715	2006	6396	4214	17380
8	Khagaria Bhagalpur Road (Near Bihpur)	1947	1319	1050	4223	668	9206
9	Bhagalpur -Madhepura Road Near Chausa	1309	3250	512	5382	801	11254
10	Sonbarsa Nepal Border Road (Sitamarhi)	316	2112	109	2130	202	4869
11	Raxaul -Nepal Border Road	3116	8600	673	5655	1004	19049
12	Bagha-Nepal Border Road (Paschim Champaran)	418	3283	1990	2085	523	8300
13	Gopalganj Gorakhpur Road (Near Kuchal Kot)	2651	3377	304	562	742	7636
14	Ararai- Nepal Bordar Near Forbes Ganj	950	1291	1761	6143	1204	11348
15	Supaul Nepal Border Road Near Basant Pur	1107	3682	215	1871	591	7466

Source: Primary Survey September '2008

2.6 GOODS MOVEMENT CHARACTERSTICS

2.6.1 Traffic Volume of Goods Vehicles and Sample Size

The origin destination survey of goods vehicles was conducted as per survey proforma at **Annexure 2.2** at the identified 15 locations along with traffic volume surveys on sample basis. The goods/ commodities have been categorized in different groups as given in **Table 2.9**

Table 2.9: Constituents of Commodity Group

Code	Commodity Group	Commodity
1	Construction Material	Sand, Stone, Bricks, Iron, Steel, Cement, Marble and Stone Slab, Hardware, Fitting & Fixture, Timber & Furnishing Work, Machinery - Light & Heavy
2	Cereals/Cash Crops	Wheat, Rice, Bajra, Jawar, Millets, Maize, Gram, Pulses, Sugar Cane, Cotton, Barley, Oil Seed, Tobacco, Dry Chilies, Other
3	Perishable Commodities	Fruit, Vegetable, Dairy / Poultry Products, Fishing and Meat
4	Petroleum Products	Petrol, Diesel, Kerosene and L.P.G
5	Conventional Fuels	Coal and Firewood
6	Live Stock	Animals, Oil Cake and Bhusa
7	Chemicals	Fertilizer, Wine, Beverage & Soft drink, Acids
8	Mineral Ore	Lime Stone, Iron and Copper Ore
9	Others	Consumer Goods, Kirana /Perchun Appliances, Edible Oil, Refined Oil, Paper Products and Others
10	Empty	Empty Vehicle

As a part of Traffic surveys, the total number of goods vehicles passing at the survey locations were counted continuously for the duration of 72 hours (for three days). Total number of 14336 goods vehicle including trucks, LMV, MAV etc were interviewed. Sample Size varies from about 8% to 62% of goods vehicles at various locations. The location wise number of sample vehicles interviewed and their percentage distribution is given in **Table 2.10**.

Table 2.10 VOLUMES OF GOODS VEHICLES AND SAMPLE SIZE

SN	Name of Location	Average Daily Goods Traffic				Average Sample Goods Traffic				Percentage of Sample Goods Traffic			
		LCV	Truck	MAV	Total	LCV	Truck	MAV	Total	LCV	Truck	MAV	Total
1	Hajipur Bridge	2327	5888	256	8471	294	376	90	760	12.63	6.39	35.20	8.97
2	Ara Buxar Road (Near Undawant Nagar)	1441	3996	238	5675	222	280	14	515	15.38	7.00	5.73	9.07
3	Muzaffarpur-Darbhanga Road (Near Galghati)	936	1384	109	2429	141	193	5	339	15.06	13.92	4.59	13.94
4	Jahanabd Road (Near Bhita)	305	369	27	701	65	56	4	125	21.44	15.10	14.63	17.84
5	Jahanabad Road (Near Punpun)	172	142	3	317	92	23	0	115	53.49	16.20	0.00	36.24
6	Muzaffarpur Purbi Champuran Road (Kanti)	1600	3215	429	5244	319	472	42	832	19.91	14.68	9.71	15.87
7	Aurangabad - Jahanabad Road (Near Obra)	301	591	6	898	100	130	7	237	33.11	22.04	129.41	26.43
8	Khagaria Bhagalpur Road (Near Bihpur)	184	889	101	1174	60	673	50	783	32.67	75.73	49.34	66.71
9	Bhagal Pur MadhePura Road Near Chusa	139	217	0	355	25	79	0	104	18.03	36.62	0.00	29.36
10	Sonbasara Nepal Border Road (Sita Marhi)	66	77	4	147	17	42	1	60	25.38	54.31	36.36	40.91
11	Raxaul Nepal Border Road	315	662	70	1047	74	280	11	365	23.47	42.32	15.24	34.83
12	Bagha NepaL Border Road (Paschim Champaran)	700	654	10	1364	60	40	0	100	8.58	6.11	0.00	7.33
13	Gopalganj Gorakhpur Road (Near Kuchkal Lot)	130	932	130	1193	37	350	21	408	28.64	37.54	15.90	34.21
14	Ararai NepaL Border (Near Forbesganj)	35	56	1	92	10	13	1	24	28.30	23.81	66.67	25.99
15	Supaul Nepal Border Road (Near Basantpur)	52	61	4	117	28	34	0	61	53.55	54.89	0.00	52.27

2.6.2 Commodity wise Goods Traffic

The total volume of good traffic (in tonnes) at various locations is given in **Table No. 2.11.**

Table 2.11: Distribution of Location wise Goods Traffic

S. No.	Location	Tonnage (3 Day)	Tonnage (Average)
1	Hajipur Bridge	71589	23863
2	Ara Buxar Road (Near Undawant Nagar)	51920	17307
3	Muzaffarpur- Darbhanga Road (Near Galghatti)	46003	15334
4	Jahanabad Road (Near Bihta)	3599	1200
5	Jahanabad Road (Near Punpun)	2461	820
6	Muzaffarpur Purvi Champaran Road (Near Kanti)	132984	44328
7	Aurangabad-Jahanabad Road (Near Obra)	11326	3775
8	Khagaria Bhagalpur Road (Near Bihpur)	36562	12187
9	Bhagalpur -Madhepura Road Near Chausa	10189	3396
10	Sonbarsa Nepal Border Road (Sitamarhi)	3509	1170
11	Raxaul -Nepal Border Road	17626	5875
12	Bagha-Nepal Border Road (Paschim Champaran)	16316	5439
13	Gopalganj Gorakhpur Road(Near Kuchal Kot)	40799	13600
14	Ararai- Nepal Bordar Near Forbes Ganj	3159	1053
15	Supaul Nepal Border Road Basant Pur	2869	956

2.7 INDUSTRIAL SURVEY

2.7.1 Industrial Survey was conducted at industries with a samples size of 103 as per Survey Proforma at **Annexure 2.3**. No. of industries covered this survey were Vaishali (50Nos), Patna (31 Nos), Mujaffarpur (17 Nos.) and Aurangabad (5 Nos). The summarized output in respect of the above has been presented in **Tables-2.12 to 2.14.** The industrial survey data has been given in **Annexure 2.4**.

Table No. 2.12 gives the type of commodities manufactured. It is observed from the table that about 39% of the manufactured items are construction material; where as 42% of the manufactured goods are household and food items. The remaining about 19% manufactured commodities are petroleum, mineral ores etc.

Table 2.12: Type of Commodity Manufactured as per Industries Survey

Code	Commodity Group	Type of Commodity Manufactured	Sample	%
1	Construction Material	Sand. Stone, Bricks, Iron, Steel, Cement, Marble and Stone Slab, Hardware, Fitting & Fixture, Timber & Furnishing Work, Machinary - Light & Heavy	40	38.83
2	Cereals/Cash Crops	Wheat, Rice, Bajra, Jawar, Millets, Maize, Gram, Pulses, Sugar Cane, Cotton, Barley, Oil Seed, Tobacco, Dry Chilies, Other	7	6.80
3	Perishable Commodities	Fruit, Vegetable, Diary / Poultry Products, Fishing and Meat	4	3.88
4	Petrolium Products	Petrol, Diesel, Kerosene, L.P.G	1	0.97
5	Conventional Fuels	Coal, Fire Wood	0	0.00
6	Live Stock	Animals, Oil Cake, Bhusa	1	0.97
7	Chemicals	Fertilizer, Wine, Beverage & Soft drink, Acids.	8	7.77
8	Mineral Ore	Lime Stone, Iron and Copper Ore.	10	9.71
9	Others	Consumer Goods, Kirana /Perchun Appliances, Edible Oil, Refined Oil, Paper Products and Others	32	31.07
Total			103	100.00

Source: Primary Survey September '2008

2.7.2 Distribution of Goods Movement by Mode of Transport

Table No.2.13 reveals that the entire goods manufactured by industries are transported through road based transport. Trucks are predominant mode of transport for the movements of goods. Only 1% of industrial goods are transported by railway.

Table 2.13: Mode used for Commodity Movement

Sl.No	Mode of Travel	No of Surveyed Establishments.	%age
1	Truck	93	90.29
2	Railway	1	0.97
3	LCV	3	2.91
4	CAR	1	0.97
5	Tractor	1	0.97
6	Truck + LCV	3	2.91
7	Truck+Railway	1	0.97
Total:-		**103**	**100.00**

Source: Primary Survey September '2008

2.7.3 Opinion survey

Opinion survey was carried out to obtain preference of industrial owners about shifting to Inland water transport system for the goods movement. The respondents were asked their willingness to shift to Inland water Transport with respect to their existing transport mode used. The **Table 2.14** shows a positive response from the industrials owners. The table indicates that 51% are willing to shift to Inland Water Transport if the existing cost of transport for the movement of goods remains the same with Inland water Transport system. Whereas 17% are willing to shift with reduction of 10% tariff in Inland Water transport as compared to road transport and additional 8% respondents are willing to shift with reduction of 20% of tariff as compared to the present transport system used by industries. About 25% respondents showed no response.

Table 2.14: Willingness to use Inland Water Transport from the Existing Mode of Transport use for Commodity Movements

S. No.	Category	No. of Surveyed Establishments	%age
(a)	Existing Cost	52	50.5
(b)	10% Cost Saving	17	16.5
(c)	15% Cost Saving	0	0.0
(d)	20% Cost Saving	8	7.8
(e)	No Response	26	25.2
Total		**103**	**100.00**

Source: Primary Survey September '2008

2.8 BASE YEAR (2008-09) FREIGHT TRAFFIC RELEVANT FOR IWT

2.8.1 The road freight captured during the O-D traffic surveys organized at selected road side locations forms the base traffic from which traffic relevant for IWT has been identified. The traffic relevant for IWT have identified giving due consideration to the following aspects.

- Nature of the commodity: For example perishable commodities like fruits, vegetables, milk etc have not been considered relevant for IWT movement. Similarly, inflammable and dangerous cargo e.g. petrol, diesel, kerosene etc. are not considered Further, cargo flows having origin and/or destinations far away from the river front have been excluded.

- Comparative cost of movement by road transport versus IWT has formed the basis for identifying cargo traffic that is likely to shift to IWT if this mode is developed.

2.8.2 Keeping view the above considerations, the following commodities/commodity groups have been considered relevant for Inland Water Transport (IWT) is given in **Table 2.15**

Table 2.15: Constituents of Commodity Identified For IWT

Code	Commodity Group	Commodity
1	Construction Material	Sand, Stone, Bricks, Iron, Steel, Cement, Marble and Stone Slab, Hardware, Fitting & Fixture, Timber & Furnishing Work, Machinery - Light & Heavy
2	Cereals/Cash Crops	Wheat, Rice, Bajra, Jawar, Millets, Maize, Gram, Pulses, Sugar Cane, Cotton, Barley, Oil Seed, Tobacco, Dry Chilies, Other
5	Conventional Fuels	Coal and Firewood
6	Live Stock	Animals, Oil Cake and Bhusa
7	Chemicals	Fertilizer, Wine, Beverage & Soft drink, Acids
8	Mineral Ore	Lime Stone, Iron and Copper Ore
9	Others	Consumer Goods, Kirana /Perchun Appliances, Edible Oil, Refined Oil, Paper Products and Others

2.8.3 For the user of any transport mode, total cost of transport from the initial origin to the final destination forms the major consideration in deciding a particular mode for transport for movement cargo. Other thing being the same or similar, a user prefers that mode whose transport cost less vis-a- vis other available modes of transport in the present context. A broad comparative cost analysis for moving a commodity for different distances by IWT and road transport has been carried. This analysis brings out that IWT will be less costly vis-a- vis road transports for distance above 50 kms. The details are presented in **Table 2.16.**

Table 2.16: Comparative Cost of by Road Transport and IWT (2006-07 Price Level)

Distance (Km)	Road Transport Cost/ Tonne (Rs.)	Cost of Transport by IWT (Rs./Tonne)				Additional Cost by Road (Rs./Tonne)
		Vessel	Local Cartage*	Additional Handling**	Total cost	
25	38.68	14.07	23.91	20	57.98	-19.30
50	77.36	28.14	23.91	20	72.05	5.31
75	116.04	42.21	23.91	20	86.12	29.91
100	154.71	56.28	23.91	20	100.19	54.52
125	193.39	70.36	23.91	20	114.27	79.13
150	232.07	84.43	23.91	20	128.34	103.74
* Average Local Cartage: 3 Km on either side i.e. 6 km in total						
** One additional handling on either side i.e. 2 additional handlings @ Rs. 10/tonne (Loading & Unloading)						

Source : Rites Report of IWT of Andhra Pradesh

2.8.4 Based on the commodity characteristics and comparative cost and allied considerations, the base year (2008-09) traffic relevant for IWT has been identified from the total O-D traffic flow estimates derived from the data collected during the O-D traffic surveys.

2.8.5 Even if the cost of movement by IWT is less between an O-D pair, the entire traffic may not shift from road transport to IWT in of some exigencies like urgency, non-availability of IWT at the required time. It has been assumed that 50% of traffic relevant for IWT System from road transport may shift to IWT. Considering above commodity specific traffic estimates is presented in the following tables for the proposed IWT System in the Kosi river.

2.8.6 Project Influence Area – Kosi River

The base year commodity wise Traffic and Section loading in metric tonnes per day is estimated for inland water transport system on Kosi River and is given in the **Tables 2.17 -2.18.**

Table 2.17 Estimated Base Year Commodity wise Traffic on Kosi River (in Metric Tonnes per Day)

Origin	Commodity wise Tonnage							Total Tonnage/day
	1	2	5	6	7	8	9	
Direction 1 - Patna to Nepal								
Naugachhia	192	226	0	4	27	14	82	545
Kosi	27	61	0	0	25	25	29	167
Supaul	111	45	0	0	7	6	43	211
Nepal	0	0	0	0	0	0	0	0
Total	**329**	**331**	**0**	**4**	**59**	**45**	**154**	922
Direction 2 - Nepal to Patna								
Nepal	219	181	0	0	2	68	92	562
Supaul	121	196	28	7	6	0	4	362
Kosi	39	170	0	10	13	10	26	268
Naugachhia	0	0	0	0	0	0	0	0
Total	**379**	**547**	**28**	**17**	**21**	**77**	**122**	1192
Both Direction								
Naugachhia	192	226	0	4	27	14	82	1089
Kosi	65	231	0	10	39	34	55	869
Supaul	232	241	28	7	12	6	47	1144
Nepal	219	181	0	0	2	68	92	1121
Grand Total	**708**	**878**	**28**	**21**	**79**	**122**	**276**	2112

Type of Commodities : 1 Construction Material, 2. Cereals/Cash Crops, 5. Conventional Fuels, 6. Live Stock, 7. Chemicals, 8. Mineral Ore, 9. Others

Table 2.18: Estimated Base Year Commodity wise Section Loading on Various Sections on Kosi River (in Metric Tonnes per Day)

SECTION		Commodity wise Tonnage							Total Tonnage/day
From	To	1	2	5	6	7	8	9	
Direction 1 - From Patna to Nepal									
Naugachhia	Kosi	192	226	0	4	27	14	82	545
Kosi	Supaul	93	186	0	0	43	39	91	451
Supaul	Nepal	197	216	0	0	24	34	129	600
Direction 2 - From Nepal to Patna									
Nepal	Supaul	240	199	5	0	5	70	100	618
Supaul	Kosi	256	336	28	7	8	30	50	714
Kosi	Naugachhia	249	450	28	10	15	27	70	849
Both Direction on Kosi River									
Nepal	Supaul	437	414	5	0	30	104	229	1218
Supaul	Kosi	348	521	28	7	50	69	141	1165
Kosi	Naugachhia	441	676	28	14	42	41	152	1394

Type of Commodities: 1 Construction Material, 2. Cereals/Cash Crops, 5. Conventional Fuels, 6. Live Stock, 7. Chemicals 8. Mineral Ore 9. Others

2.9 FORECAST FOR IWT TRAFFIC

The major determinants level of demand for transport and the flow pattern of cargo are the demand and supply levels of various commodities and services, their location and interaction patterns in the related area. These in turn crucially depend on existing anticipated economic activities, population and their income levels and distribution, availability of quality infrastructure etc. in the region. The GDP of the state Bihar, Jharkhand and the country Nepal plays a vital role in order to determine the growth of traffic. The GSDP of Bihar, Jharkhand and GDP of Nepal is given in Table 2.19. It is seen from the Table that the growth of GSDP of Bihar, Jharkhand and GDP of Nepal is more than 6% p. a.

Table 2.19 GSDP Bihar, Jharkhand State and GDP of Nepal

YEARS	GSDP of Bihar in US $ (Billions)	GSDP of Jharkhand in US $ (Billions)	GDP of Nepal in US $ (Billions)
1999-00	9.10	7.33	27.4
2000-01	9.70	6.64	33.7
2002-03	9.80	7.29	35.6
2003-04	11.60	8.37	36
2000-04	11.90	9.72	38.29
2004-05	12.60	12.58	39.53
2005-06	13.4	13.99	39.15
2006-07		16.61	41.18

Source: Bihar, Jharkhand Department of Planning & Development

Considering above for the projection of traffic, the growth of 6% p.a. has been considered for the next 25 years. Within the framework of the forecasting methodology referred to above, O-D freight traffic flows for each river stretch , terminal wise originating, terminating and total cargo loads have been worked for the four horizons i.e. 2014-15, 2020-21, 2025-26 and 2030-31.These estimates are presented in the **Tables 2.20 - 2.21,** for Kosi river project influence area.

Table : 2.20 Estimated Total Annual Traffic for Horizon Years on Kosi River (in Tonnes)

Origin	2008-09	2012-13	2015-16	2020-21	2025-26	2030-31	2035-36
Direction 1 - Patna to Nepal							
Naugachhia (Bhagalpur)	185300	233937	278623	372860	498971	667735	893581
Kosi	56780	71683	85376	114253	152896	204609	273813
Supaul	71740	90570	107870	144355	193180	258518	345955
Nepal	0	0	0	0	0	0	0
Total	**313820**	**396191**	**471869**	**631467**	**845046**	**1130862**	**1513349**
Direction 2 - Nepal to Patna							
Nepal	191080	241234	287314	384491	514535	688564	921454
Supaul	123080	155386	185067	247661	331426	443523	593534
Kosi	91120	115037	137011	183351	245365	328354	439412
Naugachhia (Bhagalpur)	0	0	0	0	0	0	0
Total	**405280**	**511657**	**609391**	**815503**	**1091327**	**1460442**	**1954400**
Both Direction							
Naugachhia (Bhagalpur)	185300	233937	278623	372860	498971	667735	893581
Kosi	147900	186720	222387	297604	398261	532963	713225
Supaul	194820	245956	292937	392016	524606	702041	939489
Nepal	191080	241234	287314	384491	514535	688564	921454
Grand Total	**719100**	**907847**	**1081261**	**1446970**	**1936373**	**2591304**	**3467749**

Table 2.21 Estimated Horizon Years Section Loading of Traffic on Various Sections on Kosi River (in Metric Tons)

Section		2008-09	2012-13	2015-16	2020-21	2025-26	2030-31	2035-36
From	To							
Direction 1 - Naugachhia (Bhagalpur) to Nepal								
Naugachhia	Kosi	185300	233937	278623	372860	498971	667735	893581
Kosi	Supaul	153340	193588	230567	308550	412910	552566	739459
Supaul	Nepal	204000	257545	306741	410488	549326	735122	983759
Direction 2 - Nepal to Naugachhia (Bhagalpur)								
Nepal	Supaul	210120	265272	315943	422803	565805	757175	1013271
Supaul	Kosi	242760	306479	365021	488481	653698	874795	1170673
Kosi	Naugachhia	288660	364427	434038	580841	777296	1040197	1392018
Both Direction								
Nepal	Supaul	473960	598364	712661	953701	1276267	1707933	2285599
Supaul	Kosi	396100	500067	595588	797031	1066607	1427361	1910131
Kosi	Naugachhia	414120	522817	622683	833291	1115131	1492297	1997030

Commodity wise freight traffic flows have been worked for the six horizon years i.e. 2012-13, 2015-16, 2020-21, 2025-26, 2030-31 and 2035-36. These estimates are presented in the **Tables 2.22 to 2.28** for Koshi river project influence area.

Table 2.22 Annual Cargo Loads by Commodity for Year 2008-09 on Koshi River (in Tonnes)

Origin	Commodity wise Tonnage - 2008-09							Total Tonnage Per Annum
	1	2	5	6	7	8	9	
Direction 1 - Patna to Nepal								
Naugachhia	65280	76840	0	1360	9180	4760	27880	**185300**
Koshi	9180	20740	0	0	8500	8500	9860	**56780**
Supaul	37740	14960	0	0	2380	2040	14620	**71740**
Nepal	0	0	0	0	0	0	0	**0**
Total	**112200**	**112540**	**0**	**1360**	**20060**	**15300**	**52360**	**313820**
Direction 2 - Nepal to Patna								
Nepal	74460	61540	0	0	680	23120	31280	**191080**
Supaul	41140	66640	9520	2380	2040	0	1360	**123080**
Koshi	13260	57800	0	3400	4420	3400	8840	**91120**
Naugachhia	0	0	0	0	0	0	0	**0**
Total	**128860**	**185980**	**9520**	**5780**	**7140**	**26520**	**41480**	**405280**
Both Direction								
Naugachhia	65280	76840	0	1360	9180	4760	27880	**185300**
Koshi	22440	78540	0	3400	12920	11900	18700	**147900**
Supaul	78880	81600	9520	2380	4420	2040	15980	**194820**
Nepal	74460	61540	0	0	680	23120	31280	**191080**
Grand Total	**241060**	**298520**	**9520**	**7140**	**27200**	**41820**	**93840**	**719100**

Table 2.23 Estimated Annual Cargo Loads by Commodity for Year 2012-13 on Koshi River (in Tonnes)

Origin	Commodity wise Tonnage - 2012-13							Total Tonnage Per Annum
	1	2	5	6	7	8	9	
Direction 1 - Patna to Nepal								
Naugachhia	82414	97009	0	1717	11590	6009	35198	**233937**
Koshi	11590	26184	0	0	10731	10731	12448	**71683**
Supaul	47646	18887	0	0	3005	2575	18457	**90570**
Nepal	0	0	0	0	0	0	0	**0**
Total	**141650**	**142079**	**0**	**1717**	**25325**	**19316**	**66103**	**396191**
Direction 2 - Nepal to Patna								
Nepal	94004	77693	0	0	858	29188	39490	**241234**
Supaul	51938	84131	12019	3005	2575	0	1717	**155386**
Koshi	16740	72971	0	4292	5580	4292	11160	**115037**
Naugachhia	0	0	0	0	0	0	0	**0**
Total	**162683**	**234795**	**12019**	**7297**	**9014**	**33481**	**52368**	**511657**

Origin	Commodity wise Tonnage - 2012-13							Total Tonnage Per Annum
	1	2	5	6	7	8	9	
Both Direction								
Naugachhia	82414	97009	0	1717	11590	6009	35198	233937
Koshi	28330	99155	0	4292	16311	15023	23608	186720
Supaul	99584	103018	12019	3005	5580	2575	20174	245956
Nepal	94004	77693	0	0	858	29188	39490	241234
Grand Total	**304333**	**376875**	**12019**	**9014**	**34339**	**52797**	**118471**	907847

Table 2.24 Estimated Annual Cargo Loads by Commodity for Year 2015-16 on Koshi River (in Tonnes)

Origin	Commodity wise Tonnage - 2015-16							Total Tonnage Per Annum
	1	2	5	6	7	8	9	
Direction 1 - Patna to Nepal								
Naugachhia	98157	115539	0	2045	13803	7157	41921	278623
Koshi	13803	31185	0	0	12781	12781	14826	85376
Supaul	56747	22494	0	0	3579	3067	21983	107870
Nepal	0	0	0	0	0	0	0	0
Total	**168707**	**169219**	**0**	**2045**	**30163**	**23006**	**78730**	471869
Direction 2 - Nepal to Patna								
Nepal	111960	92533	0	0	1022	34764	47034	287314
Supaul	61859	100202	14315	3579	3067	0	2045	185067
Koshi	19938	86910	0	5112	6646	5112	13292	137011
Naugachhia	0	0	0	0	0	0	0	0
Total	**193758**	**279645**	**14315**	**8691**	**10736**	**39876**	**62371**	609391
Both Direction								
Naugachhia	98157	115539	0	2045	13803	7157	41921	278623
Koshi	33741	118095	0	5112	19427	17893	28118	222387
Supaul	118606	122696	14315	3579	6646	3067	24028	292937
Nepal	111960	92533	0	0	1022	34764	47034	287314
Grand Total	**362465**	**448864**	**14315**	**10736**	**40899**	**62882**	**141101**	1081261

Table 2.25 Estimated Annual Cargo Loads by Commodity for Year 2020 - 21 on Koshi River (in Tonnes)

Origin	Commodity wise Tonnage - 2020-21							Total Tonnage Per Annum
	1	2	5	6	7	8	9	
Direction 1 - Patna to Nepal								
Naugachhia	131356	154617	0	2737	18472	9578	56100	372860
Koshi	18472	41733	0	0	17104	17104	19840	114253
Supaul	75940	30102	0	0	4789	4105	29418	144355
Nepal	0	0	0	0	0	0	0	0
Total	**225768**	**226453**	**0**	**2737**	**40365**	**30787**	**105359**	631467

Origin	Commodity wise Tonnage - 2020-21							Total Tonnage Per Annum
	1	2	5	6	7	8	9	
Direction 2 - Nepal to Patna								
Nepal	149828	123831	0	0	1368	46522	62942	**384491**
Supaul	82782	134093	19156	4789	4105	0	2737	**247661**
Koshi	26682	116305	0	6841	8894	6841	17788	**183351**
Naugachhia	0	0	0	0	0	0	0	**0**
Total	**259292**	**374228**	**19156**	**11630**	**14367**	**53363**	**83466**	**815503**
Both Direction								
Naugachhia	131356	154617	0	2737	18472	9578	56100	**372860**
Koshi	45154	158038	0	6841	25998	23945	37628	**297604**
Supaul	158722	164195	19156	4789	8894	4105	32155	**392016**
Nepal	149828	123831	0	0	1368	46522	62942	**384491**
Grand Total	**485060**	**600681**	**19156**	**14367**	**54732**	**84150**	**188825**	**1446970**

Table 2.26 Estimated Annual Cargo Loads by Commodity for Year 2025 - 26 on Koshi River (in Tonnes)

Origin	Commodity wise Tonnage - 2025-26							Total Tonnage Per Annum
	1	2	5	6	7	8	9	
Direction 1 - Patna to Nepal								
Naugachhia	175784	206913	0	3662	24720	12818	75075	**498971**
Koshi	24720	55848	0	0	22889	22889	26551	**152896**
Supaul	101625	40284	0	0	6409	5493	39368	**193180**
Nepal	0	0	0	0	0	0	0	**0**
Total	**302129**	**303045**	**0**	**3662**	**54017**	**41199**	**140994**	**845046**
Direction 2 - Nepal to Patna								
Nepal	200504	165713	0	0	1831	62257	84230	**514535**
Supaul	110781	179446	25635	6409	5493	0	3662	**331426**
Koshi	35706	155642	0	9155	11902	9155	23804	**245365**
Naugachhia	0	0	0	0	0	0	0	**0**
Total	**346991**	**500802**	**25635**	**15564**	**19226**	**71412**	**111696**	**1091327**
Both Direction								
Naugachhia	175784	206913	0	3662	24720	12818	75075	**498971**
Koshi	60426	211490	0	9155	34791	32044	50355	**398261**
Supaul	212406	219730	25635	6409	11902	5493	43031	**524606**
Nepal	200504	165713	0	0	1831	62257	84230	**514535**
Grand Total	**649120**	**803847**	**25635**	**19226**	**73243**	**112612**	**252690**	**1936373**

Table 2.27 Estimated Annual Cargo Loads by Commodity for Year 2030 - 31 on Koshi River (in Tonnes)

Origin	Commodity wise Tonnage - 2030-31							Total Tonnage Per Annum
	1	2	5	6	7	8	9	
Direction 1 - Patna to Nepal								
Naugachhia	235239	276896	0	4901	33080	17153	100467	667735
Koshi	33080	74737	0	0	30630	30630	35531	204609
Supaul	135998	53909	0	0	8576	7351	52684	258518
Nepal	0	0	0	0	0	0	0	0
Total	**404317**	**405542**	**0**	4901	**72287**	**55134**	**188681**	**1130862**
Direction 2 - Nepal to Patna								
Nepal	268319	221762	0	0	2450	83314	112719	688564
Supaul	148250	240140	34306	8576	7351	0	4901	443523
Koshi	47783	208284	0	12252	15928	12252	31855	328354
Naugachhia	0	0	0	0	0	0	0	0
Total	**464352**	**670186**	**34306**	**20828**	**25729**	**95566**	**149475**	**1460442**
Both Direction								
Naugachhia	235239	276896	0	4901	33080	17153	100467	667735
Koshi	80863	283022	0	12252	46558	42882	67386	532963
Supaul	284247	294049	34306	8576	15928	7351	57585	702041
Nepal	268319	221762	0	0	2450	83314	112719	688564
Grand Total	**868669**	**1075728**	**34306**	**25729**	**98016**	**150700**	**338156**	**2591304**

Table 2.28 Estimated Annual Cargo Loads by Commodity for Year 2035 - 36 on Koshi River (in Tonnes)

Origin	Commodity wise Tonnage - 2035-36							Total Tonnage Per Annum
	1	2	5	6	7	8	9	
Direction 1 - Patna to Nepal								
Naugachhia	314803	370549	0	6558	44269	22954	134447	893581
Koshi	44269	100015	0	0	40990	40990	47548	273813
Supaul	181995	72142	0	0	11477	9838	70503	345955
Nepal	0	0	0	0	0	0	0	0
Total	**541067**	**542707**	**0**	6558	**96736**	**73782**	**252498**	**1513349**
Direction 2 - Nepal to Patna								
Nepal	359072	296767	0	0	3279	111493	150843	921454
Supaul	198391	321361	45909	11477	9838	0	6558	593534
Koshi	63944	278732	0	16396	21315	16396	42630	439412
Naugachhia	0	0	0	0	0	0	0	0
Total	**621407**	**896860**	**45909**	**27873**	**34432**	**127889**	**200031**	**1954400**
Both Direction								
Naugachhia	314803	370549	0	6558	44269	22954	134447	893581
Koshi	108213	378747	0	16396	62305	57386	90178	713225
Supaul	380387	393503	45909	11477	21315	9838	77061	939489
Nepal	359072	296767	0	0	3279	111493	150843	921454
Grand Total	**1162475**	**1439567**	**45909**	**34432**	**131168**	**201671**	**452529**	**3467749**

Table 2.29 O - D Survey : KOSI IWT TRAFFIC : ORIGINATING TRAFFIC

Direction 1 - Patna to Nepal

ORIGIN	DESTINATION	COMMODITY	Annual Traffic in Metric Tonnes						
			2008-09	2012-13	2015-16	2020-21	2025-26	2030-31	2035-36
Naugachhia (Bhagalpur)	Kosi, Supaul, Nepal	Construction Material	65280	82414					
		Cereals/Cash Crops	76840	97009					
		Conventional Fuels	0	0					
		Live Stock	1360	1717					
		Chemicals	9180	11590					
		Mineral Ore	4760	6009					
		Others	27880	35198					
		Sub -Total	**185300**	**233937**	**278623**	**372860**	**498971**	**667735**	**893581**
Koshi	Supaul, Nepal	Construction Material	9180	11590					
		Cereals/Cash Crops	20740	26184					
		Conventional Fuels	0	0					
		Live Stock	0	0					
		Chemicals	8500	10731					
		Mineral Ore	8500	10731					
		Others	9860	12448					
		Sub -Total	**56780**	**71683**	**85376**	**114253**	**152896**	**204609**	**273813**
Supaul	Nepal	Construction Material	37740	47646					
		Cereals/Cash Crops	15300	19316					
		Conventional Fuels	0	0					
		Live Stock	0	0					
		Chemicals	2380	3005					
		Mineral Ore	2040	2575					
		Others	14280	18028					
		Sub -Total	**71740**	**90570**	**107870**	**144355**	**193180**	**258518**	**345955**
Nepal	Nepal	Construction Material	0	0					
		Cereals/Cash Crops	0	0					
		Conventional Fuels	0	0					
		Live Stock	0	0					
		Chemicals	0	0					
		Mineral Ore	0	0					
		Others	0	0					
		Sub -Total	**0**	**0**	**0**	**0**	**0**	**0**	**0**

Table 2.30 O - D Survey : KOSI IWT TRAFFIC : ORIGINATING TRAFFIC

Direction 2 - Nepal to Patna

ORIGIN	DESTINATION	COMMODITY	Annual Traffic in Metric Tonnes 2008-09	2012-13	2015-16	2020-21	2025-26	2030-31	2035-36
Nepal	Supaul, Kosi, Naugachhia	Construction Material	74460	94004					
		Cereals/Cash Crops	61540	77693					
		Conventional Fuels	0	0					
		Live Stock	0	0					
		Chemicals	680	858					
		Mineral Ore	23120	29188					
		Others	31280	39490					
		Sub -Total	**191080**	**241234**	**287314**	**384491**	**514535**	**688564**	**921454**
Supaul	Kosi, Naugachhia	Construction Material	41140	51938					
		Cereals/Cash Crops	66640	84131					
		Conventional Fuels	9520	12019					
		Live Stock	2380	3005					
		Chemicals	2040	2575					
		Mineral Ore	0	0					
		Others	1360	1717					
		Sub -Total	**123080**	**155386**	**185067**	**247661**	**331426**	**443523**	**593534**
Kosi	Naugachhia	Construction Material	13260	16740					
		Cereals/Cash Crops	57800	72971					
		Conventional Fuels	0	0					
		Live Stock	3400	4292					
		Chemicals	4420	5580					
		Mineral Ore	3400	4292					
		Others	8840	11160					
		Sub -Total	**91120**	**115037**	**137011**	**183351**	**245365**	**328354**	**439412**
Naugachhia	Naugachhia (Bhagalpur), Patna	Construction Material	0	0					
		Cereals/Cash Crops	0	0					
		Conventional Fuels	0	0					
		Live Stock	0	0					
		Chemicals	0	0					
		Mineral Ore	0	0					
		Others	0	0					
		Sub -Total	**0**	**0**	**0**	**0**	**0**	**0**	**0**

Annexure 2.1

DEVELOPMENT OF INLAND WATER TRANSPORT IN PATNA BIHAR
SURVEY BY RITES (A GOVERNMENT OF INDIA UNDERTAKING)

CLASSIFIED TRAFFIC VOLUME COUNT

Location Number
Approach Name
Direction From To

Name of Enumerator
Name of Supervisor
Duration
Day Date

Time Period	Motorised vehicle											Non- Motorised			
	Passenger Vehicle					Goods Vehicle			Agricultural Vehicle		Others	Slow Moving		Others	Remarks
	Car/Jeep/Van	Scooter/ Motorcycle	Auto	Minibus	Bus	LCV	2-3 Axle	MAV	Tractor	Tractor Trailer		Cycle	Cycle Rickshaw		

Annexure 2.2

DEVELOPMENT OF INLAND WATER TRANSPORT IN PATNA BIHAR
SURVEY BY RITES (A GOVERNMENT OF INDIA UNDERTAKING)

ORIGIN-DESTINATION SURVEY FOR GOODS VEHICLE

Location and Location Number :

Day:

Name of Surveyor :

Name of the Road :

Date:

Name of Supervisor :

Direction :

Number of Hours :

TIME OF SURVEY	TYPE OF VEHICLE	ORIGIN	DESTINATION	COMMODITY	TONNAGE	FREQUENCY	ROUTE DETAILS	TRIP		
								LENGTH	TIME	COST
1	2	3	4	5	6	7	8	9	10	11

NOTE : LIST TO BE EXPANDED AS PER SITE CONDITIONS

FREQUENCY : 1. DAILY 2. WEEKLY 3. MONTHLY

Annexure 2.3

DEVELOPMENT OF INLAND WATER TRANSPORT IN PATNA, BIHAR SURVEY BY RITES (A GOVERNMENT OF INDIA UNDERTAKING)

INDUSTRIAL SURVEY

Date : Enumerator's Name :
Form No : Supervisor's Name :
Traffic Zone No. :

(1) Type of Industry
(a) Small scale
(b) Medium scale
(c) Large scale

(2) Full Address

(3) Size/Area of Industry: Plot Area _____Sqm. Floor Area_____ Sqm.

(4) No. of workers:

(5) No. of visitors/day:

(6) Commodity manufactured:

(7) Total Annual Production (in Metric Ton):

(8) **Raw Material Details:**

Raw material required	
Place of origin of raw material and their tonnage	
Mode used	
Total distance and route details	
Time incurred	
Cost incurred	

(9) **Finished Product Details:**

Finished Product type:	
Place of destination of finished product and their tonnage	
Mode used	
Total distance and route details	
Time incurred	
Cost incurred	

(10) Opinion to shift to Inland water Transport:
At what cost savings:

a. Existing cost
b. At 10% extra cost
c. At 15% extra cost
d. At 20% extra cost

(11) Any future industry expansion plan (in terms of tonnage of finished product):

Annexure 2.4 Industrial Survey Data (2008-09)

Sl.No	Code	Type of Industry	Size of Industry (in Sq.Ft.)		No. of Workers	No. of Visitors	Commodity Manufacturec		Annual Production (In ton)	RAW Material Requirec		Place of Origin		Mode Used	Total Distance and Routx	Time Incurred (in Hrs.)	Finish Product		Place of Destinatior		Mode Used	Total Distance and Routx	Time Incurred	Opinion Code
		1	Plot Area	Floor Area	4	5	6	Code	7	8	Code	8	Zone Code	8	8	8	9	Commodity Code	9	Zone Code	9	9	9	10
1	14	A	30000	15000	15	20	Plywood, Board, Furniture	1	150	Wood, Pinal, Gond, Ply etc.	1	Aurangabad	14	Truck	Bihar, Jharkhand	48	Plywood	9	Patna, Bihar, Jharkhand	9,40	Truck	50 Km	8	a
2	14	B	30000	20000	25	5	Alkatra,Koltar	1	12	chemical	7	Gaya	15	Truck	120	8	koltar	1	Patna ,Aurangabad,Alwar	9,14,37	Truck	175--250	48	b
3	14	B	25000	25000	22	5	Dhan	2	5	dhan	2	Auran Gabad,Gaya	14,15	Truck	120	8	rice	2	Aurangabad,Patna	14,9	Truck	175	8	a
4	14	B	110000	110000	60	20	Ply Wood	1	365	pinal ,gond m,coal	1	palamu ,Jharkand	40	Truck	Gt Road	2	Plywood	1	Patna,Aurangabad,Gaya	9,14,15	Truck	G.t Road	48	a
5	14	A	10000	10000	25	5	Aulmumnium Utilise	1	50	oid alumunium	1	Aurangabad	14	Truck	Gt Road	2	alumunium	8	Patna,Aurangabad,Gaya	9,14,15	Truck	50	48	a
6	6	C	16000	10000	7	5	Aata, Chokar	2	25	wheat	2	Bihar	9	Truck	Bipaa,Mu to Bihar	48	atta	9	Bhiar Dharbanga North Bihar	9,24	Truck	Bipss Bihar,North Bihar	48	0
7	6	C	16000	4000	60	125	Tawar,Spector	8	15	iron	8	Raipur, Kolkata	37,41	Truck	Bipass Raipur,kol to Muz	120	goloanaze,tawer,	9	Electricity, Railway10--15	8	Truck	Bipass Muz to all India	120	a
8	6	B	10000	10000	25	10	HD Pipe	8	20	rezing	8	Delhi,Patna	37,9	Truck	Bipass Delhi,Patna-Muz	48	hd pipe	1	Bihar, 20 Bundle Pipe	9	Truck	bipass muz-bihar	48	0
9	6	B	15000	10000	35	10	Pressure Metre,Tembeure Metre	1	20	iron ,steel glass	1	Delhi,Mumbai,	37,37	Truck	Bipass Delhi,Mumbai to Muz	240	pressure metre	9	All India ,1400pc	9,40	Truck, Railway	bipass&railway all india	240	0
10	6	B	4000	4000	8	5	Iron Keel	8	4	iron kowyel	8	Bokara,Patna to Muz	40,9,6	Truck	Bakara,Patna to Muz by Bipass	48	kanti	1	Muz , 1ton	6	Truck	Bypass	48	a
11	6	B	8000	4000	25	5	Micro Newton Mixture	7	50	boron ,copper, zink, mag	7	Mumbai, Puntab	37,37	Truck	Mumbai, Punjab to Muz 40--50 ton	240	micro newton mixture	9	All Bihar 40--50ton	9,40	Truck	Mumbai,Punjab,to Muz,Bipass	240	0
12	6	C	160000	60000	450	60	Wagon	1	20	loha ,steel, iron ,rod	1	Railway Supply of India	8	Railway	Railway	240	wagon	8	All Railway Supply	9,22,32	Railway	Railway, Truck, Bypass	240	b
13	6	C	15000	15000	50	10	Pottery Feed	2	150	makka, khali, dara, prestimize	2	M.P Bihar 100--150	37,9,	Truck	M.p Bihar by Pass& Railway	200	dana, cuttle feed	6	Bihar U.p Asam Jharkand	9,38,40	Truck ,Railway	Muz to U.p, Asam , Jharkand Bypass	240	0
14	6	C	32000	16000	10	5	Medical,Feed Speriment	9	1000	jim,zera,kala namak	9	Mumbai Karnour 4ton	37	Truck	Mumbai ,Karnal to Muz ,by Pass	10	feed speriment	9	Ranchi,Kalihan,Darbanga	40,33,24	Truck	Ranchi, Kalihar to Muz Bypass	92	0
15	6	C	7000	7000	10	7	Lether,Processing Chemical	7	1000	salted skin,weagh blue	7	All Bihar 1000 ton	9	Truck & Van	Muz to Kolkatta, by Pass	48	lether processing	9	Muz to Kolkata ,1000 ton	6,41	Truck ,van	Muz to Kalkaata 1000 ton	48	0
16	6	C	16000	8000	30	8	Plastic Pipe P.V.C	1	2	plastic dana	1	Lucknow,Delhi, Kanpur 2ton	37,37,37	Truck	Lucknow, Delhi, Kanpur to Muz,Bypass	92	p.v.c pipe	1	Patna, Bhagalpur	9,32	Truck	All India-Muz Bypass	48	a
17	6	B	8000	8000	20	9	Khadh	7	8	gobar,khaine kaa dust	7	Motihari, Siwasn,Sit Marhi 500 bora	2,4,7	Truck	Muz to Mafihani,Siwan,Sitamarhi	48	kadh	7	Nepal,Bihar,Jharkand,500 bora	42,9,39	Truck	Muz to Nepal,Bihar,,Jharkand,	48	0
18	6	B	10000	10000	20	7	Iron Keel	8	30	loha coal	8	Muz,Patna,Bihar,25*35	6,9,	Truck	Muz to Patna,Bihar,by Pass	48	kanti	8	All Bihar 25*35	9	Truck	Muz to All Bihar Bypass	48	a
19	6	B	7000	7000	20	5	Iron Keel	8	30	loha, coal	8	Muz to Patna 25-32	6,9	Truck	Muz to Patna by Pass	48	kanti	8	Muz to Bihar 25*32	6,9	Truck	Muz to Bijar 25*32	48	a
20	6	C	16000	16000	25	10	Thresher	9	10	kacha loha	9	Delhi,Bihar,Ranchi,10 ton	37,9,40	Truck	Muz to Delhi,Bihar,Ranchi,byPass	92	thresher	9	Bihar,,Jharkand 10ton	9,39	Truck	Muz to Bihar Jharkand Bypass	92	a
21	6	0	15000	15000	25	5	Kit Nasak Dana	7	10	shope scroll(power)& chemival	7	10 ton	6	Truck	u.p to muz bypass	92	kit nasak dana	7	All India 10 ton	9,39,40,41	Truck	Bipass Muz to all India	240	a
22	6	B	10000	10000	20	10	Plastic,Pancell,Spupt,Pvc Pipe	8	5	rool spring, useless plastic	9	Muz,Bihar 1000kg	6,9	Truck	bypass bihar to muz	4	plastic,pandel,spuput	9	All Bihar,Patna	9,40,41,37	Truck	Bipass Muz to all India	72	a
23	9	B	80000	60000	50	25	Ply Board	1	5	mango,cernal,popular(wood)	1	Muz 2 ton	6	Truck	bypass muz tofuthwa	4	Plywood	9	Bihar,Patna	9,	Truck	Bypass	48	a
24	9	C	40000	38000	410	90	Basan,Aata	9	20000	chana ,wheat	2	Calcutta,M.p, Indore	41,37,37	Truck	bypass road,crnal	114	basan,atta	9	All Bhar,Bengal	9,41	Truck	G.t Road	120	b
25	9	C	75000	70000	100	20	Tablet,Liquid,Intuction&Medicine	9	1	vitamine(b1,b2,b6)para	9	Calcutta,Delhi,Mumbai	41,37,37	Truck	Gt Road	100	diff type of medicine	9	Patna,U.p,Jharkand,Asam	9,38,39,41	Truck	Bypass& G.t Road	72	a
26	9	B	85000	85000	90	15	Mobile Oil	4	2	black oil,kamical,box	4	Jharkand,Bihar,Patna	40,9	Truck, LCV	Gt Road	48	mobele	4	Delhi,Bironi	37,22	Truck & LCV	G.t Road	96	a
27	9	B	13000	13000	25	3	Ply Board	1	1	semal, popular mango	1	Bihar-Sitamarhi 25--30pit	9,7	Truck	Bihar to Sita Mari,Bypass	48	ply	9	Patna,Jharkand 20--25ft	9,40	Truck	Jharkand to Bihar20--25ft	0	a
28	9	C	200010	180000	300	50	Cement	1	1800	dinkar,hipson,slay,coal,pathar	5	Rajsthan,Jharkand w.b	37,40,41	Truck	G.t Road Bypass	168	cement	1	Patna,Jharkand 20--25ft	9,40	Truck	G.t Road	24	d
29	9	C	150000	140000	200	70	Biscute,Cream Biscute	9	1800	maida,sugar,aata,cent	9	Bihar,Delhi,Jiharkand	9,37,40	Truck	G.t Road Bypass	48	biscute,cream biscute	9	Patna,Bogusarai,Jharkand,U.p	9,22,40,38	Truck	G.t Road	36	0
30	9	B	110000	100000	85	25	Ply Wood	1	10	pangal,faran qund,kur,coal	5	Bihar,Jharkand	9,40	Truck	Gt Road	48	ply wood	9	Patna,Jharkand,Other City	9,39	Truck	G.t Road	36	a
31	9	C	100000	85000	100	10	Ply Wood	1	10	kur,pinal,gullu,face	1	Chatra, Jharkand, Calcutta	40,40,41	Truck	Gt Road	48	ply wood	9	Buxar, Bthra, Jharkand	11,40	Truck	Bypass& G.t Road	36	a
32	9	B	131000	131000	70	5	Ply Wood	1	5	pinal,faran,kur,gullu	1	Bihar Jharkand	9,39	Truck	G.t Road Bypass	48	ply wood	9	All Bihar& Other City	9	Truck	g.t road, by pass	36	a
33	8	B	85000	841101	50	15	Ply Wood	1	4	pinal,gund	1	Jharkand,Calcutta	40,41	Truck	Nh Road,G.t Road	72	ply wood	9	Bihar Only	9	Truck	N.H. Road	24	a
34	8	B	70000	60000	65	20	Aata,Malda,Suji	9	10	wheat,juo,makai	2	Punjab,Harayana	37,37	Truck	Gt Road	144	malda,aata,suji	9	All Bihar & Jharkand	9,40	Truck	N.H. Road	36	0
35	8	B	25000	20000	25	75	Glass Factory	1	5	hazipur	8	Hajipur	8	Truck	Hazipur,Vaishali	0	I want to make glass	9	Vaisali	8	Truck	Hazipur,Vaishali		0
36	8	C	90000	75000	250	30	Sugar Factory	9	5	carbon,hydrogen,oxygen mix	9	punjab	37	Truck	Gujarat to HJajipur,Vaishali	72	bake sugar	9	Punjab	37	Truck	Gujrat to Hajipur, Vaishali	192	b
37	8	B	60000	40000	50	300	Juice Factory	9	80	mango chemical	7	Allahabad	38	Truck	Muzaffarpur	14	make juice	3	Allahahab	38	Truck	Muzarar puir	14	a
38	8	B	80000	60000	50	75	Juice Factory	9	80	lichi kamical	7	Sata Madi, Muz	7,6	Truck	Bypass Road Vaishali	12	tulce	3	Sita madi,Muz	7,6	Truck	Bypass Road Vaishali	12	a
39	8	B	70000	55000	30	20	Machine Made Pipe	1	5	mix up cement	1	Patna	9	Tractor	Mahatma Gandhi Saita Pull	4	cement pipe	1	Patna	9	Tractor	Mahatma Gandhi Saitu	4	a
40	8	B	60000	50000	60	35	Masalla	9	2	masala	9	Patna	9	LCV	Hajipur to Patna	2	masala	9	Patna	9	LCV	Mahatma Gandhi Saitu	2	a
41	8	A	40000	25000	50	20	Potato Keep In Store	2	2	machine keep potato safe	2	Patna, Mathipur	9	Truck	Gandhi Saitu Pull	3	potato keep	3	patna mathipur	9	Truck	Mahatma Gandhi Saitu	3	a
42	8	A	40000	30000	150	100	Potato,Mango Keep	2	5	chemical	7	Hatipur	8	Truck	Bypass	4	potato ,mango	3	Hajipur	8	Truck	bypass road vaishali	4	a
43	8	B	75000	55000	160	85	Prepare Coldrink	7	8	chemical	7	patna	9	Truck	Bypass	5	cold rink	7	Patna	9	Truck	Bypass	5	a
44	8	A	50000	35000	30	22	Potato	9	2	potato	9	Bajar Samiti	9	Truck	Gandhi Saitu Pull to Market Samiti	4	potato	3	Bajar Samiti	9	Truck	Bypass	4	a
45	8	B	50000	45000	50	80	Cold Milk	3	40	soda	3	Chapra	5	Truck , Trolly	Chapra to Vaishali	3	cold milk	3	Fulvari	9	Truck & Trolly	Bypass	3	a
46	8	A	50000	40000	80	45	Prepare Khad	7	2	with the help of machine	7	Patna,Bihar	9	LCV	Bypass road	4	prepare khad	7	Patna	9	LCV	Bypass	4	a
47	8	A	50000	40000	25	10	Thermacoal	9	2			Patna	9	Truck	Gandhi Saitu Road	4	prepare thermacoal	7	Bindasarif ,Patna	18,9	Truck	Mahatma Gandhi Saitu	4	0
48	8	A	40000	35000	85	30	Prepare Bread	9	1	aata,maida sugar	9	Patna	9	Truck	Mahyma Gandhi Saitu Pull	3	bread	9	Patna	9	Truck	Mahatma Gandhi Saitu	3	a

Sl.No	Code	Type of Industry	Size of Industry (in Sq.Ft.)		No. of Workers	No. of Visitors	Commodity Manufacture		Annual Production (In ton)	RAW Material Require		Place of Origin		Mode Used	Total Distance and Route	Time Incurred (in Hrs.)	Finish Product		Place of Destinatior		Mode Used	Total Distance and Route	Time Incurred	Opinion Code
		1	Plot Area	Floor Area	4	5	6	Code	7	8	Code	8	Zone Code	8	8	8	9	Commodity Code	9	Zone Code	9	9	9	10
49	8	B	45000	40000	115	50	Shakti Tube Ltd	9	4	sulason	9	pahadi	9	Truck	Pahad to Vishali	2	prepare tube	9	Bihar,Patna	9	Truck	Bypass	2	a
50	8	A	50000	35000	60	25	Potato,Onion,Mango Keep	9	2	chemical	7	Bajar Samiti Patna	9	Truck	Mahtma Gandhi Saitu Pull	4	potato,mango,protect	3	Patna	9	Truck	Mahatma Gandhi Saitu	4	0
51	8	A	40000	35000	50	20	Prepare Chemical	7	1	powder,chemical	7	Exibishion Road	9	Truck	Mahtma Gandhi Saitu Pull	3	chemical	7	Patna	9	Truck	Mahatma Gandhi Saitu	3	b
52	8	C	210000	210000	250	70	Cock Food	6	3	wheat,juo,bajra,makka,vitamine	2	Darbanga,M.p. punjab	24,37,37	Truck	Gt Road	150	cock food	6	Patna,Jharkand	9,40	Truck & LCV	G.t Road	52	d
53	9	A	5250	4500	13	3	CB Boxes	9	8	kgsaph peper	9	Kasipur,100 ton	37	Truck	Kasipur to Patna	120	cb boxes	9	Bata India Pvt,Bata Jang pat 100 ton	9	Truck & LCV	4km	1	a
54	9	B	5000	6000	40	10	Polythin,Plastic Bag	9	4	linnes low density polythene	9	Gujarat,3--4 ton	37	Truck	Gujarat to Patna,Bypass	200	printad polythene	9	Bihar, Jharkand,U.p 3--4 ton	9,40,38	Truck	patna	192	b
55	9	B	10000	10000	35	50	Medical	9	2	paraSATIC MAIE	9	Delhi,Mumbai 40--50 peti	37,37	Truck, Railway	Railway& Truck Bypass Road	120	l.p medical	9	Delhi,Mumbai	37	Truck & Rail	Railway & Truck Bypass Delhi,Mumbai	120	0
56	9	B	15000	10000	12	10	Cement	1	10	asland,clekars,gipusium	1	u.p 10ton	38	Truck	Bypass to Ptahwa	160	cemebt	1	Bihar,10 ton	9	Truck	Bypass ,Bihar	48	0
57	9	C	26000	20000	20	8	Cement	1	12	aslong,clekar	1	Girdhia,up 15 ton	38	Truck	Bypass Girdhia up to Fathwa	100	cement	1	Bihar 15 ton	9	Truck	Bypass Futhwa to Bihar	48	b
58	9	B	16000	16000	40	10	Pkly Board	1	2	semal,mango(wood)	1	MUFF, 2TON	6	Truck,LCV	Bypass Muz to Patna	4	ply board	9	Bihar 2 ton	9	Truck	Bypass Futhwa to Bihar	72	a
59	9	B	16000	16000	50	10	Satoo,Besan,Aata	2	5	chana,wheat,gera,goki	2	Bihar,up,Jharkand	9,38,40	Truck	Bypas,Bihar,U.p,Jharkand to Fatkwa	400	satoo,besan,aata	9	Bypass Oil India	9	Truck	Bypas Fathwa to all India	480	0
60	9	B	17000	17000	12	10	D.C Set (Scrap Cutting)	1	25	karkar	1	Tata 1000 ton-1500 ton	39	Truck	Tata to Patna,Bypass	96	karkar	1	Bihar 50 ton- 100 ton	9	Truck	Patna Bihar Bypass	48	a
61	9	B	14000	14000	20	12	Ply Board	1	1	mango,semal,popular(wood)	1	Muz 40--50sq.ft	6	Truck	Muz to Patna,Bypass	0	pky board&cut slide	9	Only to Patna 40--50sq.ft	9	Truck	Patna to Muz, Bypass		a
62	9	A	13000	13000	15	7	Ply Board	1	1	mango,semal,popular(wood)	1	Muz 40--50sq.ft	6	Truck	Bypass	24	ply board	9	Bihar,Maharastra	9,37	Truck	Bihar to Maharastra,Bypass	150	b
63	9	A	9000	9000	20	7	Ply Board	1	2	mango,semal,popular(wood)	1	u.p to patna 40--45sq.ft	38,9	Truck	Bypass	120	ply	9	U.p to Bihar,30--32sq.ft	38	Truck	U.p to Bihar,Bypass	120	a
64	9	A	8000	8000	30	5	Ply Board	1	2	mango,semal,popular(wood)	1	Bihar to Muz ,30--35sq.ft	9,6	Truck	Bihar to Muz ,Bypass	48	ply board only	9	Only to Patna 40--50sq.ft	9	Truck	Bihar to Muz ,Bypass	48	b
65	9	C	11000	11000	40	8	Ply Board	1	2	mango,semal,popular(wood)	1	Bihar,Muz ,15--25sq.ft	9,6	Truck	Patna to Muz,Bypass	0	ply	9	Patna, Muz	9,6	Truck	Patna,Muz,Bypass	24	b
66	9	B	16000	16000	60	20	Tmt Sariya,8m.M,10mm,6mmsariya	1	30	ingota	8	Bihar,10ton	9	Truck	Bihar to Patna,Bypass	24	tmt sariya	1	Magadh Iron,Bihar	9	Truck	Bypass	24	a
67	9	B	48000	48000	40	20	Airtel,Hutch,Idea,Mobile Tower Part	9	3	ingel,patel,cabel,nal-volt	9	10,Ton,Patwari Patra	9	Truk, Tractor	Bihar & Jharkand	48	mobile tower parts	9	Bhagalpur & Patna	32,9	Truck	Bihar & Jharkand	48	a
68	9	A	40000	40000	55	20	Food Product Process	9	2			u.p 100ton	38	Truck	U.p to Patna,Bypass	48	food product&biscute	9	Patna	9	Truck	only Patna & Bihar	48	b
69	9	B	30000	30000	100	10	Silco Magniz	9	3	magniz,cock,&dola-mite	9	Udisaa,Gujrat,M.p	40,37	Truck	Bypass	168	silco maging	9	U.p, Gujrat, Gzb	38,37,37	Truck	U.p,Gujarat,Gaziyabad	72	a
70	9	C	205000	20200	300	90	Ply Board	1	5	kur,pinal,gullu,face	1	West Bengal,Jharkand,U.p	41,40,38	Truck	Gt Road	120	ply wood	9	Fathuwa,Jharkand,U.p	9,40,38	Truck	Bypass,Ara, patna Road & G.t Road	72	d
71	9	C	1500000	150000	220	30	Alkatra	1	25	char coal,coal,wood	1	Jharkand,W.b	39,41	Truck	Gt Road	96	alkatra	1	Patna,Jharkand	9,40	Truck	Bypass& G.t Road	72	a
72	8	B	85000	85000	60	25	Ply Wood	1	15	gund,pinal,coal,vora	1	Kodarama,Jharkand	40	Truck	0	48	ply wood	9	Patna,Barhi Lakhisarai	9,21	Truck ,Van	0	24	a
73	8	B	95000	90000	85	30	Ply Wood	1	50	bore,gullu,faran,coal	1	Chatra,Jharkand	39	Truck	G.t Road & N.h.37	24	ply wood	9	Patna Only	9	Truck	N.h-37,45	48	a
74	9	B	130000	130000	50	30	Cement	1	9	chuna ,stone,jipsum	1	Ramgad,Tata	39,40	Truck	Gt Road	144	cement	1	Patna,Other City	9	Truck	G.t Road	72	0
75	8	B	30000	20000	20	12	Plastic Prepare	1	1	chemical,durty fplastic	1	Patna	9	Truck	Mahatma Gandhi Sita Pull	4	prepare polythene	9	Patna	9	Truck	Mahatma Gandhi Saitu	4	a
76	8	B	40000	35000	40	25	Makkai	2	1	hen food	6	Bihar,Maimar	9	Truck	Mahatma Gandhi Sita Pull	5	hen food	6	Bihar,Lakhisaraya	9,21	Truck	Mahatma Gandhi Saitu	5	a
77	8	B	75000	60000	80	25	Chad,Loha	1	4	wetting loha	1	Sitamadi	7	Truck	Bypass	7	chad	1	Sitamadi,Bas saraya	7,22	Truck	Bypass	7	b
78	8	B	60000	50000	50	20	plastic pipe	1	1	plastic wetting	1	Patna	9	Truck	Bypass	3	plastic pipe	8	Patna	9	Truck	Bypass	3	a
79	8	A	30000	20000	25	10	Almira	8	2	loha chadar	8	sitamadi	7	Truck	Bypass	6	almira	9	Sitamadi,Patna	7,9	Truck	Bypass	24	a
80	8	B	40000	25000	50	35	Fruit Juice Mango,Lichi,Pineapple	3	5	mango,pineapple,lichi	3	Patna	9	Truck	Mahatma Gandhi Sita Pull	4	juice	3	Patna	9	Truck	Mahatma Gandhi Saitu	4	b
81	8	C	185000	150000	160	35	Juice Factory	3	584	fruit&alchol	3	Bihar,Asam,Kashmir	9,41,37	Truck	G.t Road,Bypass Road	192	juice	3	Patna,Begusarai &U.p	9,22,38	Truck & LCV	N.H Road	48	b
82	8	B	20000	15000	35	10	Big Poly Bag Of Biscute	9	2	plastic	9	Purvi Champaran	2	Truck	250 km bypass road	15	biscute poly bag	9	Patna	9	Truck	80 km bypas	4	0
83	8	B	40000	35000	90	40	Potato,Onion,Baigan Are Keep	9	8	chemical machine	9	Patna,Aatra,Vaksar	9,10,11	Truck	Bypass	8	all product keep good	9	Patna ,Aara	9,10	Truck	Bypass	8	b
84	8	A	65000	50000	50	15	Aata,Sujl,Maida	9	3	makka,wheat,juo	9	Muz,Hariyana,Punjab	6,37,37	Truck	G.t road 800km	120	aata, maida, sujl	9	Patna, Bihar, Other City	9	Truck	Patna,Bihar,& Other City	48	0
85	8	B	40000	30000	30	15	Ply Wood	1	2	cut to machine	1	sitamadi	7	Truck	70 km Bypass	8	ply wood	9	Patna,Sitamadi	9,7	Truck	80km Bypass	8	a
86	8	C	240000	228000	300	90	Plastic Pipe	8	20	plane plastic&chemical	8	West Bangal & Jharkand	41,40	Truck	500--700km	72	plastic pipe	8	Patna,Bihar,Jharkand	9,40	Truck	70--400km	48	d
87	8	C	200000	200000	210	40	Aata,Maida,Sugi	9	50	hweat,maida	9	Darbanga, Haryana,Punjab,U.p	24,37,38	Truck	G.t Road 125--1500km	120	aata,maida,sugi	9	Bihar ,Patna	9	Truck,LCV,MAX	60km N.H Road	48	d
88	8	C	48000	8000	80	35	Cold Milk	3	600	milk	3	Vaishali Gilla	8	Truck	Bypass	48	cold milk	3	Patna	9	Truck	Bypass	48	0
89	8	B	65000	50000	50	15	Tractor	9	50	tractor engine,tractor part	9	Chapda	5	Truck	60 km	24	tractor	9	Bakhtiyapur, Jharkand, Punjab	9,40,37	Truck	90--1500 km	72	0
90	8	B	20000	15000	20	10	Cement Pipe,Nada,Gamla	1	2	cement,chad,reta,gitti	1	Jharkand,Muz	40,6	Truck & LCV	G.t Road,550 km	48	pipe,nada,gamala,	8	Local City,Patna	9	Truck & LCV	N.H Road	24	a
91	8	C	140000	140000	110	40	Small Metal	1	1500	stone	1	Rohtash,Raxaul	13,2	Truck	N.h road	24	small metal	1	patna,bihar,Jharkand	9,40	Truck	N.H Road & G.t Road	72	d
92	8	C	250000	250000	263	100	Malda,Sujl,Aata	9	14	wheat,bajara,juo,makka	2	Hariyana,Punjab,Darbanga	37,24	Truck	0	120	maida,aata,sugi	9	Begusarai & Jharkand	22,40	Truck & LCV	125--500km	48	d
93	9	C	340000	325000	460	100	Tmt Bars	1	10	reta	1	Jharkand,U.p	39,38	Truck	G.t Road,Bypass Road	144	tmt bars	1	Bihar,,Jharkand,Delhi,Calcutta,Other	9,39,37,41	Truck	G.t Road	120	d
94	8	A	40000	25000	40	25	Shoes Brush	9	7	bala or plastic	9	Hajipur	8	LCV	Bypass	1	shoes brush	9	Patna	9	LCV	Mahatma Gandhi Saitu	3	a
95	8	B	60000	30000	20	15	Jewellery Work	9	0	gold,machine	9	Hajipur	8	CAR	Bypass	4	gold jewellers	9	Patna	9	BIKE	Bypass	4	b
96	8	B	40000	25000	30	20	Gitti	1	15	stone cut to machine	1	Gaya	15	Truck	Bypass	6	gitti	1	Gaya,	15	Truck	Bypass	6	a
97	8	B	50000	40000	50	20	Tractor Part	9	1	loha chapra	9	Sita madi	7	Truck	Bypass	8	tractor part	9	Patna Sitamadi	9,7	Truck	Bypass	8	b
98	8	B	70000	50000	40	25	Coconut	9	1	coconut	9	Patna	9	Truck	Bypass	3	gadda	9	Patna	9	Truck	Bypass	3	b
99	8	B	70000	40000	35	25	Plastic Pipe	8	1	plastic pipe	8	Patna	9	Truck	Mahatma Gandhi Sita Pull	2	pipe,nada,gamala,	1	Patna	9	Truck	Mahatma Gandhi Saitu	2	b
100	8	B	50000	40000	30	15	Prepare Khad	7	2	with the help of gobbar	7	Gaya,Bihar	15,9	Truck	Bypass	5	khad	7	Gaya,Bihar	15,9	Truck	Bypass	6	b
101	8	B	50000	30000	35	20	Glass Fiver	8	18	plastic	8	Patna	9	Truck	Mahatma Gandhi Sita Pull	3	plastic glass	9	Patna	9	Truck	Mahatma Gandhi Saitu	3	a
102	8	B	60000	45000	40	25	Alkatra	1	80	suloson	1	Muz,Patna,Bihar,25*35	6,9	Truck	Bypass	8	alkatra	1	Hajipur,Patna	8,9	Truck	Bypass	6	b
103	8	B	90000	70000	100	50	Potato Onion	9	500	mix chemical in machine	9	Muzaffpur	6	Truck	Bypass	8	to safe wheat	2	Muzaffarpur ,Bihar	6,9	Truck	Mahatma Gandhi Saitu	8	b

List of Codes

(1) Industry Type Code
(a) Small scale
(b) Medium scale
(c) Large scale

(2) Opinion Code
a. Existing cost
b. At 10% extra cost
c. At 15% extra cost
d. At 20% extra cost
e. 0 - no response

Annexure – 2.5

INDEX MAP: PROPOSED KOSI TERMINAL LOCATION

CHAPTER-3

ADVISE ON VESSEL

3.0 INTRODUCTION

The main parameters governing Inland Waterway Fleet design are:

- Waterway characteristics like river course, depth of water, radius of bends, current/velocities of water etc.
- Cargo characteristics like type of cargo, quantum of cargo, distance of transportation.
- The vessel dimensions like length, beam, moulded depth, minimum and maximum draft.
- Physical constraints like clearance under bridges, navigation locks size etc. and
- Capital, Operating and maintenance cost.

3.1 FACTORS INFLUENCING DESIGN PARAMETERS

3.1.1 CARGO CHARACTERISTICS

The cargo consists of Construction Material (Cement, Sand, Stone, Iron, Steel etc), Cereals/Cash Crops (Wheat, Rice, Pulses, Sugar etc), Conventional Fuels (Coal and Firewood etc), Live Stock (Animals, Oil Cake etc), Chemicals (Fertilizer, Wine etc), Mineral Ore (Lime Stone, Iron etc), Others (Consumer Goods, Kirana/Perchun Appliances, Edible Oil, Paper Products etc). The volume of total cargo originating and terminating from different terminals is shown in Traffic chapter.

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

3.1.2 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 and or available.

- Average lot size and length of Haul.
- Balance of out and return cargo.
- Requirement for protection against weather.

3.1.3 WATERWAY FEATURES / HYDRAULIC AND MORPHOLOGICAL FACTORS

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

- Variations in vertical clearance and enough river widths all along the waterway available throughout the year.
- Some stretches shallow water depth and some stretches sufficient navigational depths available.
- Radius of Bends.
- Current Velocities.

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

3.1.4 PHYSICAL CONSTRAINTS

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

3.1.5 OPERATIONAL FACTORS

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

3.2 TYPES OF VESSELS

For Inland water transportation there are mainly two types of vessels namely self propelled barges and dumb barges in tow.

3.2.1 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 rivers, low draught vessels are designed with twin screws in tunnels. These vessels are not economical to run in deeper waters. Similarly vessels designed for deeper draft cannot be used in shallow rivers. Costly cargoes which can stand a high freight rate like perishable goods requiring 'scheduled navigation' are transported by self propelled river vessels. These vessels have a low turn around time in ports and locks (since no time is lost in anchoring and making up tows), are speedy and can call at many ports along the route. 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.

3.2.2 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. So bulk, unpacked and imperishable cargo is transported in such barges which offer a low freight rate. In Europe (Danube and Rhine) and U.S.A. river transportation is done in dumb barges in private sector.

3.2.2.1 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 depths and widths as well as the weather conditions experienced along the route.

a) Towing astern
b) Towing alongside and,
c) Push towing

The first method, towing astern or pull towing has been used in European waters. A long towline is paid out from the stern of the river tug (moving in front) to the foremost barge 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 barge thus increasing the resistance of the barge flotilla. There can be an augmentation of resistance as high as over 80% of the individual barge due to this. 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 disadvantage being that the width of the waterway required should be more to accommodate flotilla of twin barge width. **The conventional method on the National waterway no.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 rows, 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. Also since all the barges and tug are close together, the incidence of increase in resistance due to interference is minimum. This system is prevalent in USA and is now being adopted in Europe and elsewhere including India (eq. CIWTC) for its obvious advantages over pull towing. The individual units of barges are normally full with rectangular bilge with/without end shapes.

3.2.2.2 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.

The various types of propulsion system 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 and raised tunnels and rudder-propeller propulsions.

The paddle wheel propulsion has disappeared since quite long from most of world waterways 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 rudders behind propellers and flanking rudders 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 efficiency 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 provided 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 units 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 propellers 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 disadvantage of being less maneuverable.

3.2.2.3 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 dimensions 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 speeds in shallow and narrow canals. In shallow water of unrestricted width, the economic speed in m /sec should be less than $2.5*\sqrt{H}$ where H is the depth of water. In narrow canals, economic speed should be less than $1.2x\sqrt{A/C}$ 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 sq.mtrs. The vessel speed on the above consideration should not be higher than 6.12 knots/hr. in river section and 2.68 knots 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 a greater control than is possible in 'pull towing' operations. 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.*

3.2.3 TOWED FLOTILLA V/s SELF PROPELLED VESSEL

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

A) 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.

B) 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.

C) 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. The system efficiency 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.

D) Dumb barges are simple and less expensive to build and comparatively few towing tugs are required to operate the flotilla combinations. 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.

E) It is well known in naval architecture that long slender vessels experience less resistance in motion. Well designed (ends properly shaped) dumb barges in flotillas 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 barge 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.

F) 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 required. Thus crew wage bill is reduced by half in case of towed system.

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

3.3 TRAFFIC:

Estimated Traffic on various sections on Kosi River:

Section	Base Year 2012-13 (Tons)	2025-26 (Tons)	2035-36 (Tons)
Naugachhia - Kosi	3,64,427	7,77,296	13,92,018
Kosi – Supaul	3,06,479	6,53,698	11,70,673
Supaul - Nepal	2,65,272	5,65,805	10,13,271
Total	**9,36,178**	**19,96,799**	**35,75,962**

3.4 OPTIMAL VESSEL SIZE

Keeping in view the channel parameters and propulsion systems as discussed above, the following type of self propelled vessel having cargo capacity 100 tonnes is proposed.

100 tonnes vessel is recommended for channel 25.0m wide X 1.2m depth and attract private Entrepreneurs to divert the traffic-load from rail/road sector and this vessel will carry 100 tonnes when restricted draught D = 1.0m. This type of vessel will reduce expenditure on dredging.

Principal particulars of this self propelled vessel for operation on river are:-

100 tonne vessel

Length Over All	:	32.00 metres
Breadth	:	5.00 metres
Draught	:	1.00 metres
Cargo capacity	:	100 tonnes when 1.0m draft.
Propulsion System:		Marine Diesel Engines with propeller = 2 nos, Output = 100 BHP

3.5 FLEET REQUIREMENT

The fleet requirement has been estimated considering the relevant factors as under:

- Volume of traffic to be moved.
- Nature of cargo.
- Return of load available.
- Movement distance.
- Vessel characteristics.
- Capacity and speed.
- Water constraints – limiting speed, draft available round the year.
- Loading/Unloading capacities.
- No. of operational days in a year.

The following parameters have been used in the estimation of fleet requirement.

3.5.1 VESSEL CAPACITY UTILISATION

Due to difference in density of cargo and storage characteristics the utilization factor has been taken as 0.8 for bulk and general cargo.

Return load

Same vessel will carry return cargo. i.e both direction traffic in this waterway in 2012-13 is **16,21,248** Tons., same vessel will transport remaining balance traffic (16,21,248 – 9,36,178) Tons = **6,85,070** Tons.

Annual Operational Days

Annual Operational days are 300 per year.

Average Voyage Speed

The average speed has been taken as 10km per hr. for 100t capacity vessel.

Cargo average distance

Kosi Barrage to Kalyanpur is 31.500 km.
Kalyanpur to Basbitti is 41.785 km.
Basbitti to Dambharaghat is 70.715 km
Dambharaghat to Kursela is 88.000 km

Loadings / Unloading rate

For general cargo as well as bulk cargo average loading and unloading rate according to system design is 5T X 10C/hr i.e. 50TPH loading/unloading per crane.

Waiting at Terminals

For Vessel average 2 hours berth waiting at each terminal has been considered.

3.5.2 100 Tonnes Vessel :

Nepal to Kursela Route:

Average speed of Vessel	5.3 knots or 10 km/hr
No. of working days per year a) Waterway b) Vessel	 300 days 300 days vessel will be available.
BHP	2 X 100 = 200 BHP
Vessel Utilization Factor	80%
Crane	5TX10C /hr i.e. 50TPH loading / unloading
Loading efficiency	75%
Unloading efficiency	55%
Detention time at each terminal for loading and unloading	24hrs(12hours per day)
Number of working hrs of the vessel / year	300 X 24 = 7200 Hrs.
Average Loading Time (hrs.)	(100 X 0.8) / (50 X 0.75) =2.1 Hrs.
Average Unloading Time (hrs.)	(100 X 0.8) / (50 X 0.55) =2.9 Hrs.
Berth Waiting Time (hrs.)	2 Hrs.
Average Trip distance – km (eachway)	232 km
Average Round Trip Time (Hrs.)	2.1 + 2.9 + 2 + 232 /10 = 30.2.
Number of Round Trips Per Year	7200/30.2 = 238.4 Say 238 Round Trip.

No. of Vessel Requirement (100T)

Base Year (2012-13):

Throughput Per Vessel Per Annum (Tonnes)	238 X 100 = 23,800 Tonnes.
Total Annual Throughput	9,36,178 tpa.
No. of Vessel Required	9,36,178 / 23,800 = 39.3
Therefore, Nos. of Vessel Required	39.0

2025-26:

Throughput Per Vessel Per Annum (Tonnes)	238 X 100 = 23,800 Tonnes.
Total Annual Throughput	19,96,799 tpa.
No. of Vessel Required	19,96,799 / 23,800 = 83.89
Therefore, Nos. of Vessel Required	84.0

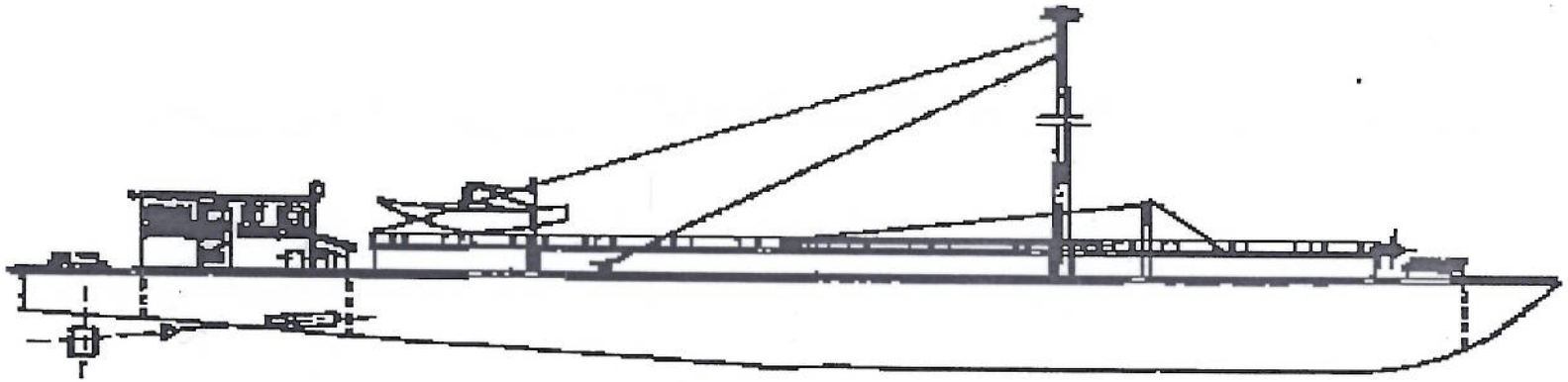
2035-36:

Throughput Per Vessel Per Annum (Tonnes)	238 X 100 = 23,800 Tonnes.
Total Annual Throughput	35,75,962 tpa.
No. of Vessel Required	35,75,962 /23,800 = 150.25
Therefore, Nos. of Vessel Required	150.0

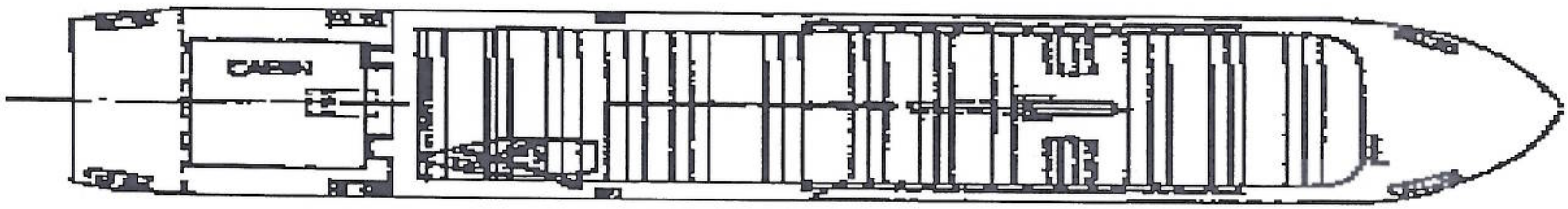
3.5.3 Summary

Summary (100T Vessel):

		Additional no. of Vessel	
	Base Year 2012 - 13	2025-26	2035-36
Kosi River :			
Nepal to Kursela	39	45	66



ELEVATION



PLAN

Fig:- A Typical Diagram of Vessel

CHAPTER - 4

WATERWAY

CHAPTER – 4

WATERWAY

4.1 HYDROGRAPHIC SURVEY

Thalweg survey on river Kosi was carried out from Kosi barrage at Hanumannagar to Ganga confluence at Kursela **(Fig. 4.1).** The details of the equipment used for Thalweg survey are as follows:

Hydrotrac

Make	ODOM Hydrographic system USA
Frequency	33 - 200 kHz (Single frequency)
Accuracy (for measuring depth)	200kHz – 1cm +/- 0.1% depth 33 kHz – 10cm +/- 0.1% depth
Accuracy (for GPS)	Less than +/- 5m when used in differential mode

The soundings were recorded along the deep course of the river. The surveys were carried out using recording type Echo sounder cum Global Positioning System (Hydrotrac) as described below:

Hydrotrac is specially designed equipment which records a continuous profile of the reservoir bed along with global positioning system. The vital part of the hydrotrac is transducer. The transducer transmits the sound pulses downward into the water and receives the reflected echoes from the bed and converts the acoustical energy to electrical energy. The echo sounder measures the time interval between the emission of the sound pulse (acoustic signal) and its return as an echo and converts it into a linear distance in meters.

The hydrotrac has an integrated Starlink Invicta 210L GPS receiver with a built-in DGPS correction receiver. With DGPS correction the receiver gives an accuracy of 1 m.

Prior to commencement of the Thalweg surveys, a limited topographic survey was carried out using GPS and Total Station.

The depths recorded using Hydrotrac were subjected to the water level and sounding datum corrections before plotting survey drawings (L-Section drawings).

The hydrographic survey data was supplemented with the latest satellite imageries to update the information on high banks, islands, sand chars, and tributaries and channel bifurcations etc.

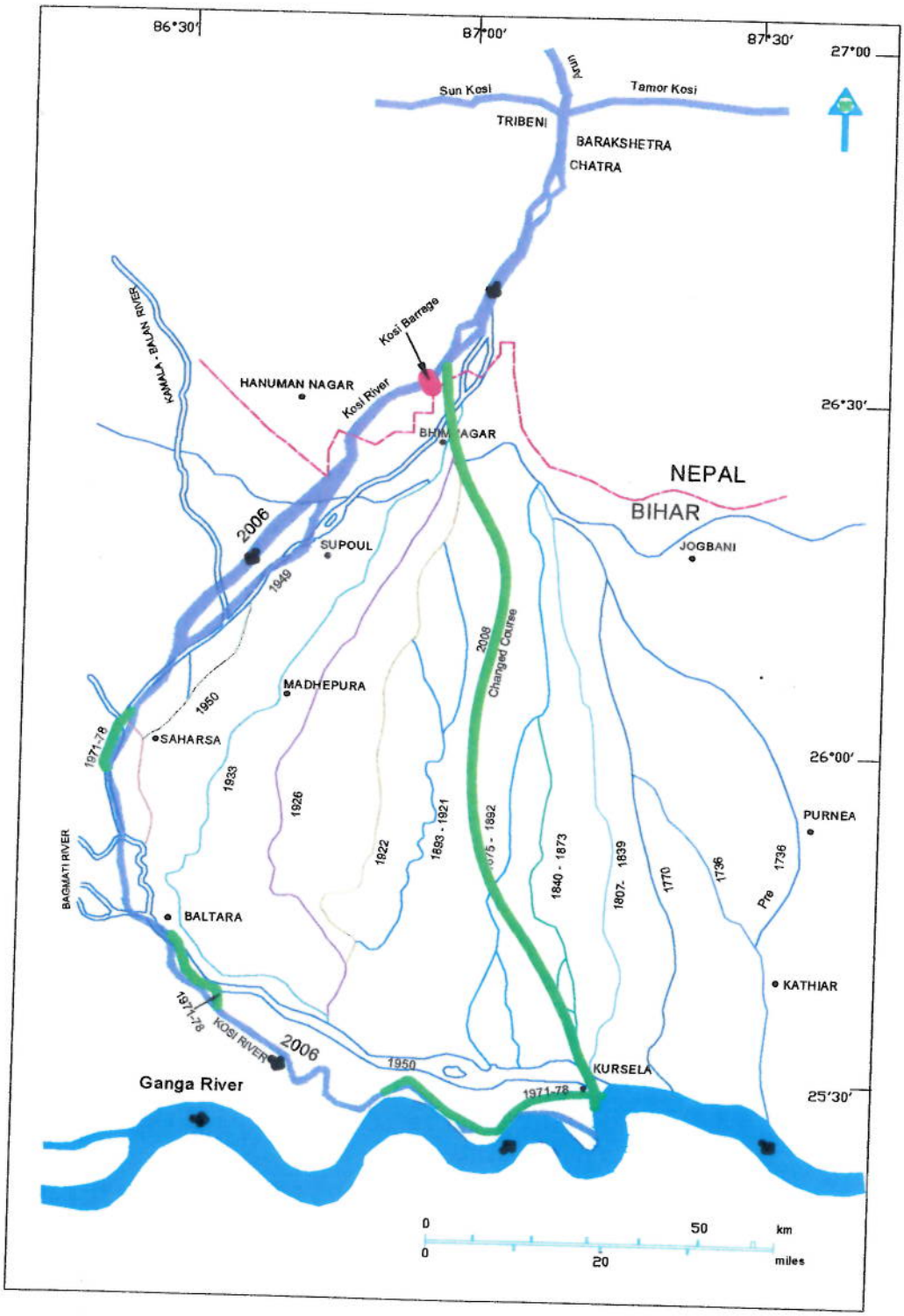


Fig. 4.1: River Kosi from Kosi barrage to Ganga confluence at Kursela

4.2 RIVER HYDROLOGY

4.2.1 Collection of data

To study the availability of navigational depths during different seasons in a year it is required to analyze the historical water level data on the waterway under consideration for development. It is a standard practice to analyze at least 5 to 10 year's water level data to arrive meaningful standard low water levels.

The hydrological data such as water levels, discharges and sediment load on river Kosi have been collected from Central Water Commission, Patna for the period from 1996 to 2005 at the available gauge stations Birpur, Basua, Baltara and Kursela (Fig. 4.1) and analyzed to establish standard low water level and to study the availability of water for navigation.

4.2.2 Analysis of hydrological data

Birpur/Bhimnagar:

The monthly maximum and minimum water levels at Birpur for the years 1996 to 2005 are presented in **Table 4.1**.

Table 4.1: Monthly maximum and minimum water levels at Birpur

Maximum and Minimum water levels over the year on River Kosi at Birpur/Bhimnagar												
Month	Jan		Feb		Mar		Apr		May		Jun	
Year	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min
1996	73.030	72.090	72.390	71.780	72.690	71.780	72.540	71.780	73.460	72.330	74.620	72.690
1997	72.245	72.025	73.085	71.995	72.755	71.945	72.775	72.085	72.970	72.365	74.280	73.820
1998	73.240	72.720	73.000	72.540	73.150	72.400	73.690	72.690	73.700	73.150	74.520	73.330
1999	73.515	72.570	72.630	72.365	74.305	72.245	73.030	72.150	74.675	72.785	75.470	73.610
2000	73.585	73.425	73.635	73.425	73.635	73.210	74.065	73.180	74.765	73.605	75.350	75.130
2001	73.450	72.910	73.450	72.910	73.270	72.690	73.790	73.210	74.460	73.300	75.250	73.670
2002	72.600	72.000	72.540	72.180	72.580	72.115	73.150	72.335	74.370	72.540	74.980	73.210
2003	72.785	72.245	72.490	72.180	72.850	72.150	74.065	72.540	74.215	73.095	75.740	73.910
2004	73.000	72.660	73.000	72.460	73.150	72.365	73.760	72.940	74.215	72.940	74.520	70.215
2005	72.850	72.425	72.490	72.335	72.785	72.305	72.910	72.425	73.210	72.030	74.280	72.880

Month	Jul		Aug		Sep		Oct		Nov		Dec	
Year	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min
1996	75.350	74.310	75.04	74.07	74.65	73.34	74.01	72.47	72.85	72.09	72.85	72
1997	74.185	74.005	74.92	74.49	74.675	74.55	73.91	72.42	72.66	72.195	73.3	72.72
1998	75.010	74.280	75.59	74.37	75.59	74.37	74.62	73.61	74.68	73.4	73.79	73.46
1999	75.470	73.610	75.35	74.07	75.43	74.1	74.98	73.46	73.88	72.82	73.85	73.325
2000	75.680	74.830	75.71	74.98	75.53	73.88	74.37	72.72	73.21	71.935	73.3	73.18
2001	75.500	74.370	75.98	74.83	75.53	74.46	75.86	73.7	73.79	72.46	73.095	72.245
2002	76.020	74.130	75.77	74.47	75.29	74.4	74.55	73.15	73.395	72.69	73.25	72.185
2003	76.020	74.130	75.71	74.68	75.35	74.31	74.49	73.13	73.515	73.15	75.15	72.91
2004	75.345	74.125	74.615	73.76	74.43	73.24	74.065	72.18	72.91	72.425	72.91	72.54
2005	74.735	74.005	75.13	74.125	74.585	73.515	74.125	72.94	73.27	72.69	72.785	72.395

The table indicates that the low water levels are generally observed during March and high water levels are noticed during July. The lowest low water

levels are noticed in the year 1996. The lowest low water level of 71.780 m is observed in March and April in the year 1996 whereas the high water level of 75.350 m is observed in July. Therefore, the water level in the river varies by 3.570 m over a year from lean season to flood season. The hydrograph of river Kosi at Birpur based on last ten years average data (1996-2005) is depicted in **Fig. 4.2 (a).**

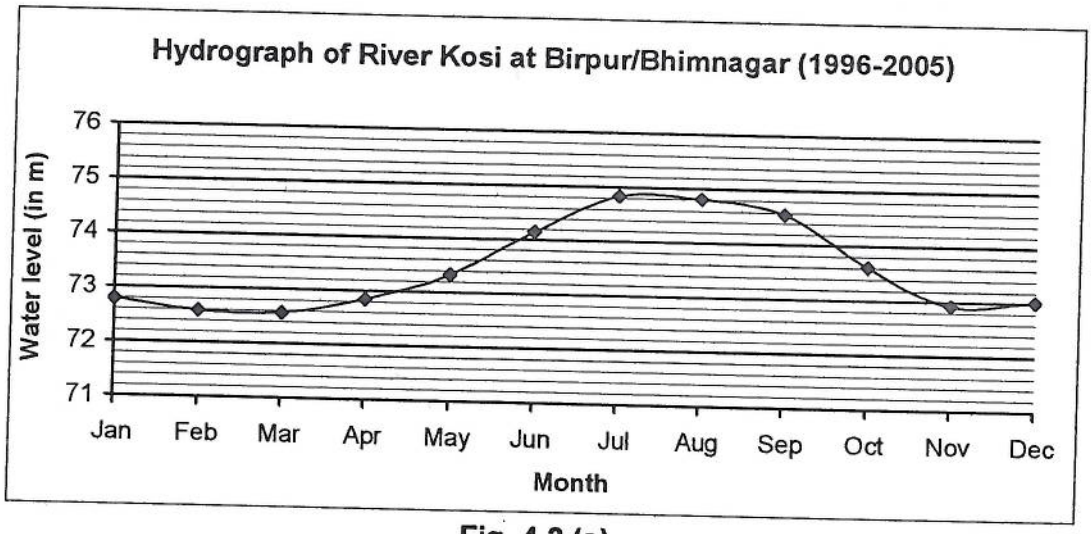


Fig. 4.2 (a)

This hydrograph indicates that the general behaviour of the water level variations in the river Kosi at Birpur. The river starts rising from May and reaches peak during July. The flood waters are however prevailing up to September / October. The water levels start falling from October / November. A typical hydrograph for the year 1996 where the lowest low waters in the river are observed is depicted in **Fig. 4.2 (b).**

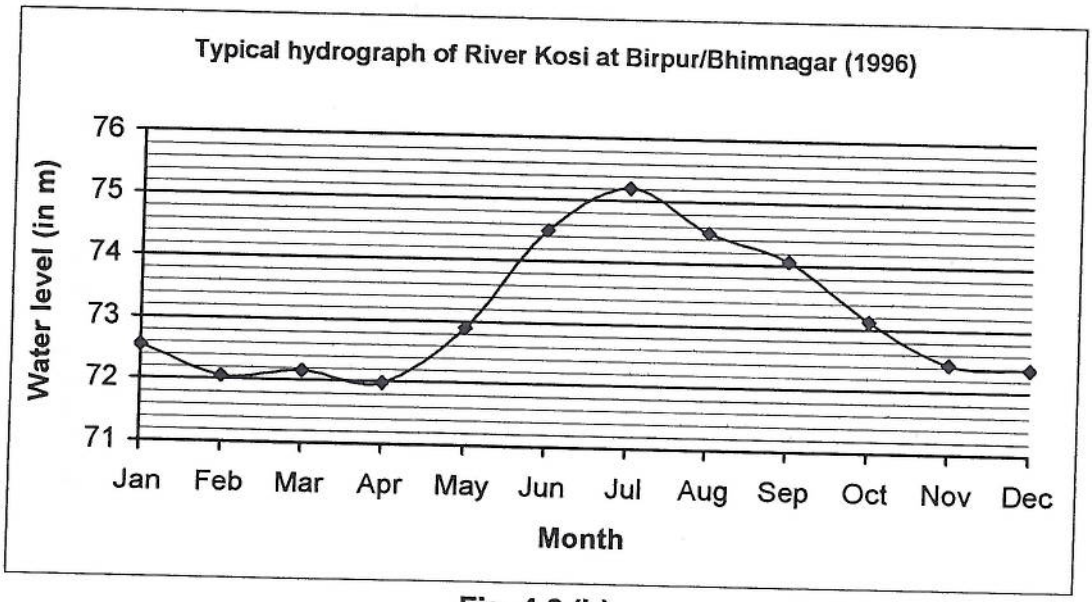


Fig. 4.2 (b)

This hydrograph also indicates that the river experiences lowest low waters during April, and the river starts rising from May and reaches peak food during July.

Basua:

At Basua, the water level data is available only during flood season as the gauge station is meant for flood warning purpose. Hence the data is not so useful for analysis of the availability of depths particularly during lean period from the navigation point of view. The water level data during monsoon period is presented in **Table. 4.2**.

Table 4.2

Month	Jun		Jul		Aug		Sep		Oct	
Year	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min
1996	47.444	46.200	48.480	47.247	48.144	47.464	47.908	47.369	47.547	46.983
1997	46.758	45.674	47.860	47.291	48.159	47.253	47.709	47.192	46.729	46.258
1998	-	-	-	-	-	-	-	-	-	-
1999	-	-	-	-	-	-	-	-	-	-
2000	-	-	-	-	-	-	-	-	-	-
2001	47.277	46.590	47.548	46.704	48.075	46.858	47.53	46.854	47.647	46.677
2002	46.346	46.069	48.197	46.372	47.615	46.715	46.707	46.191	46.34	46.1
2003	47.775	45.679	48.624	47.322	48.082	46.349	47.232	46.64	46.626	46.42
2004	47.370	45.240	48.780	46.010	47.88	47.05	47.78	46.81	47.09	46.15
2005	-	-	-	-	-	-	-	-	-	-

The peak flood level of 48.780 was observed in the month of July, 2004. In general the peak flood month is noticed as July.

Baltara:

The monthly maximum and minimum water levels at Baltara for the years 1996 to 2004 are presented in **Table 4.3**.

Table 4.3

Maximum and Minimum water levels over the year on River Kosi at Baltara

Month	Jan		Feb		Mar		Apr		May		Jun	
Year	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
1996	30.162	30.852	29.652	30.132	29.412	29.972	28.502	29.382	28.622	30.692	30.052	33.732
1997	28.912	29.452	28.652	29.032	28.392	28.772	28.642	29.252	29.182	29.652	29.692	32.522
1998	29.292	29.892	28.712	29.302	28.632	28.952	28.092	29.332	29.402	30.632	30.082	33.972
1999	29.007	29.652	28.712	29.002	28.422	28.732	28.392	28.752	28.612	29.492	29.492	33.522
2000	29.812	29.922	29.402	29.937	29.242	29.522	29.202	29.452	29.043	29.522	29.542	33.757
2001	29.502	29.892	29.382	29.502	29.332	29.432	29.352	29.472	29.472	29.852	29.832	33.222
2002	31.467	32.002	30.687	31.442	29.807	30.652	29.93	30.402	30.312	30.737	30.752	32.582
2003	31.882	31.942	31.842	31.912	31.802	31.902	31.612	31.902	31.452	31.692	31.422	33.932
2004	31.802	32.012	31.527	31.792	31.422	31.532	31.422	31.612	31.402	31.632	31.632	32.597
2005	-	-	-	-	-	-	-	-	-	-	-	-

Cont. Table 4.3

Month	Jul		Aug		Sep		Oct		Nov		Dec	
Year	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
1996	33.742	35.592	34.902	35.372	31.282	35.222	31.227	34.027	30.582	31.387	29.492	30.562
1997	32.602	35.032	34.022	35.142	33.557	34.987	31.207	34.097	30.027	31.752	29.972	30.952
1998	33.917	35.512	35.452	35.772	33.842	35.722	31.887	33.872	31.052	31.962	29.682	30.857
1999	33.677	35.152	34.372	35.672	34.027	35.512	30.932	34.112	32.027	32.632	29.852	32.002
2000	33.507	34.912	34.862	35.582	32.227	35.442	31.352	34.962	31.057	31.342	29.907	31.032
2001	32.742	34.582	34.637	35.862	34.307	35.802	32.462	35.252	32.092	32.452	32.002	32.142
2002	32.462	35.962	34.282	35.812	32.432	34.212	32.202	32.972	32.082	32.262	31.932	32.092
2003	33.232	34.892	34.252	37.797	33.772	34.642	32.107	33.767	32.002	32.122	31.952	32.072
2004	32.652	35.872	33.537	35.097	32.152	34.042	32.182	32.727	-	-	-	-
2005	-	-	-	-	-	-	-	-	-	-	-	-

The table indicates that the low water levels are generally observed during March and April and high water levels are noticed during August. The lowest low water level of 28.092 m is observed in April and in the year 1998 whereas the high water level of 35.772 m is observed in August. Therefore, the water level in the river varies by 7.68 m over a year from lean season to flood season. The hydrograph of river Kosi at Baltara based on last nine years average data (1996-2004) is depicted in **Fig. 4.3 (a)**.

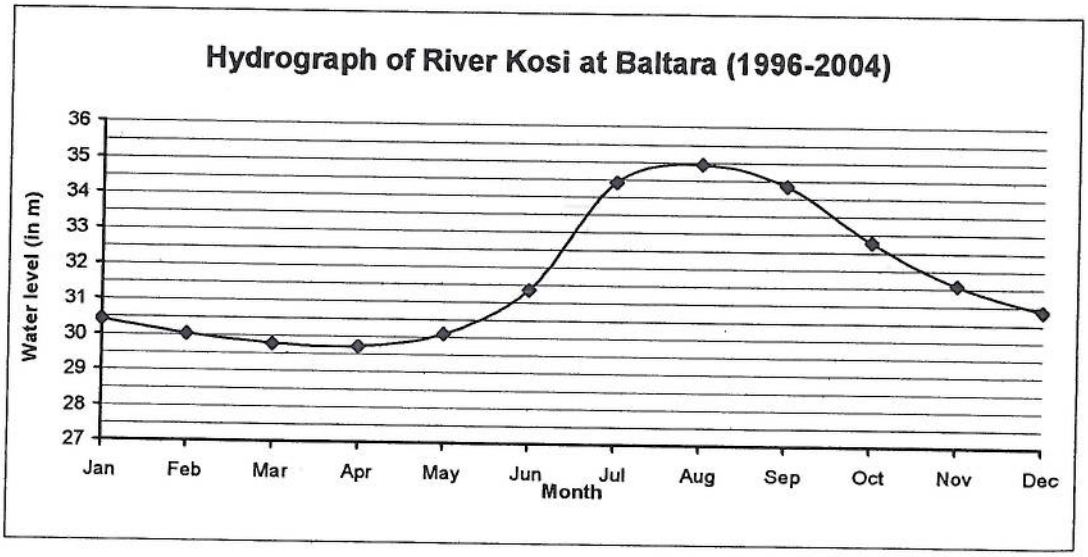


Fig. 4.3 (a)

This hydrograph indicates that the general behaviour of the monthly water level variations in the river Kosi at Baltara. The river starts rising from May and reaches peak during August. The flood waters are however prevailing up to October. The water levels start falling from November. A typical hydrograph for the year 1997 where the significant low waters in the river are observed during lean season is depicted in **Fig. 4.3 (b)**.

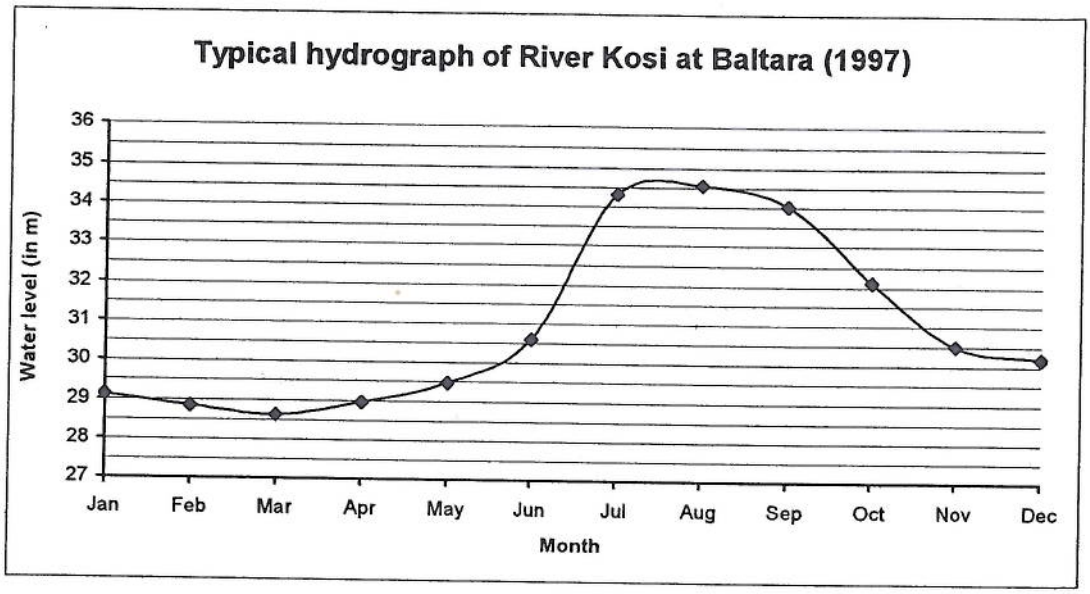


Fig. 4.3 (b)

This hydrograph indicates that the river experiences lowest low waters during March, and the river starts rising from May and reaches peak flood during August.

Mean monthly discharges of river Kosi at Baltara for the last nine years (1996 to 2004) are furnished in **Table 4.4**.

Table 4.4

Discharges at Baltara for the Years 1996 to 2004												
Year	*Jan*	*Feb*	*Mar*	*Apr*	*May*	*Jun*	*Jul*	*Aug*	*Sep*	*Oct*	*Nov*	*Dec*
1996	378	224	284	213	658	1782	5546	5267	4070	1987	1052	668
1997	410	307	214	304	485	918	4500	4946	3828	1744	955	1148
1998	825	385	314	435	1271	2885	7738	10375	8634	4129	2159	1276
1999	849	588	478	472	731	1803	7680	8327	8189	5584	2859	1446
2000	1238	735	590	469	621	1538	4415	6529	6317	3106	1953	1494
2001	1035	922	1149	896	1040	1678	3782	6386	6586	5180	3035	2707
2002	2492	2029	1398	1402	1587	2200	4841	6361	3627	2948	2758	2636
2003	2572	2535	2519	2497	2325	2543	5022	5297	4933	3200	2676	2638
2004	2568	2405	2244	2278	2265							

The months of March and April experiences low discharges whereas high discharges are noticed during August. The lowest low discharge of about 213 cumecs is observed during April in the year 1996 and the highest discharge during the corresponding year is 5,546 cumecs occurred in the month of July. The highest discharge recorded is about 10,375 cumecs during August in the year 1998 whereas the low discharge for the corresponding year is about 314 cumecs occurred in the month of March. A typical stage – discharge curve for the year 1997 is depicted in **Fig. 4.4**.

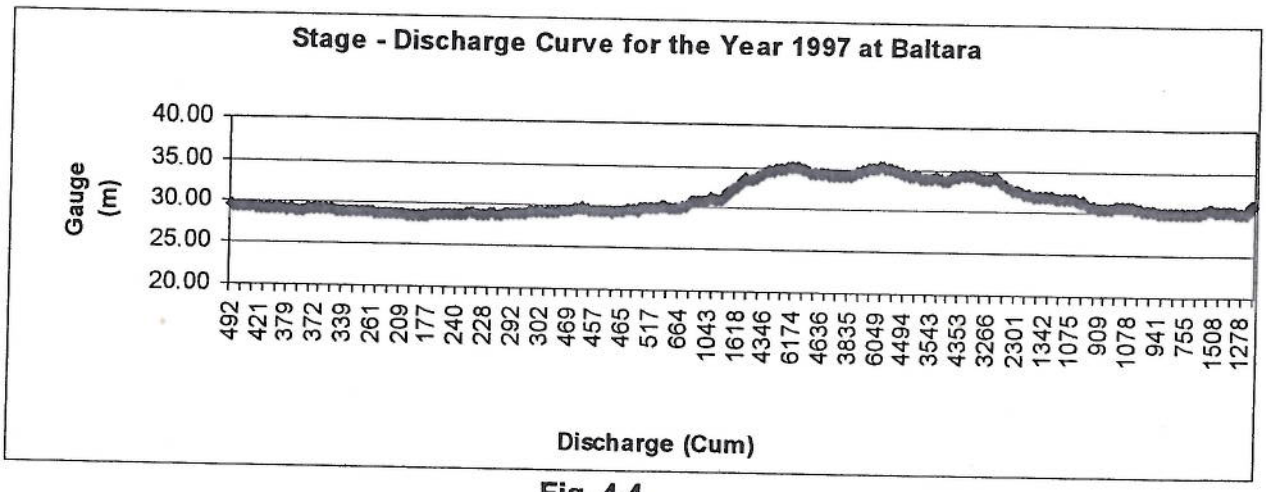


Fig. 4.4

The stage – discharge curve indicates that if the discharges into the river are increased by about 6000 cumecs, from lean season to flood season, the stage of the river rises by about 7 m.

It is interesting to note that during the recent past from 2001 to 2004 the average monthly low discharges observed during lean months of March and April are generally exceeded 1000 cumecs.

Kursela:

The monthly maximum and minimum water levels at Kursela for the years 1996 to 2005 are presented in **Table 4.5**.

Table 4.5

Maximum and Minimum water levels over the year on River Kosi at Kursela

Month	Jan		Feb		Mar		Apr		May		Jun	
Year	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min
1996	24.950	24.485	24.480	24.220	24.265	24.015	24.015	23.660	24.600	23.655	27.400	24.120
1997	24.760	24.520	24.530	24.130	24.130	23.770	23.770	23.540	24.020	23.650	25.775	24.030
1998	25.810	25.315	25.400	24.720	24.720	24.200	24.890	23.880	24.210	23.790	26.830	24.230
1999	25.220	24.500	24.490	24.130	24.125	23.710	23.720	23.500	32.810	23.500	27.690	24.550
2000	25.095	24.405	24.510	24.125	24.120	23.550	23.620	23.500	25.130	23.650	28.900	25.150
2001	24.260	23.750	23.750	23.500	23.545	23.500	23.545	23.500	23.870	23.500	27.110	23.900
2002	24.490	23.820	23.920	23.625	23.660	23.500	23.680	23.500	24.740	23.695	25.965	24.310
2003	25.105	24.660	24.660	24.460	24.460	23.890	23.880	23.500	23.990	23.520	27.400	23.975
2004	25.375	24.860	24.860	24.380	24.370	23.940	23.950	23.805	23.870	23.500	27.040	23.870
2005	25.000	23.970	23.970	23.755	23.750	23.615	23.685	23.510	23.920	23.505	25.100	23.745

Cont. Table 4.5

Month	Jul		Aug		Sep		Oct		Nov		Dec	
Year	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min
1996	29.640	27.410	31.46	29.49	31.56	28.74	28.735	26.4	26.38	25.46	25.45	24.77
1997	29.660	26.025	30.58	29.13	30.83	29.025	28.985	25.77	25.84	25.33	26.93	25.05
1998	-	-	-	-	-	-	29.36	27.7	28.12	26.33	26.3	25.24
1999	-	-	-	-	-	-	30.19	27.79	27.75	25.91	25.88	25.095
2000	-	-	-	-	-	-	29.16	26.035	26.02	25.03	25.02	24.27
2001	30.235	27.240	30.81	29.1	30.555	28.575	29.59	26.94	26.91	25.03	25.02	24.5
2002	29.880	25.900	30.455	28.81	30.17	28.77	29.07	26.24	26.22	25.65	25.64	25.115
2003	29.760	27.230	31.05	29.78	31.8	30.55	30.865	27.515	27.98	26.04	26.025	25.385
2004	30.040	26.725	39.42	28.92	30.07	27.605	28.42	26.33	26.97	25.77	25.765	25.05
2005	-	-	-	-	-	-	28.68	26.5	26.56	25.1	25.08	24.11

The table indicates that the low water levels are generally observed during March, April and May; and high water levels are noticed during August. The lowest low water level of 23.50 m is observed from February to May in the year 2001 whereas the high water level of 30.81 m is observed in August. Therefore, the water level in the river varies by 7.31 m over a year from lean season to flood season.

The hydrograph of river Kosi at Kursela based on last ten years average data (1996-2005) is depicted in **Fig. 4.5 (a)**.

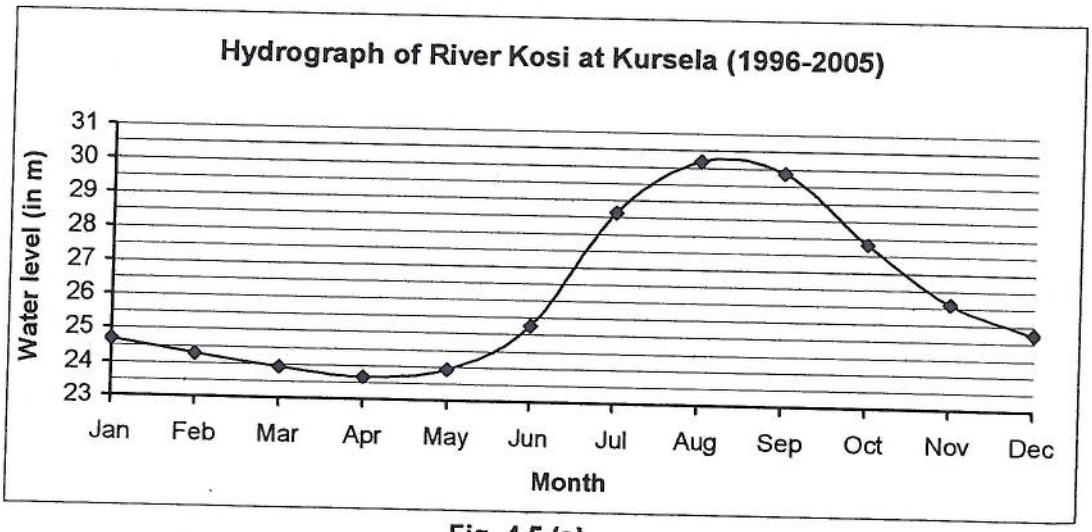


Fig. 4.5 (a)

This hydrograph indicates that the general behaviour of the monthly water level variations in the river Kosi at Kursela. The river starts rising from June and reaches peak during August. The flood waters are however prevailing up to September / October. The water levels start falling from October / November. A typical hydrograph for the year 2001 where the significant low waters in the river are observed during lean season is depicted in **Fig. 4.5 (b)**.

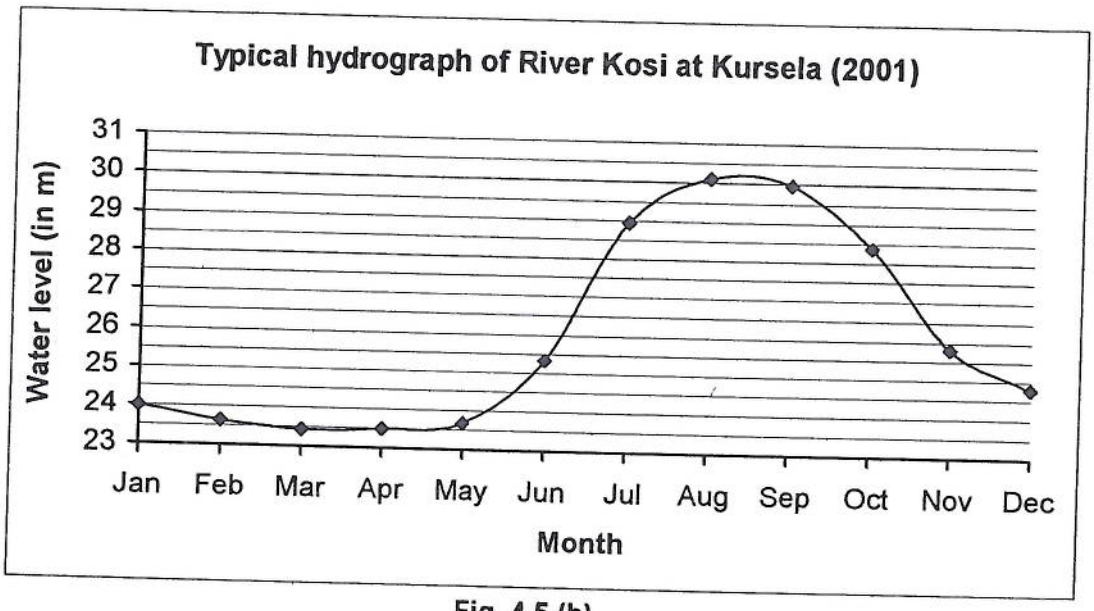


Fig. 4.5 (b)

This hydrograph indicates that the river experiences low waters from February to May, and the river starts rising from June and reaches peak flood by August.

The foregoing discussion on analysis of water levels and discharges illustrates the behaviour of the river during different years and also during lean season and flood seasons in a year. The tendency of the water levels and discharges particularly during lean season are important for navigation.

4.2.3 Standard low water level (chart datum)

The standard low water level (SLWL) has been fixed by analyzing long period water level data at the available four gauge stations being maintained by Central Water Commission, downstream of Kosi barrage. The long period water level data was supplemented with the water level data collected during survey period and some data already available with the consultants'.

The chart datum values fixed at the three gauge stations viz., Birpur, Baltara and Kursela have been extended for the intermediate stations of the waterway based on the short period water level observations during survey period and by interpolation. The chart datum values for the entire river reach from Kosi barrage to Kursela are shown in **Table no. 4.6**.

Table 4.6: The chart datum (CD) values and river gradient of Kosi

Gauge Location	Chainage from Kosi barrage (km)	Chart datum value in 'm' (SLWL)	River Distance (km)	Gradient (m)
Kosi Barrage	0	73.500	34.162	1:2523
Birpur / Bhimnagar	0.77	72.200	0.770	
Kalyanpur	30.704	60.644	30.704	1:2657
Basbiti	72.514	45.392	41.810	1:2741
Mahisarho	101.805	39.970	29.291	1:5402
Koparia	140.823	33.133	39.018	1:5707
Kathmara	162.353	30.700	21.530	1:8849
Baltara	190.434	28.700	28.081	1:14041
Phulot	202.888	27.100	12.454	1:7784
Kursela	231.988	23.500	29.100	1:8083

4.2.4 Depths for Navigation

The reduced depths below the chart datum are used to assess the navigation depths. The reduced depths, that is, the depths below the chart datum indicate that these depths would be ensured even during dry season on long term basis.

4.2.5 Longitudinal Section of river Kosi:

The depths along the deeper course of the river in the form of longitudinal section carried out based on the surveys are presented in **Fig. 4.6**.

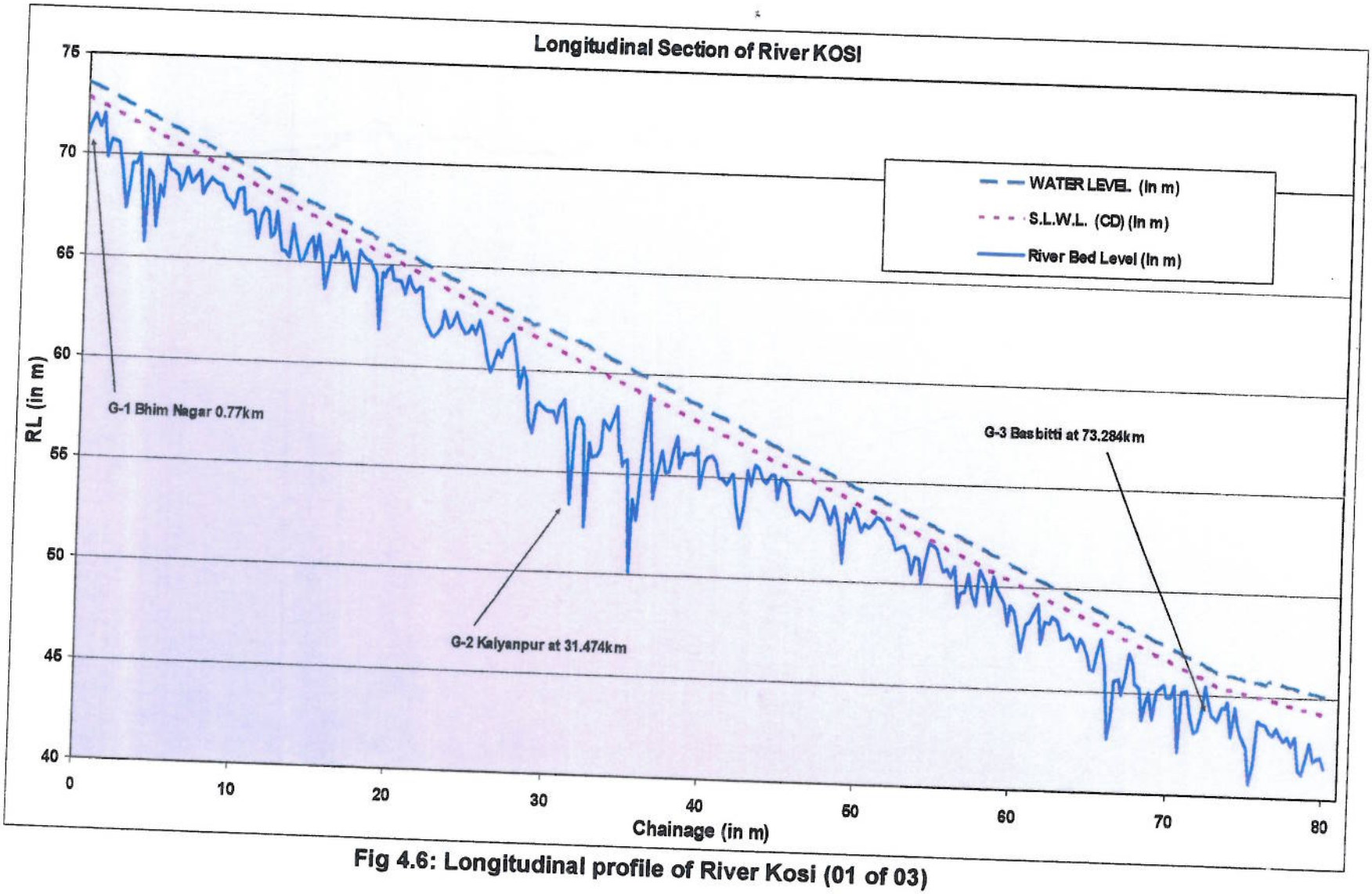


Fig 4.6: Longitudinal profile of River Kosi (01 of 03)

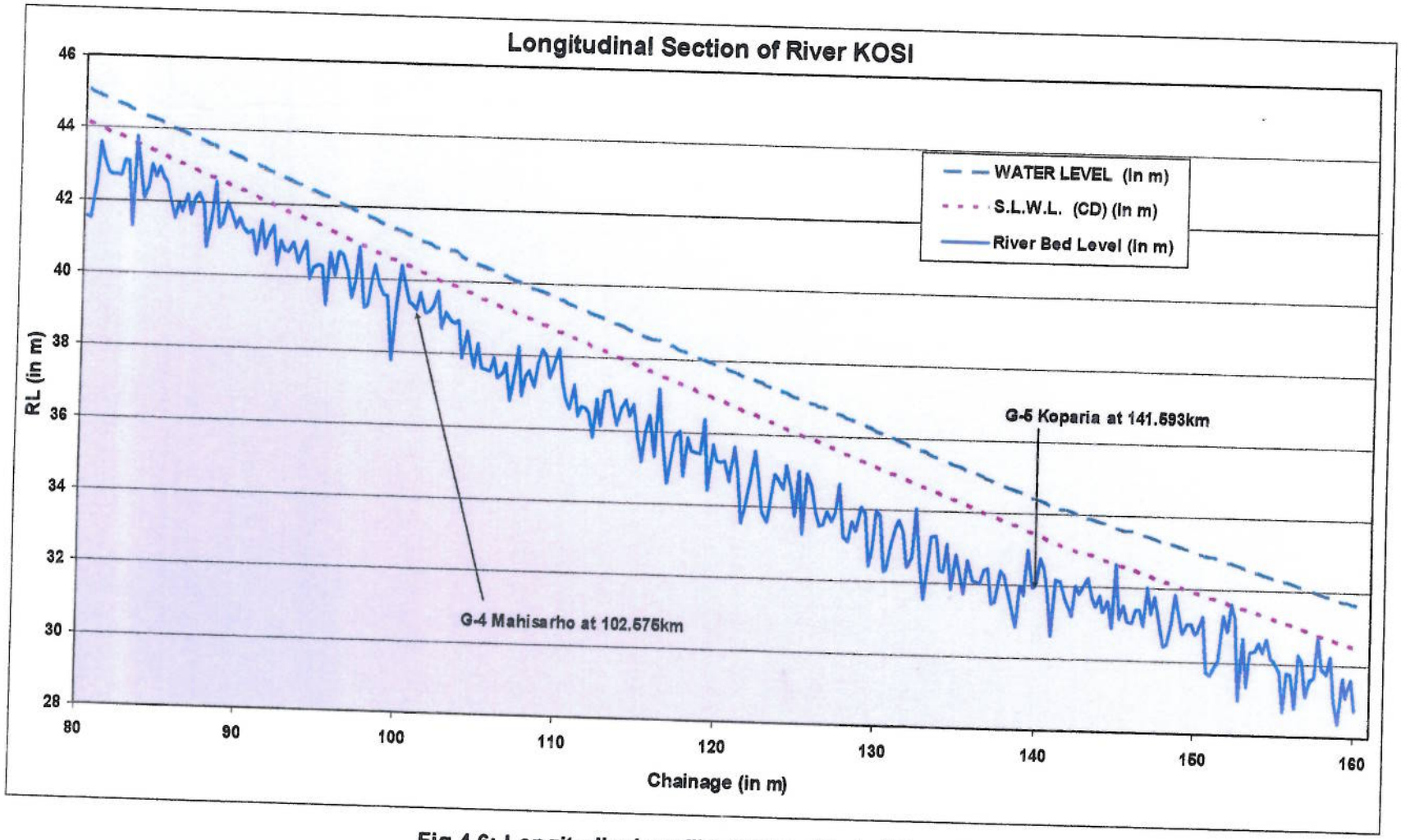


Fig 4.6: Longitudinal profile of River Kosi (02 of 03)

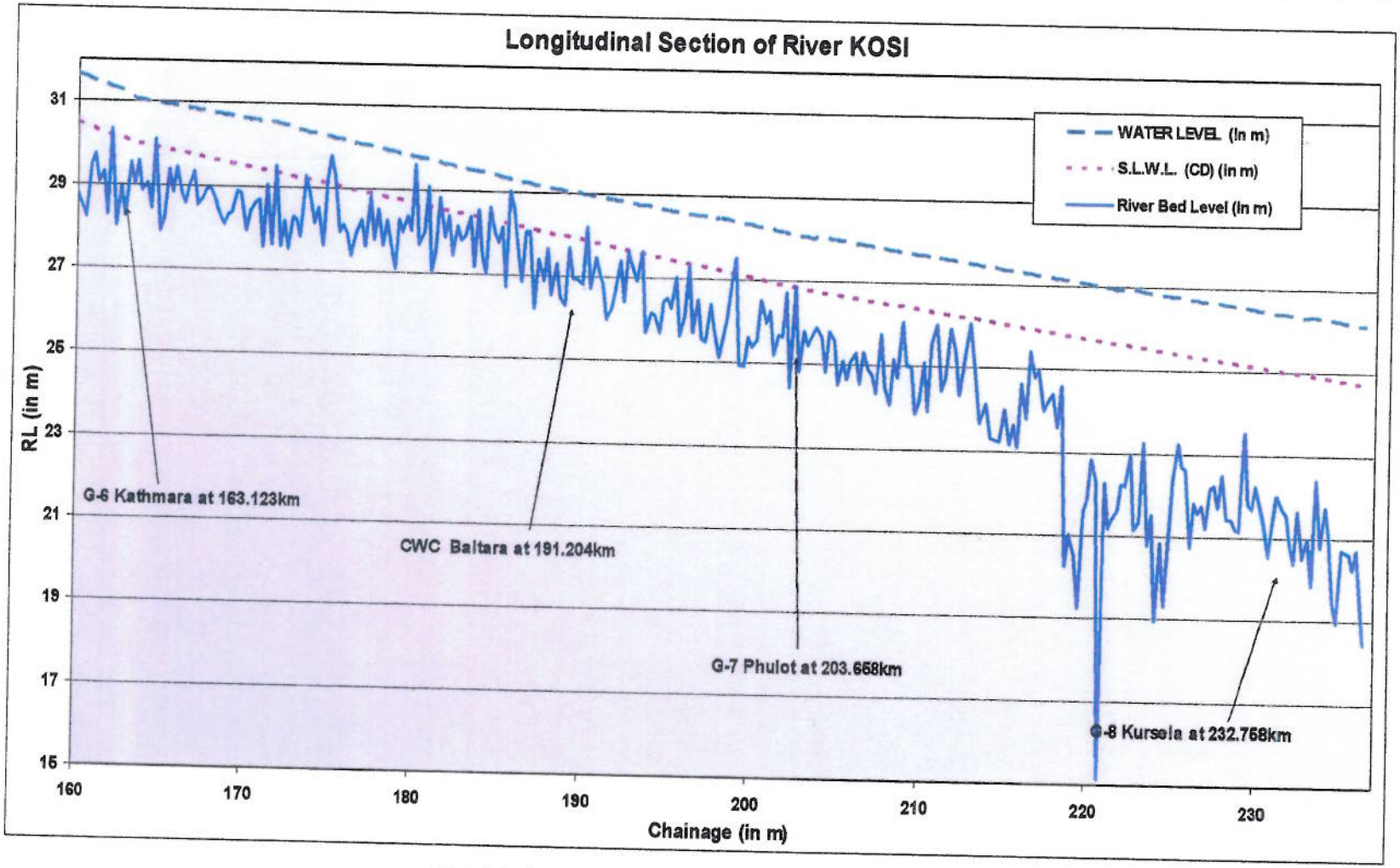


Fig 4.6: Longitudinal profile of River Kosi (03 of 03)

4.3 SATELLITE MODEL STUDIES

The river course changes have been examined using latest satellite model imageries. The hydro morphological changes are as follows:

4.3.1 Hydro Morphological Changes of River Kosi

The Kosi River is notorious, for its heavy sediment load, brought down from its Himalayan catchment and its shifting nature in the Gangetic plain, below the Chatra gorge. The river, flowing near Purnea in the east in 1736, shifted progressively towards west. The river now flows east of Saharsa. Various migrations undergone by the river Kosi over the years is shown in Fig. 4.1. The total shifting was about 112 km between the years 1736 and 1954. The maximum rate of shift was 2.6 km per year, during the years 1922 and 1923. In 1938, the river swung west of Mansi-Saharsa railway line. In this process of lateral shifting, the river was building its alluvial fan (inland delta). A satellite picture of the lateral shifting of the river and its alluvial fan is in **Fig. 4.7**. The lateral shifting of river Kosi has rendered some 1,295 sq km of land in Nepal and 7,770 sq km in India is useless as a result of sand deposition.

The present status of the Kosi river course based on recent satellite imageries (2006 - 07), has been worked out. The shifting of the Kosi river course to its present position has been evaluated by comparing with Survey of India toposheets. The survey of India had carried out the surveys between 1971 and 1978. The details of the shifting of the Kosi river to its current position of 2006-07 from 1971-78 are furnished in following **Table 4.7.**

Table 4.7: Shifting of the River Kosi during 2006-07 from 1971-1978

Sl. No	2006-07		Shifting (Km)	River Side	Remarks
	Easting	Northing			
1	86° 44' 42"	26° 21' 00"	2	Western	Survey held during 1971-1978
2	86° 40' 12"	26° 19' 48"	1	Western	
3	86° 44' 24"	26° 19' 48"	1	Western	
4	86° 39' 00"	26° 18' 00"	2	Western	
5	86° 37' 48"	26° 16' 12"	3	Western	
6	86° 31' 48"	26° 10' 48"	1	Western	
7	86° 31' 48"	26° 09' 00"	3	Western	
8	86° 27' 54"	26° 01' 48"	3	Eastern	
9	86° 25' 48"	25° 58' 12"	1.5	Eastern	
10	86° 31' 48"	25° 42' 00"	1.5	Western	
11	86° 31' 48"	25° 40' 12"	3	Western	
12	86° 31' 48"	25° 39' 36"	3	Western	
13	86° 33' 00"	25° 38' 24"	3	Western	
14	86° 34' 48"	25° 37' 48"	4	Western	
15	86° 48' 36"	25° 27' 36"	1	Western	
16	86° 55' 48"	25° 29' 24"	1.5	Eastern	
17	86° 58' 12"	25° 27' 36"	1	Western	
18	87° 00' 00"	25° 27' 00"	1	Eastern	
19	87° 01' 12"	25° 25' 12"	4	Western	
20	87° 15' 36"	25° 24' 36"	11	Western	Survey held at Ganga confluence during 1971-72

Fig. 4.7

In general the river has been shifted by about 1 to 4 km towards west over a period of about 30 years. The major shifting of the river of about 11 km towards west is noticed at the confluence of Ganga. It means that the confluence point of river Kosi with Ganga is shifting towards west. The present status of the Kosi River is compared with historical shifting of the Kosi river course by superimposing and shown in **Fig. 4.1**.

A breach was occurred in August, 2008 at Kusrha in Nepal, on the left embankment just upstream of Kosi barrage. As a result of breach the river course was shifted. In the course of shifting, many towns and villages are wiped out affecting human settlement and cattle life apart from heavy losses of property and cultivable land. The satellite imagery of the changed course of river in the year 2008 can be seen in the following **Fig 4.8**. Subsequently, the breach was pegged and the river course was brought back to its normal course during January, 2009.

Fig. 4. 8: Changed course of river during 2008 breach

A combination of factors is influencing the complex behaviour of Kosi. These are hydrological factors, sedimentological factors, tectonic factors related to Himalaya as well as response of basement structures to plate movement, regional slope and geomorphology etc.

Because this process is now occurring on the extreme western end of the fan, there is a strong possibility that migration will now begin toward the east. A major

shift to the east by avulsion would also be possible, were it not for massive artificial levees constructed to stabilize the river in its present position.

Various studies carried out on river Kosi indicate that the lateral movement of the river occurred due to the following reasons:

- Steep gradient
- Heavy silt charge with excessive coarse sediment
- Low bed resistance
- Tectonic movement of sub surface plates
- No boulders in steep reaches
- High discharge against normal flood
- Aggrading and degrading tendency of river
- Considerable difference between valley gradient and bed gradient.

4.3.2 Navigational Route based on Satellite imageries

Hanumannagar to Kalyanpur

The braiding pattern of the river continues downstream of the Kosi barrage with active channel (Thalweg) runs along the centre (SI 4.1). The eastern and western Kosi embankments and the spurs for bank protection can also be seen in the imagery (SI 4.1). At latitude 26030'36"N the thalweg moves right (western) embankment and then the thalweg continues along the right (western) embankment up to latitude 26023'24"N (SI 4.2). At this point the thalweg crosses towards the left (eastern) embankment and the flow hugs along the Kalyanpur bank (SI 4.3).

When the Kosi barrage was commissioned in 1963, it was expected that after construction of the barrage, the river discharge with the reduced sediment load would deepen and stabilize its course below the barrage and if such a channel keeps more or less towards the centre of the embankment and thereby hazards to the embankment would be minimized. But contrary to the expectations, it was reported that the river renewed its attacking during 1963 floods and a breach in the embankment for length of about 1280 m near Dalwa along the right bank (Western embankment), 12 km down stream of the barrage.

The recent satellite imagery and the river surveys indicated that the main channel of the river has now occupied more or less central position immediately downstream of the barrage for a length of about 6 to 8 km only. Beyond this, the main Kosi channel is directed towards the western kosi embankment which is protected by embankment and spurs (SI 4.1 and 4.2). The river slope in this reach is steep of the order of about 1 m fall in 2.6 km (1:2593), resulting the velocities during floods are high of the order of 4.6 to 5.5 m / sec, and the lean period velocities are of the order of 0.86 m / sec. This type of high velocity may be observed in Peak flood period i.e. August. Maximum 10 days in mid August navigation may be suspended.

Kalyanpur to Basbitti

At Kalyanpur the active channel (thalweg) runs along the eastern embankment side. Down stream of the Kalyanpur the river is divided into two major channels due to Central Island and the main thalweg is along the eastern embankment (SI 4.2). About 12 km down stream of Kalyanpur, the river is started diverting away from the eastern embankment and the main course traverses more or less centre of the embankments (SI 4.3). At Basbitti the main course (thalweg) of the river is again shifts towards the eastern embankment. The CWC gauge at Basua is located along this eastern embankment. The river course right from Kosi barrage to Basbiti runs from northeast to southwest direction.

Basbitti to Mahisarho

In this reach, main course of the river runs close to the eastern embankment and the direction of the river is from north to south. The western embankment is about 15 to 20 km away from the main course of the river (SI 4.5 and 4.6). In the main course that runs along the eastern embankment, the braiding pattern continues due to formation of the islands and sand bars. The secondary feeder channels / streams run along the western embankment side.

Mahisarho to Koparia

In this reach the main course of the river continues to run close to eastern embankment and the river changes its orientation towards southeast from down stream of the latitude $25^0$45'N. The western embankment side is under flood water (SI 4.7 and 4.8). The main course of the river becomes narrow from this reach.

Koparia to Kathmara

In this reach the Baghmati River, with its number of distributaries, meets river Kosi along the western embankment. The northern eastern railway line crosses the Kosi where the width of the river is narrow. The orientation of the river continues from northwest to southeast. The river runs about 5 to 6 km away from the eastern embankment. At Kathmara – Osraha, the road bridge crosses the river. Down stream of Baghmati river confluence, the characteristic features of the river change i.e., from Kosi barrage to Baghmati river confluence the river exhibits braided pattern whereas from downstream of Bagmati river confluence to Kursela the river meanders. The name of the river Kosi also becomes Ghugri from down stream of Baghmati confluence.

Kathmara to Kursela

The river in this reach changes its character from braided pattern to meandering. That is, from Kosi barrage to Bagmati river confluence, the river exhibits braided pattern with number of channels separated by islands and sand bars. The gradient of the river becomes flat from 1 m fall in 6.9 km to 1 m fall in 12.3 km.

The river more or less follows a single course from Kathmara to Kursela (SI 4.11 to 4.14). The river becomes narrow with single channel. The discharges of Bagamati will help to maintain deeper course in this reach. The Baltara gauge of CWC is located downstream of Kosi confluence. Downstream of Kathmara road bridge the river has a circular meandering bed with oxbow shape (SI 4.11). Further downstream of this oxbow bend, the river changes its orientation from southeast to east and then the river continues to run in west – east direction till it confluences with river Ganga at Kursela.

4.3.3 Morphological changes of river Kosi based on hydrographic surveys

The rivers can generally be grouped into three types: braided, straight, and meandering. Braided channels are those marked by successive divisions and rejoining of the flow around alluvial islands. Straight channels are those which have, at the bank-full stage, a negligible sinuosity over a distance many times the channel width. Meandering channels show more or less regular inflections in the direction of the channel and are quite sinuous in plan. The Kosi typically exhibits braided and meandering pattern.

The river Kosi runs in plains downstream of Kosi barrage and exhibits braided pattern due to formation of islands and sand bars (locally known as sand chars) at the centre of the river. The sand chars are a product of the river itself and are composed of both bed load and suspended sediment. The islands with vegetation in green colour shown in satellite imageries are more or less stable and can be considered as semi-permanent or permanent. On the other hand the sand bars without vegetation are unstable and change their location frequently. Out of the several channels, the river in general possesses one or two main channels and the rest are secondary channels. The main active channel is known as "thalweg" (deepest channel). Within the islands and sand bars/chars the active flow channel (thalweg) meanders from one bank to another bank as shown in satellite imageries.

The detailed processes responsible for the formation of a braided river are still poorly understood. From the past studies, it appears that the braided channels occur in river systems having a relatively steep slope, an overabundance of bed load, or a combination of the two. In mountainous streams, slope is the dominant factor causing braiding, but in large alluvial river such as the Kosi extreme bed load is the more important factor. The channels have a wide and shallow bed choked with sand bars. Water flows in a number of branching and reuniting channels, with one or two often serving as major channels. The mid-channel sand chars and sand banks shift rapidly with the ever changing flow regimes, and in consequence there is a day-to-day variation in channel configuration. The position of the main current in a braided stream is extremely unstable and causes the river course constantly to shift its position. There is also a distinct lack of tight bends between the sand chars, and only gently curved thalwegs exist within the wide and shallow channel. The Kosi exhibits most of these features. A typical cross section downstream of the Kosi barrage where the river is braided is shown in **Fig. 4.9**. In this cross section profile, three low

water channels were separated by sand chars. Out of the three the centre channel was the thalweg channel and the remaining two channels on either side were secondary channels.

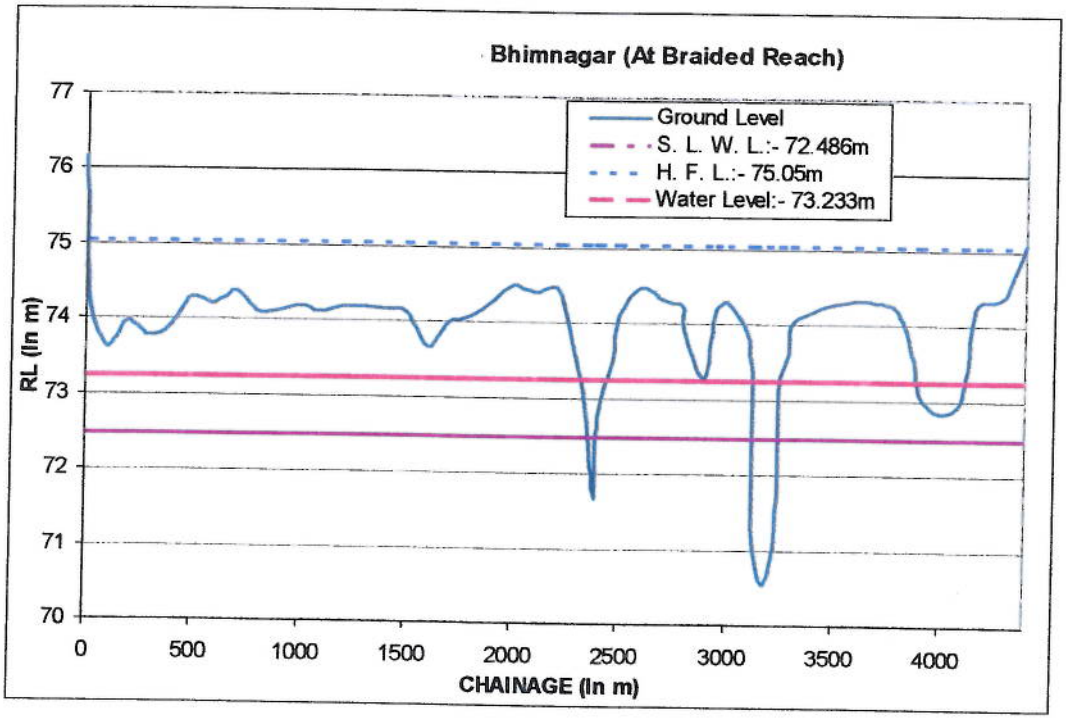


Fig. 4.9: Cross section of the river Kosi at Bhimnagar, downstream of Kosi Barrage

The formation of sand bars along the channel is shown in **Fig. 4.10**, which is a characteristic feature of the river Kosi. The navigational channel is restricted due to formation of the shoals on either side of flow. Due to formation of huge sand bars in the river, the channel width and depths are limited. Further the channel meanders with a lot of sharp bends as shown in the **Fig. 4.10** and these bends may pose problems for free maneuverability of the vessel. Since most sand chars modify their size, shape and location from time to time, they cause drastic changes in cross sectional area at any one point and hence are critical for navigation. The result of this constant change in cross-sectional area is rapid cutting and filling along the banks. Thus the bank lines of most braided river channels are indistinct. Another common effect of the chars or islands is sudden shifting of the main channel across the entire river at any one point which causes serious problems for maintaining the thalweg.

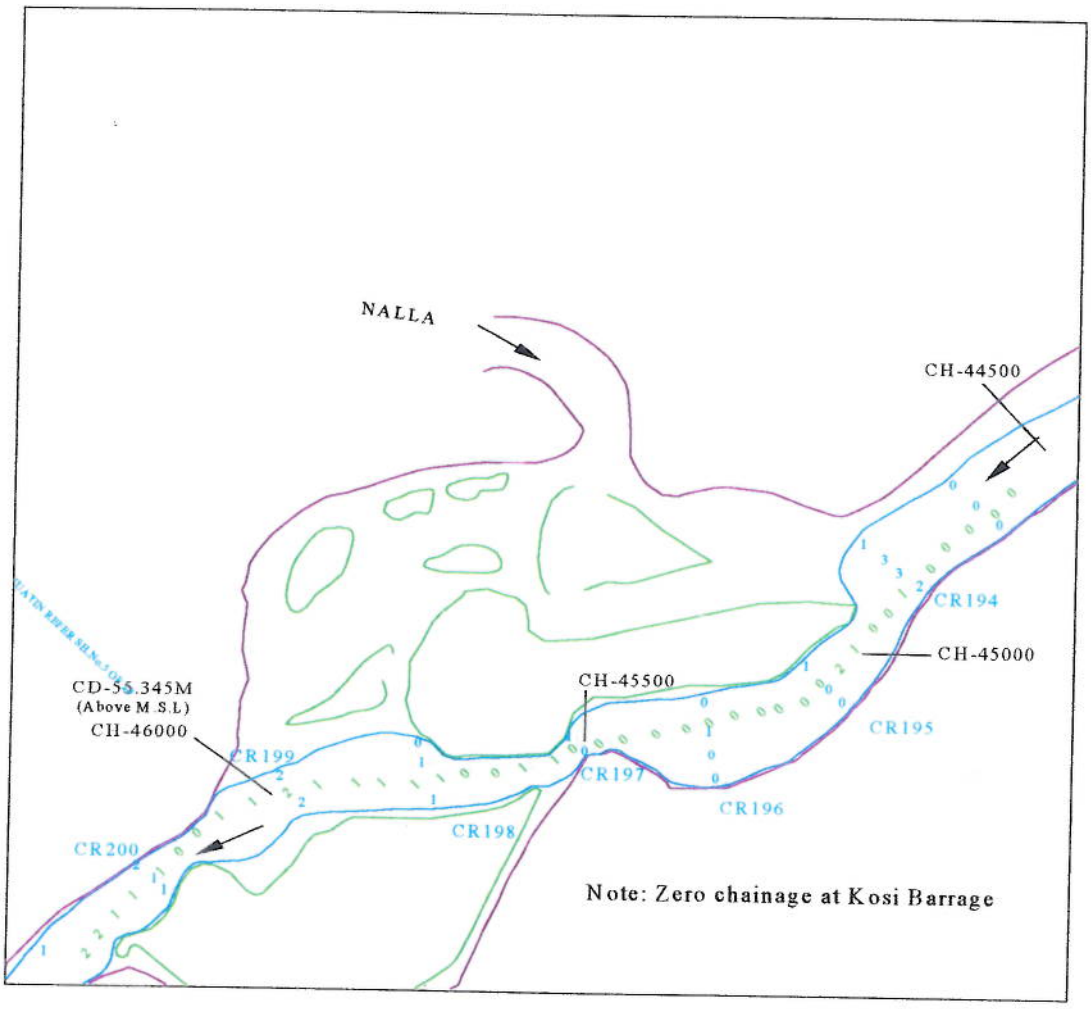


Fig.4.10: Formation of sand bars in the navigation channel

The streams / tributaries that join the Kosi river carry silt and accumulate in the river bed which causes formation of shoals. One of the major tributaries of River Kosi i.e, the river Kamla-Balan joins at about 111 km down stream of the Kosi barrage. The average annual discharge of the Kamala – Balan is 68 cumecs and the average sediment load is 8 million tones / year. The Baghmati River, the major tributary of River Kosi with its number of distributaries, meets river Kosi along the western embankment at several locations **(Fig.4.1).** The waters of Bagmati carry high silt content. The average annual discharge of Baghmati is 189 cumecs and the average annual sediment load is 7 million tons / year. The Baghmati joins Kosi at two to three locations right from 169 km to 172 km downstream of the Kosi barrage and the entire confluence area is formed like a delta system.

Downstream of Baghmati river confluence, the characteristic features of the river change i.e., from Kosi barrage to Baghmati river confluence the river exhibits braided pattern whereas from downstream of Bagmati river confluence to

Kursela the river meanders. The cross section recorded at Baltara where the river meanders is shown in **Fig. 4.11**. In this cross section one thalweg channel exists.

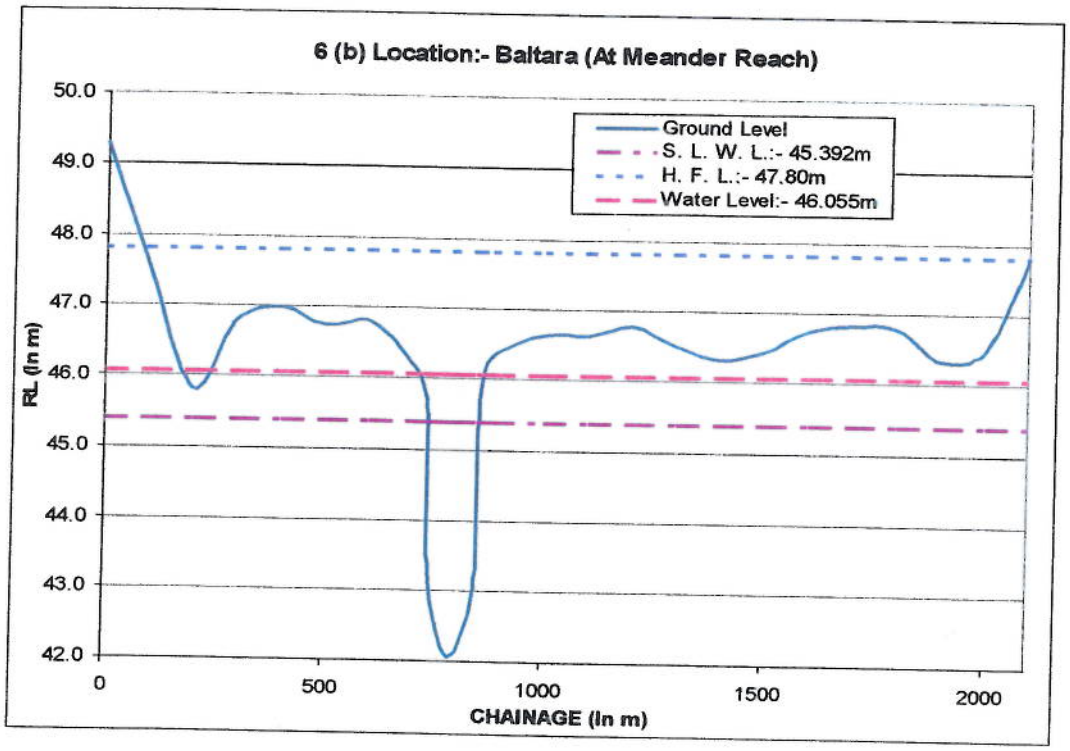


Fig. 4.11: Cross section of the river Kosi at Baltara, downstream of Bagmati river confluence

Meanders are always associated with downstream movement of the whole train of loops or bends in which cut-off could occur either across the outside of curves or narrow necks. The river Kosi downstream of Baltara exhibits a circular course of meandering as shown in satellite imagery which is likely to get cut off from the main stream, leaving behind an oxbow lake while the river finds itself a new route. Further downstream of this oxbow bend, the river changes its orientation from southeast to east and then the river continues to run in west – east direction till it confluences with river Ganga at Kursela. The gradient of the river in end reaches of river Kosi becomes flat from 1 m fall in 6.9 km to 1 m fall in 12.3 km. The river becomes narrow with single channel.

4.3.4 Model run for Water Requirement for Navigation

The maximum flood discharge of river Kosi over the years 1996 to 2005 are provided in the following **Table 4.8**.

Table – 4. 8 : Discharge (Cumecs) in flood season of river Kosi

S.No.	Year	Barakshetra	At Kosi Barrage	Baltara
1	1996	9268	9373	8335
2	1997	8064	8061	6481
3	1998	8928	8819	10800
4	1999	10230	10764	10050
5	2000	8928	8968	8272
6	2001	8511	7442	7170
7	2002	9784	1094	7280
8	2003	8511	11036	5570
9	2004	8104	11282	
10	2005	6643	9489	

From the above table it can be noticed that there is no much reduction in discharges from upstream reaches to downstream reaches of the river as the flow is augmented by tributaries all along the river course. As the water requirement problem arises during lean period to maintain the navigable depths, the lean period discharges available at Baltara over the years have been studied. The minimum available discharge in a month (monthly minimum discharges) during lean period over the years at Baltara is provided in the following **Table 4.9**.

Table – 4.9: Minimum discharge (cumecs) in a month during lean period at Baltara on river Kosi

Year	*Nov*	*Dec*	*Jan*	*Feb*	*Mar*	*Apr*	*May*
1996	880	504	272	164	242	141	228
1997	687	719	361	229	167	197	389
1998	1770	1050	427	275	231	324	645
1999	2650	1230	710	560	390	375	495
2000	1776	1200	1210	563	394	306	556
2001	2710	2630	950	885	870	875	935
2002	2710	2590	2240	1720	1200	1260	1500
2003	2630	2590	2540	2510	2490	2330	2230
2004			2480	2270	2210	2210	2190

From the above table it can be seen that a minimum discharge of 141 cumecs is observed in April, 1996, which is lowest discharge recorded during the last ten years period. It is interesting to note that minimum discharge during lean period is increasing from year 2000 onwards. Comfortably a discharge of more than 1000 cumecs is available during the entire lean period from 2002 to 2004. However, by short term river conservancy works like bandalling, the available discharge can be confined / diverted to the deeper channel and thereby to scour the channel to improve the navigable depths.

Since the discharge data in different reaches of river are not available from CWC, the observed discharges of the river Kosi in the active channel in different reaches during the survey period by RITES are presented in the following **Table 4.10**. Also the required discharges for navigable channel under post dredging conditions suitable to design vessel have been assessed and provided in the same **Table 4.10**.

Table 4.10
Stretch wise available and required discharges during lean period on river Kosi

S. No	River stretch		Chainage (Km)	Gradient	Discharge Available (Cumecs)	Discharge Required for Navigable Channel (Cumecs)	Remarks
	From	To					
1	Birpur	Kalyanpur	0.770	2523	160	50	Adequate
2	Kalyanpur	Basbitti	88.805	2657	560	50	Adequate
3	Basbitti	Mahisarho	130.615	5402	140	30	Adequate
4	Mahisarho	Koparia	159.904	5707	150	30	Adequate
5	Koparia	Kathmara	198.923	8849	115	30	Adequate
6	Kathmara	Baltara	220.453	14041	180	20	Adequate
7	Baltara	Phulot	248.534	7784	170	30	Adequate
8	Phulot	Kursela	260.989	8083	200	30	Adequate

The above table clearly illustrates the available discharges in different stretches of the river Kosi during lean period and required discharges for navigable channel under post dredging conditions. Adequate water will be available for navigation channel suitable to the design vessel.

4.4 WATERWAY DEVELOPMENT

4.4.1 Classification of Inland Waterway of India

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. In India, classification of inland waterways does not exist. Although some basic data about depth and width of navigational channels are available based on the techno-economic feasibility studies conducted for some waterways. RITES have

carried out most of the techno-economic feasibility studies on various waterways in India. The recommendations for different Inland Waterway systems in India and sub-continent by RITES are given in fairway design section.

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. Therefore, 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-à-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.

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

Various classes of waterways are as given 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, (in case 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 2.0 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, minimum 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:

Table 4.11: Classification of Inland Waterways in India

Classification of Water way	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 x 1.0	80x5x1.0	200	1.2	30	1.5	20	300
II	300	45 x8 x 1.2	110 x 8 x 1.2	600	1.4	40	1.8	30	500
III	500	58 x 9 x 1.5	141 x 9 x 1.5	1000	1.7	50	2.2	40	700
IV	1000	70 x 12 x 1.8	170 x 12 x 1.8	2000	2.0	50	2.5	50	800
V	1000	70 x 12 x 1.8	170 x 24 x 1.8	4000	2.0	80			800
VI	2000	86 x 14 x 2.5	210 x 28 x 2.5	4000	2.75	60	3.5	60	900
VII	2000	86 x 14 x 2.5	210 x 28 x 2.5	8000	2.75	100			900

SPV = Self Propelled Vessel
B = Beam width
L = Overall length
D = Loaded draft

4.4.2 Bridges on river Kosi

Four bridges exist across river Kosi, the horizontal and vertical clearances of these bridges are provided below in **Table 4.12**:

Table - 4.12: Details of bridges across Kosi river

Sl.No.	Location of bridge	Type of bridge	No. of spans	Clear span of bridge (m)	HFL in (m)	Vertical clearance	
						Based on HFL (m)	Based on SLWL (m)
1	Dhambara ghat Rail bridge	Steel	4	220	36.358	2.80	8.5
2	Dumari ghat Road bridge (Oshra)	RCC	8	376	34.165	2.95	9.7
3	Kursela Road bridge	RCC	17	1025	32.750	3.20	10.2
4	Kursela Rail bridge	Steel	20	1200	32.617	4.30	11.6

4.4.3 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 / 1000 T vessel
1.0 / 1.5 m for 2000 / 3000 T vessel

For rivers in hilly And mountainous areas: 0.5 m for 100 / 300 T vessel
1.0 / 1.5 m for 500 / 3000 T vessel

At Rail and road bridge, waterways navigation is restricted to singleway 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. The 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.

4.4.4 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 RITES are furnished below:

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.
- 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.

Our experience in inland waterways in India and sub-continent (Nepal, 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.

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
W = Navigation channel width for two-way navigation.
BM = Maneuvering zone for the design vessel which takes into account the directional stability of vessel.
BM1= Maneuvering zone for the upcoming vessel which takes into account the directional stability of vessel.
C = Width of separating zone.
C1 = Width of the security area, between the maneuvering zone and the channel side which is accounted for environmental and human factors including bank suction.

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

BM = 1.3 B to 3.0 B
BM = BM1
C = 0.5 B to 1.0 B
C1 = 0.3 B to 1.5 B

Where B = Beam of a design vessel.

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

BM = 1.4 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

The above norms also at par with the National Waterway No.1 (Ganga-Bhagirathi -Hooghly river system) considering future development.

Slopes

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

Width Allowance at Bends

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

The drift angle is larger for vessels 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 - 4.13:**

Table. 4.13 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 250 m as most of the critical bends having less than 250m radius and considering provision of higher size of vessel in future. Wherever the radius of the bend is less than 4 times of the length of the designed vessel i.e. 4x32 = 128, additional widths are provided for free maneuverability of the vessel. The additional width provided in the present fairway system for a designed vessel is:

$\Delta b = L^2/R = 32.0X32.0/128 = 8.0$ m

As per the design criteria discussed above the channel dimensions for the proposed waterway is as follows:

Table 4.14: Design channel dimension for 100 tonnes capacity vessel

Channel	100 tonnes vessel
Bottom width	25 m
Depth below CD (SLWL)	1.2 m
Side slopes	1:5

4.4.5 Dredging of Navigational channel

The analysis of hydrological data on river Kosi from Birpur to Kursela has indicated the availability of water level above the chart datum level (Standard Low Water Level) under natural conditions for navigation purpose. The availability of depths below chart datum level together will provide the availability of depths for navigation.

The dredging quantity for the above design channel has been worked out based on the bathymetric surveys carried out. The dredging quantity for above option of channel is as follows:

Table 4.15: Dredging quantities for designed channel

Option of channel	Dredging quantity in million cu m
Bottom width 25 m Depth: 1.2 m (100 tons vessel)	1.94

Dredgeability of the bed material

The selection of a suitable dredger is however, depends upon the type of material to be dredged and other morphological and physical constraints in a specific waterway.

The results of the sieve analysis of the riverbed material of river Kosi from Kosi barrage to Kursela are in **Table - 4. 16:**

Table - 4.16: Type of bed material for different places of River Kosi

Sl.No.	Location	Type of bed material		
		Clay + Silt in %	Sand in %	Gravel in %
1.	Bhimnagar	4	96	Nil
2.	Kalyanpur	1	99	Nil
3.	Basbitty	2	98	Nil
4.	Mahisarho	3	97	Nil
5.	Koparia	2	98	Nil
6.	Kathmara	1	99	Nil
7.	Phulot	4	96	Nil
8.	Kursela	3	97	Nil

Type of Bed Material for different places of River Kosi

Sl. No.	Location	Type of Bed Material			
		Clay (in %)	Silt (in %)	Sand (in %)	Gravel (in %)
1	Kosi Barrage	0	8	92	Nil
2	Balua Ghat	0	11.5	88.5	Nil
3	Vijay Ghat	14	31	55	Nil
4	Dumri Ghat	11	32	57	Nil
5	Kursela Ghat	9	61	30	Nil

The above results indicate that the bed material is composed of mainly sand.

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 Kosi 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. 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 Kosi waterway are indicated below:

- Length overall : 20 m
- Width : 4.1 m
- Dredging depth : 6 m
- Suction pipe : 325 mm
- Discharge pipe : 300 mm
- Installed capacity : 350 k.w.
- Cutter power : 50 k.w.
- H.P : 500 BHP
- Draft : 1.0 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 : 9.05 m
- Beam : 2.5 m
- Draft : 0.5 m
- B.H.P : 63 BHP
- Weight : 7.5 tons
- Digging depth : 2.75 m over stern
  : 3.75 m over side
- 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.

4.5 SHORT TERM RIVER CONSERVANCY WORKS IN KOSI

In planning short term river conservancy works, there are no uniform rules of procedure due to a variety of factors, which vary considerably from river to river viz., size of the river, geological formation of bed and banks, mobility and migratory tendency of the river course, quantity and character of sediment in suspension and on bed, low water discharges, extent of channel meandering and bank caving, sources of sediment load, navigation requirements etc. Under such circumstances, the first step in planning consists in dividing the river into suitable reaches. After determination of low water profiles, the minimum

navigable depths should be drawn on the hydrographic charts to provide guidance for suitable measures to be undertaken. Before taking up regulation of an entire river stretch, it is desirable to restrict to certain test stretches in the first instance to study the effectiveness so that the same could be suitably implemented in other reaches for better-cost control.

The descriptions of the existing features of the waterway as supported by the hydrographic survey drawings show that there are number of shoals between chainages 19.0 km and 96.0 km, downstream of Kosi barrage. These shoals or sand bars are pronounced below the confluence of tributaries / Nallas / streams which limit the depths in the navigation channel. The details of prominent shoals are provided in the flowing table. These shoals reoccur during every lean season as the confluence streams carry silt and get deposit at the mouth. Hence short term river conservancy measures required to maintain the navigable channel particularly during lean season when the navigable depths are reduced to minimum. The details of the shoal locations are furnished in **Table 4.17**.

Table - 4. 17: Details of Shoals along river Kosi

SL No	Chainage (in km)		Approximate Length (in m)		Chainage (in km)		Approximate Length (in m)
	From	To			From	To	
1	19.1	19.75	650	10	56.65	56.75	100
2	20	20.25	250	11	57.1	57.2	100
3	44.05	44.25	200	12	84.35	84.45	100
4	44.5	44.75	250	13	84.85	85.05	200
5	49.05	49.2	150	14	86.9	87	100
6	50.5	50.7	200	15	88	88.15	150
7	51.95	52.15	200	16	92.5	92.75	250
8	55.4	55.5	100	17	93.45	93.8	350
9	55.5	55.8	300	18	95.35	95.45	100

Bandals are proposed at the above shoal areas to close a minor channel and indirectly improve the navigable depths in the main channel. They are vertical mats or screens of bamboo supported on bamboo poles driven into the bed. These are generally immersed from the surface of water by a third to a half of the water depths. They generally form angles of 30^0 to 45^0 with the surface currents that they are expected to divert towards the navigable channel. The position of the bandals to close the secondary channels and divert the flow to scour the main navigation channel at the identified shoal areas are shown in **Fig.4. 12.**

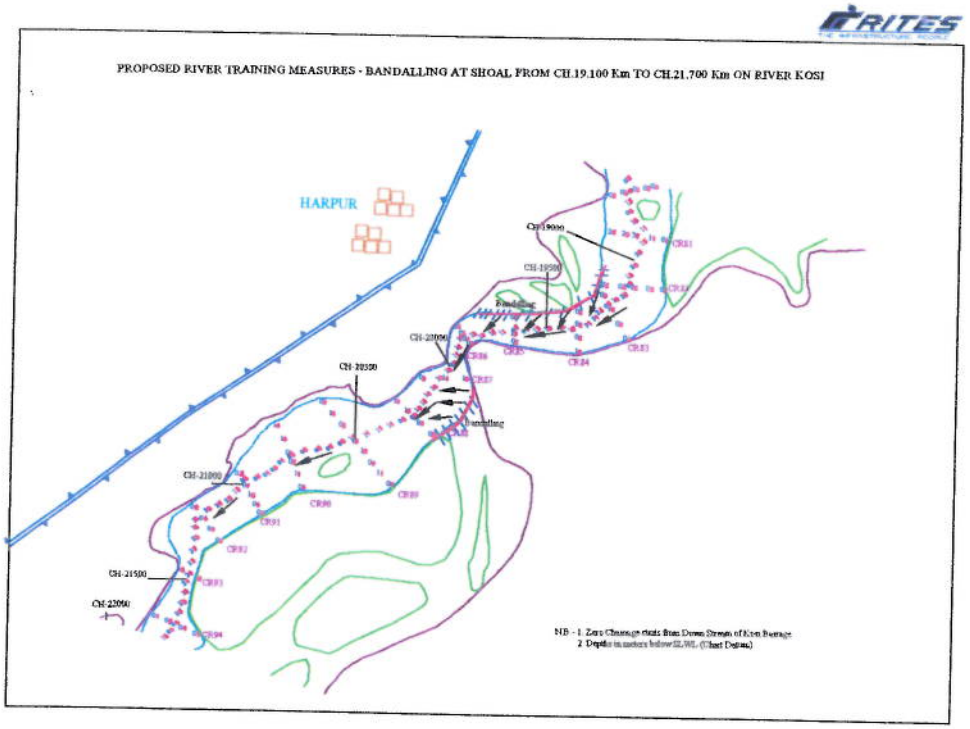


Fig. 4.12: A typical sketch on river Kosi showing bandals for diverting flow

The Bandals have the secondary effect of encouraging deposition of the rivers' bed load thereby indirectly deepening the navigable channel. Bandals are built in composite units; each about 20 m in length nearly continuous and spaced about 25 m apart formed with bamboo screens called mats. These mats are fixed and held up in position by vertical bamboo poles.

A typical design sketch of the proposed Bandals is shown in **Fig.4. 13.** They are generally set at mean falling stage when the depths are in the range of 3 to 3.5 m. The minimum depth when a bandal construction is taken up is generally 1.8 m to 2 m. Actual layout and orientation of the bandals can be decided at the time of execution of the short term river conservancy works depending upon the direction of currents, depth of flow, size, shape and location of sand chars etc.

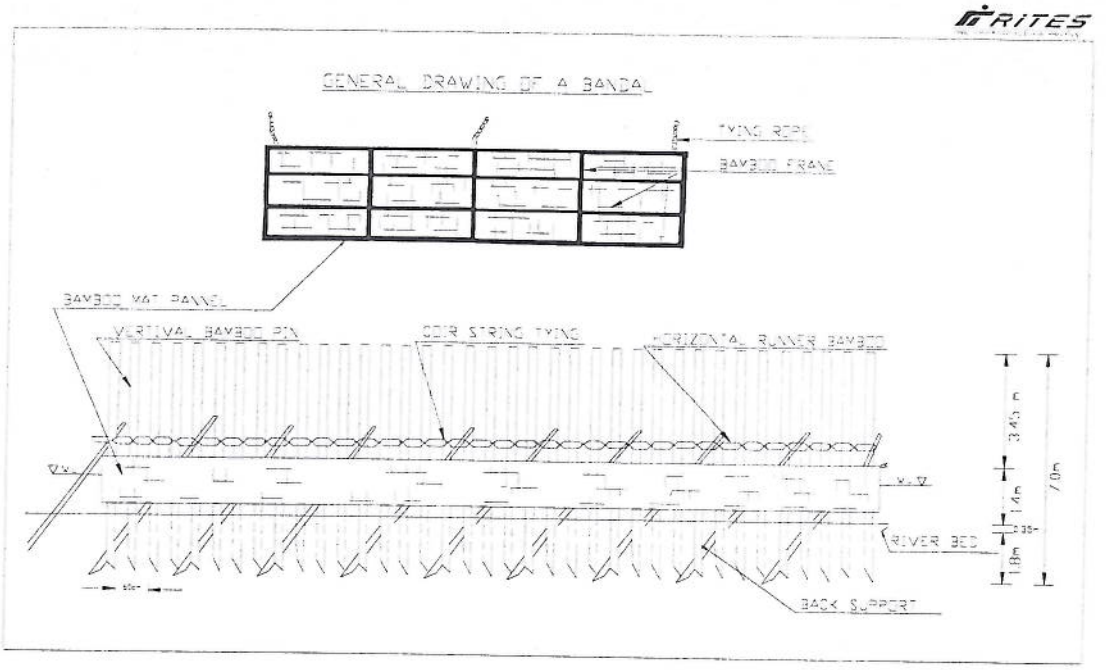


Fig. 4.13: A typical sketch of proposed Bandals as short term river conservancy works

4.5.1 Improvement of the navigable depths at the confluence of streams with River Kosi:

Formation of shallow areas is generally noticed at the mouths of the streams join with main Kosi river. The sand bars are formed below point of confluence of streams. The formation of sand bars at these locations may recur periodically and intensity of bars depends upon the silt carrying capacity of the joining streams. Generally, dredging is the only solution in such reaches, since formation of bars below tributary mouths is inherent in the nature of rivers. Thus, a combination of Bandalling and Dredging is proposed at these locations.

4.6 AIDS TO NAVIGATION

The navigational channel goes on shifting due to change in river morphology depending on season with untrained rivers like Kosi. 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 are shallows, snags etc. The channel marking is also very important for the safety and speed of navigation because in the inner bends of a curved channel in the river the current velocity is much lower than the outer bend. If proper markings are provided, ships/vessels 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 marking of shifting nature of navigable channel is to have the simple marks which could be shifted easily with less manpower and equipments.

As per the international conventions, 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 equipments on board a ship.

4.6.1 Proposed aids to navigation system on river Kosi

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 grounds between the navigational channel, bifurcated channels and isolated dangers in the middle of the navigational channel.
- Shore Marks
  - Bank wise Marks, to indicate the channel at points where it approaches a bank.
  - Crossing Marks, to indicate crossings 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 vessels in one-way or sequential passage or to prohibit navigation.
- Marks on Bridges, to indicate the passage through bridges.
- Depth Indicator marks, to indicate shallow areas ahead in the navigational channel.
- Width Indicator marks, to indicate the narrow stretches ahead in the navigational channel.
- Short terms river conservancy Marks, to indicate the ongoing short river conservancy 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 Kosi can be seen in **Figure 4. 14.**

Navigational Aids Proposed for River Kosi

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

(a) Left:

Colour: White

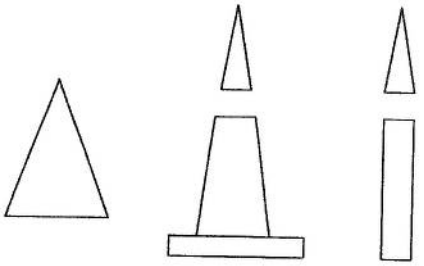
Shape: Conical Pillar or spar

Top Mark: Single,white cone,point upward

Light:

Colour: Green

Rhythm: Single flashing



(a) Right:

Colour: Red

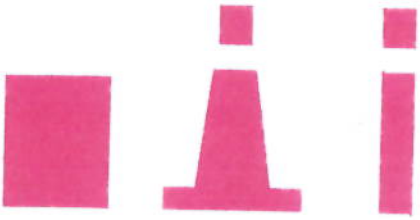
Shape: Cylindrical (Can) Pillar or spar

Top Mark: Singlered cylinder (can)

Light:

Colour: Red

Rhythm: Single flashing



2. Bifurcation Marks: To Mark middle ground,bifurcated channels and isolated dangers in mid-channels.

Colour: Red and White Vertical Strips

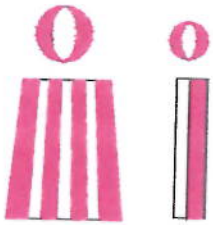
Shape: Truncated Cone , Pillar or spar

Top Mark: Single Sphere with Red and White Vertical Strips

Light:

Colour: White

Rhythm: Group Flashing flashing with three flashes



3. Shore Marks: To indicate the channel at points where it approaches a bank.

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

4.14: Typical schematic sketch of proposed aids to navigation (contd)

4. Crossing Marks: To indicate crossing & alignment of the channel from one bank to another.

Left Bank:

Colour: White top mark , White/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 tborder & slant, and black ship figure.

Shape: Circular

Light:

Colour: Green

Rhythm: Quick Flashing Light.

6. Marks on Bridges: To indicate passage through Bridges..

No Pass

Pass

Pass with attention.

4.14: Typical schematic sketch of proposed aids to navigation (contd)

Details of aids to navigation proposed in river kosi

7. Sound Signal Marks:

To indicate use of horning or other sound signal.

Colour: White board with black horn figure.

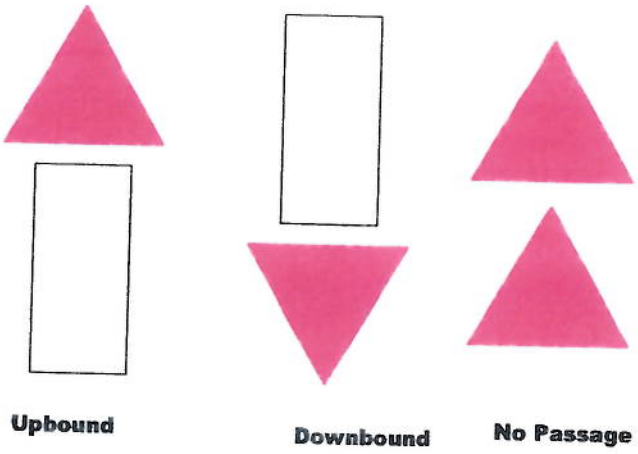
Shape: Hexagon

Light:

Colour: Green

Rhythm: Quick flashing light.

8. Marks for Traffic Control: To upbound or downbound vessels in oneway or sequential passage or to prohibit navigations.



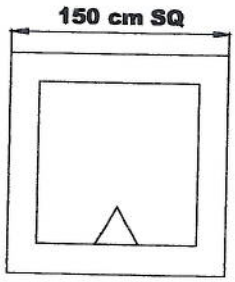
Upbound **Downbound** **No Passage**

4.14: Typical schematic sketch of proposed aids to navigation (contd)

9. Depth IndicationMarks :

To indicate the shallow areas or where

Depth Of Water Limited

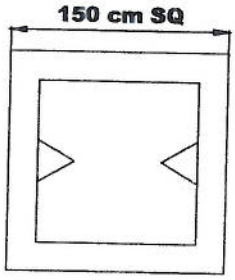


Depth Of Water Limited

10. Width Indicator Marks:

To indicate the areas where the

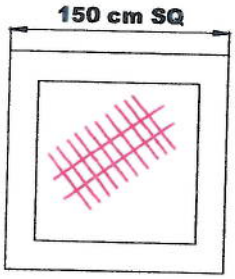
Width Of Channel Limited



Width Of Channel Limited

11. River Training Marks:

To indicate the areas where the the river training works viz. Bandalling etc. are in progress to the Navigator.



River Training Works are in Progress

4.14: Typical schematic sketch of proposed aids to navigation(contd)

The various types of aids to navigation proposed in the river Kosi are given in **Figure 4 .15** with detailed description and figures. These aids to navigation are to be provided along the river at various locations as indicated below:

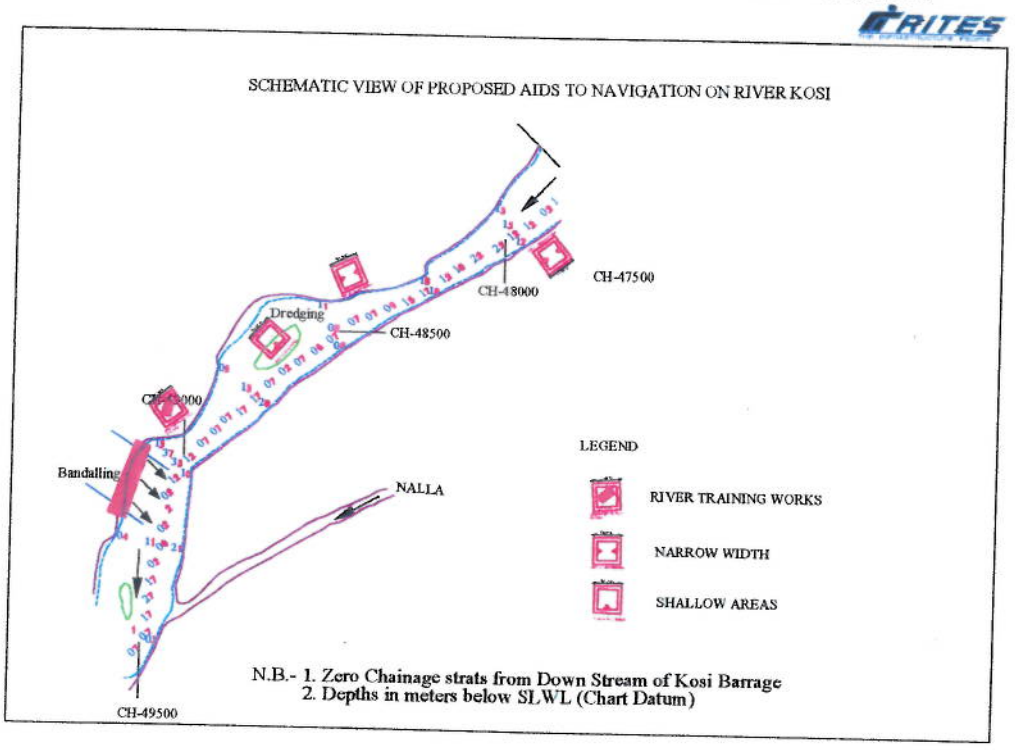


Fig. 4.15: A typical sketch showing proposed aids to navigation on river Kosi (contd)

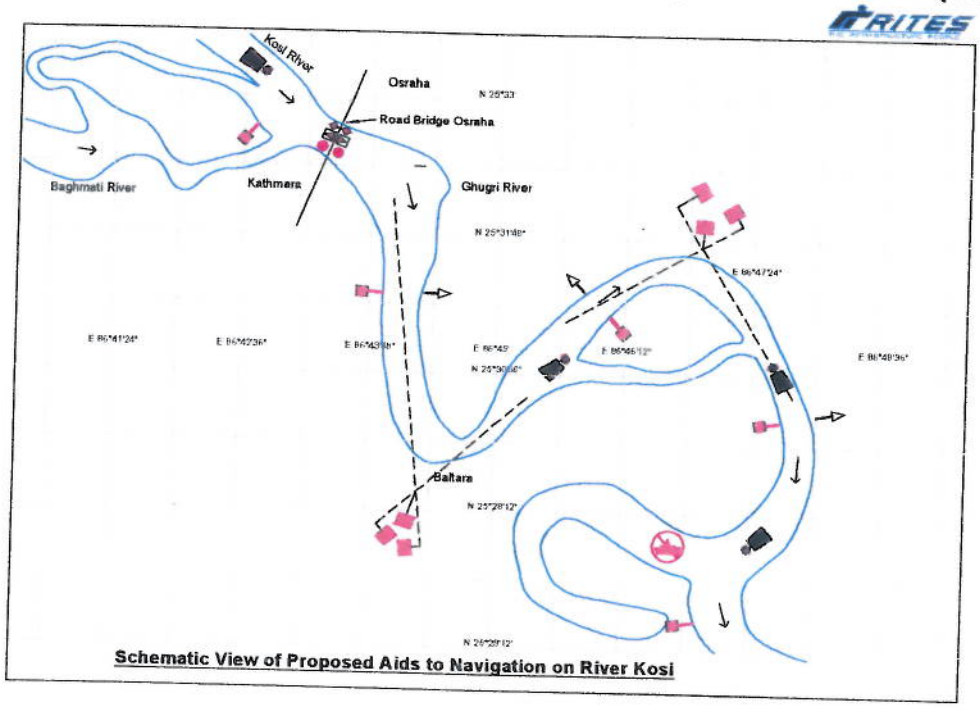


Fig. 4.15: A typical sketch showing proposed aids to navigation on river Kosi (cont)

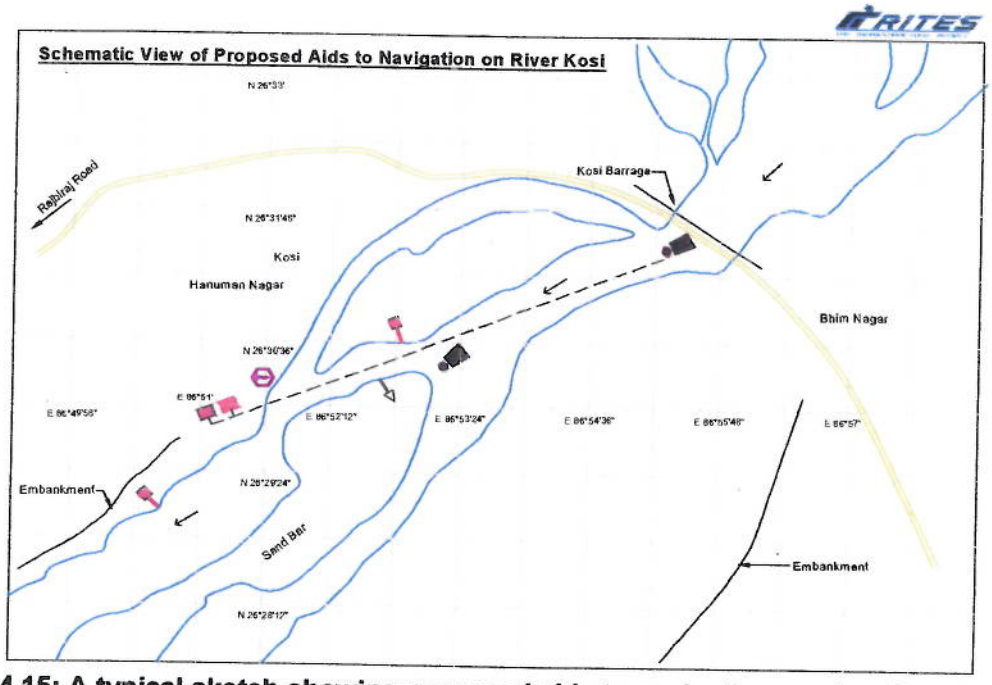


Fig. 4.15: A typical sketch showing proposed aids to navigation on river Kosi (contd)

Locations

Shoals/Sand Chars:

The Aids to Navigation has to be provided at various shoals present in river Kosi which creates hazards to safe navigation to vessels/ship plying in the river. The details of some prominent shoals that are encountered during Navigation in the navigation channel of river Kosi and have to be properly marked for early warning to the navigator are listed in the **Table 4.18** given below:

Table 4.18: Requirement of Aids to Navigation at Major Shoals Where Short Term River Conservancy Marks are to be Provided

S.No.	Chainage (in Km.)		Approximate	Remarks
	From	To.	Length	
1	19.100	19.750	650	The locations of shoals and Chars present in River Kosi where short term River conservancy Marks are provided Whenever short term River conservancy works are in progress
2	20.000	20.250	250	
3	44.050	44.250	200	
4	44.500	44.750	250	
5	49.050	49.200	150	
6	50.500	50.700	200	
7	51.950	52.150	200	
8	55.400	55.500	100	
9	55.500	55.800	300	
10	56.650	56.750	100	
11	57.100	57.200	100	
12	84.350	84.450	100	
13	84.850	85.050	200	
14	86.900	87.000	100	
15	88.000	88.150	150	
16	92.500	92.750	250	
17	93.450	93.800	350	
18	95.350	95.450	100	

Shallow Areas:

The Shallow Areas present in the River Kosi have been identified and are provided in the above table. These areas are to dredged out for sufficient depth or properly marked for safe navigation.

The navigation aids – Proceed with Caution/ shallow area has to be provided and narrow channel areas are properly marked for speed limit and no overtaking zone. As mentioned above the above data is based on Surveys conducted during May/June,1998-2000, however before installation of the navigation aids a detailed hydrographic survey is required and same should be periodically repeated to access the actual depth in future as river carries considerable amount of sediment load from its catchment areas/distributaries joining it . The transported sediment load has 90% fine materials which are deposited in the river in due course of time, by virtue of this behaviour river changes its course year by year.

Bends:

The bends are dangerous areas for safe navigation, as the line of sight is not clear in those areas and because of poor visibility there is always possibility of head on collision between the ships/vessels coming from opposite directions.

These areas should be properly marked for bends and speed restriction to avoid any accident.

The bends present in the main channel of the Kosi River based on hydrographic survey conducted during May/June, 1998 by RITES from Birpur to Kursela has been found out from the Hydrographic Survey Chart and presented in **Table 4.19**.

Table 4.19: The details of critical bends

S. No.	Chainage (in Km)	Radius (in m)
1	1.250	238
2	2.250	275
3	9.000	118
4	11.250	243
5	14.750	172
6	15.000	120
7	17.000	312
8	17.500	264
9	20.000	127
10	21.750	282
11	22.300	196
12	24.500	166
13	25.000	112
14	29.250	186
15	32.000	195
16	35.250	206
17	36.750	166
18	37.000	286
19	38.500	280
20	39.500	254
21	39.750	326
22	40.250	172
23	49.250	106
24	50.500	219
25	55.500	253
26	56.250	200
27	56.750	160
28	58.000	209
29	58.500	122
30	59.500	214
31	60.000	194
32	62.500	219
33	64.000	103

S. No.	Chainage (in Km)	Radius (in m)
34	65.000	127
35	66.750	284
36	67.750	252
37	68.000	203
38	68.750	184
39	69.250	178
40	79.000	95
41	84.250	264
42	85.000	327
43	87.500	146
44	88.250	220
45	90.500	225
46	99.000	236
47	114.000	232
48	114.750	343
49	116.500	182
50	117.000	165
51	119.750	241
52	139.250	249
53	144.500	238
54	149.500	345
55	150.500	299
56	156.500	310
57	158.500	283
58	160.500	323
59	162.500	237
60	173.000	178
61	176.500	329
62	185.500	323
63	189.750	197
64	205.750	207
65	210.750	257
66	219.000	270

Bifurcation of Channel

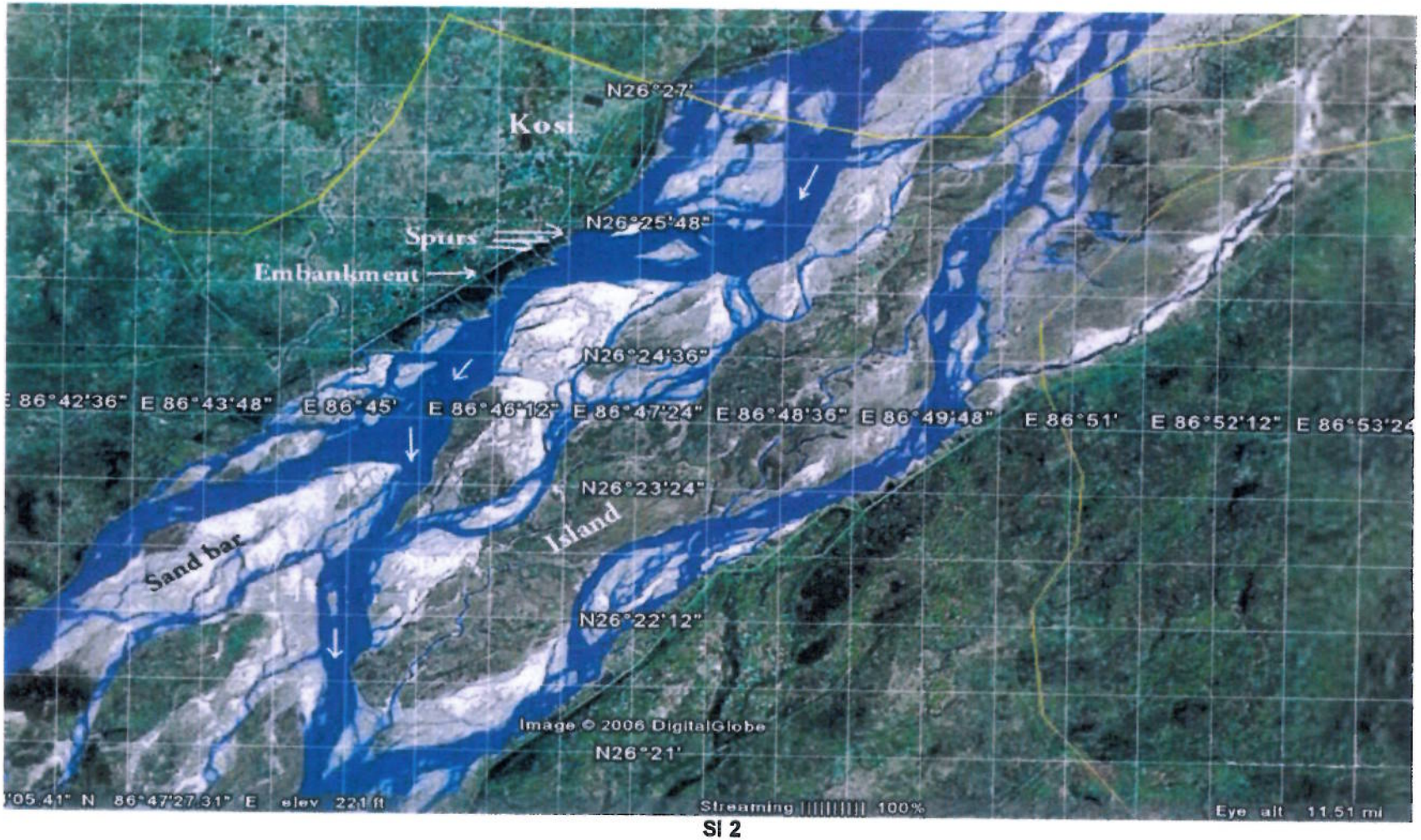
The bifurcation of channel into two or more channels / streams has been recommended for proper marking i.e. Bifurcation Marks are to provided in advance to warn the navigators. The major bifurcations present in the river from Birpur to Kursela has been identified and given in **Table 4.20**.

Table 4.20
The Aids to Navigation Required at Major Bifurcation Present in the River Kosi

S. No.	Position		Location	Remarks
	Easting	Northing		
1	86°55'00"	26°31'48"	Near BhimNagar	
2	86°53'24"	26°30'36"	D/s of BhimNagar	
3	86°48'36"	26°27'00"	D/s of BhimNagar	
4	86°46'12"	26°23'24"	D/s of BhimNagar	
5	86°43'48"	26°18'36"	D/s of Kalyanpur	
6	86°40'12"	26°16'48"	D/s of Kalyanpur	
7	86°37'48"	26°14'12"	D/s of Kalyanpur	
8	86°35'24"	26°12'36"	D/s of Kalyanpur	
9	86°31'48"	26°10'12"	D/s of Kalyanpur	
10	86°30'36"	26°06'00"	Near Basbitti	
11	86°30'36"	26°06'36"	Near Basbitti	
12	86°29'24"	26°04'12"	D/s of Basbitti	
13	86°27'00"	26°00'00"	Near Naulakhatola	
14	86°25'48"	25°54'36"	Near Mahisarho	
15	86°27'00"	25°52'12"	U/s of Mahishi	
16	86°26'24"	25°50'24"	U/s of Maina	
17	86°28'12"	25°45'48"	D/s of Maina	
18	86°31'48"	25°40'12"	U/s of Harpur	
19	86°46'12"	25°30'36"	Near Baltara	Bifurcation Marks are to be provided at the locations where channel is bifurcating in two or more than two streams , in advance to the Navigator and route to be followed.
20	86°47'24"	25°28'48"	D/s of Baltara	
21	86°53'24"	25°28'12"	D/s of Baltara	
22	86°06'00"	25°25'36"	D/s of Baltara	
23	87°14'36"	25°24'36"	Near Kursela	


N26°33'
Kosi Barrage
Road
Rajbiraj
N26°31'48"
Kosi
Hanumannagar
N26°30'36"
Bhimnagar
E 86°47'24"
E 86°48'36"
E 86°49'48"
E 86°51'
E 86°52'12"
E 86°53'24"
E 86°54'36"
E 86°55'48"
E 86°57'
Spurs
N26°29'24"
Embankment
Sand Bar
Kosi
28'12"
Embankment
N26°27'
Image © 2006 DigitalGlobe

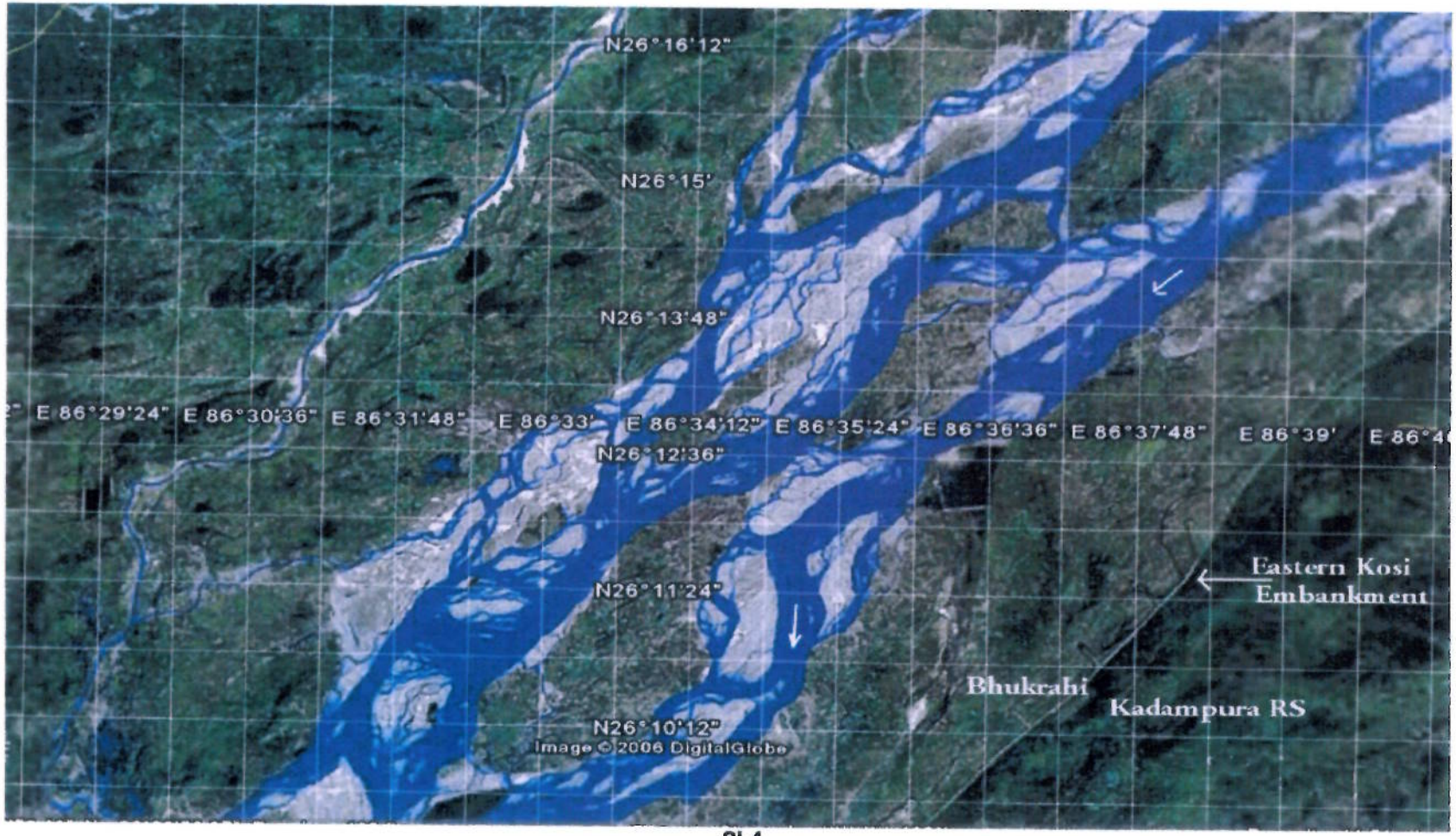
SI 1


N26°27'
Kosi
Spurs
N26°25'48"
Embankment
N26°24'36"
E 86°42'36"
E 86°43'48"
E 86°45'
E 86°46'12"
E 86°47'24"
E 86°48'36"
E 86°49'48"
E 86°51'
E 86°52'12"
N26°23'24"
Island
Sand bar
N26°22'12"
Image © 2006 DigitalGlobe
N26°21'
Streaming 100%
Eye alt 11.51 mi

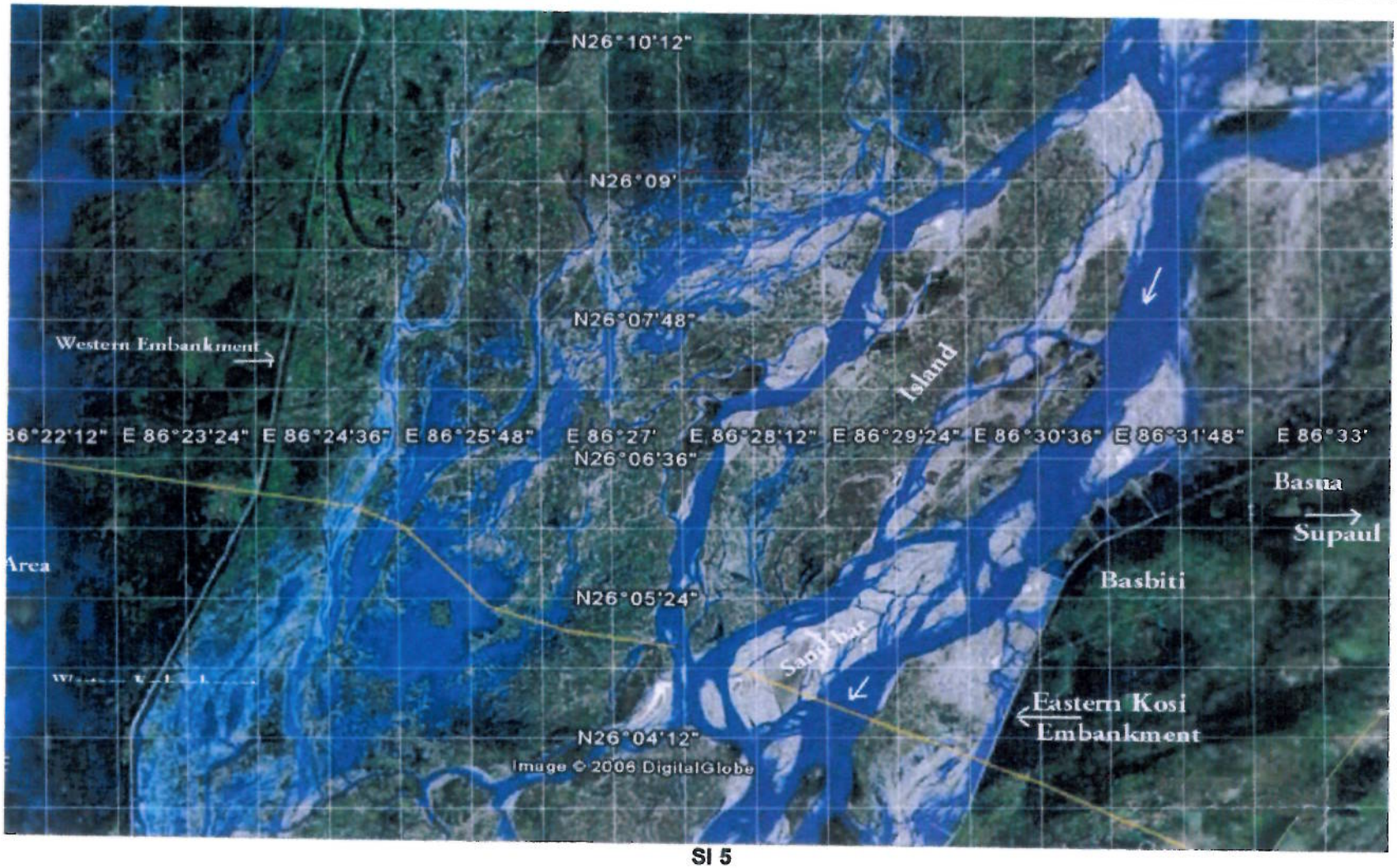
SI 2


N26°21'
N26°19'48"
Kalyanpur
N26°18'36"
Island
E 86°34'12"
E 86°35'24"
E 86°36'36"
E 86°37'48"
E 86°39'
E 86°40'12"
E 86°41'24"
E 86°42'36"
E 86°43'48"
E 86°45'
N26°17'24"
Spurs
N26°16'12"
Embankment
Image ©2006 DigitalGlobe

Sl 3


N26°16'12"
N26°15'
N26°13'48"
E 86°29'24"
E 86°30'36"
E 86°31'48"
E 86°33'
E 86°34'12"
E 86°35'24"
E 86°36'36"
E 86°37'48"
E 86°39'
N26°12'36"
N26°11'24"
N26°10'12"
Image © 2006 DigitalGlobe
Eastern Kosi Embankment
Bhukrahi
Kadampura RS

SI 4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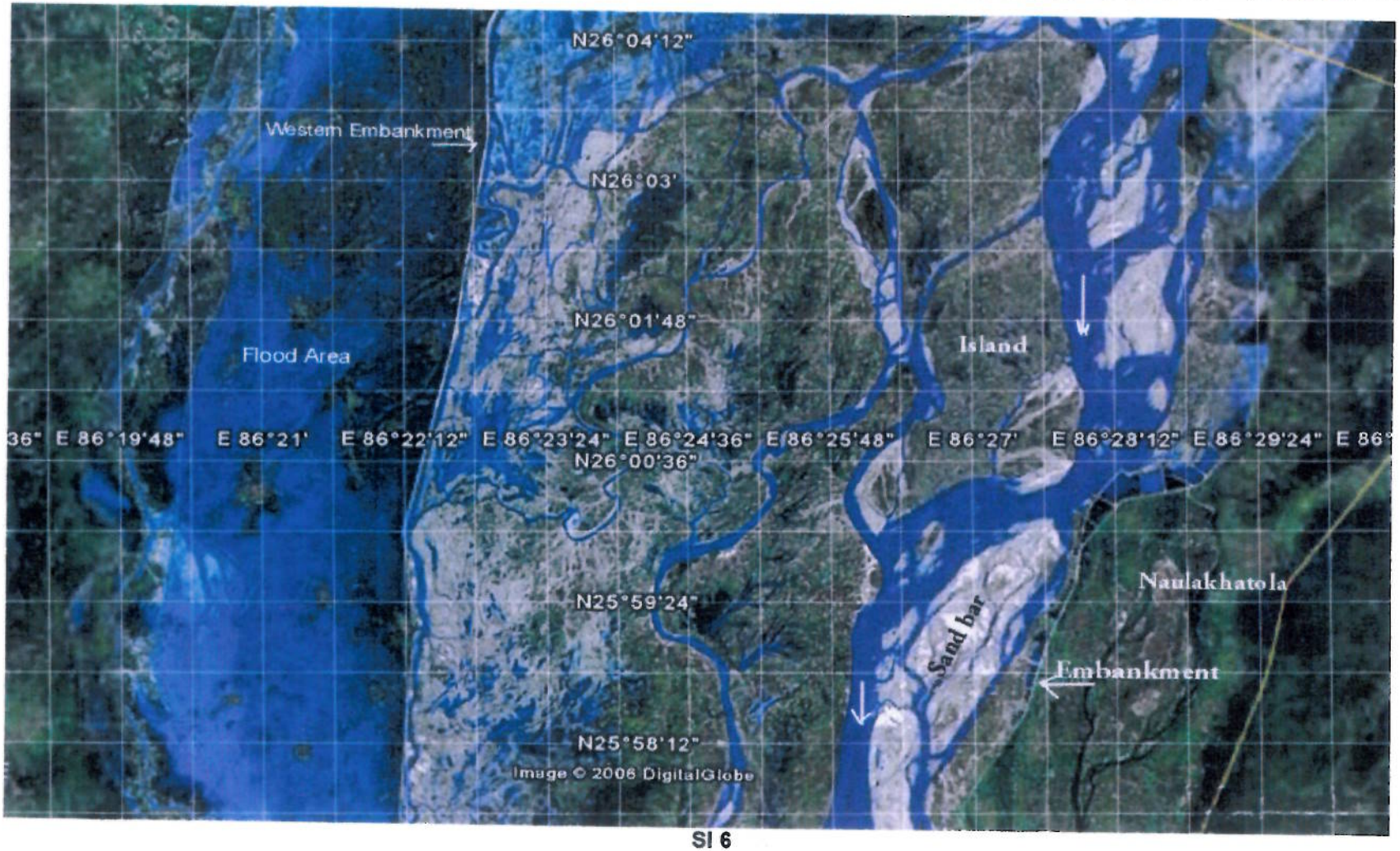
N26°09'
N26°07'48"
Western Embankment
Island
E 86°22'12"
E 86°23'24"
E 86°24'36"
E 86°25'48"
E 86°27'
E 86°28'12"
E 86°29'24"
E 86°30'36"
E 86°31'48"
E 86°33'
N26°06'36"
Basua
Supaul
Area
Basbiti
N26°05'24"
Eastern Kosi
Embankment
N26°04'12"
Image © 2006 DigitalGlobe

SI 5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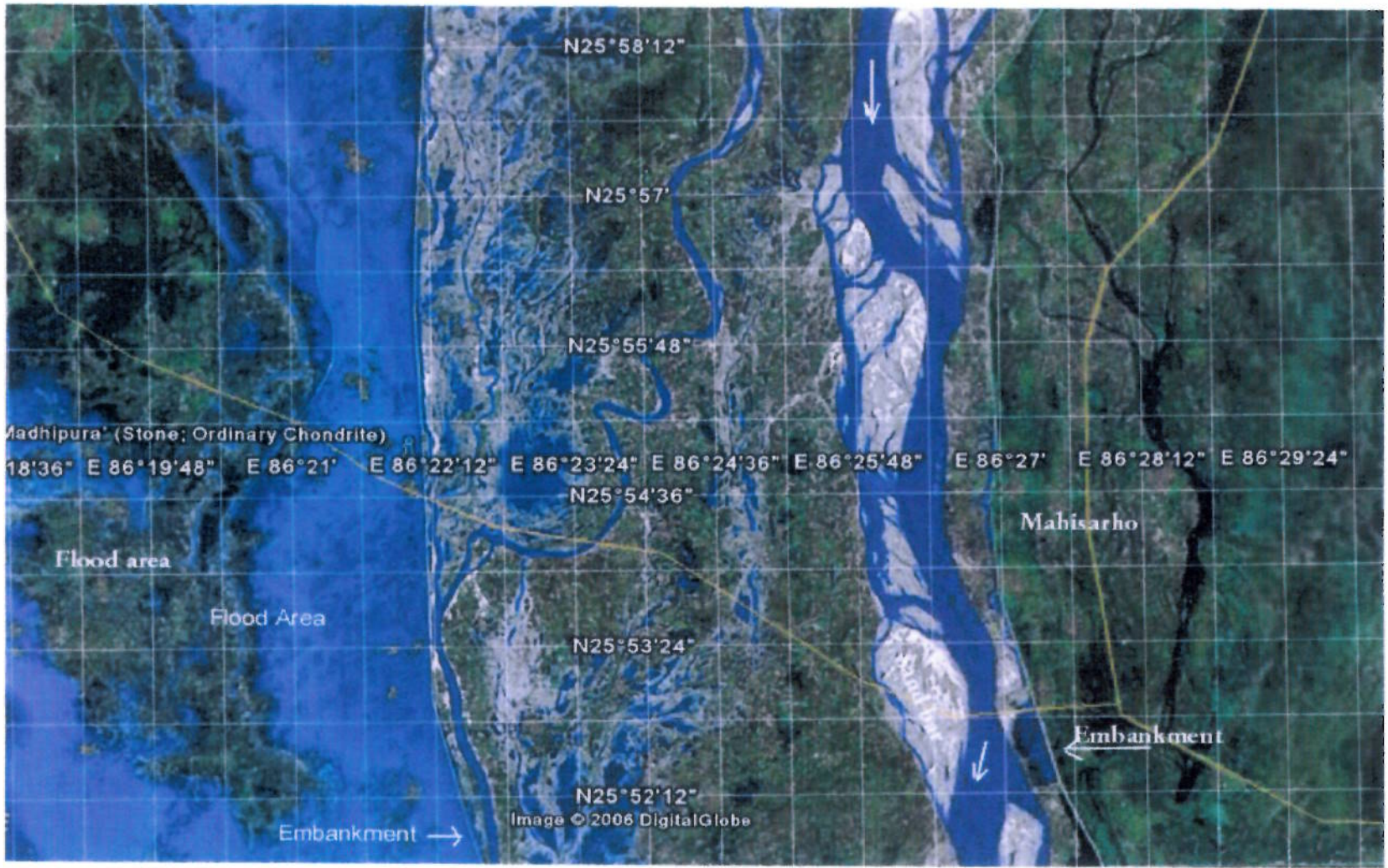
Western Embankment
N26°03'
N26°01'48"
Flood Area
Island
36" E 86°19'48"
E 86°21'
E 86°22'12"
E 86°23'24"
E 86°24'36"
E 86°25'48"
E 86°27'
E 86°28'12"
E 86°29'24"
N26°00'36"
N25°59'24"
Naulakhatola
Sand bar
Embankment
N25°58'12"
Image © 2006 DigitalGlobe

SI 6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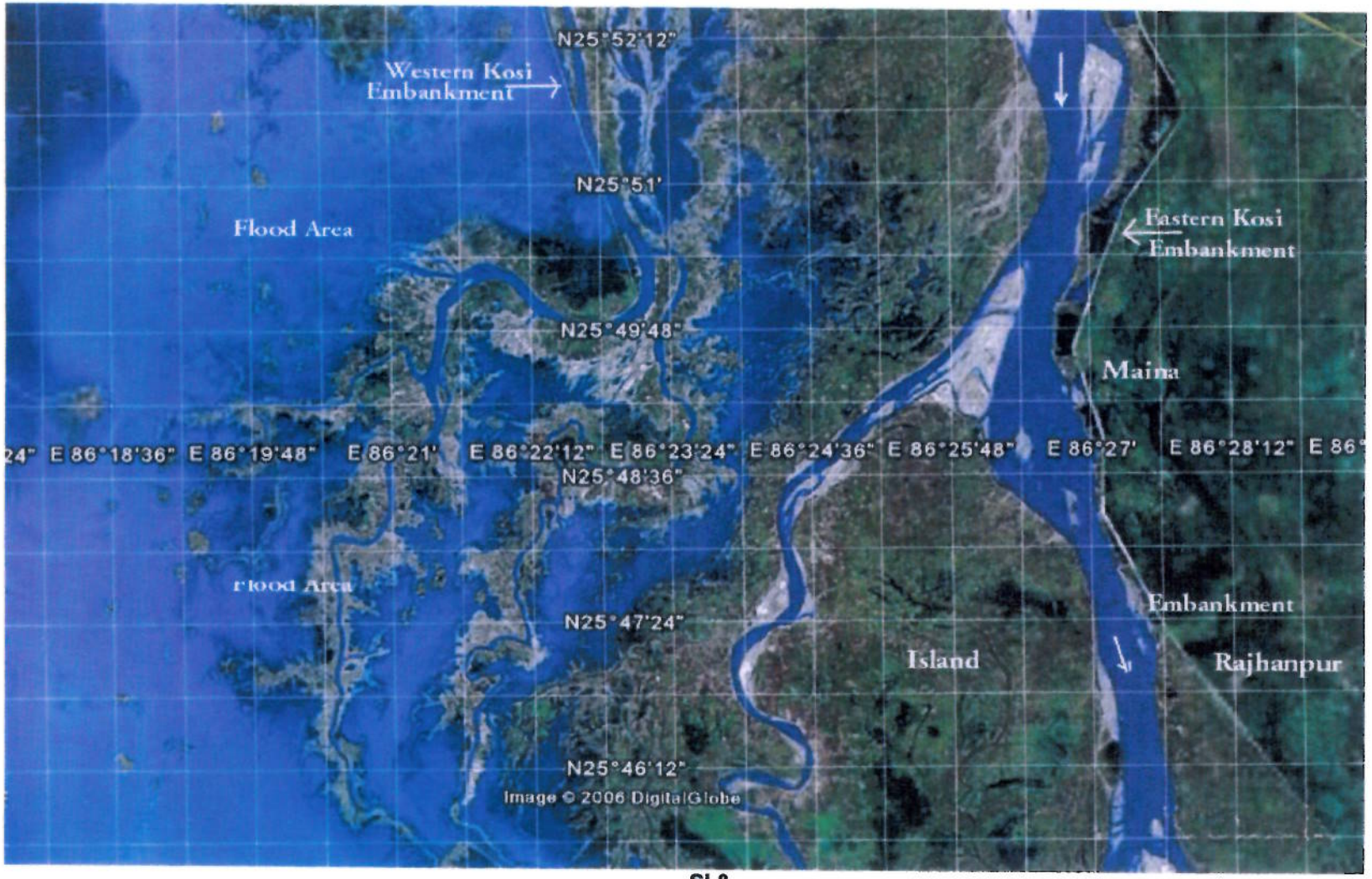
N25°57'
N25°55'48"
Madhipura' (Stone; Ordinary Chondrite)
18'36" E 86°19'48" E 86°21' E 86°22'12" E 86°23'24" E 86°24'36" E 86°25'48" E 86°27' E 86°28'12" E 86°29'24"
N25°54'36"
Mahisarho
Flood area
Flood Area
N25°53'24"
Embankment
N25°52'12"
Image © 2006 DigitalGlobe
Embankment

SI 7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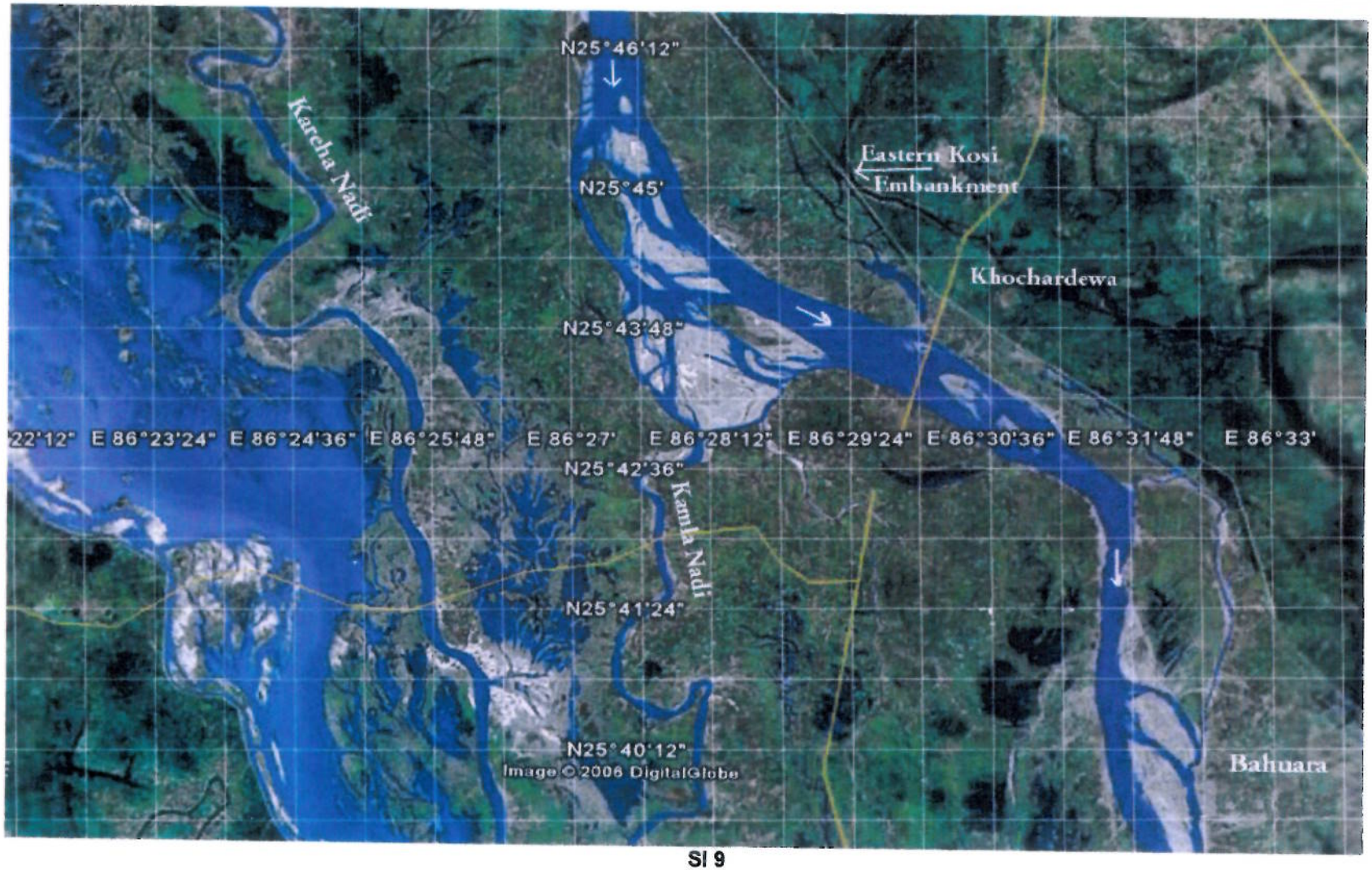
Western Kosi
Embankment
N25°51'
Flood Area
Eastern Kosi
Embankment
N25°49'48"
Maina
24" E 86°18'36" E 86°19'48" E 86°21' E 86°22'12" E 86°23'24" E 86°24'36" E 86°25'48" E 86°27' E 86°28'12" E 86°
N25°48'36"
Flood Area
Embankment
N25°47'24"
Island
Rajhanpur
N25°46'12"
Image © 2006 DigitalGlobe

Sl 8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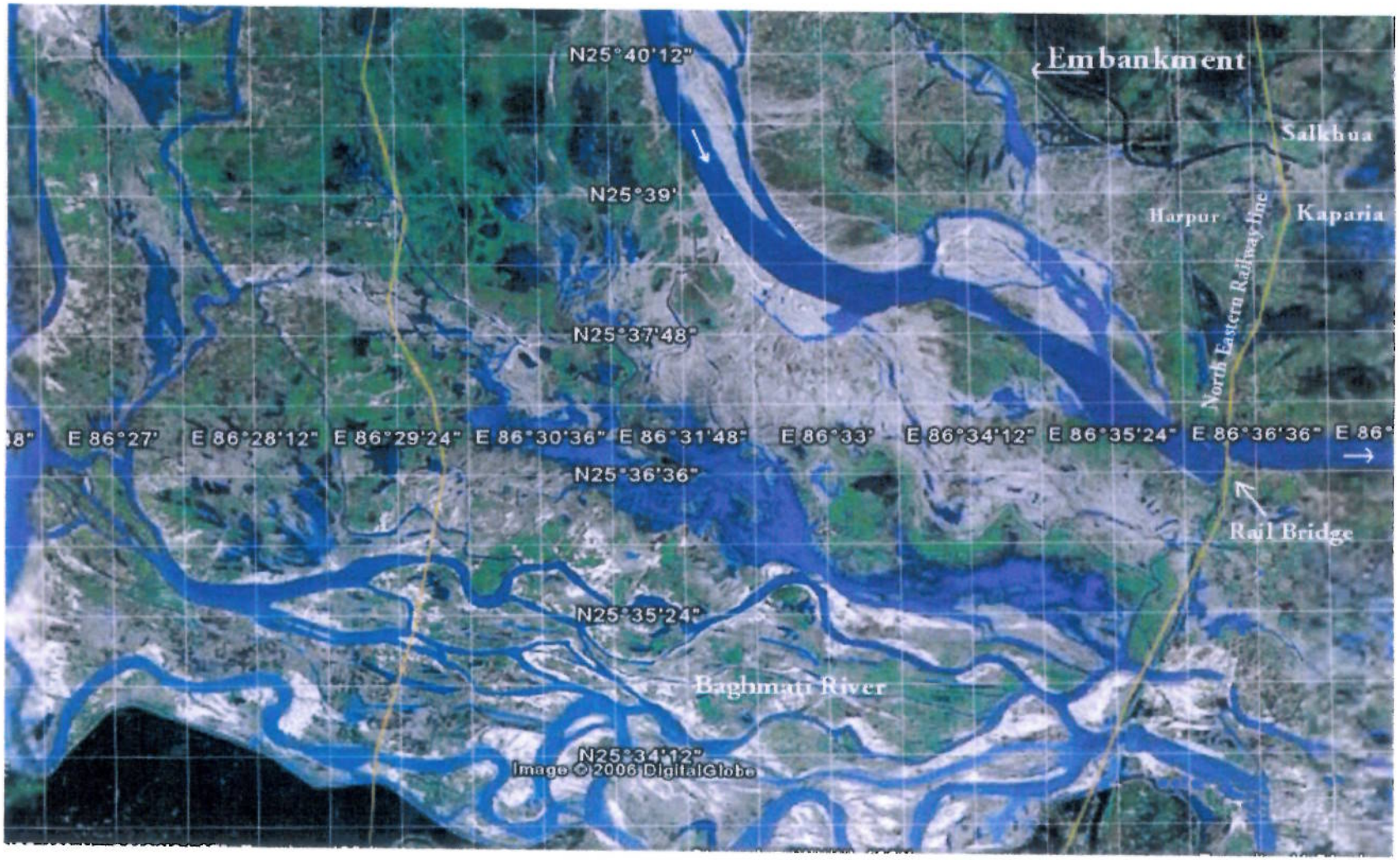
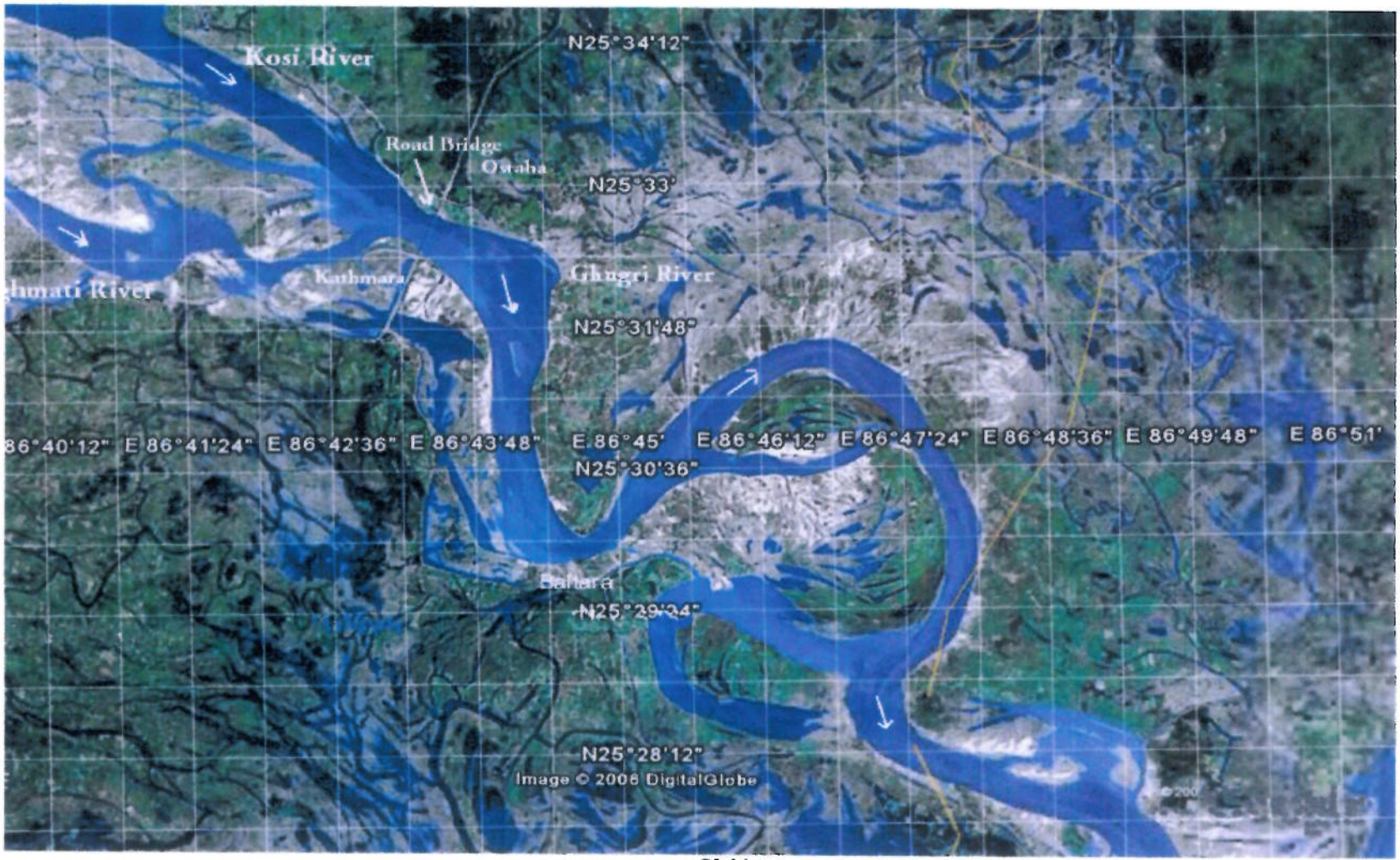
Karcha Nadi
Eastern Kosi
Embankment
N25°45'
Khochardewa
N25°43'48"
22'12" E 86°23'24" E 86°24'36" E 86°25'48" E 86°27' E 86°28'12" E 86°29'24" E 86°30'36" E 86°31'48" E 86°33'
N25°42'36"
Kamla Nadi
N25°41'24"
N25°40'12"
Image © 2006 DigitalGlobe
Bahuara

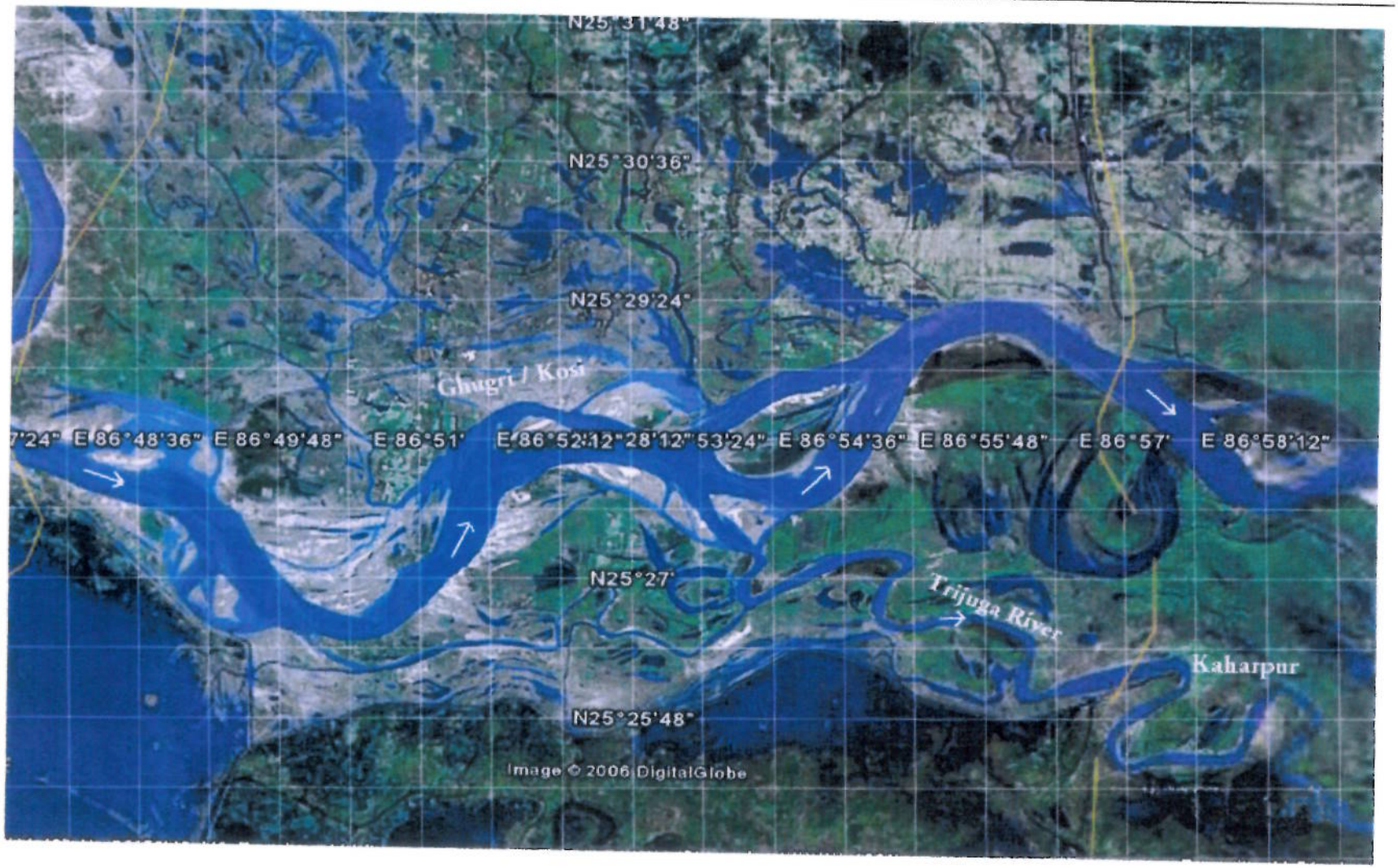
SI 9


N25°40'12"
Embankment
Salkhua
N25°39'
Harpur
Kaparia
North Eastern Railway line
N25°37'48"
E 86°27'
E 86°28'12"
E 86°29'24"
E 86°30'36"
E 86°31'48"
E 86°33'
E 86°34'12"
E 86°35'24"
E 86°36'36"
N25°36'36"
Rail Bridge
N25°35'24"
Baghmati River
N25°34'12"
Image © 2006 DigitalGlobe

SI 10


Kosi River
N25°34'12"
Road Bridge
Ostaha
N25°33'
Kathmara
Ghugri River
N25°31'48"
E 86°40'12"
E 86°41'24"
E 86°42'36"
E 86°43'48"
E 86°45'
E 86°46'12"
E 86°47'24"
E 86°48'36"
E 86°49'48"
E 86°51'
N25°30'36"
N25°29'24"
N25°28'12"
Image © 2006 DigitalGlobe

SI 11


N25°31'48"
N25°30'36"
N25°29'24"
Ghugri / Kosi
7'24" E 86°48'36" E 86°49'48" E 86°51' E 86°52'12" 28'12" 53'24" E 86°54'36" E 86°55'48" E 86°57' E 86°58'12"
N25°27'
Trijuga River
Kaharpur
N25°25'48"
Image © 2006 DigitalGlobe

SI 12


Bahaura Topra
N25°28'12"
Farakka
Kursela
N25°27'
Road Bridge
N25°25'48"
07'48"
E 87°09'
E 87°10'12"
E 87°11'24"
E 87°12'36"
E 87°13'48"
E 87°15'
E 87°16'12"
E 87°17'24"
E 87°18'36"
Kosi
N25°24'36"
Rail Bridge
Kursela
River Ganga
N25°23'24"
Patna
Image © 2006 DigitalGlobe
N25°22'12"

SI 14

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Annexure – 4.1

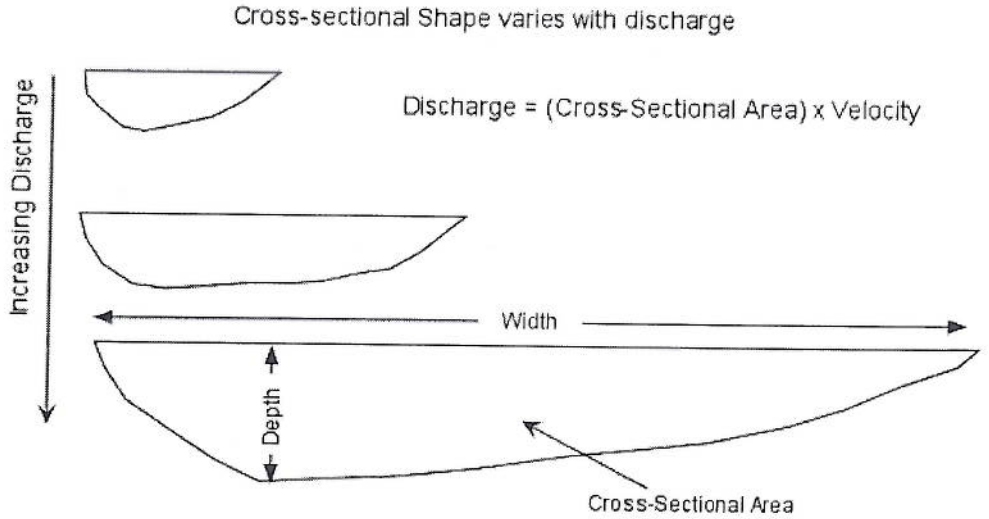
Mechanism to increase River discharge :

i) **By method of dredging width and depth can be increased, consequently discharge will be improved**

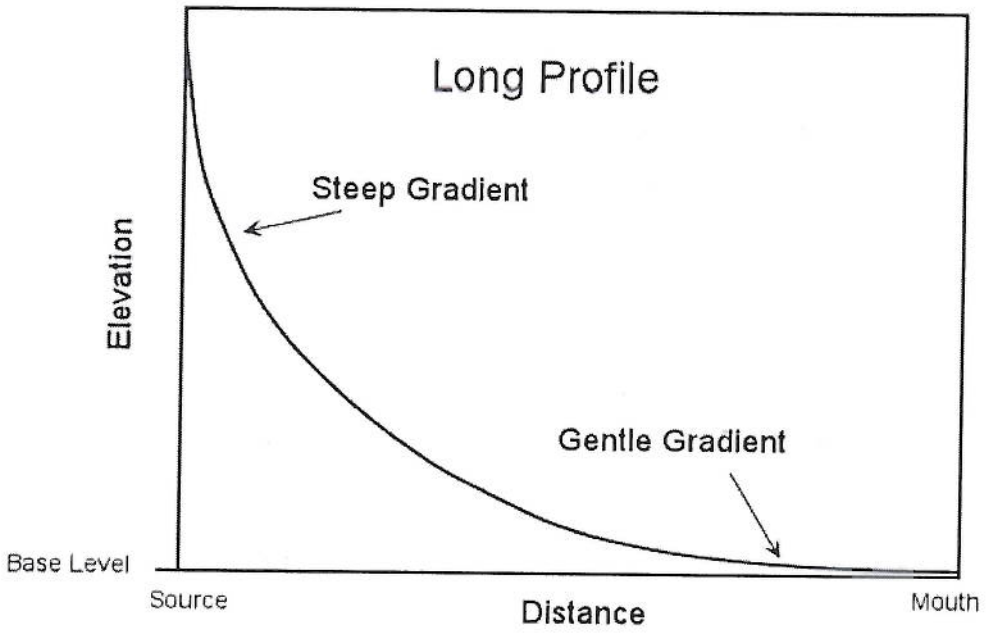
- **Geometry and Dynamics of Stream Channels**

The stream channel is the conduit for water being carried by the stream. The stream can continually adjust its channel shape and path as the amount of water passing through the channel changes The volume of water passing any point on a stream is called the discharge. Discharge is measured in units of volume/time (m^3/sec).

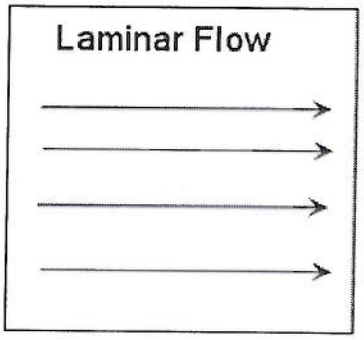
- Cross Sectional Shape - varies with position in the stream and discharge. The deepest parts of a channel occur where the stream velocity is the highest. Both width and depth increase downstream because discharge increases downstream. As discharge increases the cross sectional shape will change, with the stream becoming deeper and wider.

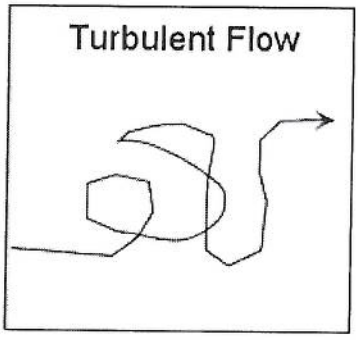


- Long Profile - a plot of elevation versus distance. Usually shows a steep gradient near the source of the stream and a gentle gradient as the stream approaches its mouth.



- Velocity - A stream's velocity depends on position in the stream channel, irregularities in the stream channel caused by resistant rock, and stream gradient.





The average velocity is the time it takes a given particle of water to traverse a given distance. Stream flow can be either laminar, in which all water molecules travel along similar parallel paths, or turbulent, in which individual particles take irregular paths. Turbulent flow can keep sediment in suspension longer than laminar flow and aids in erosion of the stream bottom. Average linear velocity is generally greater in laminar flow than in turbulent flow.

- Discharge - The discharge of a stream is the amount of water passing any point in a given time.

$$Q = A \times V$$

Discharge (m^3/sec) = Cross-sectional Area (width x average depth) (m^2) x Average Velocity (m/sec)

As the amount of water in a stream increases, the stream must adjust its velocity and cross sectional area in order to form a balance. Discharge increases as more water is added through rainfall, tributary streams, or from groundwater seeping into the stream. As discharge increases, generally width, depth, and velocity of the stream also increase. Increasing the depth and width of the stream may cause the stream to overflow is channel resulting in a flood.

ii) Release of water from Kosi Barrage

River discharge can be controlled / increased by monitoring Kosi barrage. If release of water by Kosi Barrage increases, river gets more discharge for navigation.

iii) Creating a reservoir of required water

Assuming 300 days navigation, water required
= 300 X additional discharge required for augmentation(in cumecs) X 60 X 60 X 24
= Y M cum

Therefore a reservoir to supply Y M cum of water annually for navigation purposes may have to be created. A careful study of the topography of the area and water course would have to be undertaken to locate exactly this reservoir.

iv) River Training Measures

There are two basic methods for river training works:

1) Water Restriction method.
2) Water Guide method.

The first method consists of restriction, compression of the channel and an increase in average flow velocity in order to achieve necessary scour of the river bed. The second method provides for increased flow in the predetermined alignment to obtain the designed depth. Both the method involve an interference with the morphological and hydraulic aspects of the river. It is an established fact that the river reacts violently on any human interference. Hence a comprehensive study of the river including the hydraulic and morphological process is to be undertaken before arriving at any permanent workable solution for the river training works.

It is suggested to adopt an experimental solution of using the dredge spoils for positive purpose of providing a guidance to the flow at no additional cost. The method envisages

dumping the dredged soil obtainable from capital / maintenance dredging, in strategic locations so as to divert the flow into the predetermined channel. Of course, there exists the danger that greater part of the dumped material may flow back to the predetermined channel if proper selection of dumping region is not done. This, however, provides valuable knowledge of flow pattern and changes in course with time as an insight into the mechanism of river behavior, an understanding of the hydraulic characteristics and their consequences to human interference, experimentation with such means would contribute to an understanding of the river behaviour and valuable data acquisition at no additional cost for implementation of the permanent measures for river training and control works. In addition to the inadequacy of data for a workable solution for river training works, other consideration which influence the decision are:

- The depth deficiencies occur at a limited number of locations.
- The depth deficiency occurs only during well defined period.

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Annexure – 4.2

DEPTH AND WIDTH OF RIVER KOSI AT 10km INTERVAL

Chainage (in Km)	Main Channel Width (in m)	Depth below C.D. (in m)		Remarks
		(Max.Depth)	(Min.Depth)	
0	1035	3.7	1.2	Near Kosi Barrage
10	320	0.0	0.0	
20	112	1.5	0.8	
30	256	3.3	2.3	Near Kalyanpur
40	158	2.0	1.8	
50	204	0.7	0.0	
60	98	1.7	1.2	
70	117	1.8	1.2	Near Basbitti
80	170	2.1	1.3	
90	167	2.6	1.0	
100	200	0.6	0.1	Near Mahisarho
110	240	1.5	1.0	
120	114	1.7	1.6	
130	320	2.1	1.9	
140	243	1.6	1.5	Near Koparia
150	130	1.4	1.2	
160	181	2.9	2.3	Near Kathmara
170	165	2.3	1.4	
180	210	1.9	1.4	
190	238	2.0	1.5	Near Baltara
200	291	2.4	2.3	Near Phulot
210	306	2.0	2.0	
220	409	4.5	3.0	
230	232	1.8	1.7	
236	411	2.5	2.4	Near Kursela

Dredging Quantity on River Kosi (100 T Vessel)

Width at Bottom level = 25 m
Draft depth below C.D. = 1.2 m
Side slope in Soil = 1: 5

Chainage (m)	Length (m)	Reduced Soundings w.r.t C.D. (m)			Depth of cutting (m)			Average depth of cutting (m)	Area (m^2)	Quantity (m^3)
		Left	C	Right	Left	C	Right			
		25	0	25	25	0	25			
1	2	3	4	5	6	7	8	9	10	11
0.00	0.00	1.49	1.89	1.89	0.00	0.00	0.00	0.00	0.00	0.00
250.00	250.00	2.58	1.18	0.78	0.00	0.02	0.42	0.14	3.71	463.69
500.00	250.00	0.68	0.68	0.48	0.52	0.52	0.72	0.59	16.35	2506.95
750.00	250.00	0.48	1.18	0.48	0.72	0.02	0.72	0.49	13.38	3715.81
1000.00	250.00	0.38	0.38	0.48	0.82	0.82	0.72	0.79	22.87	4531.28
1250.00	250.00	1.67	2.47	5.07	0.00	0.00	0.00	0.00	0.00	2858.74
1500.00	250.00	2.27	1.47	1.07	0.00	0.00	0.13	0.04	1.08	134.45
1750.00	250.00	1.17	1.47	2.07	0.03	0.00	0.00	0.01	0.25	166.07
2000.00	250.00	1.87	1.47	1.57	0.00	0.00	0.00	0.00	0.00	31.63
2250.00	250.00	2.27	2.57	0.97	0.00	0.00	0.23	0.08	1.99	248.59
2500.00	250.00	1.96	4.56	2.76	0.00	0.00	0.00	0.00	0.00	248.59
2750.00	250.00	2.56	3.26	3.26	0.00	0.00	0.00	0.00	0.00	0.00
2850.00	100.00	2.26	2.16	1.66	0.00	0.00	0.00	0.00	0.00	0.00
3200.00	350.00	1.46	2.06	1.86	0.00	0.00	0.00	0.00	0.00	0.00
3400.00	200.00	0.45	1.45	1.15	0.75	0.00	0.05	0.26	6.94	694.25
3700.00	300.00	6.55	5.75	4.05	0.00	0.00	0.00	0.00	0.00	1041.37
4000.00	300.00	2.25	2.05	1.05	0.00	0.00	0.15	0.05	1.27	190.99
4250.00	250.00	2.45	2.35	1.55	0.00	0.00	0.00	0.00	0.00	159.16
4500.00	250.00	5.24	4.64	2.44	0.00	0.00	0.00	0.00	0.00	0.00
4700.00	200.00	0.64	2.54	2.24	0.56	0.00	0.00	0.19	4.82	482.11
4900.00	200.00	3.04	3.04	4.84	0.00	0.00	0.00	0.00	0.00	482.11
5200.00	300.00	1.24	0.94	0.84	0.00	0.26	0.36	0.21	5.42	813.64
5400.00	200.00	1.74	1.44	1.14	0.00	0.00	0.06	0.02	0.54	596.24
5600.00	200.00	2.03	1.43	1.53	0.00	0.00	0.00	0.00	0.00	53.82
5850.00	250.00	2.33	1.53	1.53	0.00	0.00	0.00	0.00	0.00	0.00
6000.00	150.00	1.53	2.23	1.53	0.00	0.00	0.00	0.00	0.00	0.00
6200.00	200.00	2.03	1.93	2.53	0.00	0.00	0.00	0.00	0.00	0.00
6400.00	200.00	0.73	0.93	1.53	0.47	0.27	0.00	0.25	6.54	653.72
6700.00	300.00	1.52	1.52	1.22	0.00	0.00	0.00	0.00	0.00	980.57
6900.00	200.00	0.52	1.32	1.42	0.68	0.00	0.00	0.23	5.91	590.79
7250.00	350.00	2.02	0.72	1.22	0.00	0.48	0.00	0.16	4.14	1758.66
7400.00	150.00	2.02	1.82	0.22	0.00	0.00	0.98	0.33	8.73	965.21
7500.00	100.00	2.22	1.42	0.52	0.00	0.00	0.68	0.23	5.96	734.33
8000.00	500.00	1.61	0.81	1.21	0.00	0.39	0.00	0.13	3.32	2320.05
8250.00	250.00	0.91	0.81	0.71	0.29	0.39	0.49	0.39	10.53	1732.07
8400.00	150.00	1.01	0.91	1.51	0.19	0.29	0.00	0.16	4.17	1102.71
8600.00	200.00	1.61	0.91	1.01	0.00	0.29	0.19	0.16	4.20	836.87
8900.00	300.00	2.00	1.40	0.00	0.00	0.00	1.20	0.40	10.77	2245.64
9250.00	350.00	1.00	1.50	1.50	0.20	0.00	0.00	0.07	1.69	2180.56
9400.00	150.00	2.00	1.70	1.50	0.00	0.00	0.00	0.00	0.00	126.78
9700.00	300.00	0.70	0.70	1.00	0.50	0.50	0.20	0.40	10.93	1638.95
10000.00	300.00	0.29	0.49	1.19	0.91	0.71	0.01	0.54	14.97	3884.85
10250.00	250.00	0.69	1.69	1.99	0.51	0.00	0.00	0.17	4.39	2420.31
10500.00	250.00	0.19	1.39	1.49	1.01	0.00	0.00	0.34	9.00	1673.79
10750.00	250.00	0.69	1.39	1.49	0.51	0.00	0.00	0.17	4.43	1678.97
10900.00	150.00	2.68	2.58	2.28	0.00	0.00	0.00	0.00	0.00	332.35
11200.00	300.00	1.28	1.38	1.28	0.00	0.00	0.00	0.00	0.00	0.00
11400.00	200.00	1.28	0.88	0.98	0.00	0.32	0.22	0.18	4.67	466.54
11750.00	350.00	1.38	0.98	1.28	0.00	0.22	0.00	0.07	1.89	1147.16
11900.00	150.00	1.98	2.18	2.98	0.00	0.00	0.00	0.00	0.00	141.74
12100.00	200.00	0.47	1.87	2.37	0.73	0.00	0.00	0.24	6.35	634.93
12300.00	200.00	0.77	0.67	0.57	0.43	0.53	0.63	0.53	14.61	2096.06
12500.00	200.00	2.57	2.47	0.77	0.00	0.00	0.43	0.14	3.69	1830.12
12750.00	250.00	2.57	2.47	3.57	0.00	0.00	0.00	0.00	0.00	461.24
13000.00	250.00	3.26	2.66	2.46	0.00	0.00	0.00	0.00	0.00	0.00
13250.00	250.00	1.56	0.96	1.06	0.00	0.24	0.14	0.12	3.20	400.22
13500.00	250.00	0.66	1.96	0.66	0.54	0.00	0.54	0.36	9.64	1605.62
13750.00	250.00	2.46	2.56	2.06	0.00	0.00	0.00	0.00	0.00	1205.41

Chainage (m)	Length (m)	Reduced Soundings w.r.t C.D. (m)			Depth of cutting (m)			Average depth of cutting (m)	Area (m^2)	Quantity (m^3)
		Left	C	Right	Left	C	Right			
		25	0	25	25	0	25			
1	2	3	4	5	6	7	8	9	10	11
28700.00	200.00	4.32	4.32	4.02	0.00	0.00	0.00	0.00	0.00	0.00
28900.00	200.00	3.32	4.82	7.02	0.00	0.00	0.00	0.00	0.00	0.00
29200.00	300.00	7.31	3.31	3.21	0.00	0.00	0.00	0.00	0.00	0.00
29400.00	200.00	3.31	3.11	3.71	0.00	0.00	0.00	0.00	0.00	0.00
29700.00	300.00	2.81	3.31	3.31	0.00	0.00	0.00	0.00	0.00	0.00
30000.00	300.00	3.31	3.31	3.81	0.00	0.00	0.00	0.00	0.00	0.00
30250.00	250.00	4.10	3.20	4.10	0.00	0.00	0.00	0.00	0.00	0.00
30500.00	250.00	3.70	3.60	4.00	0.00	0.00	0.00	0.00	0.00	0.00
30750.00	250.00	3.90	2.80	3.90	0.00	0.00	0.00	0.00	0.00	0.00
31000.00	250.00	3.80	2.30	4.00	0.00	0.00	0.00	0.00	0.00	0.00
31250.00	250.00	3.80	4.30	3.50	0.00	0.00	0.00	0.00	0.00	0.00
31500.00	250.00	4.80	7.30	5.60	0.00	0.00	0.00	0.00	0.00	0.00
31700.00	200.00	2.60	3.30	7.30	0.00	0.00	0.00	0.00	0.00	0.00
31900.00	200.00	7.30	2.80	3.60	0.00	0.00	0.00	0.00	0.00	0.00
32000.00	100.00	3.60	2.80	2.30	0.00	0.00	0.00	0.00	0.00	0.00
32250.00	250.00	2.90	3.00	2.10	0.00	0.00	0.00	0.00	0.00	0.00
32500.00	250.00	8.10	8.00	9.80	0.00	0.00	0.00	0.00	0.00	0.00
32700.00	200.00	4.60	3.80	4.10	0.00	0.00	0.00	0.00	0.00	0.00
32850.00	150.00	4.30	4.40	3.90	0.00	0.00	0.00	0.00	0.00	0.00
33100.00	250.00	5.10	4.20	5.60	0.00	0.00	0.00	0.00	0.00	0.00
33400.00	300.00	5.10	3.80	5.90	0.00	0.00	0.00	0.00	0.00	0.00
33500.00	100.00	2.60	2.30	1.90	0.00	0.00	0.00	0.00	0.00	0.00
33750.00	250.00	2.20	2.40	3.30	0.00	0.00	0.00	0.00	0.00	0.00
34000.00	250.00	2.50	2.60	2.60	0.00	0.00	0.00	0.00	0.00	0.00
34250.00	250.00	2.10	2.00	2.40	0.00	0.00	0.00	0.00	0.00	0.00
34400.00	150.00	3.00	1.30	1.20	0.00	0.00	0.00	0.00	0.00	0.00
34600.00	200.00	3.10	3.40	3.60	0.00	0.00	0.00	0.00	0.00	0.00
34700.00	100.00	5.80	3.10	2.90	0.00	0.00	0.00	0.00	0.00	0.00
34800.00	100.00	3.10	4.10	4.10	0.00	0.00	0.00	0.00	0.00	0.00
34900.00	100.00	4.30	3.80	8.10	0.00	0.00	0.00	0.00	0.00	0.00
35100.00	200.00	1.10	3.60	5.50	0.10	0.00	0.00	0.03	0.84	83.89
35400.00	300.00	7.50	9.10	5.60	0.00	0.00	0.00	0.00	0.00	125.84
35600.00	200.00	5.60	5.40	5.90	0.00	0.00	0.00	0.00	0.00	0.00
35800.00	200.00	5.10	6.40	6.60	0.00	0.00	0.00	0.00	0.00	0.00
36100.00	300.00	4.60	3.10	1.90	0.00	0.00	0.00	0.00	0.00	0.00
36300.00	200.00	2.10	1.60	1.10	0.00	0.00	0.10	0.03	0.84	83.89
36500.00	200.00	1.10	-0.10	0.60	0.10	1.30	0.60	0.67	18.89	1972.78
36800.00	300.00	3.10	4.90	5.10	0.00	0.00	0.00	0.00	0.00	2833.34
37000.00	200.00	3.60	3.50	2.10	0.00	0.00	0.00	0.00	0.00	0.00
37400.00	400.00	6.30	2.30	5.10	0.00	0.00	0.00	0.00	0.00	0.00
37600.00	200.00	2.10	3.30	2.60	0.00	0.00	0.00	0.00	0.00	0.00
37800.00	200.00	2.00	3.20	2.50	0.00	0.00	0.00	0.00	0.00	0.00
38000.00	200.00	1.10	2.00	1.20	0.10	0.00	0.00	0.03	0.84	83.89
38300.00	300.00	1.60	1.20	0.60	0.00	0.00	0.60	0.20	5.20	905.84
38500.00	200.00	1.90	2.70	1.40	0.00	0.00	0.00	0.00	0.00	520.00
38750.00	250.00	2.70	1.90	2.40	0.00	0.00	0.00	0.00	0.00	0.00
39000.00	250.00	1.70	1.90	1.20	0.00	0.00	0.00	0.00	0.00	0.00
39250.00	250.00	0.70	1.70	0.20	0.50	0.00	1.00	0.50	13.75	1718.75
39500.00	250.00	1.70	1.70	1.70	0.00	0.00	0.00	0.00	0.00	1718.75
39600.00	100.00	1.20	1.20	1.20	0.00	0.00	0.00	0.00	0.00	0.00
39900.00	300.00	1.70	3.20	1.70	0.00	0.00	0.00	0.00	0.00	0.00
40000.00	100.00	1.70	1.80	1.80	0.00	0.00	0.00	0.00	0.00	0.00
40200.00	200.00	1.60	1.50	1.40	0.00	0.00	0.00	0.00	0.00	0.00
40600.00	400.00	1.50	1.30	1.20	0.00	0.00	0.00	0.00	0.00	0.00
40800.00	200.00	1.80	1.50	0.40	0.00	0.00	0.80	0.27	7.02	702.23
41000.00	200.00	1.20	2.20	2.20	0.00	0.00	0.00	0.00	0.00	702.23
41250.00	250.00	2.70	2.20	2.10	0.00	0.00	0.00	0.00	0.00	0.00
41500.00	250.00	2.40	2.40	2.50	0.00	0.00	0.00	0.00	0.00	0.00
42000.00	500.00	2.00	1.70	1.20	0.00	0.00	0.00	0.00	0.00	0.00
42200.00	200.00	0.50	3.20	1.40	0.70	0.00	0.00	0.23	6.11	610.56
42400.00	200.00	4.20	4.20	3.70	0.00	0.00	0.00	0.00	0.00	610.56
42700.00	300.00	3.20	3.10	3.00	0.00	0.00	0.00	0.00	0.00	0.00
42900.00	200.00	4.00	1.10	4.20	0.00	0.10	0.00	0.03	0.84	83.89

Chainage (m)	Length (m)	Reduced Soundings w.r.t C.D. (m)			Depth of cutting (m)			Average depth of cutting (m)	Area (m^2)	Quantity (m^3)
		Left	C	Right	Left	C	Right			
		25	0	25	25	0	25			
1	2	3	4	5	6	7	8	9	10	11
58500.00	250.00	0.40	1.70	2.00	0.80	0.00	0.00	0.27	7.02	2596.53
58750.00	250.00	0.00	0.20	0.70	1.20	1.00	0.50	0.90	26.55	4196.53
59000.00	250.00	1.20	0.70	0.70	0.00	0.50	0.50	0.33	8.89	4429.87
59500.00	500.00	2.40	1.20	2.00	0.00	0.00	0.00	0.00	0.00	2222.23
59750.00	250.00	2.60	2.20	0.70	0.00	0.00	0.50	0.17	4.31	538.20
60000.00	250.00	1.20	1.20	0.70	0.00	0.00	0.50	0.17	4.31	1076.39
60200.00	200.00	0.70	1.40	1.20	0.50	0.00	0.00	0.17	4.31	861.12
60400.00	200.00	1.30	2.20	1.00	0.00	0.00	0.20	0.07	1.69	599.45
60600.00	200.00	0.50	3.20	0.20	0.70	0.00	1.00	0.57	15.77	1746.12
60950.00	350.00	1.40	1.70	1.60	0.00	0.00	0.00	0.00	0.00	2760.14
61200.00	250.00	1.00	1.50	1.40	0.20	0.00	0.00	0.07	1.69	211.12
61500.00	300.00	2.80	1.00	2.20	0.00	0.20	0.00	0.07	1.69	506.67
61750.00	250.00	2.10	0.40	0.60	0.00	0.80	0.60	0.47	12.76	1805.56
62000.00	250.00	2.20	2.30	1.70	0 00	0.00	0.00	0.00	0.00	1594.45
62200.00	200.00	4.70	1.10	0.70	0.00	0.10	0.50	0.20	5.20	520.00
62400.00	200.00	1.20	1.10	2.00	0.00	0.10	0.00	0.03	0.84	603.89
62600.00	200.00	0.50	0.70	1.40	0.70	0.50	0.00	0.40	10.80	1163.89
62900.00	300.00	1.20	0.80	0.70	0.00	0.40	0.50	0.30	7.95	2812.50
63200.00	300.00	1.00	1.60	0.70	0.20	0.00	0.50	0.23	6.11	2108.34
63400.00	200.00	1.80	1.40	0.80	0.00	0.00	0.40	0.13	3.42	952.78
63700.00	300.00	0.80	1.10	0.70	0.40	0.10	0.50	0.33	8.89	1846.67
63900.00	200.00	0.30	1.30	0.80	0.90	0.00	0.40	0.43	11.77	2066.12
64100.00	200.00	2.30	1.80	0.80	0.00	0.00	0.40	0.13	3.42	1519.45
64400.00	300.00	1.30	1.10	0.80	0.00	0.10	0.40	0.17	4.31	1159.17
64600.00	200.00	1.10	1.30	2.30	0.10	0.00	0.00	0.03	0.84	514.45
64900.00	300.00	1.60	1.80	1.80	0.00	0.00	0.00	0.00	0.00	125.84
65100.00	200.00	1.80	2.30	2.10	0.00	0.00	0.00	0.00	0.00	0.00
65350.00	250.00	1.70	2.30	1.80	0.00	0.00	0.00	0.00	0.00	0.00
65500.00	150.00	1.10	1.30	1.60	0.10	0.00	0.00	0.03	0.84	62.92
65750.00	250.00	1.00	0.60	1.10	0.20	0.60	0.10	0.30	7.95	1098.62
66000.00	250.00	2.00	1.80	2.20	0.00	0.00	0.00	0.00	0.00	993.75
66250.00	250.00	3.50	5.30	2.30	0.00	0.00	0.00	0.00	0.00	0.00
66500.00	250.00	2.70	4.10	3.30	0.00	0.00	0.00	0.00	0.00	0.00
66700.00	200.00	2.50	2.30	1.60	0.00	0.00	0.00	0.00	0.00	0.00
66950.00	250.00	2.60	2.10	2.30	0.00	0.00	0.00	0.00	0.00	0.00
67100.00	150.00	1.60	2.80	1.40	0.00	0.00	0.00	0.00	0.00	0.00
67250.00	150.00	0.80	2.40	2.30	0.40	0.00	0.00	0.13	3.42	256.67
67350.00	100.00	1.80	1.90	1.80	0.00	0.00	0.00	0.00	0.00	171.12
67500.00	150.00	1.40	0.60	1.80	0.00	0.60	0.00	0.20	5.20	390.00
67750.00	250.00	0.80	0.90	0.80	0.40	0.30	0.40	0.37	9.84	1879.87
68000.00	250.00	2.60	1.90	2.00	0.00	0.00	0.00	0.00	0.00	1229.87
68250.00	250.00	1.80	2.00	2.00	0.00	0.00	0.00	0.00	0.00	0.00
68500.00	250.00	0.30	3.50	1.80	0.90	0.00	0.00	0.30	7.95	993.75
68700.00	200.00	1.80	2.50	2.60	0.00	0.00	0.00	0.00	0.00	795.00
68800.00	100.00	2.30	2.00	1.40	0.00	0.00	0.00	0.00	0.00	0.00
69000.00	200.00	1.50	3.20	1.30	0.00	0.00	0.00	0.00	0.00	0.00
69200.00	200.00	1.80	1.80	1.30	0.00	0.00	0.00	0.00	0.00	0.00
69550.00	350.00	2.10	1.50	2.10	0.00	0.00	0.00	0.00	0.00	0.00
69800.00	250.00	3.00	1.30	2.30	0.00	0.00	0.00	0.00	0.00	0.00
70000.00	200.00	0.80	1.80	0.80	0.40	0.00	0.40	0.27	7.02	702.23
70250.00	250.00	1.30	1.70	1.30	0.00	0.00	0.00	0.00	0.00	877.78
70500.00	250.00	1.80	1.00	1.70	0.00	0.20	0.00	0.07	1.69	211.12
70750.00	250.00	1.10	4.20	1.30	0.10	0.00	0.00	0.03	0.84	315.98
71000.00	250.00	0.50	1.20	0.30	0.70	0.00	0.90	0.53	14.76	1949.31
71250.00	250.00	-0.20	1.00	1.30	1.40	0.20	0.00	0.53	14.76	3688.89
71500.00	250.00	1.30	2.20	0.50	0.00	0.00	0.70	0.23	6.11	2607.64
71750.00	250.00	1.30	2.90	1.30	0.00	0.00	0.00	0.00	0.00	763.20
72000.00	250.00	1.60	2.70	3.10	0.00	0.00	0.00	0.00	0.00	0.00
72250.00	250.00	3.10	1.70	2.80	0.00	0.00	0.00	0.00	0.00	0.00
72500.00	250.00	1.30	0.30	1.00	0.00	0.90	0.20	0.37	9.84	1229.87
72750.00	250.00	1.10	1.20	0.80	0.10	0.00	0.40	0.17	4.31	1768.06
72850.00	100.00	1.20	1.60	0.40	0.00	0.00	0.80	0.27	7.02	566.39
73000.00	150.00	3.70	1.60	1.20	0.00	0.00	0.00	0.00	0.00	526.67

Chainage (m)	Length (m)	Reduced Soundings w.r.t C.D. (m)			Depth of cutting (m)			Average depth of cutting (m)	Area (m^2)	Quantity (m^3)
		Left	C	Right	Left	C	Right			
		25	0	25	25	0	25			
1	2	3	4	5	6	7	8	9	10	11
88750.00	250.00	1.50	1.10	0.50	0.00	0.10	0.70	0.27	7.02	2349.31
89000.00	250.00	0.10	0.50	1.10	1.10	0.70	0.10	0.63	17.84	3107.64
89250.00	250.00	1.10	0.80	0.10	0.10	0.40	1.10	0.53	14.76	4074.31
89500.00	250.00	0.50	1.10	0.80	0.70	0.10	0.40	0.40	10.80	3194.45
89750.00	250.00	0.90	0.80	-0.10	0.30	0.40	1.30	0.67	18.89	3711.12
90000.00	250.00	1.40	1.00	0.40	0.00	0.20	0.80	0.33	8.89	3472.23
90250.00	250.00	1.40	1.10	0.50	0.00	0.10	0.70	0.27	7.02	1988.89
90500.00	250.00	0.50	1.00	0.90	0.70	0.20	0.30	0.40	10.80	2227.78
90750.00	250.00	0.60	1.60	1.10	0.60	0.00	0.10	0.23	6.11	2113.20
91000.00	250.00	0.10	0.60	0.40	1.10	0.60	0.80	0.83	24.31	3801.39
91250.00	250.00	0.80	1.30	0.60	0.40	0.00	0.60	0.33	8.89	4149.31
91550.00	300.00	1.30	0.90	0.30	0.00	0.30	0.90	0.40	10.80	2953.34
91750.00	200.00	0.90	0.60	0.00	0.30	0.60	1.20	0.70	19.95	3075.00
92050.00	300.00	1.40	1.60	0.90	0.00	0.00	0.30	0.10	2.55	3375.00
92400.00	350.00	0.20	0.90	0.40	1.00	0.30	0.80	0.70	19.95	3937.50
92600.00	200.00	0.90	1.10	1.40	0.30	0.10	0.00	0.13	3.42	2337.23
92800.00	200.00	0.10	1.10	0.10	1.10	0.10	1.10	0.77	22.11	2552.78
93100.00	300.00	0.60	0.80	0.40	0.60	0.40	0.80	0.60	16.80	5835.84
93500.00	400.00	0.30	1.30	1.10	0.90	0.00	0.10	0.33	8.89	5137.78
93750.00	250.00	0.50	0.90	0.60	0.70	0.30	0.60	0.53	14.76	2955.56
94000.00	250.00	0.60	0.60	0.80	0.60	0.60	0.40	0.53	14.76	3688.89
94250.00	250.00	0.10	1.60	0.60	1.10	0.00	0.60	0.57	15.77	3815.98
94500.00	250.00	1.10	1.20	1.10	0.10	0.00	0.10	0.07	1.69	2182.64
94750.00	250.00	0.90	1.10	1.10	0.30	0.10	0.10	0.17	4.31	749.31
95000.00	250.00	1.10	1.10	0.60	0.10	0.10	0.60	0.27	7.02	1415.98
95250.00	250.00	1.10	2.10	0.50	0.10	0.00	0.70	0.27	7.02	1755.56
95500.00	250.00	1.20	0.60	0.80	0.00	0.60	0.40	0.33	8.89	1988.89
95750.00	250.00	0.60	1.20	1.10	0.60	0.00	0.10	0.23	6.11	1874.31
96000.00	250.00	1.10	0.50	0.60	0.10	0.70	0.60	0.47	12.76	2357.64
96250.00	250.00	0.90	0.50	0.80	0.30	0.70	0.40	0.47	12.76	3188.89
96500.00	250.00	1.10	0.90	1.10	0.10	0.30	0.10	0.17	4.31	2132.64
96750.00	250.00	1.40	1.60	-0.10	0.00	0.00	1.30	0.43	11.77	2009.73
97000.00	250.00	2.10	1.10	1.10	0.00	0.10	0.10	0.07	1.69	1682.64
97250.00	250.00	1.10	0.10	0.50	0.10	1.10	0.70	0.63	17.84	2440.98
97600.00	350.00	0.60	1.70	0.00	0.60	0.00	1.20	0.60	16.80	6061.81
97800.00	200.00	0.40	1.60	1.10	0.80	0.00	0.10	0.30	7.95	2475.00
98100.00	300.00	1.10	0.90	-0.30	0.10	0.30	1.50	0.63	17.84	3868.34
98350.00	250.00	0.10	0.40	1.60	1.10	0.80	0.00	0.63	17.84	4459.73
98600.00	250.00	0.30	0.80	1.10	0.90	0.40	0.10	0.47	12.76	3824.31
98900.00	300.00	0.60	1.10	0.60	0.60	0.10	0.60	0.43	11.77	3679.17
99100.00	200.00	0.10	1.10	0.60	1.10	0.10	0.60	0.60	16.80	2857.23
99500.00	400.00	0.90	2.80	0.80	0.30	0.00	0.40	0.23	6.11	4581.12
99750.00	250.00	0.40	1.30	1.10	0.80	0.00	0.10	0.30	7.95	1756.95
100000.00	250.00	0.30	0.10	1.10	0.90	1.10	0.10	0.70	19.95	3487.50
100250.00	250.00	1.10	0.50	0.20	0.10	0.70	1.00	0.60	16.80	4593.75
100500.00	250.00	0.30	1.00	0.00	0.90	0.20	1.20	0.77	22.11	4863.20
100750.00	250.00	0.90	1.00	0.80	0.30	0.20	0.40	0.30	7.95	3756.95
101000.00	250.00	0.60	1.10	0.50	0.60	0.10	0.70	0.47	12.76	2588.20
101250.00	250.00	0.70	0.60	0.00	0.50	0.60	1.20	0.77	22.11	4357.64
101500.00	250.00	0.80	1.10	0.40	0.40	0.10	0.80	0.43	11.77	4234.73
101750.00	250.00	0.80	1.00	0.70	0.40	0.20	0.50	0.37	9.84	2701.39
102000.00	250.00	0.20	0.80	0.40	1.00	0.40	0.80	0.73	21.02	3857.64
102250.00	250.00	0.40	0.30	0.10	0.80	0.90	1.10	0.93	27.69	6088.89
102500.00	250.00	1.10	1.30	0.50	0.10	0.00	0.70	0.27	7.02	4338.89
102750.00	250.00	0.20	0.80	0.30	1.00	0.40	0.90	0.77	22.11	3640.98
103000.00	250.00	1.00	1.00	0.40	0.20	0.20	0.80	0.40	10.80	4113.20
103250.00	250.00	1.00	1.00	0.40	0.20	0.20	0.80	0.40	10.80	2700.00
103500.00	250.00	1.10	0.90	1.40	0.10	0.30	0.00	0.13	3.42	1777.78
103800.00	300.00	0.50	1.90	0.80	0.70	0.00	0.40	0.37	9.84	1989.17
104100.00	300.00	2.60	1.10	0.90	0.00	0.10	0.30	0.13	3.42	1989.17
104400.00	300.00	1.80	1.60	0.40	0.00	0.00	0.80	0.27	7.02	1566.67
104600.00	200.00	1.50	2.00	1.60	0.00	0.00	0.00	0.00	0.00	702.23
104850.00	250.00	0.40	1.30	1.40	0.80	0.00	0.00	0.27	7.02	877.78

Chainage (m)	Length (m)	Reduced Soundings w.r.t C.D. (m)			Depth of cutting (m)			Average depth of cutting (m)	Area (m^2)	Quantity (m^3)
		Left	C	Right	Left	C	Right			
		25	0	25	25	0	25			
1	2	3	4	5	6	7	8	9	10	11
121400.00	200.00	1.50	1.80	1.70	0.00	0.00	0.00	0.00	0.00	1080.00
121700.00	300.00	0.10	3.10	0.20	1.10	0.00	1.00	0.70	19.95	2992.50
121900.00	200.00	0.90	2.60	1.10	0.30	0.00	0.10	0.13	3.42	2337.23
122100.00	200.00	1.30	1.80	0.50	0.00	0.00	0.70	0.23	6.11	952.78
122400.00	300.00	1.30	1.00	1.70	0.00	0.20	0.00	0.07	1.69	1169.17
122700.00	300.00	0.80	1.70	1.70	0.40	0.00	0.00	0.13	3.42	766.67
122900.00	200.00	2.20	2.60	1.30	0.00	0.00	0.00	0.00	0.00	342.23
123100.00	200.00	0.80	2.80	1.30	0.40	0.00	0.00	0.13	3.42	342.23
123500.00	400.00	1.30	2.10	1.30	0.00	0.00	0.00	0.00	0.00	684.45
123750.00	250.00	1.20	1.40	1.50	0.00	0.00	0.00	0.00	0.00	0.00
123900.00	150.00	1.60	1.50	1.70	0.00	0.00	0.00	0.00	0.00	0.00
124200.00	300.00	1.80	1.70	1.30	0.00	0.00	0.00	0.00	0.00	0.00
124450.00	250.00	1.50	1.00	0.50	0.00	0.20	0.70	0.30	7.95	993.75
124700.00	250.00	0.20	1.60	1.50	1.00	0.00	0.00	0.33	8.89	2104.87
125000.00	300.00	0.40	2.30	1.00	0.80	0.00	0.20	0.33	8.89	2666.67
125250.00	250.00	2.90	1.00	0.40	0.00	0.20	0.80	0.33	8.89	2222.23
125500.00	250.00	1.30	2.70	2.50	0.00	0.00	0.00	0.00	0.00	1111.12
125750.00	250.00	-0.10	1.00	0.50	1.30	0.20	0.70	0.73	21.02	2627.78
126000.00	250 00	0.80	1.30	1.80	0.40	0.00	0.00	0.13	3.42	3055.56
126250.00	250.00	1.30	1.90	1.80	0.00	0.00	0.00	0.00	0.00	427.78
126500.00	250.00	1.00	2.30	1.50	0.20	0.00	0.00	0.07	1.69	211.12
126750.00	250.00	1.40	2.20	1.80	0.00	0.00	0.00	0.00	0.00	211.12
127000.00	250.00	1.40	1.80	1.70	0.00	0.00	0.00	0.00	0.00	0.00
127250.00	250.00	2.00	2.00	2.20	0.00	0.00	0.00	0.00	0.00	0.00
127500.00	250.00	1.70	1.70	1.50	0.00	0.00	0.00	0.00	0.00	0.00
127750.00	250.00	1.00	0.90	1.80	0.20	0.30	0.00	0.17	4.31	538.20
128000.00	250.00	2.50	2.30	1.00	0.00	0.00	0.20	0.07	1.69	749.31
128250.00	250.00	1.80	2.40	1.30	0.00	0.00	0.00	0.00	0.00	211.12
128500.00	250.00	1.30	1.80	1.30	0.00	0.00	0.00	0.00	0.00	0.00
128750.00	250.00	1.20	2.00	1.30	0.00	0.00	0.00	0.00	0.00	0.00
129100.00	350.00	1.00	1.30	0.85	0.20	0.00	0.35	0.18	4.75	831.50
129400.00	300.00	2.00	1.40	1.00	0.00	0.00	0.20	0.07	1.69	966.05
129600.00	200.00	1.80	2.80	1.00	0.00	0.00	0.20	0.07	1.69	337.78
129800.00	200.00	0.20	2.30	0.80	1.00	0.00	0.40	0.47	12.76	1444.45
130100.00	300.00	0.20	1.20	1.40	1.00	0.00	0.00	0.33	8.89	3246.67
130350.00	250.00	1.30	1.30	0.80	0.00	0.00	0.40	0.13	3.42	1538.89
130500.00	150.00	0.50	2.80	1.30	0.70	0.00	0.00	0.23	6.11	714.59
130750.00	250.00	0.50	2.70	1.20	0.70	0.00	0.00	0.23	6.11	1526.39
131000.00	250.00	-0.20	1.95	1.50	1.40	0.00	0.00	0.47	12.76	2357.64
131250.00	250.00	0.30	1.45	1.60	0.90	0.00	0.00	0.30	7.95	2588.20
131500.00	250.00	0.20	1.20	1.00	1.00	0.00	0.20	0.40	10.80	2343.75
131750.00	250.00	0.90	1.50	1.30	0.30	0.00	0.00	0.10	2.55	1668.75
132000.00	250.00	2.00	2.40	1.00	0.00	0.00	0.20	0.07	1.69	529.87
132250.00	250.00	2.10	2.10	1.40	0.00	0.00	0.00	0.00	0.00	211.12
132500.00	250.00	0.20	0.70	1.10	1.00	0.50	0.10	0.53	14.76	1844.45
132750.00	250.00	2.00	2.10	0.50	0.00	0.00	0.70	0.23	6.11	2607.64
133000.00	250.00	0.60	3.10	1.70	0.60	0.00	0.00	0.20	5.20	1413.20
133250.00	250.00	0.70	2.20	1.00	0.50	0.00	0.20	0.23	6.11	1413.20
133500.00	250.00	1.50	1.30	0.60	0.00	0.00	0.60	0.20	5.20	1413.20
133750.00	250.00	1.50	1.20	0.80	0.00	0.00	0.40	0.13	3.42	1077.78
134000.00	250.00	1.70	2.10	0.80	0.00	0.00	0.40	0.13	3.42	855.56
134250.00	250.00	0.20	2.10	1.00	1.00	0.00	0.20	0.40	10.80	1777.78
134500.00	250.00	0.70	1.30	0.30	0.50	0.00	0.90	0.47	12.76	2944.45
134750.00	250.00	1.60	2.50	1.10	0.00	0.00	0.10	0.03	0.84	1699.31
135000.00	250.00	1.50	1.50	0.50	0.00	0.00	0.70	0.23	6.11	868.06
135300.00	300.00	0.20	2.00	0.60	1.00	0.00	0.60	0.53	14.76	3129.17
135600.00	300.00	1.30	2.45	0.30	0.00	0.00	0.90	0.30	7.95	3405.84
135800.00	200.00	0.40	1.50	0.50	0.80	0.00	0.70	0.50	13.75	2170.00
136100.00	300.00	0.40	2.00	0.30	0.80	0.00	0.90	0.57	15.77	4428.34
136300.00	200.00	0.80	1.80	2.10	0.40	0.00	0.00	0.13	3.42	1919.45
136600.00	300.00	0.00	2.00	-0.20	1.20	0.00	1.40	0.87	25.42	4326.67
136800.00	200.00	1.70	1.60	1.80	0.00	0.00	0.00	0.00	0.00	2542.23
137100.00	300.00	1.70	1.50	0.00	0.00	0.00	1.20	0.40	10.80	1620.00

Chainage (m)	Length (m)	Reduced Soundings w.r.t C.D. (m)			Depth of cutting (m)			Average depth of cutting (m)	Area (m^2)	Quantity (m^3)
		Left	C	Right	Left	C	Right			
		25	0	25	25	0	25			
1	2	3	4	5	6	7	8	9	10	11
153000.00	250.00	1.05	0.85	1.75	0.15	0.35	0.00	0.17	4.38	1250.03
153250.00	250.00	2.34	2.14	1.74	0.00	0.00	0.00	0.00	0.00	547.61
153500.00	250.00	0.83	1.13	2.53	0.37	0.07	0.00	0.15	3.77	471.27
153750.00	250.00	2.02	1.07	1.52	0.00	0.13	0.00	0.04	1.07	605.25
154000.00	250.00	1.01	0.81	1.01	0.19	0.39	0.19	0.25	6.62	961.07
154250.00	250.00	1.01	1.01	1.51	0.19	0.19	0.00	0.13	3.30	1239.68
154500.00	250.00	0.50	0.60	0.60	0.70	0.60	0.60	0.63	17.87	2645.75
154750.00	250.00	0.79	1.09	1.49	0.41	0.11	0.00	0.17	4.46	2790.51
155000.00	250.00	1.48	1.18	0.68	0.00	0.02	0.52	0.18	4.60	1132.01
155250.00	250.00	1.48	1.38	0.68	0.00	0.00	0.52	0.17	4.52	1139.73
155500.00	250.00	1.67	2.47	1.47	0.00	0.00	0.00	0.00	0.00	565.07
155750.00	250.00	1.66	1.36	1.26	0.00	0.00	0.00	0.00	0.00	0.00
156000.00	250.00	0.25	1.35	0.65	0.95	0.00	0.55	0.50	13.70	1712.38
156250.00	250.00	1.44	2.24	1.64	0.00	0.00	0.00	0.00	0.00	1712.38
156500.00	250.00	0.04	0.74	2.14	1.16	0.46	0.00	0.54	15.02	1877.32
156750.00	250.00	2.53	0.93	0.93	0.00	0.27	0.27	0.18	4.68	2461.76
157000.00	250.00	0.42	1.82	1.92	0.78	0.00	0.00	0.26	6.82	1437.49
157250.00	250.00	1.11	1.31	0.01	0.09	0.00	1.19	0.42	11.50	2291.13
157500.00	250.00	2.81	1.21	0.71	0.00	0.00	0.49	0.16	4.25	1969.67
157750.00	250.00	0.20	0.10	0.60	1.00	1.10	0.60	0.90	26.61	3858.12
158000.00	250.00	0.69	0.89	0.39	0.51	0.31	0.81	0.54	15.05	5207.41
158250.00	250.00	0.58	0.98	2.38	0.62	0.22	0.00	0.28	7.34	2798.79
158500.00	250.00	0.37	0.47	0.87	0.83	0.73	0.33	0.63	17.58	3115.68
158750.00	250.00	2.37	1.67	2.27	0.00	0.00	0.00	0.00	0.00	2197.79
159000.00	250.00	1.76	2.26	2.06	0.00	0.00	0.00	0.00	0.00	0.00
159250.00	250.00	1.75	0.95	0.75	0.00	0.25	0.45	0.23	6.08	759.64
159500.00	250.00	1.24	1.44	1.74	0.00	0.00	0.00	0.00	0.00	759.64
159750.00	250.00	0.54	0.94	1.74	0.66	0.26	0.00	0.31	8.21	1026.41
160000.00	250.00	1.23	1.73	2.33	0.00	0.00	0.00	0.00	0.00	1026.41
160250.00	250.00	0.92	2.02	1.77	0.28	0.00	0.00	0.09	2.37	296.59
160500.00	250.00	1.21	2.21	2.51	0.00	0.00	0.00	0.00	0.00	296.59
160750.00	250.00	1.30	0.90	-0.30	0.00	0.30	1.50	0.60	16.70	2087.22
161000.00	250.00	0.50	0.60	0.20	0.70	0.60	1.00	0.77	22.20	4861.91
161250.00	250.00	1.69	1.29	0.69	0.00	0.00	0.51	0.17	4.40	3324.66
161500.00	250.00	-0.42	0.98	0.68	1.62	0.22	0.52	0.79	22.71	3388.30
161750.00	250.00	-0.33	1.97	1.17	1.53	0.00	0.03	0.52	14.27	4622.58
162000.00	250.00	1.47	-0.13	-0.53	0.00	1.33	1.73	1.02	30.79	5633.40
162250.00	250.00	1.86	2.16	1.66	0.00	0.00	0.00	0.00	0.00	3849.16
162500.00	250.00	1.75	1.15	0.65	0.00	0.05	0.55	0.20	5.19	648.71
162750.00	250.00	1.84	1.84	1.64	0.00	0.00	0.00	0.00	0.00	648.71
163123.00	373.00	-0.07	0.53	0.83	1.27	0.67	0.37	0.77	22.17	4135.59
163350.00	227.00	1.43	1.03	1.03	0.00	0.17	0.17	0.11	2.92	2848.11
163500.00	150.00	0.73	0.43	0.53	0.47	0.77	0.67	0.64	18.03	1570.97
163750.00	250.00	0.42	1.12	0.52	0.78	0.08	0.68	0.51	14.00	4003.92
164100.00	350.00	0.92	0.92	1.52	0.28	0.28	0.00	0.19	4.81	3293.25
164300.00	200.00	1.52	1.52	2.02	0.00	0.00	0.00	0.00	0.00	481.47
164500.00	200.00	0.52	-0.18	-0.48	0.68	1.38	1.68	1.25	39.03	3902.89
164750.00	250.00	1.92	2.02	1.22	0.00	0.00	0.00	0.00	0.00	4878.61
165000.00	250.00	0.71	1.71	1.71	0.49	0.00	0.00	0.16	4.19	524.12
165250.00	250.00	0.41	0.51	1.01	0.79	0.69	0.19	0.56	15.46	2456.43
165500.00	250.00	1.51	1.01	0.71	0.00	0.19	0.49	0.23	5.96	2677.75
165750.00	250.00	0.41	0.41	1.21	0.79	0.79	0.00	0.53	14.65	2576.32
166050.00	300.00	2.00	1.00	0.90	0.00	0.20	0.30	0.17	4.26	2836.40
166400.00	350.00	1.20	1.20	-0.20	0.00	0.00	1.40	0.47	12.78	2983.18
166600.00	200.00	0.50	0.80	1.40	0.70	0.40	0.00	0.37	9.89	2267.94
167000.00	400.00	0.19	0.39	1.19	1.01	0.81	0.01	0.61	17.01	5381.36
167250.00	250.00	1.19	1.19	-0.51	0.01	0.01	1.71	0.58	16.06	4133.61
167600.00	350.00	0.19	0.79	1.19	1.01	0.41	0.01	0.48	13.13	5108.18
168000.00	400.00	0.38	0.68	1.78	0.82	0.52	0.00	0.44	12.10	5045.98
168250.00	250.00	1.18	0.98	0.78	0.02	0.22	0.42	0.22	5.72	2226.60
168550.00	300.00	-0.32	1.28	1.68	1.52	0.00	0.00	0.51	13.97	2952.81
168750.00	200.00	1.68	1.53	0.88	0.00	0.00	0.32	0.11	2.76	1672.74
169100.00	350.00	0.17	1.27	2.17	1.03	0.00	0.00	0.34	9.15	2083.35

Chainage (m)	Length (m)	Reduced Soundings w.r.t C.D. (m)			Depth of cutting (m)			Average depth of cutting (m)	Area (m^2)	Quantity (m^3)
		Left	C	Right	Left	C	Right			
		25	0	25	25	0	25			
1	2	3	4	5	6	7	8	9	10	11
184750.00	250.00	0.12	0.32	0.66	1.08	0.88	0.54	0.83	24.31	9186.72
185000.00	250.00	0.12	0.52	0.02	1.08	0.68	1.18	0.98	29.39	6711.78
185250.00	250.00	-0.18	0.12	0.72	1.38	1.08	0.48	0.98	29.47	7357.58
185400.00	150.00	0.91	1.51	-0.19	0.29	0.00	1.39	0.56	15.49	3372.51
185600.00	200.00	-0.99	-0.79	1.91	2.19	1.99	0.00	1.39	44.50	5999.06
185900.00	300.00	1.51	-0.44	-0.59	0.00	1.64	1.79	1.14	35.15	11946.94
186100.00	200.00	-0.99	0.61	1.01	2.19	0.59	0.19	0.99	29.76	6491.19
186350.00	250.00	1.20	1.30	-0.30	0.00	0.00	1.50	0.50	13.71	5433.57
186600.00	250.00	-1.00	0.10	-0.20	2.20	1.10	1.40	1.56	51.36	8133.39
186900.00	300.00	0.50	0.10	-0.70	0.70	1.10	1.90	1.23	38.48	13475.56
187100.00	200.00	2.10	1.90	1.80	0.00	0.00	0.00	0.00	0.00	3847.64
187400.00	300.00	1.09	0.69	0.29	0.11	0.51	0.91	0.51	13.93	2089.00
187600.00	200.00	0.19	1.19	0.29	1.01	0.01	0.91	0.64	18.08	3201.14
187900.00	300.00	-1.01	0.39	1.09	2.21	0.81	0.11	1.04	31.55	7445.66
188100.00	200.00	1.19	1.49	0.69	0.01	0.00	0.51	0.18	4.53	3608.50
188450.00	350.00	-0.02	0.73	0.48	1.22	0.47	0.72	0.80	23.18	4849.98
188700.00	250.00	0.98	1.48	0.98	0.22	0.00	0.22	0.15	3.75	3366.40
188950.00	250.00	1.68	1.68	0.28	0.00	0.00	0.92	0.31	8.15	1486.91
189100.00	150.00	0.48	0.28	-0.02	0.72	0.92	1.22	0.96	28.46	2745.69
189500.00	400.00	-0.03	0.97	0.67	1.23	0.23	0.53	0.66	16.67	9426.33
189750.00	250.00	0.27	0.97	1.27	0.93	0.23	0.00	0.39	10.39	3632.52
190000.00	250.00	0.97	1.07	1.47	0.23	0.13	0.00	0.12	3.09	1685.66
190250.00	250.00	0.27	-0.33	-0.53	0.93	1.53	1.73	1.40	44.81	5988.48
190500.00	250.00	0.46	1.11	0.96	0.74	0.09	0.24	0.35	9.44	6782.03
190750.00	250.00	-0.84	0.36	-0.04	2.04	0.84	1.24	1.37	43.71	6643.81
191000.00	250.00	0.76	0.76	1.76	0.44	0.44	0.00	0.29	7.78	6436.32
191250.00	250.00	0.96	0.96	1.76	0.24	0.24	0.00	0.16	4.19	1496.45
191500.00	250.00	0.97	1.77	1.97	0.23	0.00	0.00	0.08	1.94	765.79
191750.00	250.00	0.98	1.48	0.68	0.22	0.00	0.52	0.24	6.42	1044.34
192000.00	250.00	0.69	0.99	1.29	0.51	0.21	0.00	0.24	6.20	1577.31
192250.00	250.00	0.31	0.31	0.66	0.89	0.89	0.54	0.78	22.43	3579.32
192500.00	250.00	1.22	1.27	1.02	0.00	0.00	0.18	0.06	1.53	2995.56
192750.00	250.00	-0.17	0.03	-0.47	1.37	1.17	1.67	1.40	44.92	5805.83
193000.00	250.00	1.74	0.44	0.54	0.00	0.76	0.66	0.47	12.91	7228.16
193250.00	250.00	1.05	0.70	1.75	0.15	0.50	0.00	0.21	5.58	2310.84
193500.00	250.00	-0.13	-0.03	-0.13	1.33	1.23	1.33	1.30	40.98	5819.30
193750.00	250.00	1.28	1.88	-0.02	0.00	0.00	1.22	0.41	11.01	6498.97
194000.00	250.00	1.29	1.39	1.29	0.00	0.00	0.00	0.00	0.00	1376.84
194250.00	250.00	0.00	1.45	1.20	1.20	0.00	0.00	0.40	10.79	1348.14
194500.00	250.00	0.81	1.81	0.51	0.39	0.00	0.69	0.36	9.58	2546.01
194750.00	250.00	0.63	1.03	-0.67	0.57	0.17	1.87	0.87	25.69	4409.61
195000.00	250.00	-0.46	0.94	0.34	1.66	0.26	0.86	0.93	27.56	6656.53
195250.00	250.00	0.05	1.15	0.75	1.15	0.05	0.45	0.55	15.29	5356.42
195500.00	250.00	0.26	0.41	-0.24	0.94	0.79	1.44	1.06	31.97	5907.70
195750.00	250.00	-0.03	1.77	1.17	1.23	0.00	0.03	0.42	11.33	5412.20
196000.00	250.00	0.58	1.28	1.78	0.62	0.00	0.00	0.21	5.34	2083.47
196250.00	250.00	0.90	0.10	0.50	0.30	1.10	0.70	0.70	20.06	3175.29
196600.00	350.00	1.76	1.61	-0.39	0.00	0.00	1.59	0.53	14.62	6070.23
196800.00	200.00	-0.08	0.82	0.12	1.28	0.38	1.08	0.91	26.92	4154.06
197000.00	200.00	0.03	1.73	0.23	1.17	0.00	0.97	0.71	20.33	4725.08
197250.00	250.00	0.64	1.79	1.84	0.56	0.00	0.00	0.19	4.81	3142.45
197600.00	350.00	1.16	0.86	-0.04	0.04	0.34	1.24	0.54	14.94	3455.92
197800.00	200.00	0.17	1.47	-0.43	1.03	0.00	1.63	0.89	26.10	4103.96
198100.00	300.00	-0.22	2.08	-0.42	1.42	0.00	1.62	1.01	30.37	8469.82
198350.00	250.00	-0.40	1.60	0.60	1.60	0.00	0.60	0.74	21.11	6434.28
198600.00	250.00	1.21	1.16	0.21	0.00	0.04	0.99	0.34	9.21	3789.66
198900.00	300.00	2.02	0.22	0.12	0.00	0.98	1.08	0.69	19.48	4303.26
199100.00	200.00	1.23	-0.37	0.43	0.00	1.57	0.77	0.78	22.50	4198.21
199400.00	300.00	0.35	2.15	1.95	0.85	0.00	0.00	0.28	7.52	4504.09
199600.00	200.00	2.06	2.16	0.36	0.00	0.00	0.84	0.28	7.43	1495.68
199800.00	200.00	1.46	1.46	0.66	0.00	0.00	0.54	0.18	4.62	1205.25
200100.00	300.00	0.68	1.68	1.48	0.52	0.00	0.00	0.17	4.49	1366.38
200400.00	300.00	1.19	1.49	0.69	0.01	0.00	0.51	0.17	4.42	1337.13

Chainage (m)	Length (m)	Reduced Soundings w.r.t C.D. (m)			Depth of cutting (m)			Average depth of cutting (m)	Area (m^2)	Quantity (m^3)
		Left	C	Right	Left	C	Right			
		25	0	25	25	0	25			
1	2	3	4	5	6	7	8	9	10	11
217200.00	300.00	0.68	0.98	1.38	0.52	0.22	0.00	0.24	6.38	1694.08
217450.00	250.00	2.10	1.90	1.70	0.00	0.00	0.00	0.00	0.00	798.07
217700.00	250.00	2.22	1.72	1.72	0.00	0.00	0.00	0.00	0.00	0.00
218000.00	300.00	1.03	1.48	0.73	0.17	0.00	0.47	0.21	5.49	822.89
218250.00	250.00	3.05	2.25	1.25	0.00	0.00	0.00	0.00	0.00	685.74
218500.00	250.00	1.77	1.27	0.77	0.00	0.00	0.43	0.14	3.73	466.22
218750.00	250.00	5.48	5.58	5.78	0.00	0.00	0.00	0.00	0.00	466.22
219000.00	250.00	4.30	4.80	5.30	0.00	0.00	0.00	0.00	0.00	0.00
219250.00	250.00	6.21	5.31	4.81	0.00	0.00	0.00	0.00	0.00	0.00
219600.00	350.00	6.83	6.53	5.83	0.00	0.00	0.00	0.00	0.00	0.00
219800.00	200.00	4.35	4.20	4.35	0.00	0.00	0.00	0.00	0.00	0.00
220000.00	200.00	4.71	3.86	2.86	0.00	0.00	0.00	0.00	0.00	0.00
220400.00	400.00	3.88	2.88	2.38	0.00	0.00	0.00	0.00	0.00	0.00
220600.00	200.00	4.89	3.39	2.39	0.00	0.00	0.00	0.00	0.00	0.00
220800.00	200.00	10.41	10.56	11.41	0.00	0.00	0.00	0.00	0.00	0.00
221100.00	300.00	3.43	3.43	2.23	0.00	0.00	0.00	0.00	0.00	0.00
221300.00	200.00	4.44	4.49	5.44	0.00	0.00	0.00	0.00	0.00	0.00
221600.00	300.00	2.96	4.26	3.96	0.00	0.00	0.00	0.00	0.00	0.00
221800.00	200.00	4.27	4.02	3.97	0.00	0.00	0.00	0.00	0.00	0.00
222100.00	300.00	3.49	3.39	3.49	0.00	0.00	0.00	0.00	0.00	0.00
222400.00	300.00	3.91	3.41	2.91	0.00	0.00	0.00	0.00	0.00	0.00
222600.00	200.00	2.42	2.62	3.42	0.00	0.00	0.00	0.00	0.00	0.00
222800.00	200.00	3.43	4.43	5.43	0.00	0.00	0.00	0.00	0.00	0.00
223100.00	300.00	4.45	4.20	3.45	0.00	0.00	0.00	0.00	0.00	0.00
223500.00	400.00	2.27	2.27	1.97	0.00	0.00	0.00	0.00	0.00	0.00
223750.00	250.00	4.99	4.74	3.49	0.00	0.00	0.00	0.00	0.00	0.00
224000.00	250.00	4.50	4.00	5.50	0.00	0.00	0.00	0.00	0.00	0.00
224250.00	250.00	6.72	6.52	6.02	0.00	0.00	0.00	0.00	0.00	0.00
224500.00	250.00	5.64	4.64	4.69	0.00	0.00	0.00	0.00	0.00	0.00
224750.00	250.00	6.65	6.15	6.40	0.00	0.00	0.00	0.00	0.00	0.00
224900.00	150.00	4.66	4.66	4.16	0.00	0.00	0.00	0.00	0.00	0.00
225200.00	300.00	3.18	3.08	3.18	0.00	0.00	0.00	0.00	0.00	0.00
225400.00	200.00	1.69	2.19	2.19	0.00	0.00	0.00	0.00	0.00	0.00
225600.00	200.00	3.50	2.70	2.70	0.00	0.00	0.00	0.00	0.00	0.00
225800.00	200.00	2.72	2.77	4.72	0.00	0.00	0.00	0.00	0.00	0.00
226100.00	300.00	4.73	4.63	3.73	0.00	0.00	0.00	0.00	0.00	0.00
226400.00	300.00	3.75	3.55	1.75	0.00	0.00	0.00	0.00	0.00	0.00
226600.00	200.00	3.77	3.77	2.27	0.00	0.00	0.00	0.00	0.00	0.00
226800.00	200.00	2.68	3.58	3.78	0.00	0.00	0.00	0.00	0.00	0.00
227100.00	300.00	3.80	4.10	3.90	0.00	0.00	0.00	0.00	0.00	0.00
227400.00	300.00	2.71	3.11	1.71	0.00	0.00	0.00	0.00	0.00	0.00
227600.00	200.00	3.43	3.03	2.73	0.00	0.00	0.00	0.00	0.00	0.00
227900.00	300.00	2.75	3.55	2.25	0.00	0.00	0.00	0.00	0.00	0.00
228100.00	200.00	2.56	2.76	2.26	0.00	0.00	0.00	0.00	0.00	0.00
228400.00	300.00	2.98	3.78	4.28	0.00	0.00	0.00	0.00	0.00	0.00
228700.00	300.00	2.80	3.80	4.30	0.00	0.00	0.00	0.00	0.00	0.00
228900.00	200.00	2.61	4.01	2.81	0.00	0.00	0.00	0.00	0.00	0.00
229200.00	300.00	3.53	4.03	2.33	0.00	0.00	0.00	0.00	0.00	0.00
229400.00	200.00	2.94	1.64	1.84	0.00	0.00	0.00	0.00	0.00	0.00
229600.00	200.00	3.35	3.35	2.55	0.00	0.00	0.00	0.00	0.00	0.00
229900.00	300.00	3.87	3.47	3.37	0.00	0.00	0.00	0.00	0.00	0.00
230100.00	200.00	2.88	2.88	2.68	0.00	0.00	0.00	0.00	0.00	0.00
230400.00	300.00	3.00	3.30	4.20	0.00	0.00	0.00	0.00	0.00	0.00
230600.00	200.00	3.81	3.71	3.91	0.00	0.00	0.00	0.00	0.00	0.00
230800.00	200.00	4.73	4.53	4.83	0.00	0.00	0.00	0.00	0.00	0.00
231000.00	200.00	1.54	3.79	3.94	0.00	0.00	0.00	0.00	0.00	0.00
231250.00	250.00	2.45	3.05	1.45	0.00	0.00	0.00	0.00	0.00	0.00
231600.00	350.00	2.47	3.37	2.07	0.00	0.00	0.00	0.00	0.00	0.00
231800.00	200.00	2.19	3.49	1.89	0.00	0.00	0.00	0.00	0.00	0.00
232000.00	200.00	4.20	4.20	3.40	0.00	0.00	0.00	0.00	0.00	0.00
232250.00	250.00	2.51	4.61	4.51	0.00	0.00	0.00	0.00	0.00	0.00
232500.00	250.00	3.23	3.33	0.83	0.00	0.00	0.37	0.12	3.16	394.86
232750.00	250.00	0.75	4.45	3.05	0.45	0.00	0.00	0.15	3.90	882.64

CHAPTER - 5

PLANNING OF TERMINALS

CHAPTER-5

PLANNING OF TERMINALS

5.0 INTRODUCTION

The terminal planning and design includes selection of suitable sites in the vicinity of the cargo concentrations considering all the relevant technical factors, choosing the type of berthing facility and providing of covered/open storages, cargo handling systems and other ancillary facilities for efficient terminal operation. Once the type selection for the various facilities have been made the scale of facilities has been decided on the basis of anticipated traffic volume and the system throughputs and the type of cargo, selection of the requisite facilities will be made. The cost estimates capital and operating costs will be made for each of the proposed system at the respective terminals considering the system design and the annual throughput. These aspects are dealt in subsequent paras in the above mentioned sequence.

5.1 TERMINAL SITE SELECTION

Site selection is the most important factor as it dictates the investment for establishing the terminal facilities. Therefore utmost care is taken to select most reliable locations to minimise the capital and the recurring cost for the terminals.

5.1.1 CRITERIA FOR SELECTION OF SITE

- Traffic potentiality and commodity characteristics.
- Navigational safety.
- Optimum size of vessel expected to use the waterway.
- Cargo handling Technique.
- Availability of land required for infrastructure.
- Likely technological changes in the methods of cargo handling and vessel design etc.
- River morphology and behavior, stable river channel, sufficient depth.
- Favorable hydraulic conditions for berthing and cargo handling.
- Low water line shall be close to High bank.

5.1.2 PLANNING CONSIDERATIONS

The terminal facilities recommended include:

- Berthing facilities for vessels.
- Cargo storage facilities.
- Cargo handling facilities.
- Other ancillary facilities.

5.1.3 PROPOSED TERMINAL SITES

River	Terminal Location
Kosi River	Kalyanpur
	Basbitti
	Dambharaghat
	Kursela

5.1.4 PROJECTED TRAFFIC AT PROPOSED TERMINAL

TERMINAL	Base Year 2012-13 (Tons)	2025-26 (Tons)	2035-36 (Tons)
Kalyanpur	481180	1026323	1837989
Basbitti	400912	855117	1531384
Dambharaghat	301757	643627	1152637
Kursela	233937	498971	893581

5.2 DESCRIPTION OF SELECTED SITES

5.2.1 KALYANPUR

The river terminal is proposed downstream of the Kosi Barrage on the left bank of the river Kosi as shown in Drg.No.RITES/KALYANPUR/01. The terminal is about 31.500 km away from Kosi Barrage. The main channel is on the left bank with adequate water depth. The terminal is connected by road and will be connected to its hinterland Supaul. The terminal is very near to Terhi Bazar–Madhepura(NH-106) and will be connected to other important places like Nirmali, Madhepura, Pipra, Raghopur, Chhatapur, Kishanpur etc.

5.2.2 BASBITTI

The river terminal is proposed on the right bank of the river Kosi as shown in Drg.No.RITES/BASBITTI/01. The terminal is about 73.250 km away from Kosi Barrage. The main channel is on the right bank with sufficient water depth. The terminal is very near to Darbhanga–Madhepura (NH-57) and will be connected to other important places like Nirmali, Madhepura, Dumaria, Ghuran, Dobhari, Basua etc. Other important road in near by location Sukhpur-Pipra and Sukhpur-Marauna road. Nearby railway line is Supaul-Saharsa-Madhepura.

5.2.3 DAMBHARAGHAT

The river terminal is proposed on the left bank of the river Kosi as shown in Drg.No.RITES/DAMBHARAGHAT/01. The terminal is about 144.000 km away from Kosi Barrage and very near to Dambharaghat railway bridge. The channel has sufficient water depth. The terminal is very near to Khagaria - Sukhpur road and will be connected to other important places like Koparia, Dhanchaur, Goar, Khagaria and Kursela etc. Nearby railway line is Khagaria-Supaul.

5.2.4 KURSELA

The proposed site for terminal development is upstream of the Kursela road bridge (NH-31) on the right bank of river Kosi. Location plan of this terminal is shown in Drg.No. RITES/KURSELA/01. The terminal is about 1.187 km away from Kursela road bridge (Begusaray–Purnea).

The possibility of locating this terminal on the left bank of river upstream of the road bridge is ruled out as the channel in the lean season is far away from the left bank and formation of sand char.

5.3 TERMINAL FACILITIES

5.3.1 GENERAL

The type of cargo handling system required at the terminals is generally dependant on the type of cargo, the annual volume required to be handled and the size of the vessels deployed in the system. The various cargoes

foreseen to be handled at the terminals have been classified primarily into two groups:

(i) Incoming cargoes, and

(ii) Outgoing cargoes.

These two groups have been further sub-divided into bulk, bagged and other miscellaneous general cargo for the purpose of planning the cargo handling system requirements. The quantum and other cargo compositions will be finalised with the detailed traffic report which in progress.

- Bulk cargo (Construction Material–Sand, Stone, Bricks, Marble, Iron, Steel, Machinery–Light & Heavy; Mineral Ore–Lime stone, Iron and Copper ore; Conventional Fuels–Coal and Firewood).

- Bagged cargo(Construction Material–Cement; Chemicals-Fertilizer, Wine, Beverage & Soft Drink, Acids; Cereals/Cash crops–Wheat, Rice, Bajra, Gram, Pulses, Cotton etc).

Miscellaneous general cargo (Consumer Goods, Animals, Oil Cake, Edible oil, Refined oil, Paper Products).

5.3.2 BASIC ASSUMPTION FOR THE PLANNING OF FACILITIES

For the purposes of planning the terminal facilities and the infrastructure, the following assumptions have been made:

- Terminal facilities would be planned for the initial traffic projected for base year and would be expanded in the subsequent development phase upto the horizon year 2035-36. System will be planned in such a manner that any additions to the facilities will be possible for handling future traffic. Terminals layouts prepared will ensure that entire facilities can be expanded to meet the ultimate traffic projected for the year 2035-36.
- Number of days the berths are considered available for operation is 300 days per year.
- Navigation of vessels in the river includes day navigation except during flood season when operation would be suspended.

- Number of shifts for vessel loading/unloading operations and onshore facilities is considered as 1 per day.
- Average time required for to and fro movement from anchorage to berth, berthing time, other formalities etc. is considered as 1 hour per vessel.
- All hinterland transportation of material out of the facilities or into the facility is assumed to be by trucks.
- Since the distance between the loading and the unloading terminal is relatively large, the arrival pattern of the vessels at the terminals is expected to be random.
- Ratings of equipment as well as the storage facility requirements etc. have been planned considering the inter-arrival rate of vessels.
- Storage capacities provided at the facility will be adequate to guarantee loading or unloading of vessels even during disruption of road transportation of 5 days.
- Maximum truck size assumed is 10 Tonnes payload.
- Average vessel size is assumed as 100 T with a full loaded draft of 1.0m. One vessel load will contain material for one destination only.
- All bulk cargoes, which are not affected by weather, will be stored in open stock pile. All bagged cargo will be stored in covered sheds.
- The storm water drainage provided at the terminals will discharge into the river.
- It is assumed that captive vessel fleet will be used for transportation of bulk, bagged and miscellaneous general cargo. This arrangement will help to reduce the turn-around time of vessels and also increase the handling efficiency of the on-shore equipment. In the case of bulk cargo, the last few layers of material in the barge bottom, will require manual assistance to unload and thus will take considerable time for unloading in comparison to quantum of material to be unloaded in this manner.
- Customs clearance or any kind of security check is foreseen for the materials/cargo to be handled at these facilities.

5.3.3 TERMINAL PLANNING

Based on the above consideration and the traffic projections the terminal planning requirements have been evaluated for handling the various bagged, bulk and miscellaneous general cargoes and are summarized as per traffic study.

For the foreseen volumes of cargo required to be handled at different terminals at the various throughput development stages, terminal requirements have been worked out. The detailed description of each of the proposed terminals is as given below:

5.3.3.1 KALYANPUR TERMINAL FACILITIES

Schematic Layout of IWT Terminal at Kalyanpur is given in Drg.No. RITES/KALYANPUR/01. At this terminal, it is proposed to have 2 nos. Pontoon to meet the traffic of 2012-13 and 7 nos. Pontoon to meet the projected traffic level in the period 2035-36.

In the proposed terminal site low water line is 20m away from the high bank. Berths have been proposed 50m from the high bank to reduce the gangway length.

Considering the design vessel of 100 Tonnes, the pontoon length proposed is 35m with width of 9m. Also, gangway of 50m in length and 2.5m width is required to be provided for movement of material to & from the pontoon manually.

One mobile crawler mounted cranes of 5 tonnes capacity, with hook and grab options suitable for handling bagged and bulk cargo. The maximum outreach required for this crane is 18m.

Details of Berthing Facilities of Kalyanpur Terminal on river Kosi is given in Drg. No. RITES/KALYANPUR/02.

The facilities proposed at the terminal back-up area is the following:

- Covered storage area of (50m X 30m) for cement, fertilizer, wheat, rice, bajra, gram, pulses, cotton, wine, beverage, soft drink, paper products etc. Proposed roof truss details is given in Drg.No.RITES/TERMINAL/SHED-05 (Typical).
- Open storage area of 4800 sqm for sand, stone, bricks, marble, iron–steel, light and heavy machinery, lime stone, Iron–copper, coal–firewood.
- Two lane access road of 7.000 km will be developed to connect the terminal with its hinterland Supaul.

In addition to the above, the terminal facilities cover, the present & future requirements of truck parking area, office building cum canteen, watchman shed. Also, the terminal requirements include lighting, drainage, fencing and gate.

The phased developmental plan is as follows:

Description	Base Year 2012-13	2025-26	2035-36
Pontoon (35mX9m)	2 nos.	4 nos.	7 nos.
Gangway (50mX2.5m)	2 nos.	4 nos.	7 nos.
Crane 5T capacity (10cycles/hr,18m outreach)	1 no.	3 nos.	4 nos.
Dumper Truck	4 nos.	8 nos.	15 nos.
Covered Storage (for bagged cargo)	50m X 30m	100m X 30m	150m X 60m
Open Storage (for bulk cargo)	4800 sqm.	10440 sqm.	15200 sqm.

The total area requirement for Kalyanpur Terminal is 90m X 70m in base year, 160m X 84m in 2025-26 and 220m X 110m in 2035-36. Future land will be procured in base year.

5.3.3.2 BASBITTI TERMINAL FACILITIES

Schematic Layout of IWT Terminal at Basbitti is given in Drg.No. RITES/BASBITTI/01. At this terminal, it is proposed to have 2 nos. pontoon to meet the traffic of 2012-13 and 6 nos. to meet the projected traffic level in the period 2035-36.

In the proposed terminal site low water line is 30m away from the high bank. Berth have been proposed 70m from the high bank to reduce the gangway length.

Considering the design vessel of 100 Tonnes, the pontoon length required is 35m with width of 9m. Also, gangway of 70m in length and 2.5m width is required to be provided for movement of material to & from the pontoon manually.

One mobile crawler mounted cranes of 5 tonnes capacity, with hook and grab options suitable for handling bagged and bulk cargo. The maximum outreach required for this crane is 18m.

Details of Berthing Facilities of Basbitti Terminal on river Kosi is given in Drg.No. RITES/BASBITTI/02.

The facilities proposed at the terminal back-up area is the following:

- Covered storage area of (40m X 30m) for cement, fertilizer, wheat, rice, bajra, gram, pulses, cotton, wine, beverage, soft drink, paper products etc.

Proposed roof truss details is given in Drg.No.RITES/TERMINAL/SHED-05 (Typical).

- Open storage area of 4400 sqm for sand, stone, bricks, marble, iron–steel, light and heavy machinery, lime stone, Iron–copper, coal–firewood.
- Two lane access road of 3.000 km will be developed to connect the terminal with its hinterland District Supaul and Madhepura.

In addition to the above, the terminal facilities cover, the present & future requirements of truck parking area, office building cum canteen, watchman shed. Also, the terminal requirements include lighting, drainage, fencing and gate.

The phased developmental plan is as follows:

Description	Base Year 2012-13	2025-26	2035-36
Pontoon (35m X 9m)	2 nos.	4 nos.	6 nos.
Gangway (70mX2.5m)	2 nos.	4 nos.	6 nos.
Crane 5T capacity (10cycles/hr,18m outreach)	1 no.	2 nos.	4 nos.
Dumper Truck	3 nos.	5 nos.	10 nos.
Covered Storage (for bagged cargo)	40m X 30m	90m X 30m	140m X 60m
Open Storage (for bulk cargo)	4400sqm.	8500sqm.	11600sqm.

The total area requirement for Basbitti Terminal is 80m X 70m in base year, 140m X 80m in 2025-26 and 200m X 100m in 2035-36. Future land will be procured in base year.

5.3.3.3 DAMBHARAGHAT TERMINAL FACILITIES

Schematic Layout of IWT Terminal at Dambharaghat is given in Drg.No. RITES/DAMBHARAGHAT/01. At this terminal, it is proposed to have one pontoon to meet the traffic of 2012-13 and 4 nos. pontoon to meet the projected traffic level in the period 2035-36.

In the proposed terminal site low water line is 30m away from the high bank. Pontoon have been proposed 70m from the high bank to reduce the gangway length.

Considering the design vessel of 100Tonnes, the pontoon length required is 35m with width of 9m. Also, gangway of 70m in length and 2.5m width is required to be provided for movement of material to & from the pontoon manually.

One mobile crawler mounted cranes of 5 tonnes capacity, with hook and grab options suitable for handling bagged and bulk cargo. The maximum outreach required for this crane is 18m.

Details of Berthing Facilities of Dambharaghat Terminal on river Kosi is given in Drg.No. RITES/DAMBHARAGHAT/02.

The facilities proposed at the terminal back-up area is the following:

- Covered storage area of (35m X 30m) for cement, fertilizer, wheat, rice, bajra, gram, pulses, cotton, wine, beverage, soft drink, paper products etc. Proposed roof truss details is given in Drg.No.RITES/TERMINAL/SHED-05 (Typical).
- Open storage area of 2850sqm for sand, stone, bricks, marble, iron–steel, light and heavy machinery, lime stone, Iron–copper, coal–firewood.
- Two lane access road of 3.000km will be developed to connect the terminal with its hinterland District Khagaria and Bhagalpur.

In addition to the above, the terminal facilities cover, the present & future requirements of truck parking area, office building cum canteen, watchman shed. Also, the terminal requirements include lighting, drainage, fencing and gate.

The phased developmental plan is as follows:

Description	Base Year 2012-13	2025-26	2035-36
Pontoon (35m X 9m)	1 no.	2 nos.	4 nos.
Gangway(70mX2.5m)	1 no.	2 nos.	4 nos.
Crane 5T capacity (10cycles/hr,18m outreach)	1 no.	2 nos.	3 nos.
Dumper Truck	2 nos.	4 nos.	8 nos.
Covered Storage (for bagged cargo)	35m X 30m	80m X 30m	130m X 30m
Open Storage (for bulk cargo)	2850sqm.	6000sqm.	10500sqm.

The total area requirement for Dambharaghat Terminal is 65m X 60m in base year, 120m X 70m in 2025-26 and 180m X 80m in 2035-36. Future land will be procured in base year.

5.3.3.4 KURSELA TERMINAL FACILITIES

Schematic Layout of IWT Terminal at Kursela is given in Drg.No. RITES/KURSELA/01. At this terminal, it is proposed to have single pontoon to meet the traffic of 2012-13 and 4 nos. pontoon to meet the projected traffic level in the period 2035-36.

In the proposed terminal site low water line is 35m away from the high bank. Pontoon have been proposed 70m from the high bank to reduce the approach length.

Considering the design vessel of 100 Tonnes, the pontoon length required is 35m with width of 9m. Also, gangway of 70m in length and 2.5m width is required to be provided for movement of material to & from the pontoon manually.

One no. mobile crawler mounted cranes of 5 tonnes capacity, with hook and grab options suitable for handling bagged and bulk cargo. The maximum outreach required for this crane is 18m.

Details of Berthing Facilities of Kursela Terminal at river Kosi is given in Drg.No. RITES/KURSELA/02.

The facilities proposed at the terminal back-up area is the following:

- Covered storage area of (30m X 30m) for fertilizer and food grains, paper and paper products, machinery parts, provisions, general goods, cement, fertilizer, food grains. Proposed roof truss details is given in Drg.No. RITES/TERMINAL/SHED-05 (Typical).
- Open storage area of 2100 sqm for timber & wood, sand and building material, iron and steel.
- Two lane access road 1.187 km long to connect the terminal with Begusaray-Purnea National Highway(NH-31). Existing earthen bund will be upgraded as access road.

In addition to the above, the terminal facilities cover, the present & future requirements of truck parking area, office building cum canteen, watchman shed. Also, the terminal requirements include lighting, drainage, fencing and gate.

The phased developmental plan is as follows:

Description	Base Year 2012-13	2025-26	2035-36
Pontoon (35m X 9m)	1 no.	2 nos.	4 nos.
Gangway(70mX2.5m)	1 no.	2 nos.	4 nos.
Crane 5T capacity (10cycles/hr,18m outreach)	1 no.	1 no.	2 nos.
Dumper Truck	2 nos.	3 nos.	5 nos.
Covered Storage (for bagged cargo)	30m X 30m	50m X 30m	90m X 30m
Open Storage (for bulk cargo)	2100 sqm.	4800 sqm.	8500 sqm.

The total area requirement for Kursela Terminal is 60m X 50m in base year, 90m X 70m in 2025-26 and 140m X 80m in 2035-36. Future land will be procured in base year.

5.3.3.5 PATNA TERMINAL FACILITIES

Gaighat-IWAI terminal which is being presently operated by IWAI for water transport, will be used for these waterways.

5.4 SELECTION OF BERTHING STRUCTURE

5.4.1 GENERAL

Among the numerous structural forms and layout available for terminal planning, only few are convenient to handle the designated cargo efficiently at moderate investment levels, with distinct operational advantage.

The two possible alternative berthing structure considered in the evaluation are:

- Floating pontoon with access bridge.
- Open type structure(R.C.C deck with piles for berth and approaches)

5.4.2 FLOATING PONTOON

This alternative is generally the most cost-effective form of berthing facility that can be provided at inland water terminals with less water level variations. However, as this arrangement at best can be operated as a semi-mechanized facility with suitable loading/unloading equipment located on the pontoon, the movement of cargo to & from the pontoon through the access bridge will necessary have to be a manual operation. The entire loading/unloading operation being semi-mechanized will handle lower cargo volume per pontoon berth annually & consequently require larger number of pontoon berths for a given throughput.

Also, in terminal locations with large difference between the high and low water levels, the length of the access bridge becomes the limiting factor, considering the normal gradients that are necessary to be provided for manual working.

In view of the above limitations, this alternative of floating pontoon with access-bridge is considered further in planning the terminal facilities even though this arrangement does not influence the hydraulic regime in the river. Floating pontoon arrangement has been considered for terminals in Kosi river.

5.4.3 OPEN TYPE STRUCTURE (R.C.C. Berth & Approach Jetty on Piles)

This alternative provides many favourable features and can comply with the project requirements with minimal implications on environment and project economics.

The jetty head is located inside the river basin and is connected to the bank by approach. The R.C.C deck structure will be supported by RCC piles.

The connecting approaches are made of RCC deck supported on piles. The slender pile for the berth and approaches would not disturb the hydraulic regime in the proximity of the terminals because of the open type construction with a minimum blockage to the river flow.

5.5 DETAILS OF FLOATING PONTOON

Steel Gangway and Pontoon system has been proposed for the river terminals.

5.5.1 PONTOON AND GANGWAY SYSTEM

The river being wide enough to allow unhindered navigation, floating pontoon with steel gangway type with berthing face parallel to the main stream has been adopted at terminal sites. The option of providing RCC jetty with couple mechanical – handling system was considered in view of its inherent technical

superiority, however it has not been recommended because its cost is too prohibitive to be economically viable. Besides this water level fluctuation is approx. 7m. The berthing face has been taken up to the reported stable low water line with adequate water depth. Shore connection to the berth has been provided by an approach steel gangway with trestle. The length of approach however depends on the availability of low water line during the lean period. 35m X 9m steel pontoon has been considered for all terminal considering vessel specification and quantam of cargo. 2 nos.-35m X 2.5m i.e. 70m length of steel gangway have been considered for Basbitti, Dambharaghat, Kursela terminals.

5.6 DESIGN CRITERIA

Some suitable assumptions have been made from our previous survey report. Soil parameters summarized below are as obtained from first hand information geo-technical investigations and are based on suitable assumption at the terminal location sites are used in the design of the civil structures.

Description	Angle of internal friction (φ) in degrees	Cohesion Kg/cm^2	Bulk Density t/m^3
Kursela	32	0.0	1.5
Downstream of Kosi Barrage	30	0.0	1.8

The following considerations made for terminals.

River current Velocity : 3.0 m/sec. (Mean)

Berthing Force : 100 Tonnes vessel approaching at a velocity of 0.45m/sec at an angle of 10° to berth

Relevant Indian Standards viz. IS: 4651, IS: 456, IS: 800, IS: 875, IS: 1893, IS: 2911, IS: 5, IS: 6, IS: 78 etc have been followed in the design.

Typical cross section of the access road is shown in Drg. No.RITES/TERMINAL/03.

Typical Bank protection (stone pitching) for terminal area is shown in Drg. No.RITES/TERMINAL/04.

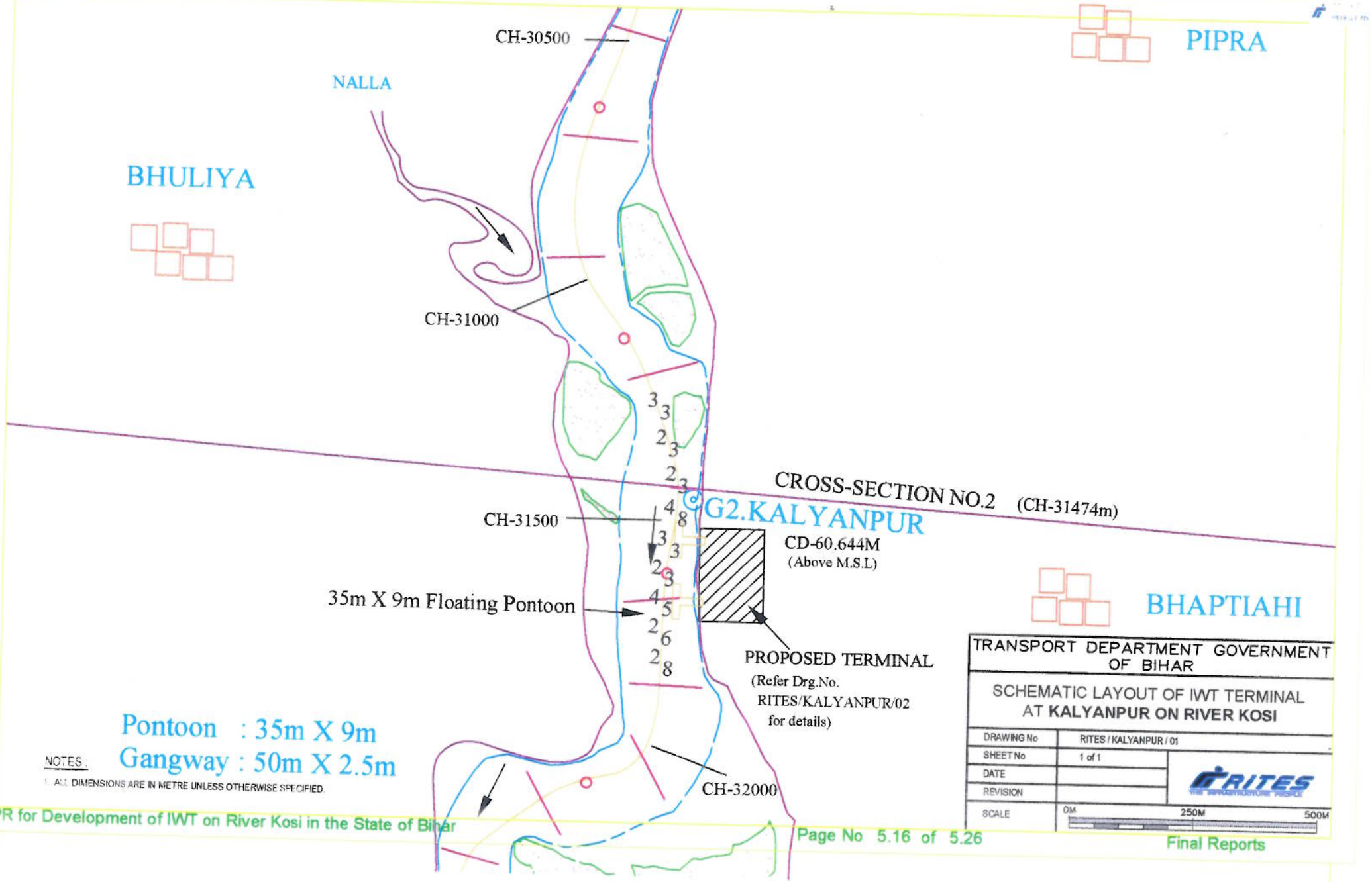
TABLE 5.1: PONTOON AND CRANE REQUIREMENTS

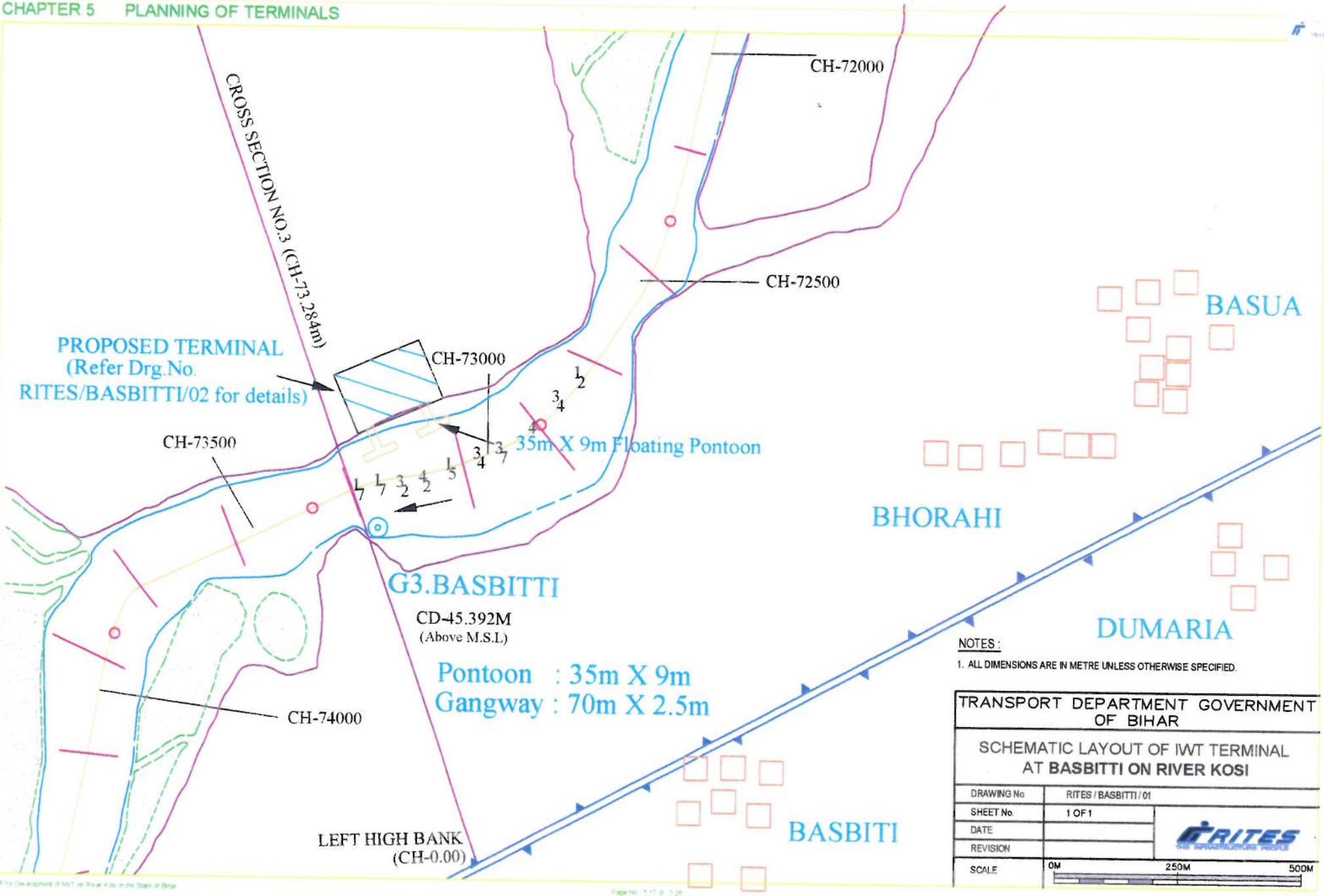
Terminal	2012-13		2035-36	
			← Additional →	
	No. of Pontoon	Crane Required Cycles/hour	No. of Pontoon	Crane Required Cycles/hour
Kalyanpur -Unloading -Loading	2	1 5T X 10C/hr	5	3 5T X 10C/hr
Basbitti -Unloading -Loading	2	1 5T X 10C/hr	4	3 5T X 10C/hr
Dambharaghat -Unloading -Loading	1	1 5T X 10C/hr	3	2 5T X 10C/hr
Kursela -Unloading -Loading	1	1 5T X 10C/hr	3	1 5T X 10C/hr

TABLE 5.2

Manpower Requirements at Each Terminal in Base Year

S.No.	Item	No. of Personnel Required
1	Crane Operators	1
2	Fork lift Truck Operator	1
3	Pay loader Operator	1
4	Dumper Truck Operator	6
5	Electrical Supervisor	1
6	Weigh Bridge Operator	1
7	Maintenance Staff -Mechanical -Electrical -Civil -Skilled -Unskilled	 1 1 2 3 3
8	Office staff -Terminal Manager/Supervisor -Clerical Staff	 1 2
9	Security Staff	3
	TOTAL	**27**


CH-30500
NALLA
PIPRA
BHULIYA
CH-31000
CROSS-SECTION NO.2 (CH-31474m)
CH-31500
G2.KALYANPUR
CD-60.644M
(Above M.S.L)
35m X 9m Floating Pontoon
BHAPTIAHI
PROPOSED TERMINAL
(Refer Drg.No.
RITES/KALYANPUR/02
for details)
CH-32000
Pontoon : 35m X 9m
Gangway : 50m X 2.5m
NOTES:
1. ALL DIMENSIONS ARE IN METRE UNLESS OTHERWISE SPECIFIED.
TRANSPORT DEPARTMENT GOVERNMENT OF BIHAR
SCHEMATIC LAYOUT OF IWT TERMINAL AT KALYANPUR ON RIVER KOSI
DRAWING No RITES / KALYANPUR / 01
SHEET No 1 of 1
DATE
REVISION
SCALE 0M 250M 500M
RITES



NOTES :

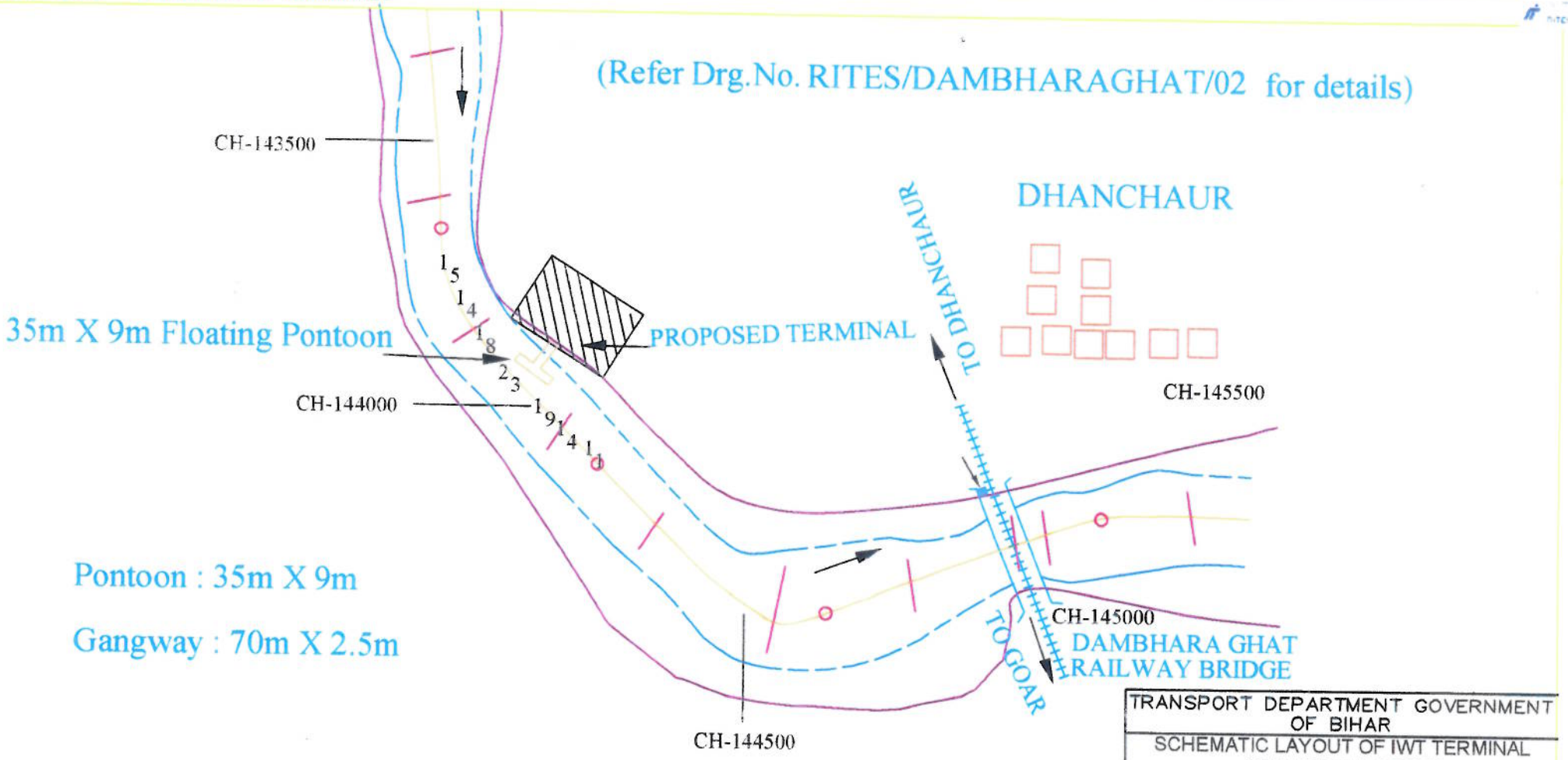
1. ALL DIMENSIONS ARE IN METRE UNLESS OTHERWISE SPECIFIED.

TRANSPORT DEPARTMENT GOVERNMENT OF BIHAR

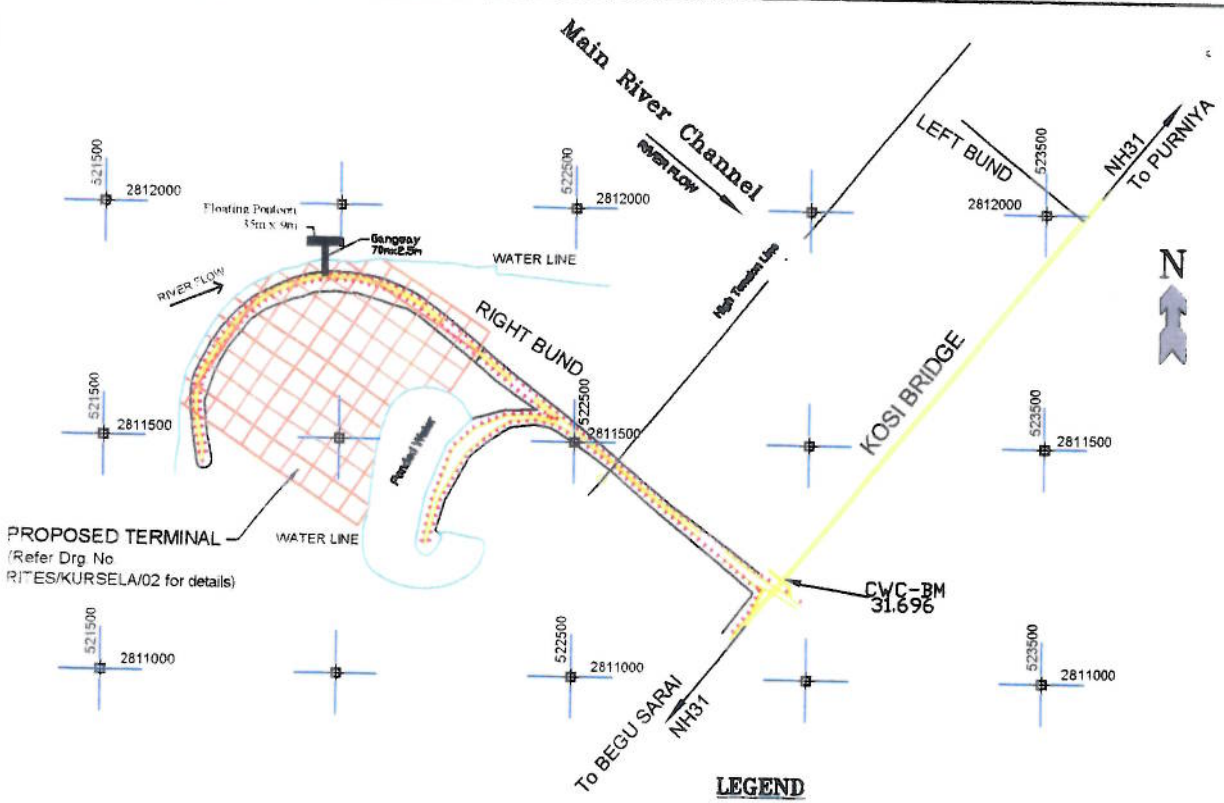
SCHEMATIC LAYOUT OF IWT TERMINAL AT **BASBITTI ON RIVER KOSI**

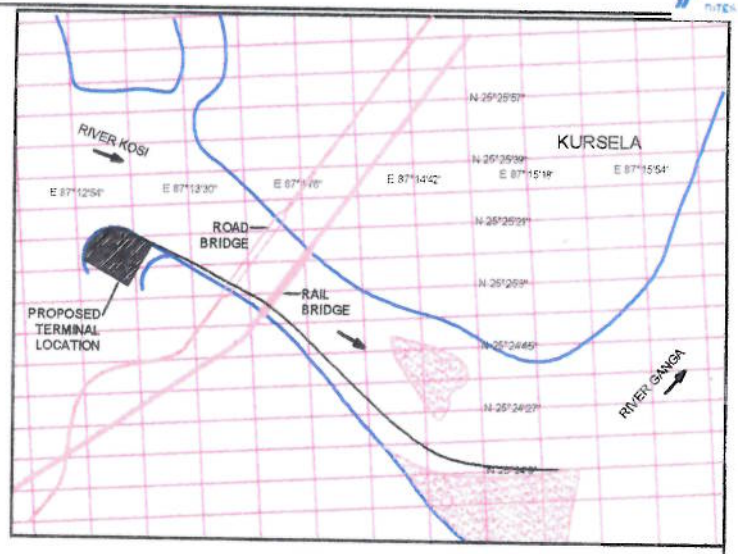
DRAWING No	RITES / BASBITTI / 01
SHEET No.	1 OF 1
DATE	
REVISION	
SCALE	0M 250M 500M

RITES THE INFRASTRUCTURE PEOPLE



TRANSPORT DEPARTMENT GOVERNMENT OF BIHAR		
SCHEMATIC LAYOUT OF IWT TERMINAL AT **DAMBHARAGHAT** **ON RIVER KOSI**		
DRAWING No	RITES / DAMBHARAGHAT / 01	
SHEET No.	1 of 1	
DATE		
REVISION		
SCALE	0M 250M 500M	





KEY PLAN

Pontoon : 35m X 9m

Gangway : 70m X 2.5m

NOTES :

1. ALL DIMENSIONS ARE IN METRE UNLESS OTHERWISE SPECIFIED.

LEGEND

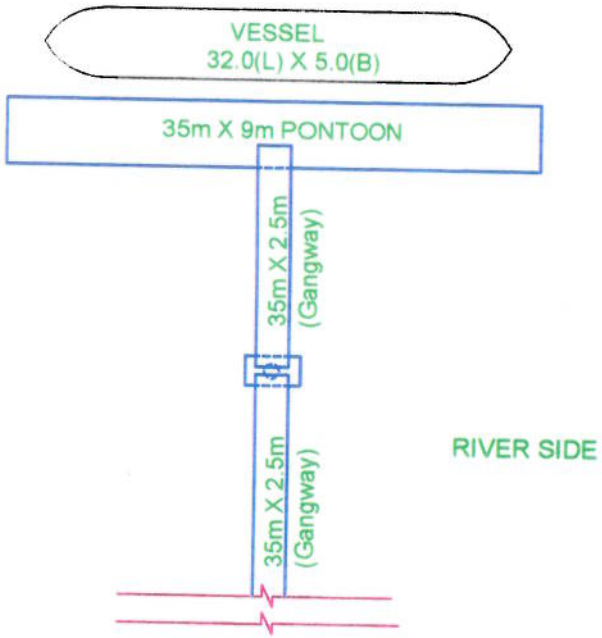
1.	KOSI RIVER/ DRAIN	
2.	WATRE LINE	
3.	METALLED ROAD	
4.	CART TRACK	
5.	ELECTRIC LINE	
6.	TELEPHONE LINE	
7.	EARTHEN BUND	
8.	HABITATION / HOUSES	

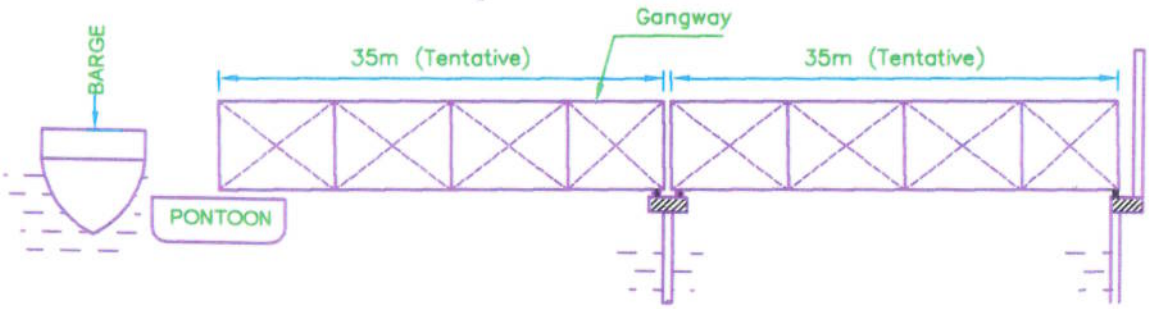
TRANSPORT DEPARTMENT GOVERNMENT OF BIHAR

SCHEMATIC LAYOUT OF IWT TERMINAL AT KURSELA ON RIVER KOSI

DRAWING No	RITES / KURSELA / 01
SHEET No.	1 OF 1
DATE	
REVISION	
SCALE	0M 500M 1000M

RITES THE INFRASTRUCTURE PEOPLE





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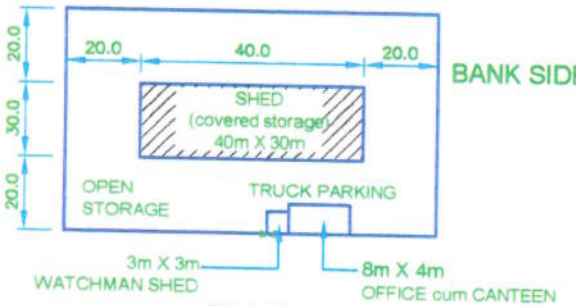


PLAN
(SCALE 1: 1000)

LEGEND :

(A) SHIP DESIGN SPECIFICATION

1. LENGTH OF VESSEL = 32.0mtr.
2. BEAM (WIDTH OF SHIP) = 5.0mtr. (Approx)
3. DRAUGHT = 1.0mtr.
4. CARGO CARRYING ~ 100 tons (D=1.0m)

(B) JETTY DESIGN SPECIFICATION

1. PONTOON = 35m (L) X 9m (W)
2. GANGWAY = 35m (L) X 2.5m (W) X 2Nos

NOTES :

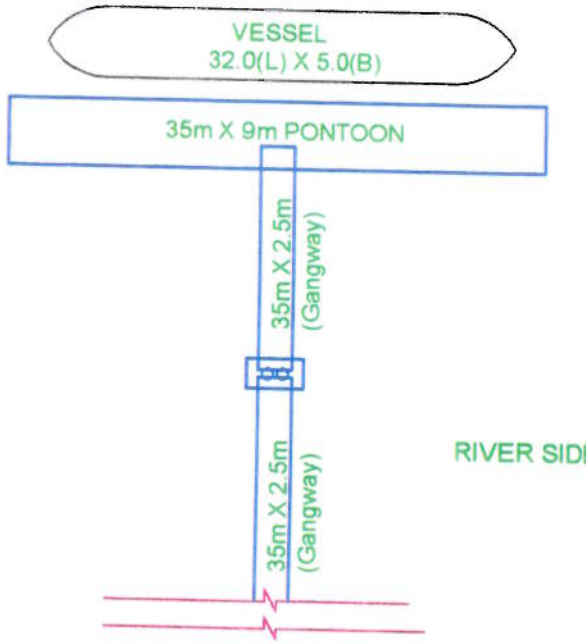
1. ALL DIMENSIONS ARE IN METRE UNLESS OTHERWISE SPECIFIED.

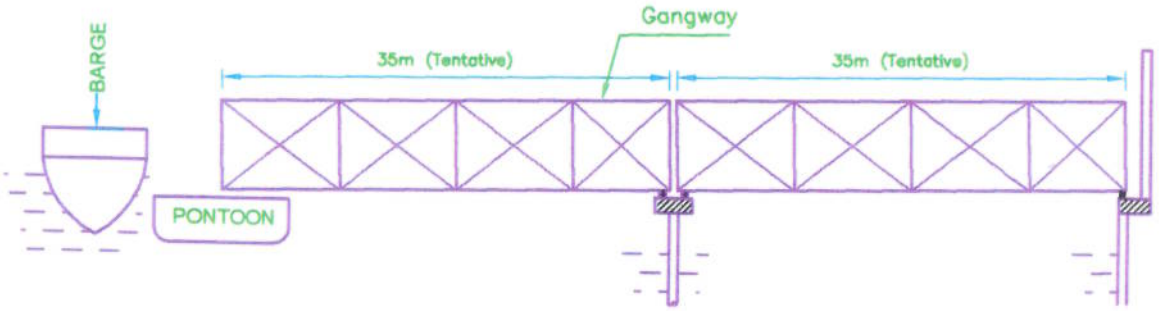
TRANSPORT DEPARTMENT
GOVERNMENT OF BIHAR

DETAILS OF BERTHING FACILITIES OF BASBITTI ON RIVER KOSI

DRAWING No	RITES /BASBITTI/ 02
SHEET No.	1 OF 1
DATE	
REVISION	
SCALE	0M 25M 50M

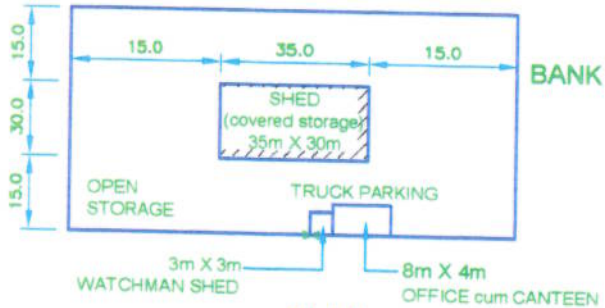
RITES
THE INFRASTRUCTURE PEOPLE





SECTION

(SCALE 1: 500)



PLAN

(SCALE 1: 1000)

LEGEND :

(A) SHIP DESIGN SPECIFICATION

1. LENGTH OF VESSEL = 32.0mtr.
2. BEAM (WIDTH OF SHIP) = 5.0mtr. (Approx)
3. DRAUGHT = 1.0mtr.
4. CARGO CARRYING ~ 100 tons (D=1.0m)

(B) JETTY DESIGN SPECIFICATION

1. PONTOON = 35m (L) X 9m (W)
2. GANGWAY = 35m (L) X 2.5m (W) X 2Nos

NOTES :

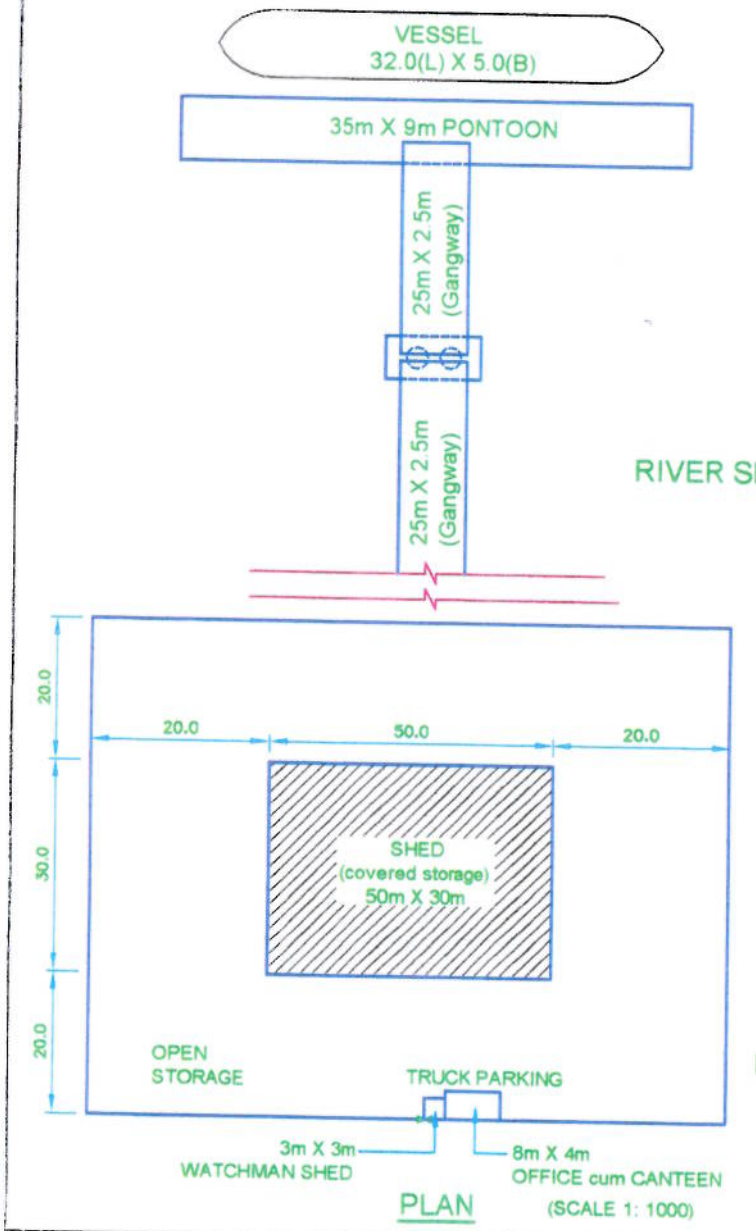
1. ALL DIMENSIONS ARE IN METRE UNLESS OTHERWISE SPECIFIED.

TRANSPORT DEPARTMENT
GOVERNMENT OF BIHAR

DETAILS OF BERTHING FACILITIES OF DAMBHARAGHAT ON RIVER KOSI

DRAWING No	RITES /DAMBHARAGHAT/ 02
SHEET No.	1 OF 1
DATE	
REVISION	
SCALE	0M 25M 50M

RITES THE INFRASTRUCTURE PEOPLE



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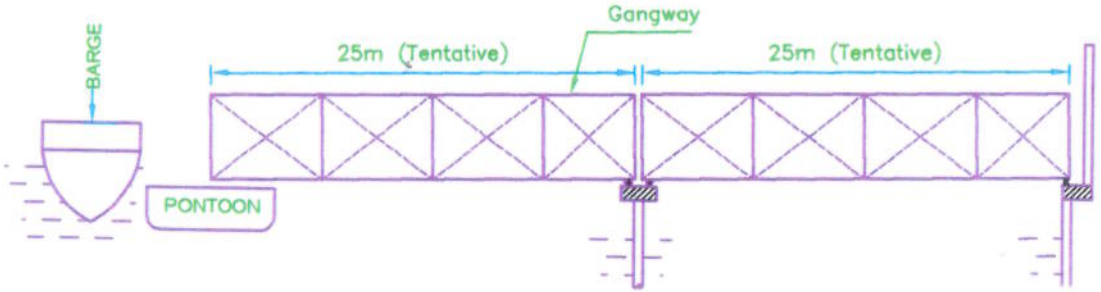


SECTION
(SCALE 1: 500)

LEGEND :

(A) SHIP DESIGN SPECIFICATION

1. LENGTH OF VESSEL	= 32.0mtr.
2. BEAM (WIDTH OF SHIP)	= 5.0mtr. (Approx)
3. DRAUGHT	= 1.0mtr.
4. CARGO CARRYING	~ 100 tons (D=1.0m)

(B) JETTY DESIGN SPECIFICATION

1. PONTOON	= 35m (L) X 9m (W)
2. GANGWAY	= 25m (L) X 2.5m (W) X 2Nos

NOTES :

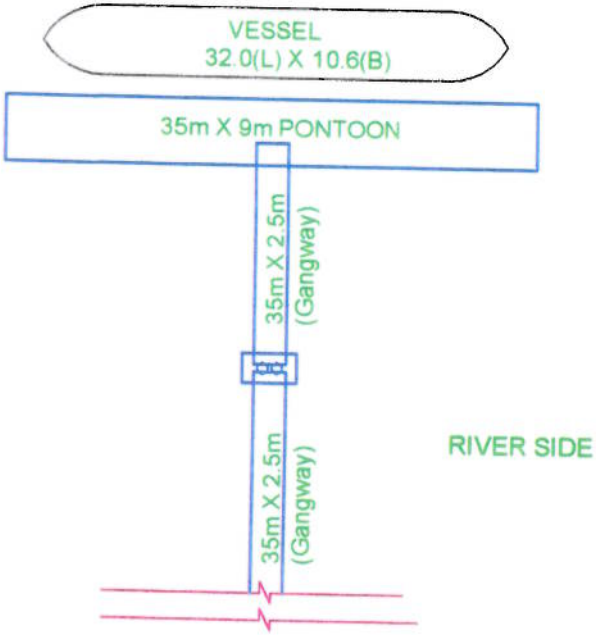
1. ALL DIMENSIONS ARE IN METRE UNLESS OTHERWISE SPECIFIED.

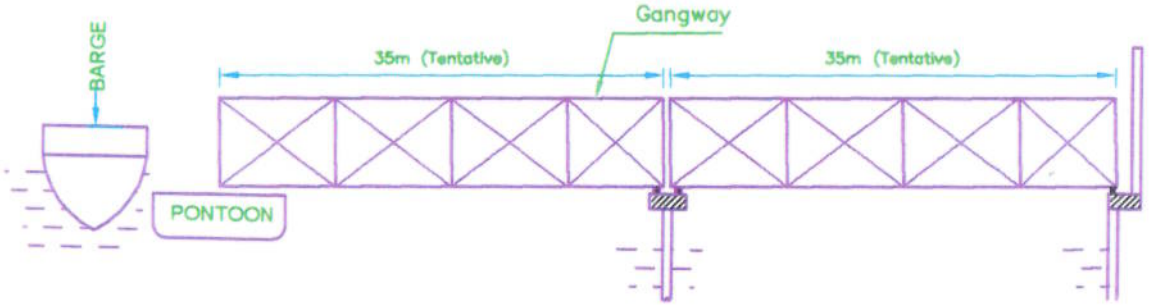
TRANSPORT DEPARTMENT
GOVERNMENT OF BIHAR

DETAILS OF BERTHING FACILITIES OF KALYANPUR ON RIVER KOSI

DRAWING No	RITES /KALYANPUR/ 02
SHEET NO	1 of 1
DATE	
REVISION	
SCALE	0M 25M 50M

RITES
THE INFRASTRUCTURE PEOPLE





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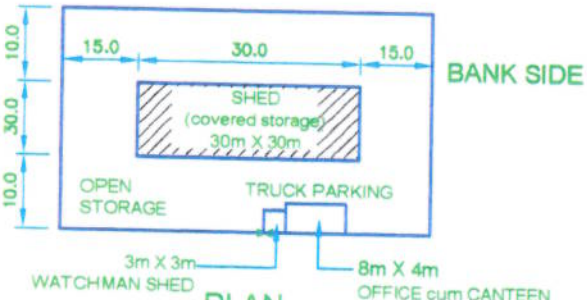


PLAN

(SCALE 1: 1000)

NOTES :

1. ALL DIMENSIONS ARE IN METRE UNLESS OTHERWISE SPECIFIED.

LEGEND :

(A) SHIP DESIGN SPECIFICATION

1. LENGTH OF VESSEL = 32.0mtr.
2. BEAM (WIDTH OF SHIP) = 5.0mtr. (Approx)
3. DRAUGHT = 1.0mtr.
4. CARGO CARRYING ~ 100 tons (D=1.0m)

(B) JETTY DESIGN SPECIFICATION

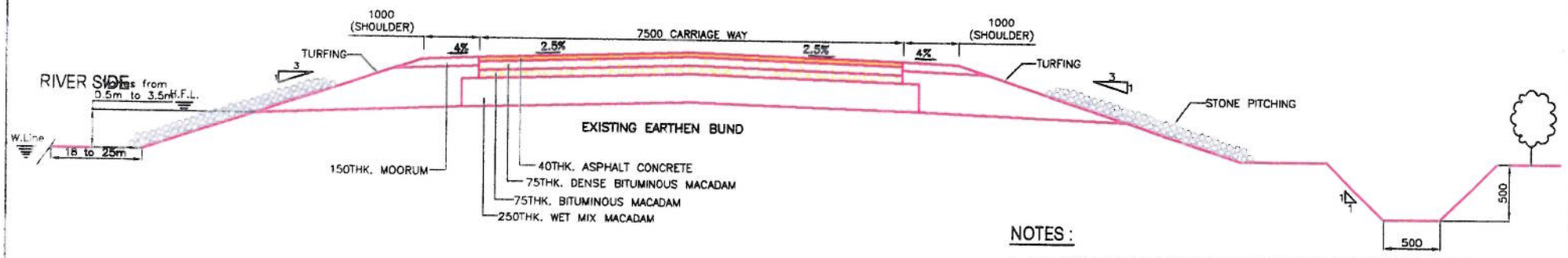
1. PONTOON = 35m (L) X 9m (W)
2. GANGWAY = 35m (L) X 2.5m (W) X 2Nos

TRANSPORT DEPARTMENT
GOVERNMENT OF BIHAR

DETAILS OF BERTHING FACILITIES OF KURSELA ON RIVER KOSI

DRAWING No	RITES / KURSELA/ 02
SHEET NO	1 of 1
DATE	
REVISION	
SCALE	0M 25M 50M

RITES
THE INFRASTRUCTURE PEOPLE

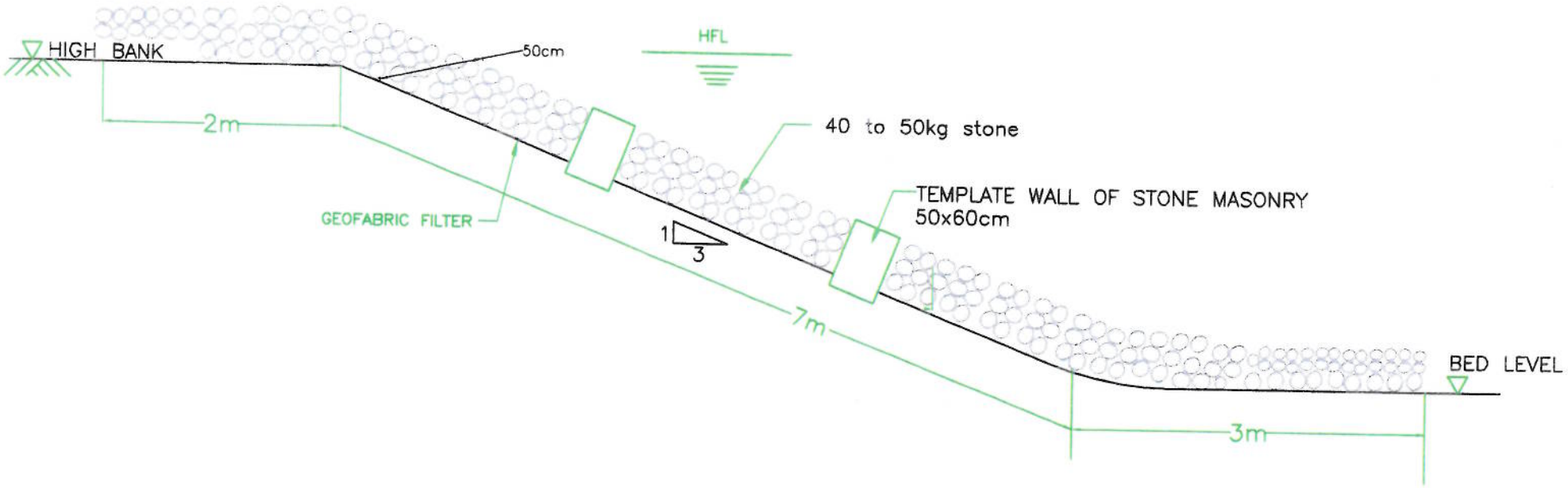


NOTES :

1. ALL DIMENSIONS ARE IN MILLIMETRES UNLESS OTHERWISE SPECIFIED.

TRANSPORT DEPARTMENT GOVERNMENT OF BIHAR	
TYPICAL CROSS SECTION OF ACCESS ROAD	
DRAWING No	RITES / TERMINAL / 03
SHEET NO	1 of 1
DATE	
REVISION	
SCALE	0mm 2500mm 5000mm

RITES
THE INFRASTRUCTURE PEOPLE



NOTES :

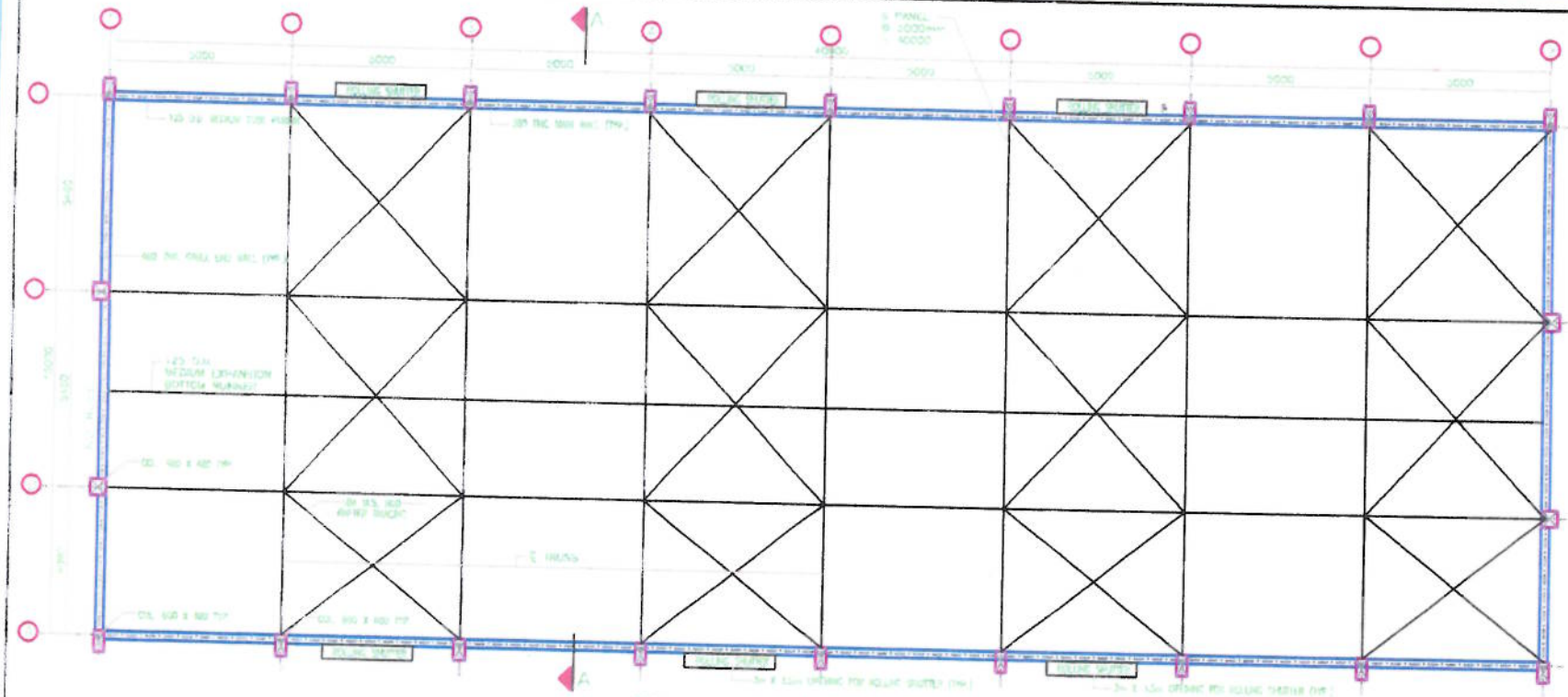
1. ALL DIMENSIONS ARE IN MILLIMETRES UNLESS OTHERWISE SPECIFIED.

TRANSPORT DEPARTMENT
GOVERNMENT OF BIHAR

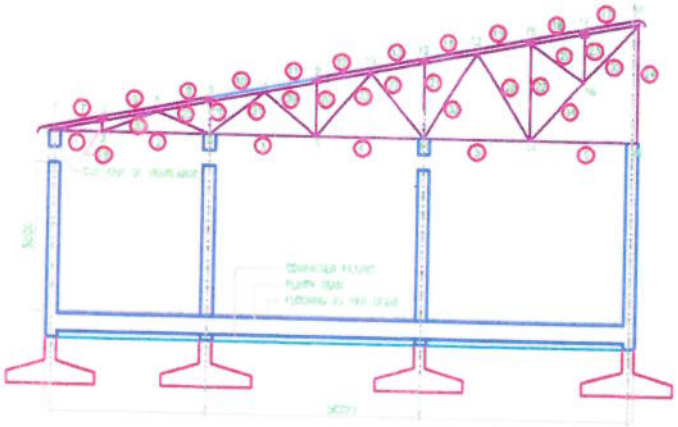
BANK PROTECTION (STONE PITCHING)

DRAWING No	RITES / TERMINAL / 04
SHEET NO	1 of 1
DATE	
REVISION	
SCALE	

RITES
THE INFRASTRUCTURE PEOPLE



MEMBERS	No.	SPACING (M) O.D
TIE	1	100mm O.D. LIGHT TUBE
TIE	2	100mm O.D. LIGHT TUBE
TIE	3	100mm O.D. LIGHT TUBE
TIE	4	100mm O.D. LIGHT TUBE
TIE	5	80mm O.D. LIGHT TUBE
TIE	6	80mm O.D. LIGHT TUBE
RAFTER	7	100mm O.D. LIGHT TUBE
RAFTER	8	100mm O.D. LIGHT TUBE
RAFTER	9	100mm O.D. LIGHT TUBE
RAFTER	10	100mm O.D. LIGHT TUBE
RAFTER	11	100mm O.D. LIGHT TUBE
RAFTER	12	100mm O.D. LIGHT TUBE
RAFTER	13	100mm O.D. LIGHT TUBE
RAFTER	14	50mm O.D. LIGHT TUBE
RAFTER	15	50mm O.D. LIGHT TUBE
RAFTER	16	50mm O.D. LIGHT TUBE
RAFTER	17	50mm O.D. LIGHT TUBE
WEB	18	25mm O.D. LIGHT TUBE
WEB	19	20mm O.D. MEDIUM TUBE
WEB	20	20mm O.D. MEDIUM TUBE
WEB	21	25mm O.D. LIGHT TUBE
WEB	22	32mm O.D. LIGHT TUBE
WEB	23	20mm O.D. MEDIUM TUBE
WEB	24	50mm O.D. LIGHT TUBE
WEB	25	32mm O.D. LIGHT TUBE
WEB	26	32mm O.D. LIGHT TUBE
WEB	27	32mm O.D. LIGHT TUBE
WEB	28	50mm O.D. LIGHT TUBE
WEB	29	20mm O.D. MEDIUM TUBE
WEB	30	32mm O.D. LIGHT TUBE
WEB	31	25mm O.D. LIGHT TUBE
WEB	32	32mm O.D. LIGHT TUBE
WEB	33	40mm O.D. LIGHT TUBE
WEB	34	65mm O.D. LIGHT TUBE
WEB	35	65mm O.D. LIGHT TUBE



TRANSPORT DEPARTMENT
GOVERNMENT OF BIHAR

STORAGE SHED - ROOF TRUSS DETAILS (15m SPAN)

DRAWING No	RITES / TERMINALS / SHED-01
SHEET NO	1 of 1
DATE	
REVISION	
SCALE	0mm 2500mm 5000mm

RITES THE INFRASTRUCTURE PEOPLE

CHAPTER - 6

PROJECT COST

CHAPTER – 6

PROJECT COST

6.1 INTRODUCTION

The project cost estimates for development of the Inland Water Transport system as well as for maintenance of the system have been worked out. The cost estimates for development of the system are termed as capital cost while for operation of the system is termed as maintenance or operating cost.

6.2 CAPITAL COSTS

The capital costs have been worked out primarily for development of the following system components:

6.2.1 Development of the waterway

Capital dredging has been envisaged initially since adequate depths are not available for round the year navigation and river was silted up over the years. Since siltation is a recurring phenomenon, a provision has been made in the operating cost for maintenance of the channel. Besides, the dredged channel is required to be identified with channel marking. Aids to navigation are also required for smooth and safe sailing of the vessel. The capital costs to procure equipment for aids to navigation and channel markers have been worked out besides maintenance cost for the items.

6.2.2 Construction of IWT terminals

Under this item all capital cost towards construction of terminals for berthing of vessels and loading and unloading cargo handling equipment into vessels and other costs such as land acquisition, surfacing and ground leveling, gate / fencing, wharf / berthing, office, workshop, roads and payments, water supply, sewerage, firefighting, electrical , telecommunication etc. are considered.

6.3 OPERATING COSTS

The cost estimate for operating the system is essential to run the system developed. The operating or maintenance cost of the systems has also two components.

6.3.1 Operating cost of Waterway

The maintenance cost of waterway for various items of work like dredging / desiltation, bank protection, fencing, brushwood turfing, channel markers and aids to navigation equipment.

6.3.2 Operating cost of IWT terminals

The terminals operating costs have been worked out based on certain standard percentage of capital costs in respect of civil works, mechanical works, electrical works, man power and fuel.

6.4 BASIS OF COSTS

The basis of cost estimates worked out is as follows:

- The standard schedule of rates for various works of Government of Bihar.
- The consultants experience on various projects sites proximity to the project area.
- Local enquiries at the time of conducting surveys.
- Market surveys and enquiries.
- Judgement based on consultants experience.

6.5 PROJECT SCHEDULE

The time schedule for construction activities of the project is considered as three years. The capital cost of the project will be incurred in phases during the construction period. Accordingly the phasing of the expenditure has been worked out and used in the cost benefit analysis. The annual maintenance cost will start after completion of the construction period.

COST OF TERMINALS

TABLE – 6.1

INLAND WATER TERMINAL AT KALYANPUR

CAPITAL COSTS 2012-13: (In Rs. lakhs)

Sl. No.	Item	Quantity	Unit Rate	Amount
1	Floating Pontoon (35m X 9m)	2 nos.	110 lakhs	220.00
2	Approach Gangway 2 nos. @ (25m X 2.5m)	2 nos..	70 lakhs	140.00
3	Retaining Wall(For Gangway on the ground portion)	2 nos.	60 lakhs	120.00
4	Cranes 5T Capacity (10cycles/hr,18m outreach)	1 no.	90 lakhs	90.00
5	Fork lift Trucks (3 T Capacity)	1 no.	10 lakhs	10.00
6	Pay loaders	1 no.	30 lakhs	30.00
7	Dumper Trucks	4 nos.	30 lakhs	120.00
8	Covered Storage Shed (for bagged cargo)	50mX30m	15000/Sq.m	225.00
9	Open Storage Area (for building material, steel, and timber) including Truck Parking Area.	4800 sqm	2500/Sq.m	120.00
10	Reclamation of storage area	6300sqmX 4mX1.2	180/Cu.m	54.43
11	Office Building	8m X 4m	15000/Sq.m	4.80
12	Weigh Bridges	1no.	15 lakhs	15.00
13	Watch and Ward	3m X 3m	7000/Sq.m	0.63
14	Internal Roads		L.S.	20.00
15	Security Fencing (2m high)		L.S.	12.00
16	Water Supply and Drainage		L.S.	20.00
17	Fire fighting Arrangement		L.S.	10.00
18	Electrical System including Terminal Lighting		L.S.	70.00
19	Land Cost	24200 sqm	2500/sqm	605.00
20	Access Road	7000m	17500/m	1225.00
			TOTAL	**3111.86**
			Detailed Engineering 2%	**62.24**
			Construction Supervision 8%	**253.93**
			Total Capital Cost	**3428.03**

Table – 6.1(a)

Gangway – Pontoon:

			Amount (Rs. in lakhs)
A. Pontoon – 1 (new) @ (35m X 9m)		=	1 X 40 = 40.0
35% Escalation		=	14.0
In year 2000	**Total**	=	54.0
In year 2010 = 54.0 X $(1.05)^{12}$		=	97.0
			Say, **110.0 lakhs**
B. Gangway – 1 (new) @ (43.5m X 2.5m)		=	1 X 20 = 20.0
35% Escalation		=	7.0
In year 2000	**Total**	=	27.0
In year 2010 = 27.0 X $(1.05)^{12}$		=	48.0
			Say, **60.0 lakhs**

For (50m X 2.5m) walkway
@ 25m each 2 nos. gangway

$$= 60 \times \frac{(50 \times 2.5)}{(43.5 \times 2.5)}$$

= 68.96 lakh

Say, **70.0 lakhs**

For (70m X 2.5m) walkway
@ 35m each 2 nos. gangway

$$= 60 \times \frac{(70 \times 2.5)}{(43.5 \times 2.5)}$$

= 96.55 lakh

Say, **100.0 lakhs**

TABLE – 6.1(i)

INLAND WATER TERMINAL AT KALYANPUR

CAPITAL COSTS 2025-26: (In Rs. lakhs)

Sl. No.	Item	Quantity	Unit Rate	Amount
1	Floating Pontoon (35m X 9m)	4 nos.	110 lakhs	440.00
2	Approach Gangway 2 nos. @ (25m X 2.5m)	4 nos.	70 lakhs	280.00
3	Retaining Wall (For Gangway on the ground portion)	4 nos.	60 lakhs	240.00
4	Cranes 5T Capacity (10cycles/hr,18m outreach)	3 nos.	90 lakhs	270.00
5	Fork lift Trucks (3 T Capacity)	2 nos.	10 lakhs	20.00
6	Pay loaders	2 nos.	30 lakhs	60.00
7	Dumper Trucks	8 nos.	30 lakhs	240.00
8	Covered Storage Shed (for bagged cargo)	100m X 30m	15000/Sq.m	450.00
9	Open Storage Area (for building material, steel, and timber) including Truck Parking Area.	10440 sqm	2500/Sq.m	261.00
10	Reclamation of storage area	13440sqm X 4m X 1.2	180/Cu.m	116.12
11	Office Building	8m X 4m	15000/Sq.m	4.80
12	Weigh Bridges	1 no.	15 lakhs	15.00
13	Watch and Ward	3m X 3m	7000/Sq.m	0.63
14	Internal Roads		L.S.	20.00
15	Security Fencing (2m high)		L.S.	12.00
16	Water Supply and Drainage		L.S.	20.00
17	Fire fighting Arrangement		L.S.	10.00
18	Electrical System including Terminal Lighting		L.S.	70.00
19	Land Cost	24200sqm	2500/sqm	605.00
20	Access Road	7000m	17500/m	1225.00
			TOTAL	**4359.55**
			Detailed Engineering 2%	**87.19**
			Construction Supervision 8%	**355.74**
			Total Capital Cost	**4802.48**

TABLE-6.1(ii)

INLAND WATER TERMINAL AT KALYANPUR

CAPITAL COSTS 2035-36: (In Rs. lakhs)

Sl. No.	Item	Quantity	Unit Rate	Amount
1	Floating Pontoon (35m X 9m)	7 nos.	110 lakhs	770.00
2	Approach Gangway 2 nos. @ (25m X 2.5m)	7 nos.	70 lakhs	490.00
3	Retaining Wall (For Gangway on the ground portion)	7 nos.	60 lakhs	420.00
4	Cranes 5T Capacity (10cycles/hr,18m outreach)	4 nos.	90 lakhs	360.00
5	Fork lift Trucks (3 T Capacity)	4 nos.	10 lakhs	40.00
6	Pay loaders	4 nos.	30 lakhs	120.00
7	Dumper Trucks	15 nos.	30 lakhs	450.00
8	Covered Storage Shed (for bagged cargo)	150m X 60m	15000/Sq.m	1350.00
9	Open Storage Area (for building material, steel, and timber) including Truck Parking Area.	15200 sqm	2500/Sq.m	380.00
10	Reclamation of storage area	24200sqm X4m X 1.2	180/Cu.m	209.08
11	Office Building	8m X 4m	15000/Sq.m	4.80
12	Weigh Bridges	1 no.	15 lakhs	15.00
13	Watch and Ward	3m X 3m	7000/Sq.m	0.63
14	Internal Roads		L.S.	20.00
15	Security Fencing (2m high)		L.S.	12.00
16	Water Supply and Drainage		L.S.	20.00
17	Fire fighting Arrangement		L.S.	10.00
18	Electrical System including Terminal Lighting		L.S.	70.00
19	Land Cost	24200sqm	2500/sqm	605.00
20	Access Road	7000m	17500/m	1225.00
			TOTAL	**6571.51**
			Detailed Engineering 2%	**131.43**
			Construction Supervision 8%	**536.24**
			Total Capital Cost	**7239.18**

TABLE – 6.2
INLAND WATER TERMINAL AT BASBITTI

CAPITAL COSTS 2012-13: (In Rs. lakhs)

Sl. No.	Item	Quantity	Unit Rate	Amount
1	Floating Pontoon (35m X 9m)	2 nos.	110 lakhs	220.00
2	Approach Gangway 2 nos. @ (35m X 2.5m)	2 nos.	100 lakhs	200.00
3	Retaining Wall (For Gangway on the ground portion)	2 nos.	60 lakhs	120.00
4	Cranes 5T Capacity (10cycles/hr,18m outreach)	1 no.	90 lakhs	90.00
5	Fork lift Trucks (3 T Capacity)	1 no.	10 lakhs	10.00
6	Pay loaders	1 no.	30 lakhs	30.00
7	Dumper Trucks	3 nos.	30 lakhs	90.00
8	Covered Storage Shed (for bagged cargo)	40m X 30m	15000/Sq.m.	180.00
9	Open Storage Area (for building material, steel, and timber) including Truck Parking Area.	4400 sqm	2500/Sq.m	110.00
10	Reclamation of storage area	5600sqm X 4m X 1.2	180/Cu.m	48.38
11	Office Building	8m X 4m	15000/Sq.m	4.80
12	Weigh Bridges	1 no.	15 lakhs	15.00
13	Watch and Ward	3m X 3m	7000/Sq.m	0.63
14	Internal Roads		L.S.	20.00
15	Security Fencing (2m high)		L.S.	12.00
16	Water Supply and Drainage		L.S.	20.00
17	Fire fighting Arrangement		L.S.	10.00
18	Electrical System including Terminal Lighting		L.S.	70.00
19	Land Cost	20000 sqm	2000/sqm	400.00
20	Access Road	3000m	17500/m	525.00
			TOTAL	**2175.81**
			Detailed Engineering 2%	**43.52**
			Construction Supervision 8%	**177.55**
			Total Capital Cost	**2396.88**

TABLE-6.2(i)

INLAND WATER TERMINAL AT BASBITTI

CAPITAL COSTS 2025-26: (In Rs. lakhs)

Sl. No.	Item	Quantity	Unit Rate	Amount
1	Floating Pontoon (35m X 9m)	4 nos.	110 lakhs	440.00
2	Approach Gangway 2 nos. @ (35m X 2.5m)	4 nos.	100 lakhs	400.00
3	Retaining Wall (For Gangway on the ground portion)	4 nos.	60 lakhs	240.00
4	Cranes 5T Capacity (10cycles/hr,18m outreach)	2 nos.	90 lakhs	180.00
5	Fork lift Trucks (3 T Capacity)	2 nos.	10 lakhs	20.00
6	Pay loaders	2 nos.	30 lakhs	60.00
7	Dumper Trucks	5 nos.	30 lakhs	150.00
8	Covered Storage Shed (for bagged cargo)	90m X 30m	15000/Sq.m.	405.00
9	Open Storage Area (for building material, steel, and timber) including Truck Parking Area.	8500 sqm	2500/Sq.m	212.50
10	Reclamation of storage area	11200sqm X 4m X 1.2	180/Cu.m	96.76
11	Office Building	8m X 4m	15000/Sq.m	4.80
12	Weigh Bridges	1no.	15 lakhs	15.00
13	Watch and Ward	3m X 3m	7000/Sq.m	0.63
14	Internal Roads		L.S.	20.00
15	Security Fencing (2m high)		L.S.	12.00
16	Water Supply and Drainage		L.S.	20.00
17	Fire fighting Arrangement		L.S.	10.00
18	Electrical System including Terminal Lighting		L.S.	70.00
19	Land Cost	20000sqm	2000/sqm	400.00
20	Access Road	3000m	17500/m	525.00
			TOTAL	**3281.69**
			Detailed Engineering 2%	**65.63**
			Construction Supervision 8%	**267.79**
			Total Capital Cost	**3615.11**

TABLE – 6.2(ii)

INLAND WATER TERMINAL AT BASBITTI

CAPITAL COSTS 2035-36: (In Rs. lakhs)

Sl. No.	Item	Quantity	Unit Rate	Amount
1	Floating Pontoon (35m X 9m)	6 nos.	110 lakhs	660.00
2	Approach Gangway 2 nos. @ (35m X 2.5m)	6 nos.	100 lakhs	600.00
3	Retaining Wall (For Gangway on the ground portion)	6 nos.	60 lakhs	360.00
4	Cranes 5T Capacity (10cycles/hr,18m outreach)	4 nos.	90 lakhs	360.00
5	Fork lift Trucks (3 T Capacity)	4 nos.	10 lakhs	40.00
6	Pay loaders	4 nos.	30 lakhs	120.00
7	Dumper Trucks	10 nos.	30 lakhs	300.00
8	Covered Storage Shed (for bagged cargo)	140m X 60m	15000/Sq.m	1260.00
9	Open Storage Area (for building material, steel, and timber) including Truck Parking Area.	11600 sqm	2500/Sq.m	290.00
10	Reclamation of storage area	20000sqm X 4m X 1.2	180/Cu.m	172.80
11	Office Building	8m X 4m	15000/Sq.m	4.80
12	Weigh Bridges	1no.	15 lakhs	15.00
13	Watch and Ward	3m X 3m	7000/Sq.m	0.63
14	Internal Roads		L.S.	20.00
15	Security Fencing (2m high)		L.S.	12.00
16	Water Supply and Drainage		L.S.	20.00
17	Fire fighting Arrangement		L.S.	10.00
18	Electrical System including Terminal Lighting		L.S.	70.00
19	Land Cost	20000sqm	2000/sqm	400.00
20	Access Road	3000m	17500/m	525.00
			TOTAL	**5240.23**
			Detailed Engineering 2%	**104.80**
			Construction Supervision 8%	**427.60**
			Total Capital Cost	**5772.63**

TABLE – 6.3
INLAND WATER TERMINAL AT DAMBHARAGHAT

CAPITAL COSTS 2012-13: (In Rs. lakhs)

Sl. No.	Item	Quantity	Unit Rate	Amount
1	Floating Pontoon (35m X 9m)	1 no.	110 lakhs	110.00
2	Approach Gangway 2 nos. @ (35m X 2.5m)	1 no.	100 lakhs	100.00
3	Retaining Wall (For Gangway on the ground portion)	1 no.	60 lakhs	60.00
4	Cranes 5T Capacity (10cycles/hr,18m outreach)	1 no.	90 lakhs	90.00
5	Fork lift Trucks (3 T Capacity)	1 no.	10 lakhs	10.00
6	Pay loaders	1 no.	30 lakhs	30.00
7	Dumper Trucks	2 nos.	30 lakhs	60.00
8	Covered Storage Shed (for bagged cargo)	35m X 30m	15000/Sq.m	157.50
9	Open Storage Area (for building material, steel, and timber) including Truck Parking Area.	2850 sqm	2500/Sq.m	71.25
10	Reclamation of storage area	3900sqm X4m X 1.2	180/Cu.m	33.69
11	Office Building	8m X 4m	15000/Sq.m	4.80
12	Weigh Bridges	1 no.	15 lakhs	15.00
13	Watch and Ward	3m X 3m	7000/Sq.m	0.63
14	Internal Roads		L.S.	20.00
15	Security Fencing (2m high)		L.S.	12.00
16	Water Supply and Drainage		L.S.	20.00
17	Fire fighting Arrangement		L.S.	10.00
18	Electrical System including Terminal Lighting		L.S.	70.00
19	Land Cost	14400 sqm	2500/sqm	360.00
20	Access Road	3000m	17500/m	525.00
			TOTAL	**1759.87**
			Detailed Engineering 2%	**35.20**
			Construction Supervision 8%	**143.60**
			Total Capital Cost	**1938.67**

TABLE – 6.3(i)
INLAND WATER TERMINAL AT DAMBHARAGHAT

CAPITAL COSTS 2025-26: **(In Rs. lakhs)**

Sl. No.	Item	Quantity	Unit Rate	Amount
1	Floating Pontoon (35m X 9m)	2 nos.	110 lakhs	220.00
2	Approach Gangway 2 nos. @ (35m X 2.5m)	2 nos.	100 lakhs	200.00
3	Retaining Wall (For Gangway on the ground portion)	2 nos.	60 lakhs	120.00
4	Cranes 5T Capacity (10cycles/hr,18m outreach)	2 nos.	90 lakhs	180.00
5	Fork lift Trucks (3 T Capacity)	1 no.	10 lakhs	10.00
6	Pay loaders	1 no.	30 lakhs	30.00
7	Dumper Trucks	4 nos.	30 lakhs	120.00
8	Covered Storage Shed (for bagged cargo)	80m X 30m	15000/Sq.m	360.00
9	Open Storage Area (for building material, steel, and timber) including Truck Parking Area.	6000 sqm	2500/Sq.m	150.00
10	Reclamation of storage area	8400sqm X 4mX 1.2	180/Cu.m	72.57
11	Office Building	8m X 4m	15000/Sq.m	4.80
12	Weigh Bridges	1 no.	15 lakhs	15.00
13	Watch and Ward	3m X 3m	7000/Sq.m	0.63
14	Internal Roads		L.S.	20.00
15	Security Fencing (2m high)		L.S.	12.00
16	Water Supply and Drainage		L.S.	20.00
17	Fire fighting Arrangement		L.S.	10.00
18	Electrical System including Terminal Lighting		L.S.	70.00
19	Land Cost	14400sqm	2500/sqm	360.00
20	Access Road	3000m	17500/m	525.00
			TOTAL	**2500.00**
			Detailed Engineering 2%	**50.00**
			Construction Supervision 8%	**204.00**
			Total Capital Cost	**2754.00**

TABLE – 6.3(ii)

INLAND WATER TERMINAL AT DAMBHARAGHAT

CAPITAL COSTS 2035-36: **(In Rs. lakhs)**

Sl. No.	Item	Quantity	Unit Rate	Amount
1	Floating Pontoon (35m X 9m)	4 nos.	110 lakhs	440.00
2	Approach Gangway 2 nos. @ (35m X 2.5m)	4 nos.	100 lakhs	400.00
3	Retaining Wall (For Gangway on the ground portion)	4 nos.	60 lakhs	240.00
4	Cranes 5T Capacity (10cycles/hr,18m outreach)	3 nos.	90 lakhs	270.00
5	Fork lift Trucks (3 T Capacity)	2 nos.	10 lakhs	20.00
6	Pay loaders	2 nos.	30 lakhs	60.00
7	Dumper Trucks	8 nos.	30 lakhs	240.00
8	Covered Storage Shed (for bagged cargo)	130m X 30m	15000/Sq.m	585.00
9	Open Storage Area (for building material, steel, and timber) including Truck Parking Area.	10500 sqm	2500/Sq.m	262.50
10	Reclamation of storage area	14400sqm X4m X 1.2	180/Cu.m	124.41
11	Office Building	8m X 4m	15000/Sq.m	4.80
12	Weigh Bridges	1no.	15 lakhs	15.00
13	Watch and Ward	3m X 3m	7000/Sq.m	0.63
14	Internal Roads		L.S.	20.00
15	Security Fencing (2m high)		L.S.	12.00
16	Water Supply and Drainage		L.S.	20.00
17	Fire fighting Arrangement		L.S.	10.00
18	Electrical System including Terminal Lighting		L.S.	70.00
19	Land Cost	14400sqm	2500/sqm	360.00
20	Access Road	3000m	17500/m	525.00
			TOTAL	**3679.34**
			Detailed Engineering 2%	**73.59**
			Construction Supervision 8%	**300.23**
			Total Capital Cost	**4053.16**

TABLE – 6.4

INLAND WATER TERMINAL AT KURSELA

CAPITAL COSTS 2012-13: **(In Rs. lakhs)**

Sl. No.	Item	Quantity	Unit Rate	Amount
1	Floating Pontoon (35m X 9m)	1 no.	110 lakhs	110.00
2	Approach Gangway 2 nos. @ (35m X 2.5m)	1 no.	100 lakhs	100.00
3	Retaining Wall (For Gangway on the ground portion)	1 no.	60 lakhs	60.00
4	Cranes 5T Capacity (10cycles/hr,18m outreach)	1 no.	90 lakhs	90.00
5	Fork lift Trucks (3 T Capacity)	1 no.	10 lakhs	10.00
6	Pay loaders	1 no.	30 lakhs	30.00
7	Dumper Trucks	2 nos.	30 lakhs	60.00
8	Covered Storage Shed (for bagged cargo)	30m X 30m	15000/ Sq.m.	135.00
9	Open Storage Area (for building material, steel, and timber) including Truck Parking Area.	2100sqm	2500/Sq.m	52.50
10	Reclamation of storage area	3000sqm X 4mX 1.2	180/Cu.m	25.92
11	Office Building	8m X 4m	15000/Sq.m	4.80
12	Weigh Bridges	1no.	15 lakhs	15.00
13	Watch and Ward	3m X 3m	7000/Sq.m	0.63
14	Internal Roads		L.S.	20.00
15	Security Fencing (2m high)		L.S.	12.00
16	Water Supply and Drainage		L.S.	20.00
17	Fire fighting Arrangement		L.S.	10.00
18	Electrical System including Terminal Lighting		L.S.	70.00
19	Land Cost	11200sqm	2500/sqm	280.00
20	Access Road	3000m	17500/m	525.00
			TOTAL	**1630.85**
			Detailed Engineering 2%	**32.62**
			Construction Supervision 8%	**133.08**
			Total Capital Cost	**1796.55**

TABLE – 6.4(i)

INLAND WATER TERMINAL AT KURSELA

CAPITAL COSTS 2025-26: **(In Rs. lakhs)**

Sl. No.	Item	Quantity	Unit Rate	Amount
1	Floating Pontoon (35m X 9m)	2 nos.	110 lakhs	220.00
2	Approach Gangway 2 nos. @ (35m X 2.5m)	2 nos.	100 lakhs	200.00
3	Retaining Wall (For Gangway on the ground portion)	2 nos.	60 lakhs	120.00
4	Cranes 5T Capacity (10cycles/hr,18m outreach)	1 no.	90 lakhs	90.00
5	Fork lift Trucks (3 T Capacity)	1 no.	10 lakhs	10.00
6	Pay loaders	1 no.	30 lakhs	30.00
7	Dumper Trucks	3 nos.	30 lakhs	90.00
8	Covered Storage Shed (for bagged cargo)	50m X 30m	15000/Sq.m	225.00
9	Open Storage Area (for building material, steel, and timber) including Truck Parking Area.	4800 sqm	2500/Sq.m	120.00
10	Reclamation of storage area	6300sqm X4m X 1.2	180/Cu.m	54.43
11	Office Building	8m X 4m	15000/Sq.m	4.80
12	Weigh Bridges	1 no.	15 lakhs	15.00
13	Watch and Ward	3m X 3m	7000/Sq.m	0.63
14	Internal Roads		L.S.	20.00
15	Security Fencing (2m high)		L.S.	12.00
16	Water Supply and Drainage		L.S.	20.00
17	Fire fighting Arrangement		L.S.	10.00
18	Electrical System including Terminal Lighting		L.S.	70.00
19	Land Cost	11200sqm	2500/sqm	280.00
20	Access Road	3000m	17500/m	525.00
			TOTAL	**2116.86**
			Detailed Engineering 2%	**42.34**
			Construction Supervision 8%	**172.74**
			Total Capital Cost	**2331.94**

TABLE – 6.4(ii)

INLAND WATER TERMINAL AT KURSELA

CAPITAL COSTS 2035-36: (In Rs. lakhs)

Sl. No.	Item	Quantity	Unit Rate	Amount
1	Floating Pontoon (35m X 9m)	4 nos.	110 lakhs	440.00
2	Approach Gangway 2 nos. @ (35m X 2.5m)	4 nos.	100 lakhs	400.00
3	Retaining Wall (For Gangway on the ground portion)	4 nos.	60 lakhs	240.00
4	Cranes 5T Capacity (10cycles/hr,18m outreach)	2 nos.	90 lakhs	180.00
5	Fork lift Trucks (3 T Capacity)	2 nos.	10 lakhs	20.00
6	Pay loaders	2 nos.	30 lakhs	60.00
7	Dumper Trucks	5 nos.	30 lakhs	150.00
8	Covered Storage Shed (for bagged cargo)	90m X 30m	15000/Sq.m.	405.00
9	Open Storage Area (for building material, steel, and timber) including Truck Parking Area.	8500 sqm	2500/Sq.m	212.50
10	Reclamation of storage area	11200sqm X 4m X 1.2	180/Cu.m	96.76
11	Office Building	8m X 4m	15000/Sq.m	4.80
12	Weigh Bridges	1 no.	15 lakhs	15.00
13	Watch and Ward	3m X 3m	7000/Sq.m	0.63
14	Internal Roads		L.S.	20.00
15	Security Fencing (2m high)		L.S.	12.00
16	Water Supply and Drainage		L.S.	20.00
17	Fire fighting Arrangement		L.S.	10.00
18	Electrical System including Terminal Lighting		L.S.	70.00
19	Land Cost	11200sqm	2500/sqm	280.00
20	Access Road	3000m	17500/m	525.00
			TOTAL	**3161.69**
			Detailed Engineering 2%	**63.23**
			Construction Supervision 8%	**257.99**
			Total Capital Cost	**3482.91**

TABLE – 6.5
Kalyanpur Terminal Facilities – Annual Operating Requirements

2012-13: **(In Rs. Lakhs)**

Sl. No.	Item	Amount
1.	Man Power cost	32.40
2.	O & M cost -Civil works (2%) -Mech. & Elec. Eqpt. (6%) -Transportation Eqpt.(8%)	 43.44 12.30 10.40
3.	Power cost	5.0
4.	Fuel cost	45.0
5.	Total Operating cost	148.54
6.	Annual throughput in tonnes	481180
7.	Unit cost / tonne in Rs.	30.87

2025-26: **(In Rs. Lakhs)**

Sl. No.	Item	Amount
1.	Man Power cost	42.00
2.	O & M cost -Civil works (2%) -Mech. & Elec. Eqpt. (6%) -Transportation Eqpt.(8%)	 61.59 24.90 20.80
3.	Power cost	5.0
4.	Fuel cost	45.0
5.	Total Operating cost	199.29
6.	Annual throughput in tonnes	1026323
7.	Unit cost / tonne in Rs.	19.42

2035-36: **(In Rs. Lakhs)**

Sl.No.	Item	Amount
1.	Man Power cost	58.80
2.	O & M cost -Civil works (2%) -Mech. & Elec. Eqpt. (6%) -Transportation Eqpt.(8%)	 98.23 33.90 39.20
3.	Power cost	5.0
4.	Fuel cost	45.0
5.	Total Operating cost	280.13
6.	Annual throughput in tonnes	1837989
7.	Unit cost / tonne in Rs.	15.24

TABLE – 6.6
Basbitti Terminal Facilities – Annual Operating Requirements

2012-13: (In Rs. Lakhs)

Sl.No.	Item	Amount
1.	Man Power cost	32.40
2.	O & M cost -Civil works (2%) -Mech. & Elec. Eqpt. (6%) -Transportation Eqpt.(8%)	 29.42 12.30 8.00
3.	Power cost	5.0
4.	Fuel cost	45.0
5.	Total Operating cost	132.12
6.	Annual throughput in tonnes	400912
7.	Unit cost / tonne in Rs.	32.95

2025-26: (In Rs. Lakhs)

Sl.No.	Item	Amount
1.	Man Power cost	37.20
2.	O & M cost -Civil works (2%) -Mech. & Elec. Eqpt. (6%) -Transportation Eqpt.(8%)	 47.73 19.50 13.60
3.	Power cost	5.0
4.	Fuel cost	45.0
5.	Total Operating cost	168.03
6.	Annual throughput in tonnes	855117
7.	Unit cost / tonne in Rs.	19.65

2035-36: (In Rs. Lakhs)

Sl.No.	Item	Amount
1.	Man Power cost	52.80
2.	O & M cost -Civil works (2%) -Mech. & Elec. Eqpt. (6%) -Transportation Eqpt.(8%)	 78.70 33.90 27.20
3.	Power cost	5.0
4.	Fuel cost	45.0
5.	Total Operating cost	242.60
6.	Annual throughput in tonnes	1531384
7.	Unit cost / tonne in Rs.	15.84

TABLE – 6.7
Dambharaghat Terminal Facilities – Annual Operating Requirements

2012-13: **(In Rs. Lakhs)**

Sl.No.	Item	Amount
1.	Man Power cost	32.40
2.	O & M cost -Civil works (2%) -Mech. & Elec. Eqpt. (6%) -Transportation Eqpt.(8%)	 22.50 12.30 5.6
3.	Power cost	5.0
4.	Fuel cost	45.0
5.	Total Operating cost	122.80
6.	Annual throughput in tonnes	301757
7.	Unit cost / tonne in Rs.	40.69

2025-26: **(In Rs. Lakhs)**

Sl.No.	Item	Amount
1.	Man Power cost	33.60
2.	O & M cost -Civil works (2%) -Mech. & Elec. Eqpt. (6%) -Transportation Eqpt.(8%)	 34.30 17.70 10.40
3.	Power cost	5.0
4.	Fuel cost	45.0
5.	Total Operating cost	146.00
6.	Annual throughput in tonnes	643627
7.	Unit cost / tonne in Rs.	22.68

2035-36: **(In Rs. Lakhs)**

Sl.No.	Item	Amount
1.	Man Power cost	44.40
2.	O & M cost -Civil works (2%) -Mech. & Elec. Eqpt. (6%) -Transportation Eqpt.(8%)	 52.89 24.90 20.80
3.	Power cost	5.0
4.	Fuel cost	45.0
5.	Total Operating cost	192.99
6.	Annual throughput in tonnes	1152637
7.	Unit cost / tonne in Rs.	16.74

TABLE – 6.8
Kursela Terminal Facilities – Annual Operating Requirements

2012-13: **(In Rs. Lakhs)**

1.	Man Power cost	32.40
2.	O & M cost -Civil works (2%) -Mech. & Elec. Eqpt. (6%) -Transportation Eqpt.(8%)	 21.52 12.30 5.6
3.	Power cost	5.0
4.	Fuel cost	45.0
5.	Total Operating cost	121.82
6.	Annual throughput in tonnes	233937
7.	Unit cost / tonne in Rs.	52.07

2025-26: **(In Rs. Lakhs)**

1.	Man Power cost	32.40
2.	O & M cost -Civil works (2%) -Mech. & Elec. Eqpt. (6%) -Transportation Eqpt.(8%)	 30.64 12.30 8.00
3.	Power cost	5.0
4.	Fuel cost	45.0
5.	Total Operating cost	133.34
6.	Annual throughput in tonnes	498971
7.	Unit cost / tonne in Rs.	26.72

2035-36: **(In Rs. Lakhs)**

1.	Man Power cost	32.40
2.	O & M cost -Civil works (2%) -Mech. & Elec. Eqpt. (6%) -Transportation Eqpt.(8%)	 47.73 19.50 13.60
3.	Power cost	5.0
4.	Fuel cost	45.0
5.	Total Operating cost	163.23
6.	Annual throughput in tonnes	893581
7.	Unit cost / tonne in Rs.	18.27

Note : (i) Av. Man power cost considered as Rs. 1,20,000 per annum per personnel.
(ii) Annual maintenance cost considered are
- For civil works : 2% of Installation Cost.
- For mech & elec works : 6% of Installation Cost.
- For Transportation eqpt : 8% of Installation Cost.

(iii) Cost of Rs. 5/Kwh is considered for power.
(iv) Cost of fuel considered as Rs.45/litre.

6.6 CAPITAL AND OPERATING COST OF WATERWAY DEVELOPMENT

Table 6.9 : Capital cost for Waterway Development

Sl No	Description	Quantity	Unit	Rate (Rs)	Amount (in lakhs)
1	Dredging				
	100T Vessel (as per Annexure 4.3)	1941839	m^3	150	2912.76
2	Aids to navigation				28.00
3	Sub total (100T vessel)				2940.76
	Contingencies 3%				88.22
	Supervision 5%				147.04
	Total (100T vessel)				3176.02

Table 6.10 : Operating cost for Waterway Development

Sl No	Description	Total Amount (in lakhs)	Rate of %	Amount (in lakhs)
1	Dredging			
	a) 100T Vessel	3176.02	10	317.60
2	Aids to navigation	28.00	5	1.40
3	Waterway Maintenance Management			50.00
			Total (in Lakhs)	369.00

CHAPTER - 7

IMPLEMENTATION SCHEDULE & IMPLEMENTATION MECHANISM

CHAPTER – 7

IMPLEMENTATION SCHEDULE & IMPLEMENTATION MECHANISM

7.1 PROJECT IMPLEMENTATION SCHEDULE

The project implementation schedule has been prepared and presented in Annexure – 7.1. The schedule has been prepared taking into account the tentative time taken for obtaining approvals for IWT project, field surveys and investigations, Design of Terminals and other structures, tendering, procurement and execution of the project. As per the schedule, it will take about 3½ year for completion of all activities and commencement of navigational activities in the river Kosi in the identified stretch of 237km. If some slippages are there in obtaining any statutory approvals, it will take about 4 years time.

7.2 PROJECT IMPLEMENTATION MECHANISM

In order to establish a monitoring mechanism for implementation of IWT project, it is recommended that a High Level Committee/ an Advisory Committee under the Chairmanship of Transport Secretary, IWAI Officer and/ or Secretary of Department of Industrial Policy & Promotion, comprising Secretaries of the Ministries/Departments of Revenue, IWT Department Govt of Bihar, Banking and Insurance Sector, Representative of Planning Commission, would be constituted. High level committee would monitor the project in all respect.

The underlying assumptions in planning the implementation mechanism of the project are:

- The Government would bear the capital cost of development of water ways and would not charge any amount on usage of waterway path from the operator
- The subsidy on the flotilla cost to the extent of 30% would be available from the Government
- The private party undertakes construction of terminals, procurement of flotilla, O & M of terminal, waterways and fleet.

The Consultants are of the view that the present trend in infrastructure sector with public-private partnerships (PPP) can be adopted for implementing the project. The initial investment and initiative being taken by the state sector would give start to the project. Since private sector would not able to take the initiative of provision of infrastructure and operate the services on its own. The State Government should take investment decision to develop the said facility. Then private sector could be expected to take participation in the project. Once the proposed services are operated by private sector, the FIRR may further improve because they would undertake intensive marketing efforts and relate it to utilizations of vessels and terminals facilities. Private participation in operating the IWT services may be considered in detail after investment decision is taken by the Govt. of Bihar to implement the project.

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Annexure - 7.1

Sl. No.		31	32	33	34	35	36	37	38	39	40	41	42
1	Submission of Report to Govt of Bih												
2	Approvals from Govt of Bihar												
3	Submission of Report to IWAI for sa												
4	Approvals of Project from IWAI												
5	Fixing of consultant for preparation Infrastructure ect.												
6	Preparation of Detailed Design of Te												
7	Approval of Terminals/ Structure De												
8	Land allotment for 4 nos of Termina												
9	Preparation of Tender documents f												
10	Tendering for River Training Works												
	a) Package 1:- Stretch From Kursela												
	b) Package 2:- Stretch From Dambal												
	c) Package 3:- Stretch From Basbitti												
11	Award of contract and commencem Channel												
12	Preparation of Tender documents f Approvals												
13	Tendering for All Terminals and Oth												
14	Award of contract and commencem others infrastructure facilities Package 1 a) Kursela & b) Dam Package 2 a) Basbitti Package 3 a) Kalyanpur												
15	**Activities for Terminals/Floating Pc (Started Simultaneously all 4 Term**												
I	Site preparation, Fencing, Grading,												
II	Procurement of River Boat for supe												
III	Construction of bank Protection wo												
IV	Construction of Terminals/Floating												
V	Construction of Terminals buildings other civil works												
VI	Procurement and Mobilization of D												
VII	Dredging of connecting Navigation												
VIII	Utilities for Terminal(water, sewera												
IX	Electrical works of Terminals												
X	Workshop for Repairing / Maintein												
XI	Procurement and installation of oth												
XII	Procurement of Permanent Navigat Channel and installations												
XIII	Commencement of Terminals opera												
16	Award of contract to Installations N the Navigation Channel												
17	Commencement of Operations of P												

CHAPTER - 8

COST BENEFIT ANALYSIS

CHAPTER – 8

COST BENEFIT ANALYSIS

8.0 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. Given the base year traffic estimates and traffic forecasts during the design life of the project (Chapter 2), this chapter presents methodology, inputs and results of economic appraisal.

8.1 APPROACH AND METHODOLOGY

For the purpose of economic appraisal two mutually exclusive project scenarios have been considered, namely "*without the project*" and "*with the project*". Under *without the project* scenario only do-minimum situation (i.e. maintaining the existing inland waterways in their present condition and allowing the present traffic movement pattern) has been assumed. In the *with the project* scenario the inland waterways with all the proposed improvements/ developments have been be considered. In this methodology, while the cost of *with the project* scenario (i.e. capital, replacement, maintenance cost of channel and terminals) represents the project cost, the total cost of moving the same traffic by alternate modes in the *without the project scenario* connotes project benefits. These project costs and benefits have been worked out for each year of the project life and discounted to arrive at Economic Internal Rate of Return (EIRR). The cost and benefit streams have been worked out for 30 years commencing from the year 2010-11. While the first three years relate to construction period, the remaining 27 years represent project economic life or operating years. In the last year of operations, due credit is given to the residual value of the assets. In case 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 true 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

costs and benefits of the project to their present values. The discount rate represents *opportunity cost of capital* in economic appraisal.

8.2 KOSI RIVER STRETCHES CONSIDERED FOR FINANCIAL AND ECONOMIC APPRAISAL

Based on the traffic forecasts presented in **Chapter 2**, the following Kosi river stretches have been considered for financial and economic appraisal.

S. No.	Name of the Waterway	Length (Km)
Kosi River		
1	Naugachhia - Kosi	91
2	Kosi - Supaul	77
3	Supaul - Nepal	75

8.3 PROJECT COSTS AND BENEFITS

Various items of project cost for the IWT alternative include incremental expenditure for i) the development of infrastructure facilities (waterway and terminal) and their operation and maintenance (O &M) and ii) user costs – mainly cost of additional handlings and local haulage at both (originating as well as terminating) IWT terminals. The project benefits comprise the cost of next best alternative foregone (in this case road transport) in case the IWT project is taken up. Details of project costs and benefits are as under:

8.3.1 Project Costs

a) Capital Costs

S. No.	Cost Category	Detailed Items of Cost
1	***Waterway***	1.1 Land Acquisition
		1.2 Dredging
		1.3 Bank Protection
		1.4 Aids to Navigation
		1.5 Modifications of Bridges and locks
		1.6 Miscellaneous
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 Kosi River stretch considered for financial and economic appraisal is presented in **Table 8.1.**

Table 8.1: Capital Cost Estimates for IWT Development For Kosi River

S.No.	Name of River	Capital Cost (in Rs. lakhs)					
		Total Cost	2010-11	2011-12	2012-13	2025-26	2035-36
1	**Kosi River**						
(i)	Waterway	3176.02	952.81	1270.41	952.81		
(ii)	Terminal :	9560.13	2868.04	3824.05	2868.04		
	Total	**12736.15**	**3820.85**	**5094.46**	**3820.85**	**3943.40**	**7044.35**

A summary of the percentage share of capital cost on waterway, terminal is given in **Table 8.2.**

Table 8.2: Percentage Composition of Capital Cost for IWT Development For Kosi River

Waterway	Terminal	Total
24.94%	75.06%	100.0%

b) Operating and 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:

i) Manpower
ii) Repair & maintenance
iii) Fuel & consumables
iv) Overheads

The assumptions and parameter estimates underlying the O&M costs terminals are presented in Project costs chapter. Summary estimates of O&M costs are given in **Table 8.3.** As the construction period is 3 years , operating cost will be incurred from 2013-14.

Table 8.3: Summary Estimates of O&M Costs

S.No.	year	Operation and Maintenance cost/year In Lakh
1	2012-2024	894.28
2	2025-34 (Additional cost)	121.38
3	2035-41 (Additional cost)	232.29

8.3.2 Project Benefits

The introduction of the IWT will yield tangible and non-tangible savings due to equivalent reduction in road traffic and certain socio-economic benefits. These include savings in road construction and maintenance, vehicle operating costs, travel time and other socio-economic benefits of travel time, better accessibility, better comfort and quality 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
- Savings in vehicle operating costs of buses and other vehicles that are using the existing transport network after the IWT is introduced due to decongestion effect on road stress.
- Savings in time of passengers of existing modes, because of reduced congestion on roads.
- Saving on account of reduction of vehicular pollution .

For the purpose of the study only savings 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 traffic by the next best alternate mode (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 has been worked out taking to account. The recent Total Transport study carried by RITES for Planning Commission has been worked out the economic cost of different commodity on different roads. The study has been worked out that the economic cost of the normal commodity movement in State Highway of two lanes is **one rupees and eighty three paise per tonne per km.** The same cost has been considered for the economic analysis.

8.3.3 Shadow Pricing

The value of Project cost and benefits have been expressed in terms of market prices. These prices, however, do not reflect the real resource cost and value of benefits derived from the project to the economy. The market prices are distorted due to variety of factors. These factors could be controlled/administered prices of inputs, monopolistic market of inputs, tax structure etc. The factors used for converting project inputs and output to economic costs are given in following **Table 8.4.**

Table 8.4 Shadow Pricing

S.NO	ITEM	FACTOR
1	Capital cost	0.85
2	Operations & maintenance cost	0.85

8.4 Financial Internal Rate of Return (FIRR)

The revenue has been worked out by considering the traffic of commodity movement by IWT as **Rupees one per tonne per km**. The cost and revenue streams of Financial Analysis are presented in **Table 8.5.** The FIRR for the Kosi River stretch of IWT system is worked out which is **8.82%**. This Analysis shows that the project is less financially viable on the basis of tariff of commodities traffic alone.

Table 8.5 FIRR For Inland Water Transport System for Kosi River

SN	Year	Capital Cost	Additional cost	O&M Expenses	Total Out Flow	estimated Traffic	revenue generation in IWT	Net Cash flow (Financial)
1	2010-2011	38.21			38.21			-38.21
2	2011-2012	50.94			50.94			-50.94
3	2012-2013	38.21			38.21			-38.21
4	2013-2014			8.94	8.94	14.01	14.01	5.07
5	2014-2015			8.94	8.94	14.85	14.85	5.91
6	2015-2016			8.94	8.94	15.74	15.74	6.80
7	2016-2017			8.94	8.94	16.69	16.69	7.75
8	2017-2018			8.94	8.94	17.69	17.69	8.75
9	2018-2019			8.94	8.94	18.75	18.75	9.81
10	2019-2020			8.94	8.94	19.87	19.87	10.93
11	2020-2021			8.94	8.94	21.07	21.07	12.13
12	2021-2022			8.94	8.94	22.33	22.33	13.39
13	2022-2023			8.94	8.94	23.67	23.67	14.73
14	2023-2024			8.94	8.94	25.09	25.09	16.15
15	2024-2025			8.94	8.94	26.60	26.60	17.66
16	2025-2026		39.43	8.94	48.37	28.19	28.19	-20.18
17	2026-2027			10.15	10.15	29.88	29.88	19.73
18	2027-2028			10.15	10.15	31.68	31.68	21.53
19	2028-2029			10.15	10.15	33.58	33.58	23.43
20	2029-2030			10.15	10.15	35.59	35.59	25.44
21	2030-2031			10.15	10.15	37.73	37.73	27.58
22	2031-2032			10.15	10.15	39.99	39.99	29.84
23	2032-2033			10.15	10.15	42.39	42.39	32.24
24	2033-2034			10.15	10.15	44.93	44.93	34.78
25	2034-2035			10.15	10.15	47.63	47.63	37.48
26	2035-2036		70.44	10.15	80.59	50.49	50.49	-30.11
27	2036-2037			12.47	12.47	53.51	53.51	41.04
28	2037-2038			12.47	12.47	56.73	56.73	44.26
29	2038-2039			12.47	12.47	60.13	60.13	47.66
30	2039-2040			12.47	12.47	63.74	63.74	51.27
31	2040-2041			12.47	12.47	67.56	67.56	55.09
							FIRR	**8.82%**

8.5 Economic Internal Rate of Return (EIRR)

Based on the traffic forecasts, estimated project costs and benefits in economic cost terms, cost and benefit streams have been worked out for the entire project life including 3 years of construction period for Kosi River stretch. The cash detailed of cost and benefit streams of Economic Analysis is presented in **Table 8.6.** The EIRRs for the Kosi River stretch of IWT system is worked out is **20.39%.** which is higher than the norm of planning commission of 12 %.

Table 8.6 EIRR for Inland Water Transport System For Kosi River

S N	Year	Capital Cost	Additional cost	O&M Expenses	Total Out Flow	estimated Traffic	Saving in Road Transport	Net Cash flow (economic)
1	2010-2011	32.48			32.48			-32.48
2	2011-2012	43.30			43.30			-43.30
3	2012-2013	32.48			32.48			-32.48
4	2013-2014			7.60	7.60	14.01	25.64	18.04
5	2014-2015			7.60	7.60	14.85	27.18	19.58
6	2015-2016			7.60	7.60	15.74	28.81	21.21
7	2016-2017			7.60	7.60	16.69	30.54	22.94
8	2017-2018			7.60	7.60	17.69	32.37	24.77
9	2018-2019			7.60	7.60	18.75	34.31	26.71
10	2019-2020			7.60	7.60	19.87	36.37	28.77
11	2020-2021			7.60	7.60	21.07	38.55	30.95
12	2021-2022			7.60	7.60	22.33	40.86	33.26
13	2022-2023			7.60	7.60	23.67	43.32	35.72
14	2023-2024			7.60	7.60	25.09	45.91	38.32
15	2024-2025			7.60	7.60	26.60	48.67	41.07
16	2025-2026		33.52	7.60	41.12	28.19	51.59	10.47
17	2026-2027			8.63	8.63	29.88	54.68	46.06
18	2027-2028			8.63	8.63	31.68	57.97	49.34
19	2028-2029			8.63	8.63	33.58	61.44	52.82
20	2029-2030			8.63	8.63	35.59	65.13	56.50
21	2030-2031			8.63	8.63	37.73	69.04	60.41
22	2031-2032			8.63	8.63	39.99	73.18	64.55
23	2032-2033			8.63	8.63	42.39	77.57	68.94
24	2033-2034			8.63	8.63	44.93	82.23	73.60
25	2034-2035			8.63	8.63	47.63	87.16	78.53
26	2035-2036		59.88	8.63	68.50	50.49	92.39	23.88
27	2036-2037			10.60	10.60	53.51	97.93	87.33
28	2037-2038			10.60	10.60	56.73	103.81	93.21
29	2038-2039			10.60	10.60	60.13	110.04	99.44
30	2039-2040			10.60	10.60	63.74	116.64	106.04
31	2040-2041			10.60	10.60	67.56	123.64	113.04
							EIRR	**20.39%**

CHAPTER - 9

CONCLUSIONS AND RECOMMENDATIONS

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The viability of Inland 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 depths 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 investments made besides several other socio-economic benefits such as employment generation, poverty alleviation in rural areas and so on. The recommendations for implementation of the project are based on the tradeoff between costs to be incurred and benefits derived.

The traffic surveys conducted in the hinterland of river Kosi have shown that about 12.8 lakhs of the traffic has been identified for movement in the base year (2008-09) and the projected traffic for the year 2035-36 will be 61.95 lakhs. Inland Water Transport terminals are recommended at four locations viz., Kalyanpur, Basbitti, Dhambaraghat and Kursela to handle the traffic.

The hydrographic surveys and hydrological investigations carried out on river Kosi, a length of about 236 km from Kosi barrage at Hanumannagar to Ganga confluence at Kursela have revealed that the waterway is feasible for navigation for about 300 days in a year (80% of the days per annum) and the discharge in the river observed during the lean period (January to May) is of the order of about 140 to 200 cumecs. The design channel recommended for development is with a depth of 1.2 m, bottom width 25 m which is suitable to ply 100 tons vessel.

The capital cost for development of the system components of the project viz., development of the design waterway and construction of IWT terminals has been worked out as Rs 127. 36 crores and the estimated operating cost per annum is Rs. 8.94 crores.

The cost benefit analysis and financial internal rate of return (FIRR) on investments have revealed that the returns on the project is 8.82%. However, the economic internal rate of return (EIRR) on the project is worked out as 20.39%. The economic appraisal and the resultant EIRR clearly indicate that investment on development of IWT on Kosi river will be economically viable though 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 investments 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. Though 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.

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

Further the Kosi waterway can be developed as international waterway since the river also traverses in Nepal territory. From this angle, the bilateral trade between India and Nepal would be developed for which certain traffic has already been identified and considered in the study. Another important aspect need to be considered is that the Kosi river will become a feeder waterway to National Waterway No. 1 (Ganga-Bhagirathi-Hooghly river system) if 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 Kosi waterway should be developed for IWT operations in consultation with Inland Waterways Authority of India, the apex body for development of waterways in India. The integrated Kosi waterway with National Waterway 1 from Allahabad to Haldia may further enhance its viability.

Given the above, it is recommended that the IWT systems, hitherto a neglected mode of transport, should be taken up for development of local/regional economy as this mode has great potential in terms of employment generation and other related developments.