INLAND WATERWAYS AUTHORITY OF INDIA, NOIDA

DETAILED PROJECT REPORT ON INTERMODAL TERMINAL AT VARANASI

Volume – I

final report

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CHAPTER – 1

INTRODUCTION AND PROJECT BACKGROUND

1.0 INLAND WATERWAYS

1.1 Introduction

The Inland Waterways Authority of India was set up on October 27, 1986 under the Inland Waterway Authority of India Act 1985 for the regulation and development of Inland Waterways for purpose of Shipping and navigation.

The important functions and powers of the Inland Waterways Authority of India (IWAI) are as follows:

1. Conducting investigations and carrying out Techno-Economic Feasibility Studies on Inland Waterways for declaration as National Waterways through act of parliament.

2. Development of declared National Waterways by means of conservancy measures, river training works, setting up of infra-structural facilities etc.

3. Other connected/ subsidiary functions like regulation of traffic, maintenance of pilotage, co-ordination of IWT in the National Waterways with intermodal transport etc.

India's navigable waterway extent nearly over 14,500 Km comprising variety of river systems, canals backwaters, creeks and tidal inlets (Ref. Table 1.1).

Most waterways suffer from navigational hazards like shallow water and narrow width during dry season. This is compounded by siltation and bank erosions. As a result only about half the river length 5,200 Km of major rivers and 485 Km of canals are suitable for mechanised craft (Ref. Table 1.2).

Movement of goods by Inland Water Transport system in India has not gained momentum. In the heyday of steam navigation, steamers used to ply from Kolkata to as far upstream as Garhmukteswar on the Ganga and Agra on the Yamuna. They also used to ply, via the Ganga- Brahmaputra linkage as far east as Sylhet and Assam.

Long range river cargo services entered a period of gradual decline beyond 1890, which ultimately led to a crash in traffic movement in early 1930's. Primary factors responsible for these trend was the decline in navigability on the river Ganga above Mirzapur and increased competition from the railways and road transportation.

Share of Inland Water Transport in developed countries like USA, Holland, China etc. are of the order of 8% to 20% of total Inland cargo, and the share in India is around 0.1% only, corresponding to 1.0 billion tonne-Km.

The following three waterways have been declared as National Waterways:

a) National Waterways No.1 (1620 Km_) Connecting Allahabad-Varanasi, Patna - Semaria – Farakka Kolkatta- Haldia on river Ganges. (Fig. 1.1)

b) National Waterway No. 2 (891 Km) connection Kolkata – Dhubri – Tejpur - Guwahati – Dibrugarh – Sedia on Brahmaputra river.

c) National Waterways No.3 (168 Km) kottapuram – Kollam stretch of the West Coast canal.

Map of India showing important waterways have been shown in Fig. 1.2.

1.2 Project background

The location of an IWT terminal along Ganga is most suitable where adequate water front area with requisite depth of water is available. The site should have an easy land transport with easy access and egress.

The Ganga – Bhagirathi – Hooghly river system from Haldia to Varanasi has been declared as National Waterway No. 1 in 1986 and since then various developmental activities on this waterway are under progress. The provision of infrastructure on the National Waterway is one of the primary responsibilities of IWAI and as a part of development IWAI felt that development of terminal location at Varanasi as an intermodal terminal is essential. With the above background, MECON Ltd., Ranchi, a Government of India Undertaking was selected to undertake a consultancy service for the preparation of Detailed Project Report (DPR) for construction of Intermodal terminal at Varanasi. The objective of the consultancy study is to prepare the DPR for developing an intermodal terminal at Varanasi so as to develop the terminal as integrated facility for operation of cargo along with shore based structure and necessary services with an intermodal connection with rail/road. The proposal will highlight the preliminary estimate, Preparation of preliminary design along with pre-construction planning through consultant.

MECON had submitted the draft final report in the month of November 2003 and also made a power point presentation to IWAI officials on the draft final report at Noida office in the month of August 2006. IWAI has sent the comments on the draft final report in October 2006. MECON, IWAI and the barge operators had a meeting at IWAI office, Kolkata in December 2006 to discuss technical feasibility of operating the barges at the terminal and finalise the optimum alternative. MECON had also made presentation on final report to IWAI officials on 19.03.2007 at IWAI office, NOIDA during which the report was accepted by IWAI.

The terms of reference for the above study are indicated below.

1.3 Terms of reference

1. Review of the traffic projections for terminal at Varanasi based on the earlier reports/as planned/projected by various concerned agencies and fix up the traffic for the future for the time frame of 2005, 2010, 2015, 2020. While working out traffic projection, the commodity wise traffic inflow and outflow will be conceptualised for the above time frame.

2. Study the river morphology and other related aspects and identify different alternative locations as possible terminal sites, in view of berthing facilities, requirement of river training/ protection works, inter model connectivity with both rail and road, easy access and egress, availability of land etc.

3. While conforming the terminal location from various possible locations, the best alternative location /locations are to be identified considering intermodal connections with road and rail, duly describing the merits and demerits of each alternative site along with the availability of backup land and the land provision in the Municipality / city development authority etc. Alternative locations should include two sites at Kaithy on opposite banks as tentatively selected by IWAI and also at Gauraghat which are downstream of Varanasi.

4. Recommend cargo-handling facilities required at the terminal. While conceptualising the facility, the norms prescribed for operation along with the inter model compatibility with road and rail, its merits and demerits will be discussed in details.

5. Undertake the required soil investigations at identified terminal for selecting and designing suitable river/ shore structures.

6. Design suitable terminal structures including berthing facility, storage, bunkering, inter model connection and mechanical handling system etc. for the identified terminal site duly describing various alternative propositions

7. Prepare the preliminary cost estimate of various alternative possibilities and recommend the optimum alternative, considering the capital cost and operation/ maintenance cost, and merits and demerits with respect of technical and operational aspects.

8. To prepare the detailed estimates, detailed drawings, bill of quantities along with tender documents containing general conditions, special conditions with technical specifications for various subheads of the terminal projects.

9. To prepare economic viability of various alternative taking into consideration the cash outflows and cash inflows and other benefits including saving in turn around time of IWT vessels and recommend option.
   Accordingly the FIRR and EIRR are to be worked out for each alternative to substantiate the optimum option recommended.

10. Recommend various charges for using the terminal facilities along with container handling / bulk cargo handling etc.

11. Prepare a realistic construction schedule for the terminal indicating the priority of works along with the schedule. The phasing of expenditure is also to be worked out.

Table 1.1

Navigable waterways in India

State	Navigable waterways * (km.)			Density of navigable waterways (per 100 sq km. of area)
	Rivers (km.)	Canals (km.)	Total (km.)	
Andhra Pradesh	309	1690	1999	0.72
Assam	1983	-	1983	2.53
Bihar	937	325	1262	0.73
Goa, Daman & Diu	317	25	342	9.00
Gujarat	286	-	286	0.15
Jammu & Kashmir	200	-	200	0.09
Karnataka	284	160	444	0.23
Kerala	840	708	1548	3.98
Maharashtra	501	-	501	0.16
Orissa	761	224	985	0.63
Tamilnadu	-	216	216	0.17
Uttar Pradesh	2268	173	2441	0.83
Westbengal	1555	782	2337	2.66
All India total	10241	4303	14544	0.44

* These include all waterways navigable by country boats

Source: Indian Ports Journal, October 2000

Table 1.2

Navigable length of important river system of India

S. No	River system	Navigable length (in km)	
		By boats	By steamers
1	Ganga River system (excluding Hoogly)	3355	85
2	Brahmaputra river system	1020	747
3	Rivers of Westbengal	961	784
4	Rivers of Orissa	438	42
5	Godavari river system	3999	-
6	Krishna river	101	-
7	Narmada river	177	48
8	Tapti river	24	24

Source: Indian Ports Journal, October 2000

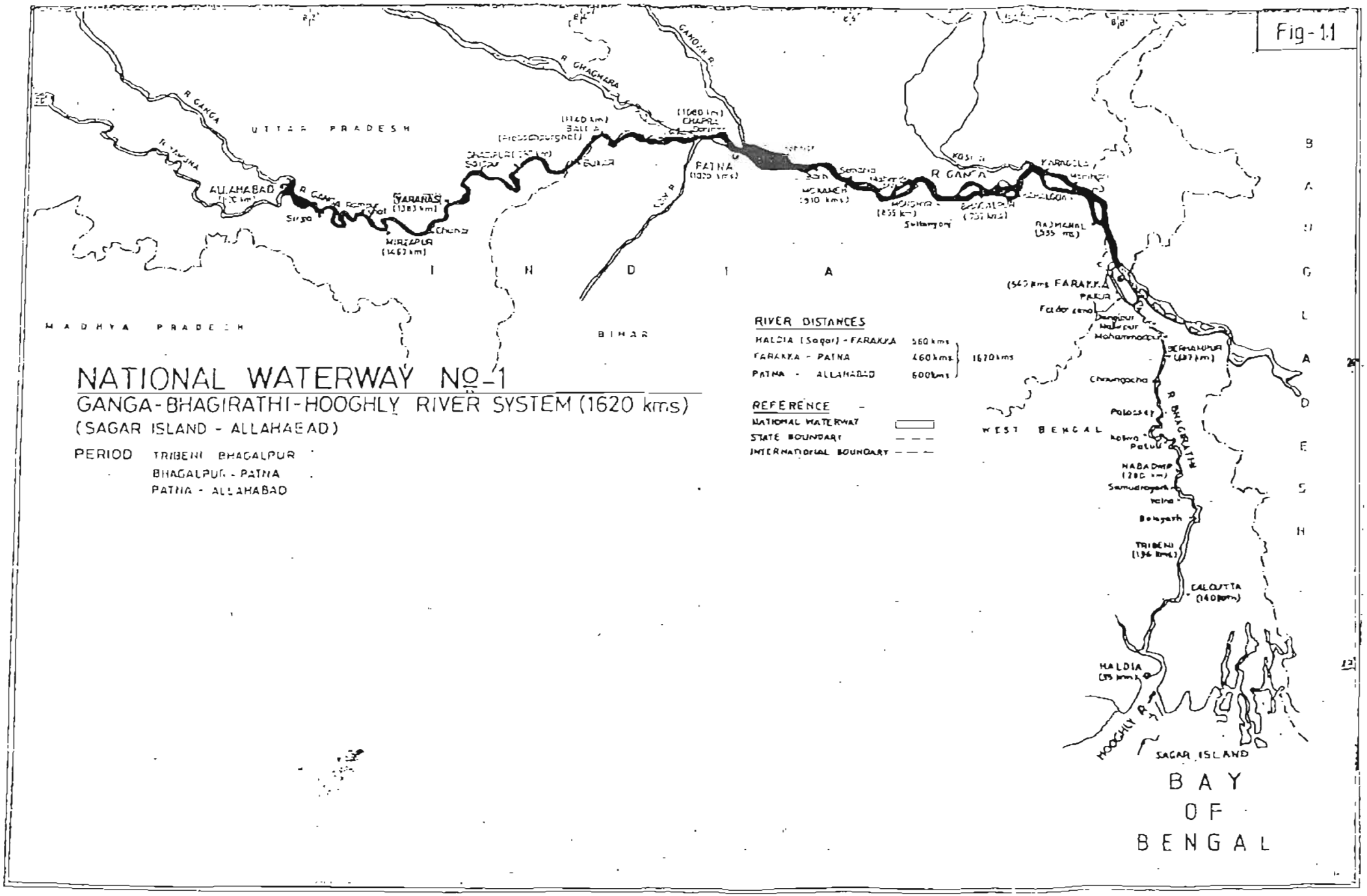
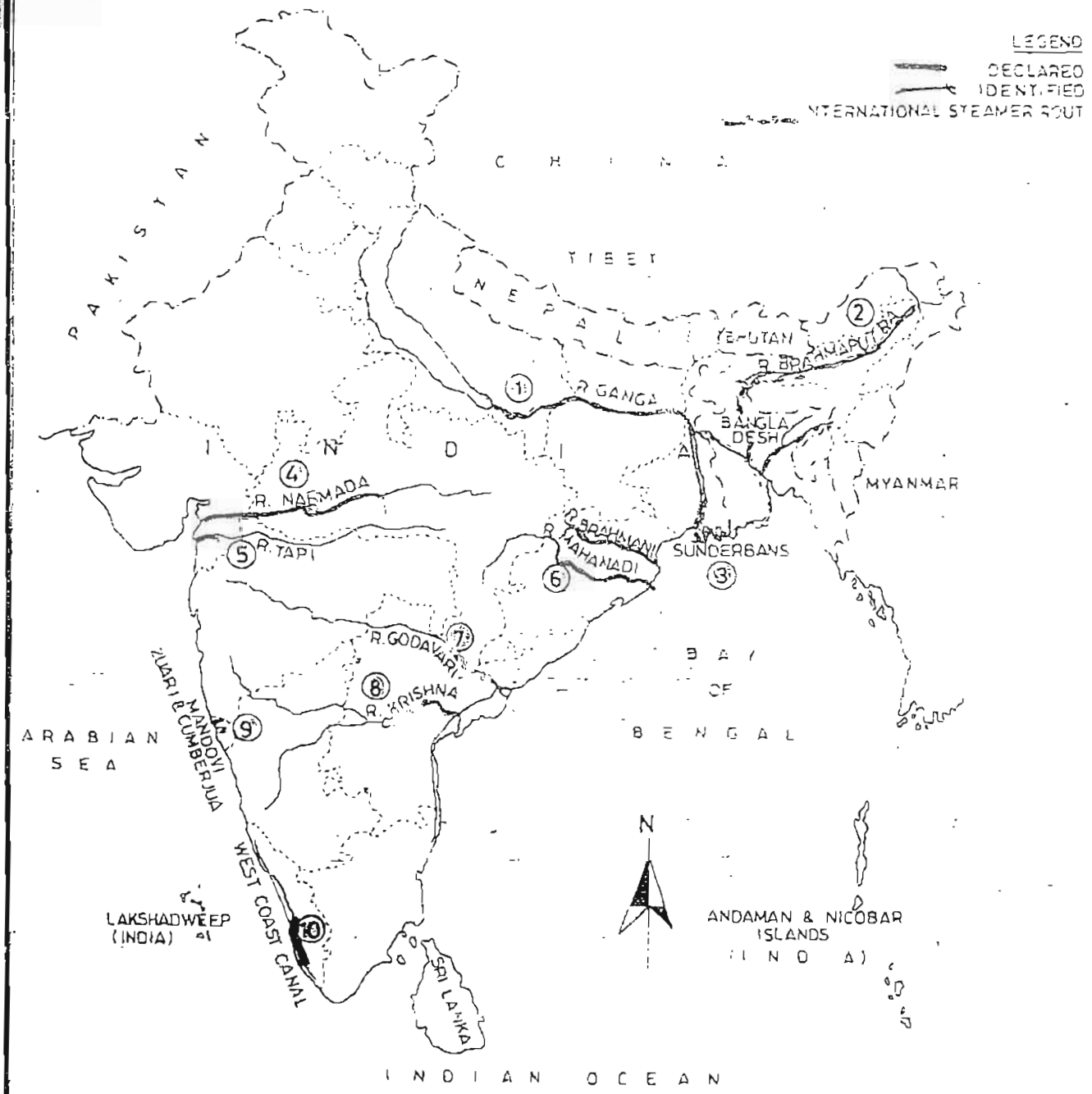


Fig-1.1
NATIONAL WATERWAY No-1
GANGA-BHAGIRATHI-HOOGHLY RIVER SYSTEM (1620 kms)
(SAGAR ISLAND - ALLAHABAD)
PERIOD TRIBENI BHAGALPUR
BHAGALPUR - PATNA
PATNA - ALLAHABAD
RIVER DISTANCES
HALDIA (Sagar) - FARAKKA 560 kms
FARAKKA - PATNA 460 kms
PATNA - ALLAHABAD 600 kms
1620 kms
REFERENCE
NATIONAL WATERWAY
STATE BOUNDARY
INTERNATIONAL BOUNDARY
I N D I A
UTTAR PRADESH
MADHYA PRADESH
BIHAR
WEST BENGAL
B A N G L A D E S H
R GANGA
R YAMUNA
R CHAGHARA
GANDAK R
R SON
R KOSI
R BHAGIRATHI
ALLAHABAD
VARANASI
MIRZAPUR
PATNA
CHAPRA
BALIA
FARAKKA
RAJMAHAL
BHAGALPUR
TRIBENI
CALCUTTA
HALDIA
HOOGHLY R
SAGAR ISLAND
BAY OF BENGAL

FIG 1.2

MAP OF INDIA
SHOWING IMPORTANT WATERWAYS
IDENTIFIED BY NATIONAL TRANSPORT POLICY COMMITEE (1980)



Sr. No	Particulars	Stretch	kms	Remarks
1	GANGA-BHAGIRATHI-HOOGHLY RIVER SYSTEM (U.P. BIHAR, WEST BENGAL)	ALLAHABAD-HALDIA(SAGAR ISLAND)	1620	DECLARED
2	BRAHMAPUTRA RIVER (ASSAM)	DHUBRI(B. BORDER)-SADIYA	891	DECLARED
3	SUNDERBANS RIVERS & CREEKS SYSTEM (WEST BENGAL)	NAMKHANA - B. BORDER	197	STUDIED
4	NARMADA RIVER(MP, GUJARAT)	HOSHANGABAD-BHARUCH	640	STUDIED
5	TAPI RIVER (GUJARAT)	SURAT - SEA MOUTH	25	IDENTIFIED
6	MAHANADI/BRAHMANI RIVER (ORISSA)	SAMBALPUR - PARADEEP TALCHER - PARADEEP DHAMRA	418 / 260	STUDIED
7	GODAVARI RIVER (ANDHRA PRADESH)	RAJAHMUNDRY - CHERLA	208	STUDIED
8	KRISHNA RIVER (ANDHRA PRADESH)	NAGARJUNA SAGAR DAM - VIJAYAWADA	193	STUDIED
9	MANDOVI, ZUARI & CUMBERJUA RIVERS (GOA)	USGAON - SEA MOUTH SANVARDAN - MARMAGAO	41.64&17 = 122	IDENTIFIED
10	WEST COAST CANAL (KERALA)	KOTTAPURAM - KOLLAM UDYOGAMANDAL & CHALIYAKARA CANALS	205	DECLARED

CHAPTER – 2

TRAFFIC ANALYSIS

2.0 TRAFFIC FORECAST

2.1 Prelude

This section deals with the assessment of traffic expected to be handled by the proposed Varanasi inter-modal terminal up to the years 2020. For the preliminary assessment, the cargo potential for the terminal at Allahabad is taken as within the command area hinterland of Varanasi terminal, as the distance between the proposed terminal at Varanasi and that of Allahabad is only 120 kms which is not a long distance for large terminals as also cargo origins and destinations because in future, it may over-lap due to further industrial development of the region. The trigger effect of the terminal is not considered in this preliminary assessment, as this is still indeterminate at this point of time. Moreover it can be influenced by the implementation of any one terminal either at Allahabad or at Varanasi.

The intermodal terminals with container handling capability and with provision of transshipment facilities are considered. 'Large' terminals require an acceptable volume of traffic even if it needs to be developed over a period of time. The consideration that road transport distances for cargo generation/receiving points from the terminal may not be applicable for 'large terminals' since the industrial development is perforce to be along the river to meet such conditions. In a situation where non-river transport models had over decades a development edge, the existing industrial locations were based on various criteria, such as weightage on rail / road transport support. If the IWT is to take advantage of the expansion / capacity additions of such existing industries, plants etc, the locations of such industries which can contribute to cargo generation

needs to be compared to the ideal near-the-bank location. In these cases, cost comparisons made by cargo owners may show favour for the continuance of the present status quo rather than the total shift of this commodity to the IWT mode. This is due to the investment already made by the owners over a long period in supporting transport infrastructure for raw material receipt and finished goods distribution. Therefore it is not conducive to use the cargo volume potentials of such industries as qualifying cargo for the IWT terminal unless the owners fully commit the cargo for passage through the terminal. Several previous studies have made traffic projections on the assumption of total shift of such cargo to the IWT mode. In subsequent paras the maximum share of the shift to IWT mode with logistics has been worked out.

However, if near the bank of river, industries become a reality by taking advantage of the terminal, the same will be due to the existence of the terminal thus causing a trigger effect. But this will take a longer period after the terminal starts functioning as the accepted norm that the terminal waits for the cargo rather than cargo waiting for the terminal is the general criteria.

The IWT mode with all its working infrastructure like intermodal terminals, navigational requirements, least available depth (LAD) safety etc, will have the following advantages : saving of fuel, relief to the Rail and Road mode caused by shift of low and medium value cargo to IWT, enabling them to carry high volume fast delivery items causing increased revenue without large incremental investments, environmental degradation is largely minimised or even eliminated which is more cost effective, additional employment generation triggering social development, ancillary and support industry development like vessel

building, vessel repair, communications etc. which enhances national economy etc.

Hence the above contribution of IWT on the national economy, will require that shift of cargo to IWT to be made mandatory in qualifying cases and that any costs to the owners for investment in support infrastructure to move cargo to and from the terminal may require to be subsidized in view of the economic gains accruable by use of the IWT mode. If this is not done the projection of traffic would only be wishful. It is worth while to mention that the National level Interactive meet on IWT organised by the IWAI and FICCI on 8th June 2001 has brought out the problems / deterrents in the introduction of IWT in the country and the IWAI paper has emphasised the above premises.

2.2 Review of past studies

Review of existing literature reveals a number of studies carried out on IWT mainly with the objective of comparing IWT operating costs vis-à-vis road transport costs. It is worth mentioning that all the studies have pointed out comparative advantage of IWT over road transportation of bulk commodities.

National Transport Policy (NPT) report prepared by the Planning Commission, 1980, is a comprehensive study on economic analysis of all major modes of transport system, v.i.z., rail, road, coastal shipping and IWT.

The Bahgwati Committee has examined the major river systems in the country and reviewed the scope for IWT services. In the study, a general

treatment was given to traffic potential. Moreover, the study also mentioned historical navigation in some of the Ganga tributaries, Ghagra, Sone and its Yamuna canal etc. The important implication of the study is that if these ever become navigable in future, can open hinterlands with impact on Allahabad / Varanasi traffic.

National Council of Applied Economic Research (NCAER) has carried out a study on IWT services on Ganga between Allahabad and Calcutta with emphasis on estimation of potential traffic, economics of barrage operation vis-à-vis other modes transport, investment appraisal of IWT services etc. A techno economic feasibility study on NH-1 as also been earlier conducted by CES. In case of traffic forecasting, the hinterland is defined as a region within 20 kms from the river. The demand for goods / cargo is assumed as function of population concentration and mining / industrial complexes. Projections are made considering the above factors, consumption and production parameters.

2.3 Traffic projection

The total route of water ways to be covered by the Varanasi terminal is in fact, Varanasi - Allhabad - Patna - Kolkata. In this route, majority of the cargo is handled between the Patna - Kolkata segment because of the advantages of sufficient water. Table-1 depicts commodity-wise cargo handled through the Patna-Kolkata segment by CIWTC. The table amply reveals that fertilizer, met coke, cement and stone chips are the major items handled during the period. It is also observed that the quantity of these items as well as total volume of inland water traffic through this segment is quite low. A close examination of the historical data on traffic handled by CIWTC during 1991-92 to 2000-01 reveal

that there is tremendous fluctuation in traffic, both in terms of quantity and value during this period. This has important implications from the point of view of quantitative analysis / modelling.

Table – 1

INLAND TRAFFIC HANDLED BY CIWTC DURING 1991-92 TO 2000-01 ON NW-I

Q = Quantity in MT V = Value in Rs lakhs

Sl. No.	Item	Unit	1991-92	1992-93	1993-94	1994-95	1995-96	1996-97	1997-98	1998-99	1999-00	2000-01
A	KOLKATA-PATNA											
1	Soap	Q	19									
		V	0.5									
2	Fertilizer	Q	180	532								
		V	0.9	1.06								
3	Stone chips	Q										
		V										
4	Met coke	Q		7409	6300				1488			
		V		18.8	18.3				9.01			
5	Paper	Q		452								
		V		1.13								
6	Pipe	Q										
		V										
7	Tug high	Q										
		V										
8	Cement	Q						500				
		V						1.4				
9	ODC	Q								594		637
		V								6.2		5.6
10	Silica sand	Q										
		V										
11	Project cargo	Q										
		V									20	
12	Jute	Q										600
		V										4.0
13	General cargo	Q										
		V										
	SUB-TOTAL (A)	Q	199	8393	6300	0	0	500	1488	594	0	1237
		V	1.4	20.99	18.3	0	0	1.4	9.01	6.2	20.0	9.6

B	PATNA-KOLKATA											
1	Soap	Q										
		V										
2	Fertilizer	Q								576		
		V								1.4		
3	Stone chips	Q	160		3155	2148						
		V	0.16		4.1	3.0						
4	Met coke	Q										
		V										
5	Paper	Q										
		V										
6	Pipe	Q		6.6								
		V		1.0								
7	Tug high	Q										
		V										
8	Cement	Q										
		V										
9	ODC	Q										
		V										
10	Silica sand	Q								228		
		V								0.46		
11	Project cargo	Q										
		V										
12	Jute	Q										
		V										
13	General cargo	Q	10	5.1								
		V	0.02	0.06								
	SUB-TOTAL (B)	**Q**	170	11.7	3155	2148	0	0	0	804	0	0
		V	0.18	1.06	4.1	2.96	0	0	0	1.86	0	0
	GRAND TOTAL (A+B)	**Q**	369	8405	9455	2148	0	500	1488	1398	0	1237
		V	1.58	22.05	22.4	2.96	0	1.4	9.01	8.06	20	9.6

The inland water cargo demand encompasses the local needs of the commodities for a short radius and primarily for river crossings. Projections norms based on population, regional economic development etc are valid but the traffic generated by the upgradation from time to time adds up to a satisfactory quantum for sustaining a long IWT waterway. But such regional developments are required to be super imposed with heavy industrial outfits like power stations, steel, cement and fertilizer plants, food grain movements, mining / mineral processing etc along the waterway. The cargo origin locations and user points supplemented by finished product out letting and distribution through base terminals will give large traffic volume with incremental argumentation for years to come. These are based on national planning i.e. Five year plans and only such large development features requires to be considered for analysing the traffic block for the terminal. Other user contribution becomes a bonus if a terminal is made to exist. Exports to other countries like Nepal or further overseas through Kolkata / Patna offer a valuable cargo base for the terminals. The influence area for the proposed terminal at Varanasi will have hinterland area extending upto Renukoot where big industrial units viz. HINDALCO, NTPC super thermal power stations and Rewa area where cluster of industries exist. The influence zone can also extend towards Kanpur and Jagdishpur / Bhadohi where big industrial areas exist.

The Tenth plan sectoral reports which are under finalisation are expected to throw light on the developments planned with regard to industrial and infrastructure projects along the hinterland of the Ganga-Bhagirathi-Hooghly river system. Their Influence on the Varanasi inter-modal terminal by way of cargo traffic generation hence requires to be assessed when the data is made available.

2.4 Traffic assessment

As mentioned earlier, the historical traffic data do not reveal any trend or cyclical pattern. The major reason being lack of proper terminal facilities in IWT. As the proposed Varanasi inter-modal terminal is developed, it is expected to attract traffic not only because of the improved facilities but also due to cost-effectiveness of transport. In such case, it is worth while adopt to the Delphi method which is based on expert opinion.

The forecasting exercises on future traffic potential were carried out on the basis of time series data available from secondary sources. The time series on different cargo transported by inland water ways through the considered route (or the study area) for the period 1991-92 to 2000-01 were thoroughly examined before selecting the most suitable forecasting technique. In course of this, the following trends were observed:

⇒ In most of the cases the time series were not complete, i.e., a particular commodity (or cargo item) observed to be transported by inland waterways in this route for very few years.

⇒ Therefore, statistical analysis like trend, econometric modelling etc. (done by way of conducting curve fitting experiment on past trend, causal relationship of demand and its determinants etc.) was not possible due to lack of "degrees of freedom".

⇒ As the number of observations (in the time series) for different cargo items were quite less, Delphi was considered as the most suitable technique and accordingly, applied in the study.

As a result, various authorities were contacted to obtain necessary feed on future traffic. To this end, the following authorities were

contacted for evaluating the possible traffic levels of cargo owned by them and to assess the extent of modal shift that can be encountered by them :

- Electric Authority
- Food Corporation of India
- Cement Manufacturer Association
- Fertilizers Association of India
- Varanasi Development Authority
- UPIDC, Varanasi
- Individual Exports in the respective fields

The general theme propounded by the above authorities is that the Cargo availability as at present is not the issue since the cargo movement in the rail route connecting Allahabad–Farakka–Calcutta is taking place over very long period with investments made in transport infrastructure. The expectation of the authorities of the above institutions is that the total package of cost in the movement of cargo to the leading terminal, the river transport and exit of cargo from the delivery terminal required to be lower then the present cost incurred by them in the existing rail / road transport of cargo.

In order to establish a cargo base for the terminal at Varanasi, it is felt that large volume commodities like coal, fertilizers, food grains, POL cement and stone would constitute a good base as the commodities for exports to Nepal. Major commodities that can be handled at the proposed Varanasi terminal can be listed as follows :

- Sugar
- Fertilizer

- Cement
- Iron and steel
- Coal
- Jute
- Stone chips
- Cereals and pulses
- Project cargo
- Consumer products
- POL
- Nepal traffic etc.

Although other potential cargo movements also exists but their viability of operation have been discussed separately under 2.4.7.

Cargo movement through Varanasi terminal is likely to be within a region (i.e., regional) or between nearby regions (i.e.,inter-regional) (Table-2). It is observed that sugar, jute, consumer products etc. are specifically subject to inter-regional movement while items such as coal, cement, stone chips etc. are usually for regional movement.

Table-2

Distribution of commodities by type of movement

Type of movements	Commodities
Regional	Coal, POL, Fertilizer, Cement, Stone chips, Cereals and pulses
Inter-regional	Cereals, iron and steel, sugar, Jute, consumer products
Through	Nepal imports and exports

It is now worth while to discuss about packaging of cargo because it is one of the major aspects in regard to safe transportation. Table-3 depicts packaging of major cargo which may be handled through Varanasi terminal. The table reveals coal is transported in bulk while other type of cargo are generally transported in bags. As the terminal at Varanasi brings more facilities for the users, a substantial share of cargo may be containerised.

Table-3

Commodity-wise packaging in practice

Commodity	Packaging
Coal	Bulk
Fertilizer	Bags of 50kg
Cement	Bags of 50kg or Drums of 250kg.
Stone chips	Bulk
Cereals and pulses	Bags of 100kg
Sugar	Bags of 100kg

On this background, the traffic assessment for the proposed inter-modal terminal at Varanasi is made. Most of the studies mentioned in the review of literature, on the Ganga-Bhagirathi-Hooghly waterway, were carried out long ago, i.e., about 10-15 years back. The latest one is the NBCC (draft-report) on Allahabad terminal which thoroughly reviewed and in turn, utilised the projections made in the previous studies / reports. The traffic projections made in the present study are discussed in the subsequent sections.

2.4.1 Coal

Coal mine companies deliver the coal at pit heads and users transport it to the thermal stations / industrial plants by rail/road as suitable to the respective destinations. In the case of power plants except for short haul road haulage to rail head from the pit head, their onward delivery to the power plant is by rail upto rake unloading point at the power station. A well planned and coordinated rail movement has been established over decades optimising the stock pile to be maintained at both mine and power plant ends, empty wagon generation and the effects of dislocations caused by monsoons, mining problems etc.

It is considered that as such the delivery cost of coal is very high. However, authoritative sources indicate that inventory costs and certain level of cargo loss also contributes to the high cost of coal delivery.

Coal Movement by IWT could obviate certain constraints as noted below.

- Relieve the rail mode future coal transport burden thus enabling the potential of higher value cargo movement by rail.
- Eliminate cargo losses
- Provide cargo sufficiency for viable IWT and terminal operation giving large quantum movement.

As regards inventory, the criteria for stock maintenance may be re-evaluated and at best inventory may not increase by use of IWT even though consignment delivery may be longer than that of rail mode. The reason being that after initial development of IWT barge sizes can be increased over a period of time and also the reliability of delivery.

Moreover like pit head power stations and coastal thermal stations river bank power stations can be developed over the next 15 – 20 years. A modal shift of this cargo can give a fillip to IWT as per above.

Most of the power stations in the NW-1 are below Patna. The power stations are located at Barauni, Kahalgaon, Farrakka, Bendel, Titagarh, Budge-Budge and Kolaghat. There are proposals to setup power stations at Barh also. The Coal Linkage Committee of the Ministry of coal has indicated a potential of 7.62 million tonnes/year in the X Plan period for movement in the NW-1. As for the Varanasi terminal, power stations in the Varanasi hinterland if developed would contribute to coal traffic from Raniganj (Coal mines) on the NW-1 and for the terminal at Varanasi. Already power plants viz. Unchahar, Renukoot, Tanda are present in the region and coal movement for these plants through IWT can be planned and moreover it can be influenced by the implementation of any one terminal either at Allahabad or at Varanasi.

The coal movement is from Rajmahal coal fields towards Allahabad and Chapra for industrial use. Coal for UP power stations is not moving by IWT and needs to be attracted by IWT. Without the confirmed power station developments for the 10^{th} plan, it is difficult to accurately assess possible coal movements through Varanasi terminal. However industrial consumption can be placed at 100,000 tonnes for 2005 and 125,000 tonnes for 2010. This is based on Coal unloading at Allahabad of 102600 tonnes for public sector and 342000 tonnes in the private sector with a total 4444,600 tonnes as reported in NBCC report. Industrial coal consumption at Varanasi destination is placed as above specifically for industrial units near Varanasi and Allahabad traffic which will not shift.

2.4.2 Fertilizers

Fertilizers are continuously increasing commodity for distribution to agrarian sector spread over the country. Though seasonal in nature, the quantum of traffic is considerable and the delivery requirements are critical. The use of urea accounts for around 70% of total fertilizer consumption and the distribution of urea under Essential Commodities Act is controlled by the Central government policy frame work.

The present mode of transport utilizing rail/road system is reaching saturation levels and the fertilizer utilization is continuously growing to meet enhanced agricultural production. Fertilizer manufacturing units are concentrated in the state of UP and the distribution is for UP, Bihar and West Bengal.

The importance of this commodity vis-à-vis transport is well understood from the fact that the present production level is about 20.0 million tonnes/year and the growth of production is going to be at least 5% per year for next 10 years if the growth rate of the 90's is to be maintained which was around 6% per year.

NCAER (2000) has taken up separate analysis of urea to be distributed from UP to Bihar and West Bengal. This is logical in the context of Varanasi terminal since NW-1 movement can originate from this terminal. Further, this analysis is for the additional movement of urea leaving the present level of rail / road transport i.e. as cited earlier this becomes a qualifying modal shift thus rendering the investments already made as usable fruitfully.

NCAER projection is cited below:

(tonnes)

UREA DISTRIBUTION FROM UP			
Year	**To Bihar**	**To W. Bengal**	**Total**
2001-02	161000	123000	284000
2006-07	378000	215000	593000

Other fertilizers such as DAP and MOP come from Haldia. The assessed requirement for 2000 for UP distribution is 1125000 tonnes of DAP and 150000 tonnes of MOP totalling 1275000 tonnes as per data of MOA cited by NCAER.

This would mean that for the present base year 2001 the total UP outgoing and incoming traffic in fertilizers would be 284000 t + 1275000 t = 1559000 t. This is a considerable quantum of traffic.

NBCC projection for Allahabad gives the following:

Year	**2000**	**2005**	**2010**	**2015**	**2020**
Unloading	68000	70000	80000	14000	15000
Loading	24000	250000	275000	280000	290000
Total (Tonnes)	**308000**	**325000**	**355000**	**420000**	**440000**

Considering the fact that Varanasi terminal will be Uttar Pradesh's inlet and outlet the terminal will cover the command area.

As for other projections, the IX plan Working Group on IWT has projected 439000 tonnes for the year 2000, 571000 tonnes for the year

2005 and 675000 tonnes for the year 2010. This is for entire NW-1 movement. This is also a very conservative estimate. Of this 70% will be UP receipts and despatches and this matches NBCC projections.

The report of the working group of IWT for the plan Ganga National Waterways No. 1 indicates that for the year 2005, 571000 tonnes will be the total movement. This includes all fertilizer movements in Phulpur – Ballia, Barauni-Chapra and up to Farraka. The NBCC projection for Allahabad terminal is 96,000 tonnes (high scenario) for 2005. Considering the fact that Varanasi has 40,000 tonnes capacity plant and taking 50% of this capacity as distributable by IWT and taking 50% of other types of fertilizers to be distributed to the Varanasi hinterland, it works out to (20,000 t, + 96,000/5) = 68,000 tonnes. In addition to this about 26.7% of the NBCC's projected fertilizer cargo , i.e., 257,000 tonnes is likely to be attracted by the Varanasi terminal. This would result in a total traffic of around 325,000 tonnes for 2005. This traffic is assumed to grow by 1.8% growth rate per year, leading to the projections for 2010 at 355,000 tonnes. Fertiliser movement by the plants in the hinterland namely IFFCO Allahabad; IGF,Jagdishpur; DUNCAN,Kanpur is envisaged to be covered by Allahabad terminal.

2.4.3 Food Grains

Food grains primarily cereals are moved from Punjab, Haryana and Western UP to other regions of the country. The long distant movement is primarily by rail with short hauls of road transport. Local distribution for commercial trade for the public distribution system [ration shops] and for industrial supplies i.e. flour mills, bakeries etc. is done from selected sub centres after rail movement from grain producing states of Punjab,

Haryana and Western UP.

Considerable food grain movement is taking place from the North to Assam and other areas in the Northeast. The movement route is Punjab/ Haryana/ Western UP rail heads to New Bongaigon by broad gauge and there after transhipment to metre gauge for onward movement to north eastern states. This movement totally takes 12-15 days, with attendant problems of double handling and additional storage. FCI statistics indicate that in 1998 broad gauge and metre gauge train movements from New Bongaigon amounted to 1280.000 tonnes. This is also referred by the NCAER (2000) study.

Discussions with FCI gave definite impression of their encouraging views on IWT for moving food grains. It was also pointed out that FCI made experimental run of 200 ton food grain barges from Allahabad to Varanasi in 1998 in order to come to full understanding of the characteristics of IWT mode. They experienced certain problems on the movement of barges at that time. But with the committed development on the water ways (NW.1 particularly) initiated by IWAI for giving complete navigational characteristics to the operating fairway the problems observed by the FCI during their trial shipments will be non-existent. NCAER (2000) study had recommended that the train movement from North can terminal at Farrakka instead of New Bangaigon and thereafter NW.II can be used to carry out barge movement from Farrakka to six terminals in North East i.e. Dhubri, Jogighopa, Pandu, Tezpur, Nemati, and Dibrugarh, covering the whole of North East. From Farrakka the protocol route via Bangla Desh can be used, as observed by the NCAER.

As for rail transport from Punjab, Haryana and Wester UP down to Farrakka as recommended above (NCAER) it can be planned inview of the advent of the Varanasi terminal (which is the nearest IWT terminal to upper Northern India) that food grain transshipment terminal can be established. To begin with ¼ of the total train movement in food grain can terminate for onward movement by barges through Varanasi terminal on NW.I and further move onwards through Farrakka to NW.II for the Dhubri, Jogighopa, Pandu, Tezpur, Nemati and Dibrugarh river ports. This fits in with the purpose of IWT experimental movement done by FCI earlier.

The absorbtion of food grain traffic on the Waterway NW.I from Varanasi - Farrakka - NW.II -- Protocol route to Assam through Kolkata and Sunderbans / NE. States can commence from ¼ of the present train movement and accommodate the further growth totally on to the Varanasi terminal-head for NW.I, NW.II for through movement to Northeast. In view of the past O-D trend of food grains, it can be argued that cargo transported by inland water ways in or out of North East, through any protocol route, will not have any significant impact on the future cargo potential (traffic) at Varanasi terminal.

As for traffic projections the following statistics are reviewed :

	2000/01	2005/06	2010	2015	2020
IX Plan Working Group (for NW.I)	900,000	1165000	1193000	--	--
NCAER	1350000	1480000	--	--	--
NBCC	365000	355000	360000	380000	430000

In the case of food grain a very large quantity consists of cereals (wheat & rice) and a smaller quantity consists of pulses and oil seads. Evidently upper northern India supplies the cereals to down south overall and in the eastern region also from Punjab / Haryana / Western UP the movement is for Northeast. Considering physical fact that nearest IWT river head for upper northern India being Varanasi Terminal the modal shift will take place at this location i.e. Railways will be relieved of carriage of grain 1620 km (equivalent) + New Bongaigon (MG) to north eastern location.

In North East, road is the major mode of transport due to its natural advantage. With extension of BG line to Tinsukia rail transport became more attractive than earlier. In such a situation, it is reasonable to assume a shift of food grain movement from Allahabad / Varanasi up to or around ¼. A higher proportion of shit may lead to serious overestimation of demand.

In the projections of Working Group on IXth plan for total passage through NW.I the component of cross traffic is not separately given.

The burden of projection in looking for cargo for modal shift, lies on getting a definitive demand pattern supplied from known source. This is Punjab/ Haryana cereals going to deficit North East. NCAER has correlated this with present Punjab/ Haryana to new Bongaigon (BG) and onwards to other North- Eastern location by (MG) as transported by Rail. Taking confidence on this ever -- to -- continue traffic, projection can be made for Varanasi as the terminal head. Taking ¼ of present traffic as modal shift from now and providing a raise of 10% for 5 years period the cargo projection is made below on NCAER/ FCI rail movement base.

Table-4

Projection on Food Grain

Year	2001	2005	2010	2015	2020
Food Grain IWT movement from Varanasi (tonnes)					
	337,500	371,250	408,375	449,212	494,133

Presently country is surplus in food grains and it is possible there can be readjustments in crop pattern for a while. However the demand of the North East will continue and increase in annual demand will exist. Hence a moderate value of 2% per year as increase in demand is taken towards IWT account. Since the grain movement from Punjab/ Haryana to New Bongaigon onwards to North East states would continue to co-exist with IWT movement of Varanasi - Farrakka - Protocol route - North East river ports (commencing with ¼ shift) the annual demand increase of 2% per annum is considered sufficient for terminal provisions for IWT of Varanasi.

2.4.4 Petroleum Oil and Lubricants (POL)

POL is energy related critical commodity. India produces around 65.0 million tonnes of crude. The refining capacity is about 62.00 million tonnes with 14 refineries. In the hinterland of Varanasi there are no refineries and therefore POL load out of any form and crude inflow will not be a terminal traffic. However the local requirements and POL movement to UP, nearby to the terminal are being catered by rail/ road from Barauni refinery. This POL traffic can be attracted to IWT mode for out loading at Varanasi terminal towards onward distribution.

Present mode of transport as has been used over long periods are Railways and pipe line transport of crude. POL products are mostly transported by rail and road. Presently pipe line mode is saturated. Potential exists for IWT for crude and product movement. This is in the overall context. As regards Varanasi terminal, the possible movement in NW.I is to be assessed. As for projection of POL traffic for the terminal the following references are cited.

NCAER 15.0 million tonnes potential for IWT on NW.I and NW.II. (Keeping the Assam refineries in context only NW.II IWT potential is projected).

Agency / Year	2000	2005	2010	2015	2020
NBCC (CES study reference 1982)					
	250,000	260,000	270,000	280,000	290,000
OCC reference (2000) Haldia – Allahabad					
	240,000	--	--	--	--
NBCC (OCC ref. Extended)					
	240,000	260,000	265,000	270,000	280,000
IX plan Working Group on IWT					
	295,000	377,000	481,000	--	--

It can be observed that all the projection are nearly similar. NBCC has extended OCC reference to additional 5 year periods with notional growth rate for 5 years. Working group on IX plan for IWT have taken a growth rate of 5.5% per year. It is observed that the projections cited above are in some range and it is considered that IXth plan Working Group's projection be adopted with 5.5% per year for growth for the year 2015 and 2020.

The projected POL traffic is as follows :

YEAR	TONS
2000/2002	295,000
2005	377,000
2010	481,000
2015	613,275
2020	781,926

2.4.5 Iron & Steel

According to NCAER (2000) study the iron and steel movement will intensify by 2007 due to the capacity upgradation of Durgapur Steel Plant. The supply of steel to northern India is about 50% of the 15470 monthly Wagon despatches and about 35% is supplied to eastern zone stockyards. All of these are along NW.I. Observing this aspect NCAER has derived that by 2007, with 3.0 million tonne / year capacity 47% of the Durgapur Steel Plant products can be moved by NW.I.

The movement of iron and steel on account of DSP expansion is in the part of NW.I i.e. Durgapur - Farrakka (onwards to Guwahati), Durgapur - Shalimar Durgapur - Haldia onward to coastal shipping to Vizag, Chennai etc., and Durgapur to Bangla Desh. So far for the prospect of using NW.I. However the iron and steel for the terminal of Varanasi requires to be examined.

The point to be noted is the present and further despatches of steel materials to northern India cited as 47% of observed monthly despatches

qualify for NW.I up steam traffic to be terminated at Varanasi for onward distribution. The monthly despatches as observed by NCAER is 15470 wagons. This at a conservative estimate amounts to about 386750 tons/ year. The NBCC study (likely Scenario) indicates the following projections on iron and steel :

Year	2000/02	2005/06	2010	2015	2020
Unloading	10,000	10,000	11,000	12,000	15,000
Loading	8,000	10,000	10,000	13,000	14,000
Total	18000	20000	21000	25000	29000
CES Study, 1982 (unloading)	11880	14270	--	--	--

There are certain iron and steel works in the Allahabad - Varanasi region. Movement of steel is both upsteam and down stream with Patna and Varanasi respectively as nodes. Howrah / Calcutta to Varanasi movement also takes place. However the intent is to make Varanasi a terminal point for north bound steel cargo emanating from Durgapur steel belt putting NW.I to best use.

Considering the fact that (NCAER Study) 47% of steel movement is for northern India as such Varanasi terminal could become a receiving point in future and the attraction of cargo to IWT mode in NW.I from SAIL plants will take place. Therefore, with these possibilities there can be a larger cargo quantum. The recommended projection based on this understanding is given below. Only unloading at the terminal is considered since load-outs have to be fabricated items and finished

product whose modal shift is indeterminate. Whereas movement due to supply from Govt's. Plant to industries is determinate.

The projections are :

YEAR	QTY. (TONNES)
2001/02	30000
2005/06	33000
2010	36300
2015	39930

The projected value of unloading (NBCC) in the initial years is taken thrice the value i.e. 3x10,000 t = 30,000 and 10% increase per 5 years is assumed. This is taken due to the fact that shift from rail mode will occur if Varanasi terminal becomes a base point for north bound cargo.

2.4.6 Cement

There are two cement plants in the Varanasi hinterland both in Mirzapur area with 2.6 million tonne/ year. NBCC study envisages movement of cement to northeast also apart from unloading at Patna for local consumption. NCAER (2000) study has envisaged cement movement to northeast on NW.I from Sindri, Chaibasa, Banjar, Tisco and Durgapur and have not considered Allahabad - Varanasi are a plant to despatch cement to northeast region.

Cement cluster in India is located to a great extent in Rewa area, which is part of hinterland of Varanasi and Allahabad. Based on the analysis of

local market profile, it is understood that the major cement manufacturers are exporting cement to various south east Asian countries including Bangladesh from this zone. Movement of cement from this cluster through Varanasi / Allahabad to especially to Bangladesh through IWT route is possible.

Projections made by NBCC are, in fact, based on All India IWT study. The NBCC study projections are as follows :

YEAR	QTY. (TONNES)
2000	230,000 UL
	280,000 L
2005	240,000 UL
	310,000 L
2010	250,000 UL
	350,000 L
2015	240,000 UL
	360,000 L
2020	295,000 UL
	370,000 L

The projections of IX plan Working Group on IWT are 168000 t for 2005 and 189000 t for 2010. This is for the total movement on NW.I. There is considerable variation in the value of projections and there is no definitive correlation in NBCC (All India Study reference) projections as for local usage plant capacity and inter regional traffic. Under the Circumstances it is recommended that only of 50% the NBCC projections be taken as realisable and only for loadings from Varanasi. Growth is

taken at 2% per year. As such the projection for Varanasi terminal is as follows:

YEAR	QTY. (TONNES)
2001/02	140000
2005/06	154000
2010	169400
2015	186340
2020	204974

2.4.7 Other Cargo

For the Varanasi terminal the following cargoes can use the terminal.

Nepal - Indian Exports.
Tea.
Sugar
Carpets
Miscellaneous and unit cargo.

It is to be noted that tea, sugar and miscellaneous cargo cannot be relied upon for a full fledged modal shift. Tea movement as a potential cargo for Inland waterways has not been recommended by NCAER also the ownership of cargo is mostly in private hands and the quantum is also less. Making any projection for modal shift will not produce any tangible result as the terminal requires support-cargo for profitable sustenance and these commodity movements will not bring in sizeable cargo volume. If the terminal comes up with coal, food grains, fertilizers, POL and iron and steel in their respective combinations and be viable, other cargo as

above in normal course will be accommodated as they come and would be bonus cargo supplementing the terminal viability.

As regards Nepal's imports (i.e. Indian Exports to Nepal) presently reliable data is not available and Nepal Embassy would offer soon workable data for evaluating projection for Varanasi terminal, which can be added later.

2.4.8 Overall traffic Projections

The summary of commodity-wise projection on cargo for milestone years for Varanasi terminal are presented in Table-5.

Table-5

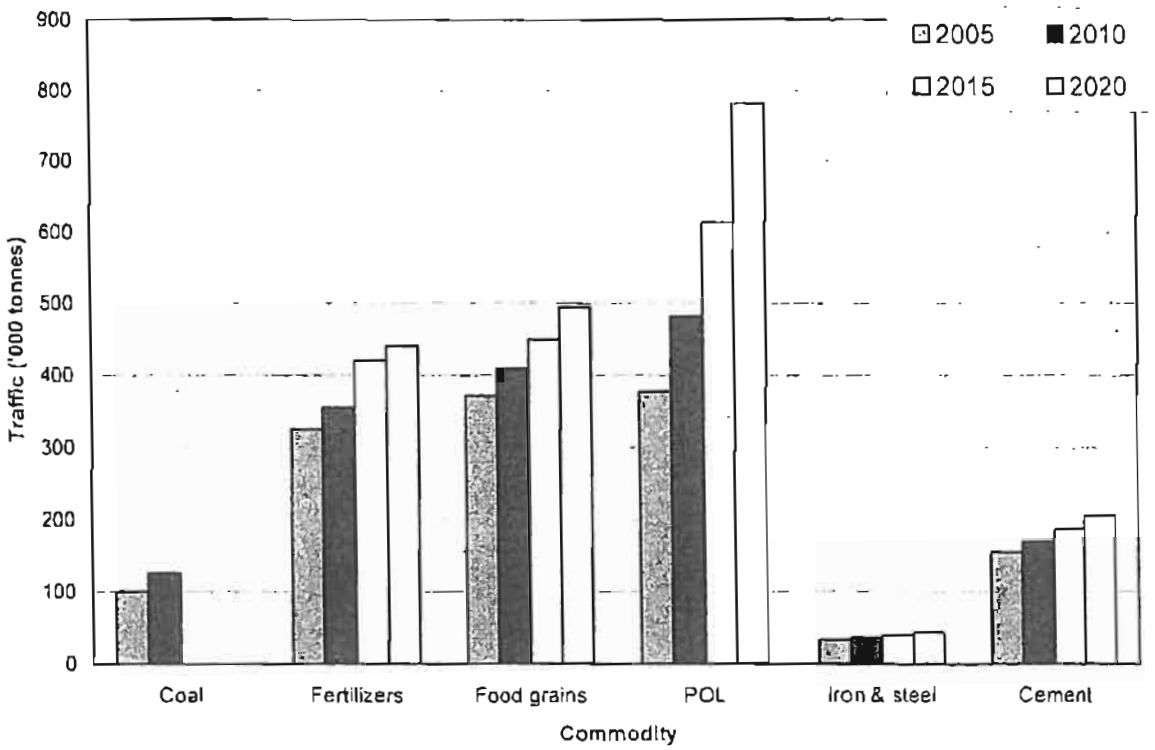
Traffic Projections for Varanasi inter-modal terminal

Commodity	2001/02	2005	2010	2015	2020
Coal	90,000	100,000	125,000	150,000	200,000
Fertilizers	308,000	325,000	355,000	420,000	440,000
Food Grains	337,500	371,250	408,375	449,212	494,133
POL	295,000	377,000	481,000	613,275	781,926
Iron & Steel	30,000	33,000	36,300	39,930	43,923
Cement	140,000	154,000	169,000	186,340	204,974
Total	**12,00,500**	**13,60,000**	**15,74,675**	**18,58,757**	**21,64,956**

The table reveals that total inland water traffic potential for 2005 is about 1.36 mt which is expected to increase to the level of 1.57 mt during 2010. During 2015 and 2020 the terminal can attract cargo to the extent of 1.9 mt and 2.17 mt respectively provided relevant

terminal facilities are developed at Varanasi. Fig.-1 provides a pictorial view of commodity-wise projected traffic for 2005, 2010, 2015 and 2020.

Fig.-1 : Projected cargo for Varanasi inter-modal terminal



The projected traffic shown in Table 5, however can be reduced by 25% considering the present traffic handled by CIWTC and the growth potential over the years. Table 6 gives the projected traffic for the corresponding period and which are taken for further analysis and terminal design.

Table 6

Traffic Projections for Varanasi inter-modal terminal

Commodity	2005	2006	2010	2015	2020
Coal	75,000	78,423	93,750	112,500	150,000
Fertilizers	243,750	248,092	266,250	315,000	330,000
Food Grains	278,250	283,643	306,281	336,909	370,600
POL	282,750	296,868	360,750	459,956	586,445
Iron & Steel	24,750	25,226	27,225	29,948	32,942
Cement	115,500	117,667	126,750	139,755	153,731
Total	**1,020,000**	**1,049,919**	**1,181,006**	**1,394,068**	**1,623,718**

CHAPTER – 3

RIVER HYDROLOGY, MORPHOLOGY AND METEOROLOGICAL CONDITIONS

3.0 RIVER HYDROLOGY, MORPHOLOGY AND METEOROLOGICAL CONDITIONS

This chapter gives the river hydrology, morphology and meteorological conditions of Varanasi.

3.1 Discharge

Some average and annual monthly discharge as available between 1971 and 1989 and also for the year 2000 are shown in Table 3.1. Considering that lean month discharge are critical for IWT, the data shows that the month of May generally indicates a low trend. The average monthly discharge in May 1989 was 160.80m^3/sec. Exceptionally a very low average of 170.80 m^3/sec occurred in June 1988. The monthly mean discharge at Varanasi is shown in Fig.3.1.

Table 3.1

Details of discharge at Varanasi in m^3/sec

(Source: CWC, Varanasi)

YEAR	AVE 71-82	AVE 84-87	AVE 85-88	1984	1985	1986	1987	1988	1989	2000
JAN	472	-	469.54	-	562.98	514.34	511.48	289.36	481.98	754.3
FEB	464	-	406.37	-	366.46	650.93	326.45	281.63	359.88	580.8
MAR	417	-	333.22	-	261.30	432.21	352.29	287.06	229.76	486.0
APRIL	370	-	274.91	-	214.89	374.00	237.26	273.50	231.03	374.0
MAY	319	-	220.59	-	164.78	295.20	237.42	184.95	160.80	332.0
JUNE	586	-	217.74	540.70	169.77	318.28	212.05	170.84	404.82	1273.0
JULY	-	-	-	2643.84	2018.52	10295.96	1192.26	6031.45	1144.7	-
AUG	-	-	-	11097.87	15782.52	18971.47	3035.65	16769.75	4447.0	-
SEP	-	-	-	13706.63	9283.33	5323.57	14921.42	4609.81	6882	-
OCT	-	-	-	1739.03	13825.34	2164.20	2430.52	3285.18	1259	-
NOV	1071	1287.05	-	897.23	2493.41	892.15	829.42	884.55	568.11	-
DEC	625	340.31	-	410.36	811.63	612.41	256.90	486.59	365	-

The minimum and maximum monthly discharges yearwise in cumecs on river Ganga at a site Varanasi from year 1991-92 to year 2005-06 are shown in Table 3.1.1.

Table 3.1.1 : Yearwise monthly discharge in cumecs

(Source: CWC, Varanasi, collected from IWAI, Kolkata)

		1991-92	1992-93	1993-94	1994-95	1995-96	1996-97	1997-98	1998-99
June	min	275.56	143.62	197.04	157.26	263.12	293.92	202.72	363.68
	max	787.48	179.5	311.29	280.7	332.92	387.09	408.42	486.62
July	min	539.58	149.22	291.76	802.38	323.62	427.4	393.9	504.35
	max	13146.4	5762.5	5777.34	17527	5935.8	12169.2	5517.36	9738.18
August	min	847.18	5243.36	564.64	11727.9	5898.38	13187.4	4378.96	1398.66
	max	28241.3	19842.9	9368.37	32225.2	20935.9	42131.5	17789.2	20895.1
September	min	3044.22	4005.7	2843.4	3896.52	4966.09	6714.91	4740.9	4314.32
	max	19346.1	7601.64	26178.2	15132.1	25019	28042.8	26848.3	16630.6
October	min	625.18	1660.56	1449.15	843	1083.53	2483.98	1550.8	3013.18
	max	2987.75	4748.72	9269.3	3679.9	4740	6262.18	4338.2	14164.8
November	min	484.32	570.62	568.38	539.32	626.28	1172.16	1108.66	1865.01
	max	618.36	1815.22	1421.08	774.58	1061.74	2283.46	2084.74	5373.56
December	min	153.74	524.4	397.82	403.74	553.08	950.58	1199.34	946.36
	max	491.02	913.82	566.14	536.8	620.24	1161.59	5950.86	1827.14
January	min	408.96	376.71	332.69	403.72	553.96	568.42	616.04	8915.59
	max	551.18	522.42	399	474.46	618.6	91.96	2157.03	995.36
February	min	325.74	339.22	2940.92	372.88	481.66	406.4	381.06	588.08
	max	408.62	374.72	361.64	440 24	599.08	466.07	558.85	967.28
March	min	233.5	339.46	212.79	341.92	409.16	306.82	321.89	492.63
	max	326.29	371.56	291.76	376.06	468.92	404.48	468.98	581.51
April	min	199.52	310.68	195.77	305.83	333.34	271.36	329.59	470.52
	max	248.46	345.8	214.45	379.48	402.56	341.18	556.86	512.2
May	min	174.98	245.22	164.26	228.58	309.7	227.08	350.03	328.25
	max	479.08	298.06	204.63	305	360.38	270.92	378.25	468.5

Table 3.1.1 : Yearwise monthly discharge in cumecs

(Source: CWC, Varanasi, collected from IWAI, Kolkata)

		1999-00	2000-01	2001-02	2002-03	2003-04	2004-05	2005-06
June	min	276.71	327.04	190.74	178.88		224.96	170.57
	max	501.5	2899.58	3168.06	537.88		1971.52	220.47
July	min	523.62	1707.28	3273.56	546.47		820.21	197.62
	max	15598.14	27819.07	16279.5	6322.48		1341.3	28763.88
August	min	8064.62	6211.87	4295.93	5155.2		1244.64	6208.71
	max	19573.53	11998.62	21112.84	33971.82		19984.1	15831.5
September	min	7958.04	4820.34	1159.39	892.58		1655.64	3522.22
	max	28783.18	16807.88	7419.92	18240.93		12261.72	7704.78
October	min	3720.86	1498.64	824.37	613.26		1535.52	2385.88
	max	11401.98	4532.27	3920.08	7258.36		2696.8	8289.9
November	min	1109.04	747.98	636.02	4461.92		751.85	1136.22
	max	3668.84	1500.12	834.69	18454.3		1540.18	2359.34
December	min	931.08	578.1	480.39	691.1		491.98	722.78
	max	1075.64	749.94	627.83	4332.88		738.9	1129.04
January	min	608.34	472.12	427.05	576.66	576.66	398.34	396.88
	max	955.46	574.14	4968.94	701.2	672.96	493.32	712.18
February	min	556.32	352.5	476.21	486.11	488.08	394.4	383.07
	max	606.25	480.08	547.22	599.95	599.6	468.4	420.24
March	min	404.81	287.86	354.9	313.84	409.24	385.78	395.75
	max	573.76	350.62	514.39	476.26	476.26	446.25	432.41
April	min	356.64	249.78	211.19	312.14	313.84	324.95	299.97
	max	400.23	288.62	353.25	469.6	407.04	406.25	379.22
May	min	322.04	208.52	173.88	235.98	235.98	220.32	
	max	351.38	249.24	210.1	407.04	315.02	321.96	

For further non-monsoon months the discharge appears to be adequate and uniform. Table 3.2 shows the maximum flood discharge at Varanasi between 1959 and 1976. The maximum discharge varied between a minimum of 18,062 m^3/sec in 1966 and maximum of 46,186 m^3/sec in 1971. During the site investigations and various discussions held by the consultant with statutory authorities such as Central Water Commission, PWD, NHAI of Varanasi it was inferred that the maximum discharge value of 46,186 m3/sec was considered in the design of the New Ramnagar by pass bridge. This bridge was completed in 1999 and located near Malahia.

Table 3.2

Data on floods at Varanasi in m^3/sec

(Source: CWC, Varanasi)

Sl. No.	Year	Gauge	Q Max (Cumecs)
1.	1959	70.71	32,590
2.	1960	70.96	29,401
3.	1961	70.00	21,169
4.	1962	70.78	25,050
5.	1963	69.84	23,451
6.	1964	69.71	24,008
7.	1965	68.85	18,220
8.	1966	69.01	18,062
9.	1967	72.81	30,736
10.	1968	68.98	19,850
11.	1969	71.01	34,702
12.	1970	71.11	34,890
13.	1971	72.69	46,186
14.	1972	64.43	24,700
15.	1973	71.03	30.451
16.	1974	69.441	21,975
17.	1975	69.42	23,662
18.	1976	69.84	20,234
19.	1977	72.16	30,362
20.	1978	67.64	-
21.	1979	-	-

On scrutiny of past mean monthly discharge records for the period from June 1984 to May 1989 for Allahabad to Varanasi and from June 1983 to May 1988 for Buxar to Patna it is inferred that peak flood discharge occurs during August and September. The minimum discharge is observed mostly during May, some time in June or April. The average ratio of the peak discharge to the lowest lean discharge is in the order of 80 for the last five years for Allahabad, Mirzapur and Varanasi and the same for Buxar and Patna is about 49.

For many years to come the strong hydro-morphological characteristics of the river Ganges will remain unchanged for various reasons like:

- The Hydrograph as well as discharge hydrograph can only be changed by projects. The desired dampening the peaks or the augmentation of the lean season water level or discharge can only be realised with huge and expensive river works like dams, giant reservoirs, spurs, afore station, linking with other rivers etc.

The minimum and maximum discharge in the Ganga, the Ghaghra and the Sone is shown in Table 3.3. The amount of water in the Ganga increase towards east as more and more tributaries drain into the main river. There is not much difference in the amount of water in the river Ganges between Allahabad and Ballia. But between Ballia and Patna two major rivers the Ghaghra from the North and the Sone from the South join and almost double the amount of water in the channel. Between Patna and Bhagalpur, the Gandak and the Burhi Gandak joint the Ganga near Khagari. Another big river Kosi joints Ganga from North near Karagola 115 Km upstream of Farakka.

The monsoon period discharge of the Ganga and its tributaries vary between 70 to 80 times of their lean season discharge.

The average annual run-off of the river water as estimated by CPWC and Dr. A.N. Khosla is indicated in Table 3.3.

Table – 3.3

Average minimum & maximum discharge of water in the rivers

(In million cubic metre per Sec.)

S.No	River and site of observatory	March	September
The Ganga			
1.	Allahabad	224	21700
2.	Mirzapur	237	22000
3.	Varanasi	246	35000
4.	Patna	740	40300
The Ghaghra			
5.	Chapra	322	28312
The Sone			
6.	Dehri-on-son	21	740

Table – 3.4

Average annual run-off of the river water as estimated by CPWC and Dr. A N Khosla

(In million cubic metre)

Sl. No.	Name of the river	CWPC	Dr. Khosla
LEFT BANK TRIBUTORIES OF THE GANGA			
1.	Gomti sub-basin	8462	-
2.	Ghagram sub-basin	114331	75760
3.	Son Basin	42308	42888
4.	The Gandak	45022	29344
5.	The Baya	2220	-
6.	The Burhi Gandak	11965	-

Sl. No.	Name of the river	CWPC	Dr. Khosla
7.	The Bagmati	13075	-
8.	The Kamla	5181	-
9.	The Kosi	70555	102922
10.	Minor basins between the Kosi and Mahananda	7031	-
11.	The Mahananda	19612	
RIGHT BANK TRIBUTORIES OF THE GANGA			
12.	Tributories joining the Ganga between Allahabad and Buxer (The Tons, the Karamnass the Karunauti and the Jirga)	14123	-
13.	The Punpun	3577	-
14.	The Kul	5797	-
15.	The Man	493	-
16.	The Chandan	1604	-
17.	The Gerus	864	-
18.	The Bhens and Koa	493	-
19.	The Gumani	864	-
20.	The Baghmari	1233	-
21.	The Pagla	370	
22.	The Dwarka	4687	-
23.	The Ajay	3207	-
24.	The Damodar	12211	-
25.	The Rupanaryanan	4441	-
26.	The Haldi	5304	-
27.	The Ganga (excld. All tributories)	42555	-
28.	The Ganga (with tributories up to East of the Son)	325564	-

3.2 Water level

Operation of IWT is essentially governed by the behavior of seasonal variations in width determined by water levels and depths for realising draughts for the fleet. Table 3.5 and 3.6 present monthly minimum and maximum water levels respectively at Varanasi between 1980 and 1989. The minimum and maximum water levels are extracted in Table 3.7 for ready reference. A minimum water level of 58.220m was recorded in June 2003. It is further observed that minimum water level mostly occurred in May and June without any apparent preference. It may also be noted that retarded scour occurs at minimum water levels some time over crossings which do not render these water levels critical. For this a comprehensive study of the crossings and the governing areas are required. Some data are also shown in Tables 3.8 and 3.9 on maximum and minimum water levels behavior 1978 and 2005 respectively essential for design of jetty levels and appurtenant works. Maximum difference of water level is of the order of 14.450m and a minimum difference is about 8.855m. Fig. 3.2 to 3.4 may also be referred for graphic appreciation.

Table 3.5

Monthly minimum water levels at Varanasi in m (Source: CWC, Varanasi)

	1980	1981	1982	1984	1985	1986	1987	1988	1989	2000
JAN	59.181	60.251	59.591			60.326	60.201	59.281		60.001
FEB	59.116	59.941	59.806			60.196	59.716	59.141		59.801
MAR	58.541	59.651	59.631		58.731	59.586	59.511	58.871	58.841	59.441
APRIL	58.371	59.561	59.631		58.596	59.246	59.346	58.701	58.681	59.211
MAY	58.241	59.351	59.541		58.466	59.041	59.181	58.471	58.331	58.570
JUNE	58.246	59.271	59.541	59.971		58.896	58.981	58.960	58.266	59.001
JULY	63.721	59.661	59.861	62.381	59.321	61.501	59.316	60.856		61.419
AUG	67.640	65.066	66.611	63.176	66.651	65.711	61.151	67.126		63.866
SEP	64.481	61.786	64.001	62.791	63.806	62.021	63.701	62.191	62.149	63.636
OCT	61.566	60.721	61.711	60.771	64.101	61.331	61.616	61.461	59.829	61.091
NOV	60.781	60.131	61.431		61.301	60.741	59.831			60.408
DEC	60.406	59.721	60.701		60.491	60.381	59.571			59.841

Table 3.6

Monthly maximum water levels at Varanasi in m

(Source: CWC, Varanasi)

MONTH	1980	1981	1982	1984	1985	1986	1987	1988	1989	2000
JAN	59.511	60.536	60.141			60.536	60.511	59.391		60.811
FEB	59.226	60.306	60.171			61.101	60.161	59.281		60.001
MAR	59.156	59.931	60.201		59.001	60.741	59.711	59.126	59.021	59.886
APRIL	58.526	59.651	60.201		58.751	59.641	59.501	58.891	58.681	59.436
MAY	58.381	59.581	60.501		58.586	59.231	59.566	58.726	58.681	59.181
JUNE	61.521	59.756	60.461	61.466		59.821	59.426	59.731		62.441
JULY	68.571	68.437	66.531	63.411	67.871	71.266	63.501	66.871		70.586
AUG	71.991	68.901	73.311	66.871	68.391	71.331	67.811	69.381		66.518
SEP	72.211	64.716	73.291	69.051	68.461	65.361	69.681	67.641	67.091	68.091
OCT	64.051	64.681	63.976	61.541	67.861	62.531	62.346	64.291	62.091	63.719
NOV	61.541	60.681	61.701		63.911	61.311	60.741			61.071
DEC	60.771	60.111	61.391		61.251	60.731	59.641			60.376

Table 3.7

Minimum and maximum water levels at Varanasi in m

(Source: CWC, Varanasi, collected from IWAI, Kolkata)

Year	Minimum	Maximum
1978	59.451	73.901
1979	59.681	-
1980	58.241	72.211
1981	59.271	68.901
1982	59.516	73.311
1983	59.941	-
1984	58.766	69.051
1985	58.391	68.461
1986	58.896	71.331
1987	58.981	69.681
1988	58.250	69.381
1989	58.261	67.116
1990	58.101	71.021

Year	Minimum	Maximum
1991	58.901	71.311
1992	58.481	72.131
1993	58.921	70.341
1994	58.521	71.941
1995	58.461	70.731
1996	58.751	72.541
1997	58.906	70.381
1998	59.061	69.301
1999	58.436	71.341
2000	58.971	70.661
2001	58.671	69.331
2002	58.600	67.640
2003	58.220	72.130
2004	58.840	69.310
2005	58.380	70.450

The minimum water levels occur generally in the month of June and maximum in the months of August or September.

Table 3.8

River data at Varanasi in m

Year	Maximum		Minimum		Average	
	Sept.	Oct	Sept.	Oct	Sept.	Oct
1989	67.091	62.091	62.149	59.829	64.712	60.692
1990	71.021	67.211	65.101	62.001	67.641	63.835
1991	70.661	62.876	63.051	60.826	66.509	61.567
1992	72.091	64.111	63.961	62.136	67.150	62.895
1993	70.299	66.069	62.246	61.498	66.670	63.210
1994	68.993	63.414	63.631	60.871	66.852	61.737
1995	70.731	63.671	63.901	61.041	67.318	62.024
1996	70.321	64.456	64.531	62.091	68.135	63.279
1997	70.381	63.811	63.851	61.431	66.259	61.993
1998	68.316	68.881	63.714	62.746	65.568	64.597
2000	68.091	63.516	63.521	62.026	65.806	62.771

Table 3.9

Water level variation (difference in max and min water levels)
(Source: CWC, Varanasi, collected from IWAI, Kolkata)

Year	Difference in water level
1978	14.450
1979	-
1980	13.970
1981	9.630
1982	13.795
1983	-
1984	10.285
1985	10.070
1986	12.435
1987	10.700
1988	11.131
1989	8.855
1990	12.920
1991	12.410
1992	13.650
1993	11.420
1994	13.420
1995	12.270
1996	13.790
1997	11.475
1998	10.240
1999	12.905
2000	11.690
2001	10.660
2002	9.040
2003	13.910
2004	10.470
2005	12.070

Reference level is 58.25m. The danger level at Varanasi is 71.262m and HFL recorded is 73.901m in 1978 (09.09.1978).

Generally, the water level is rising in the month of June and with the onset of monsoon in July, the water level rise becomes more prominent and by end of July the river attains its maximum level. It remains in this bank full condition till the end of September. With the withdrawal of the monsoon the water level falls continuously till a minimum level is reached in April – May. The water level recession is very rapid during the first two to three weeks after the end of rainy season. In the dry season the water level reaches its minimum – exposing increasing number of shoals. Channel improvement measures have to be provided by a survey, which is possible only after the fall in water level.

The minimum and maximum water level from January to December for the year 1995 to 2000 is given in Annexure – I along with the water level variations and its graphic representation. The range of water level with reference to the number of days in a year from 1989 to 2005 is depicted in Annexure – I (a).

3.3 Water level gradient

Since the river is alluvial and in the flood plains in the reach under consideration the gradient has to be flat in conformity with the geotechnical characteristics of the channel. The slope at Varanasi is about 1 in 20000. (Refer report on River Ganga Pilot Project by Netherlands Engineering Consultants and Delft Hydraulic Laboratory) It may change between 1 in 16000 and 1 in 30000 for lower and higher stages in consideration of variable bed and bank friction.

3.4 Current velocity

The average current velocity decreased from 0.9 m/s in January 1988 to about 0.6 m/s in June 1988 and the average decrement of the water level about 1.2m. Maximum current velocity observed in September is about 3.0 m/sec. (Refer

report on river Ganga Pilot Project by Netherlands Engineering Consultants and Delft Hydraulic Laboratory)

During 1989, the current velocity decreased to 0.4 m/sec in the month of June. During the peak floods, a velocity of maximum 4 m/sec. is experienced only for the limited periods and an average current velocity is 3 m/sec. Current velocities for different months are shown in Fig 3.5.

3.4.1 Velocity at shoal locations

Minor Ports Survey Organisation (MPSO) has completed detailed survey in the shoal locations on NW1 in the streatch of Varanasi to Kaithy. The velocity details as per the MPSO are tabulated in Table 3.10

Table 3.10

Velocity at shoal locations between Varanasi and Kaithy

S.No	Name of the shoal	Maximum velocity (m/sec)	Minimum Velocity (m/ses)
1	D/s Rajghat	0.75	0.14
2	Khurana	0.90	0.30
3	Nakhwa	1.03	0.65
4	Bhopauli	1.00	0.23
5	U/s Balua	0.80	0.60
6	Gaura/ U/s Gaura	0.80	0.40

3.5 Morphology

3.5.1 Introduction

The Ganga, especially. is the river of India, beloved of her people, round which are intertwined her memories, her hopes and fears, her songs of triumph, her victories and her defeats. She has been a symbol of India's age-long culture and civilization, ever changing, ever flowing, and yet ever the same Ganga.

> - Jawaharlal Nehru, First Prime Minister of India was born at Allahabad situated on the Ganges.

The Ganga is a major river of the Indian subcontinent, associated in myth and reality with the land and people of India as well as neighbouring countries like Bangladesh.

Its wide valley stretches across northern India and Bangladesh from the Himalayas to the Bay of Bengal.

3.5.2 Sources and Tributaries

The Gangotri Glacier, a vast expanse of ice five miles by fifteen, at the foothills of the Himalayas (14000 ft) in North Uttar Pradesh now Uttatanchal, is the source of Bhagirathi, which joins with Alaknanda (origins nearby) to form Ganga at the craggy canyon-carved town of Devprayag. Interestingly, the sources of Indus and the Brahmaputra are also geographically fairly close; the former goes through Himachal Pradesh and fans out through Punjab and Sind (Pakistan) into the Arabian Sea. The latter courses for most of its tremendous length under various names through Tibet/China, never far from the Nepal or Indian borders, and then takes a sharp turn near the northeastern tip of India, gathers momentum through Assam before joining the major stream of the Ganga near Dacca in Bangladesh to

become the mighty Padma, river of joy and sorrow for much of Bangladesh. From Devprayag to the Bay of Bengal and the vast Sunderbans delta, the Ganga flows some 1557 miles, passing (and giving life to) some of the most populous cities of India, including Kanpur, Allahabad, Varanasi, Patna, and Calcutta. Dacca, the capital of Bangladesh is on a tributary of the Brahmaputra, just before it joins the Ganga to form Padma. A large number of tributaries join and flow from the Ganges to drain the Northern part of India and Bangladesh.

The Yamuna, which originates less than a hundred miles east of the Bhagirathi, flows parallel to the Ganga and a little to the south for most of its course before merging with the Ganga at the holy city of Allahabad, also known as Triveni Sangam (literally, Three-way Junction, the third river being the mythical Saraswati which is also supposed to be an underground river). New Delhi, capital of India, and Agra, site of the Taj Mahal, are two of the major cities on the Yamuna.

The largest tributary to the Ganga is the Ghaghara, which meets it before Patna, in Bihar, bearing much of the Himalayan glacier melt from Northern Nepal. The Gandak, which comes from near Kathmandu, is another big Himalayan tributary. Other important rivers that merge with the Ganga are the Sone, which originates in the hills of Madhya Pradesh, the Gomti which flows past Lucknow, and the Chambal made notorious by the ravines in its valley.

The delta of the Ganga, or rather, that of the Hooghly and the Padma, is a vast ragged swamp forest (42,000 sq km) called the Sunderbans, home of the Royal Bengal Tiger , who still kill about 30 villagers each year. The silt-carrying waters of the Ganga stains the Bay of Bengal a muddier hue for more than 500 km into the ocean.

3.5.3 Morphological characteristics

The Ganges and Brahmaputra Rivers combined have formed one of the largest deltas in the world, comprising approximately 105640 km^2. The Bengal Basin, into which this delta has prograded, is bordered on the west and northwest by Lower Jurassic volcanics and on the east by Eocene sandstones and limestones. The southern boundary is the Bay of Bengal. The Ganges River originates near the Tibet/India border, and then flows southeast across India to combine with the Brahmaputra in the country of Bangladesh. The drainage basin, approximately 1.6 million km^2 in area, is geologically young, with large volumes of unconsolidated sediment available for transport (Morgan and McIntire, 1957, 1959).

The Ganges is primarily a meandering river, while the Brahmaputra is primarily a braided channel. Their combined discharge into the Bay of Bengal is approximately 82 000 m^3/sec during flood. Sediment load is extremely high, with suspended sediment load during flood stage reaching as high as 13 million tons per day (Coleman, 1969). Fig 3.6 is a band 5 version of the lower Landsat image in the Plate mosaic that highlights the vast sediment load beyond the mouths of the Ganges. Because the climate within the delta is monsoonal, rainfall is seasonal. Vegetation is highly varied and generally dense in areas that have not been reclaimed for agriculture. The Bengal coast is mesotidal, with an average tidal range of 2 m. Wave energy modifying the coast is relatively low because of the extremely low offshore gradients that front the active delta.

The mosaic covers the eastern active deltaic part of the Ganges/Brahmaputra Rivers and illustrates those landforms that are characteristic of a rapidly migrating channel system partially modified by tidal processes. The Tripura Hills (A) that bound the delta to the east consist of highly weathered Tertiary sediments that show abundant dissection resulting from the high annual runoff. These hills are a southerly extension of the folds with topography that is highly irregular and relief

ranging from a few tens of meters to several hundred meters. Emanating from these highlands are a series of heavily vegetated alluvial fans (B) and small river terraces. During the Pleistocene, large volumes of sediment were delivered to the Bengal Basin, and former Pleistocene terrace surfaces are common along the valley of the river systems. The Tippera surface (C) has been assigned a Late Pleistocene age and consists of an extremely flat terrace composed of highly oxidized and deeply weathered clays and silts. The surface is easily mapped on aerial photographs because it displays a distinctive rectangular drainage pattern (D) resulting from man's modification for agriculture practices. The surface has an elevation of several meters above the Recent fluvial and deltaic floodplain. During the Pleistocene and even in Holocene times, faulting (E) has been active in this earthquake-prone area, and many of the boundaries of Pleistocene surfaces are marked by relatively straight fault- controlled boundaries. Smaller rivers, such as the Meghna (F), have cut into these Pleistocene surfaces, forming rather extensive meander belts of abandoned channel scars.

The major part of the image shows the Recent delta surface of the Ganges/Brahmaputra Rivers. The main river channel displays a braided and anastomosing channel pattern (G). Fig 3.7 illustrates this type of channel morphology, showing part of a midchannel island with large bed forms in an active distributary of the Brahmaputra River. Note the large number of active channels and the innumerable mid channel islands or sand bars (chars) that are characteristic of this type of channel pattern (H). These sand bars separate the flow into several channels, resulting in the braided pattern of the river. In such rivers, the sediment bed load is abnormally high, and rapid aggravation in the channel is common, constantly forcing the channel to migrate laterally. Recent channel scars (I), often unvegetated, can be observed along the margins of the active channels. During flood stage, these sand bars are generally eroded on their upstream end, with deposition on the downstream end, causing significant downstream migration of the islands from year to year.

The range of river stage varies considerably from low to flood stage, and adjacent channel banks are often characterized by many over bank splays (J). These splays are responsible for building up rather thick and broad natural levees that border the active channels.

In the north-west part of the image, the morphology of the delta plain is dominated by the abandoned channel scars of former river courses (K). These abandoned courses display evidence of both migratory braided and meander channel scars. These surfaces form the bulk of the rice-and jute- farming areas of Bangladesh. In the south-eastern part of the image, the delta surface elevation becomes low enough to be inundated by tidal waters, and much of this area displays tidal plain morphology. A large percentage of the region has been diked (L), and the land has been reclaimed for agricultural purposes. The undiked regions (M), in the south-westernmost part of the image, are dominated by mangrove vegetation. Large tidal channels and tidal drainage networks characterise this part of the delta plain.

Gangatic plain, bounded by the "boundary faults" of tertiary foothill zone in the north and the spurs of the Deccan plateau in the south, is made of very thick alluvial deposits. Its depth has been recently estimated as 1300 to 1400 m. the alluvial deposits consist of silt, clay and sand intermingled with gravels.

The height of the plain decreases from the Himalayan foothills in the north (100 m) to the Plateau River in south and from west 100m to 30m in the middle and 3m from west-northwest to east south east. The Gange's slope is also influenced by local variations caused by the changing courses of rivers and the resultant deposits or erosion of sediments in their flood plain.

Ganga, the lifeline of the plain, takes its rise from its catchments area in the snowy Himalayas and following that general line of the land flows in south-south easterly direction against the plateau spurs beneath. Hence all along its course from Allahabad to Rajmahal the right bank of the river is steep and 8 to 15 m high.

It is to be noted that all important cities of the Ganga plain lie on the right bank of the river close to the plateau spurs. Allahabad, Patna, Bhagalpur grew on the right bank of the Ganga. However, Varanasi is located on the left bank of Ganga. These cities are comparatively higher and broader making them generally safe from floods. The northern tributaries of the Ganga, though receiving their waters from the snow Himalayas, are sluggishly flowing rivers. They form a type of inland delta at their confluence, the Geddes terms as "cone".

The flood plains of the river basis are dotted with tals, oxbow lakes and deserted channels of rivers.

The drainage pattern is dentritic in general and most of the rivers meet at acute angle and form parallel or sub-parallel lines to the main stream. Braiding and meandering of rivers are the common features and the sandy shoals are often liable to flood during the monsoon when changing and shifting or river channels are common features. Some tributaries like Gomti, Ghaghara, Rapti, Gandak and Kosi are notorious for shifting of their beds. The most important tributary meeting the Ganga from the south is the Son forming a narrow flood plain dotted with eroded hillocks, sometimes projecting on the riverbank.

Further east, the Ganga traverses south south-eastwards against the Rajmahal hills, the northeastern of the peninsular plateau. Then it gets divided into two large distributaries, the Bhagirathi or Hooghly running due south, and the Padma flowing to southeasterly direction. The deltaic plain here is characterised by low

elevation from 30m in the north to 4.5m in the south. Even 7m high tide is sufficient to submerge the region up to Kolkatta. The delta proper has a gradient of less than 2 cm per Km and is the land of dead and decaying rivers. To its south is the stretch of famous Sunderbans.

The topographical and drainage differences have brought significant changes in the soil morphology. They differe in texture from drift sands to fine and heavy clays. They are rich in minerals and organic plant-food but normally deficient in nitrogen. The coastal soils are the interactions of river and tides and are saline and alkaline containing gnerally half decomposed materials.

Climatically, the plain ranges from sub-humid in the upper to humid in the middle and humid sub-continental type in the lower plain. In the upper plain January mean temperature is 16° C but maximum temperature sometimes in June goes up to 40 ° C or more due to hot winds, i.e. 100, blowing from the west.

In the middle zone, the temperature conditions in general are more or less similar to those in the upper part except the range of temperature is lightly lower.

In the lower plain, no doubt, climate is little different from its counterparts in the northwest. In January, the coldest month, temperature ranges between 17 ° to 21° C increasing from east to west, e.g. Varanasi 110 cm to Agra 68 cm but increase to north and northwest, e.g. Saharanpur with 75 cm to Gonda, Bahraich with over 100 cm. But the coastal parts, e.g. Kolkatta, receive 200 cm. In winter the upper regions receive little more rain fall.

Thus, the Ganga plain is commonly divided in three zones the Upper Ganga plain, the Middle Ganga plain and the Lower Ganga plain. The Upper regions is clearly demarcated in the west by the Yamuna, but its eastern limit lacks any physical

boundary. However, 100 cm isohyte appears to be a suitable demarcating line between the upper and middle plain. In the east, the middle Ganga plain is structurally delineated by the Rajmahal spurs from where the Ganga turns to the south.

The vast plain through which the Ganga flows is almost entirely of alluvial silt except for rock outcrops at Monghyr, Sahibganj and Rajmahal, all located between Mokameh and Farakka. This soil (silt) is erodible and aided by a very flat slope of the plain, Ganga has developed into a meandering system. The river moves laterally and longitudinally in the form of meandering loops. The firm banks (Khadir) between which the river meanders is large compared to the channel width and contain churs and diara land as defined below.

Chur- It is a sand shoal which is created by the river in its normal process of erosion and shoaling. It is now lying, free from silt and is covered during the high water season. It may be in the form of an island, flanked on both sides by channels of greater or lesser imporatance, or it may subjoin firm bank (Khadir) or a proiton of the diara land.

Diara – It is land created by the same processes which form shoals or churs but its level is just below that of high flood. Its' topmost layers are largely of the finest silt making it highly fertile for producing crops. Diara land, may be in the form of islands or subjoin the khadir. Ganga from Varanasi to Allahabad (40 Km up stream of Varanasi) is normally a narrow stream during the dry season because most of its water is withdrawn for irrigation. Between Chhapra and Patna it is joined by three large tributaries, Gaghra, Son and Gandak (the last one at Patna itself). Thus, at Patna the Ganga is a fairly full river even during the dry season and erosion process continues throughout the year though less pronounced during the non-monsoon months.

3.5.4 Dams on the Ganga

There are two major dams on the Ganga. One at Haridwar diverts much of the Himalayan snowmelt into the Upper Ganges Canal, built by the British in 1854 to irrigate the surrounding land. This caused severe deterioration to the water flow in the Ganga, and is a major cause for the decay of Ganga as an inland waterway.

The other dam is a serious hydroelectric affair at Farakka, close to the point where the main flow of the river enters Bangladesh, and the tributary Hooghly (also known as Bhagirathi) continues in West Bengal past Calcutta. This barrage, which feeds the Hooghly branch of the river by a 26 mile long feeder canal, and its water flow management has been a long-lingering source of dispute with Bangladesh. Bangladesh feels that the lack of flow in the summer months causes sedimentation and makes Bangladesh more prone to flood damages. At the same time, proposals for linking the Brahmaputra to the Ganges to improve the water flow in the Ganges is hanging fire. Also, the water management problem may actually involve a number of other riparian countries such as Nepal (where there has been tremendous deforestation, leading to greater silt content).

It is likely that Ganga carried more water around the time of the Roman Empire, when Patna was the major port city of Pataliputra. Even in the eighteenth century the ships of the East India Company would come to call at the port city of Tehri, on the Bhagirathi, one of the main source river of Ganga. There are two important cross structures namely Naraura Head Works, Barrage at Kanpur existing over river Ganges. Another dam is proposed to be built on the upper reaches of a tributary of the Ganga, Mahakali, This Indo-Nepal project, the Pancheswar dam, proposes to be the highest dam in the world and will be built with US collaboration.

The upper and lower Ganga canal, which is actually the backbone of a network of canals, runs from Haridwar to Allahabad, but maintenance has not been very good and it is experienced that it probably trickles out into a small river a little beyond Kanpur.

3.5.5 General morphology of the reach Ramnagar to Kaithy

The Ganga from a straight rather narrow reach in the vicinity at Malahia at the upstream end – upstream of Varanasi widens across a crossing at Nagwa when the channel negotiates a comparatively sharp bend of radius about 500 m between Bhelupura and Dasashwa upstream of Malaviya bridge. A large sand outcrop encounters into the deep channel here from the right bank restricting manoeuverability of operation. Proceeding down the river straightens out upstream and downstream of the bridge when it widens at chainage of 1305km at Bahadurpur. The river braids there after into twin channels and the twin channels and the channel also swings to the right. Quite naturally the right braid channel commands more depth genders by the curvature. At Chittauri chainage 1285km downstream of the bridge the river takes a turn to North with the deep channel shifting to the left upto Kaithi. A large sand outcrop emerges from the right ensuring deeper depths on the left. There fore the river oscillates three times over at chainage at 1264 km reach covering the 7 proposed sites. Morphological stability at the sites will be a function of the past history. Stability of depths over a period of time seasonal behaviour of the crossings as the river alterates between right and left and right banks commencing from the upper end.

The consultant have procured National Remote sensing IRSIB Geocodal products images of river Ganges at Varanasi for the years 1990 & 1995 and have studied the river morphological changes. The images are shown in Plate 2 and Plate 3.

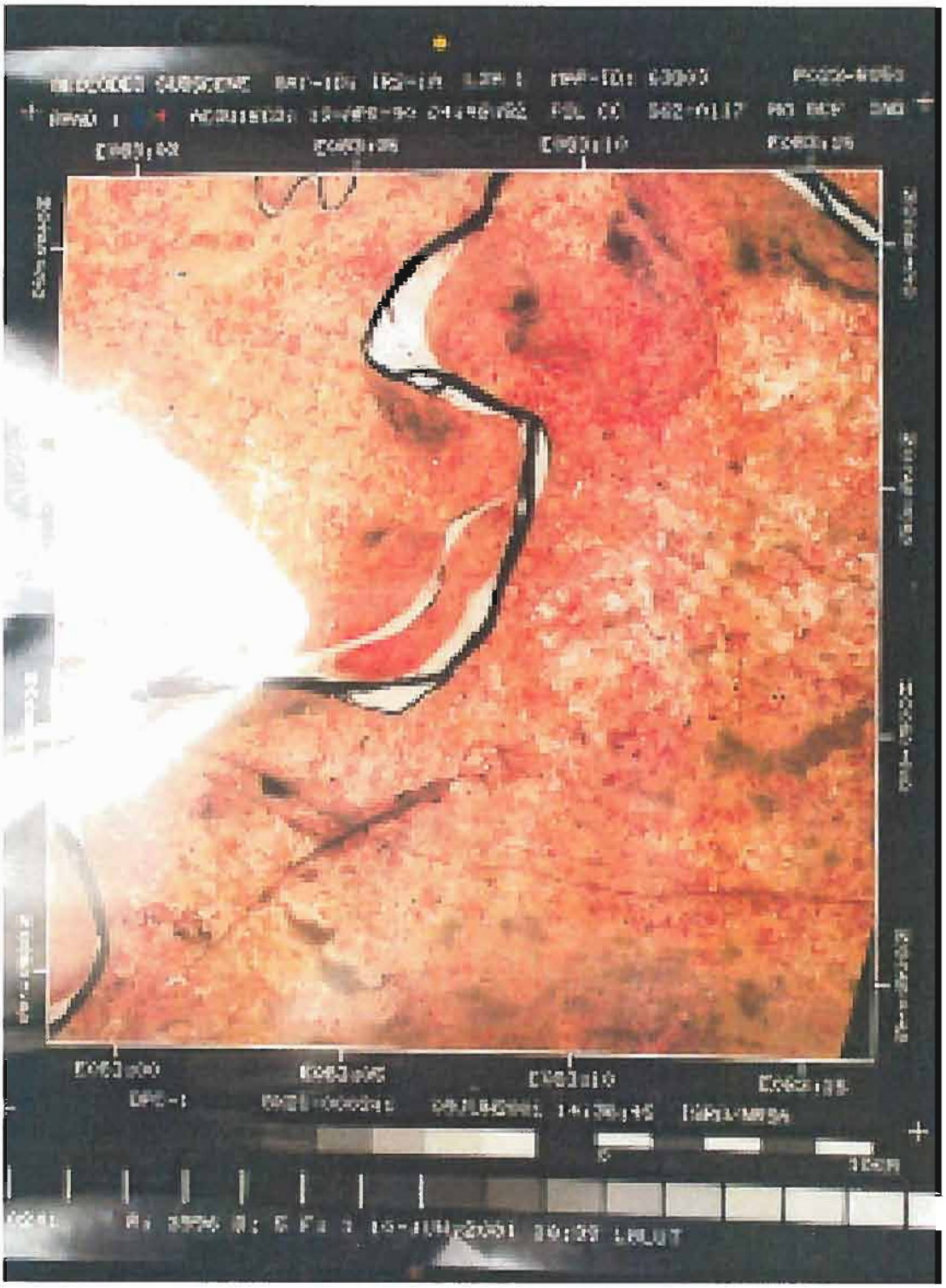


Plate 3.1 NRSA image of river Ganges at Varanasi during 1990

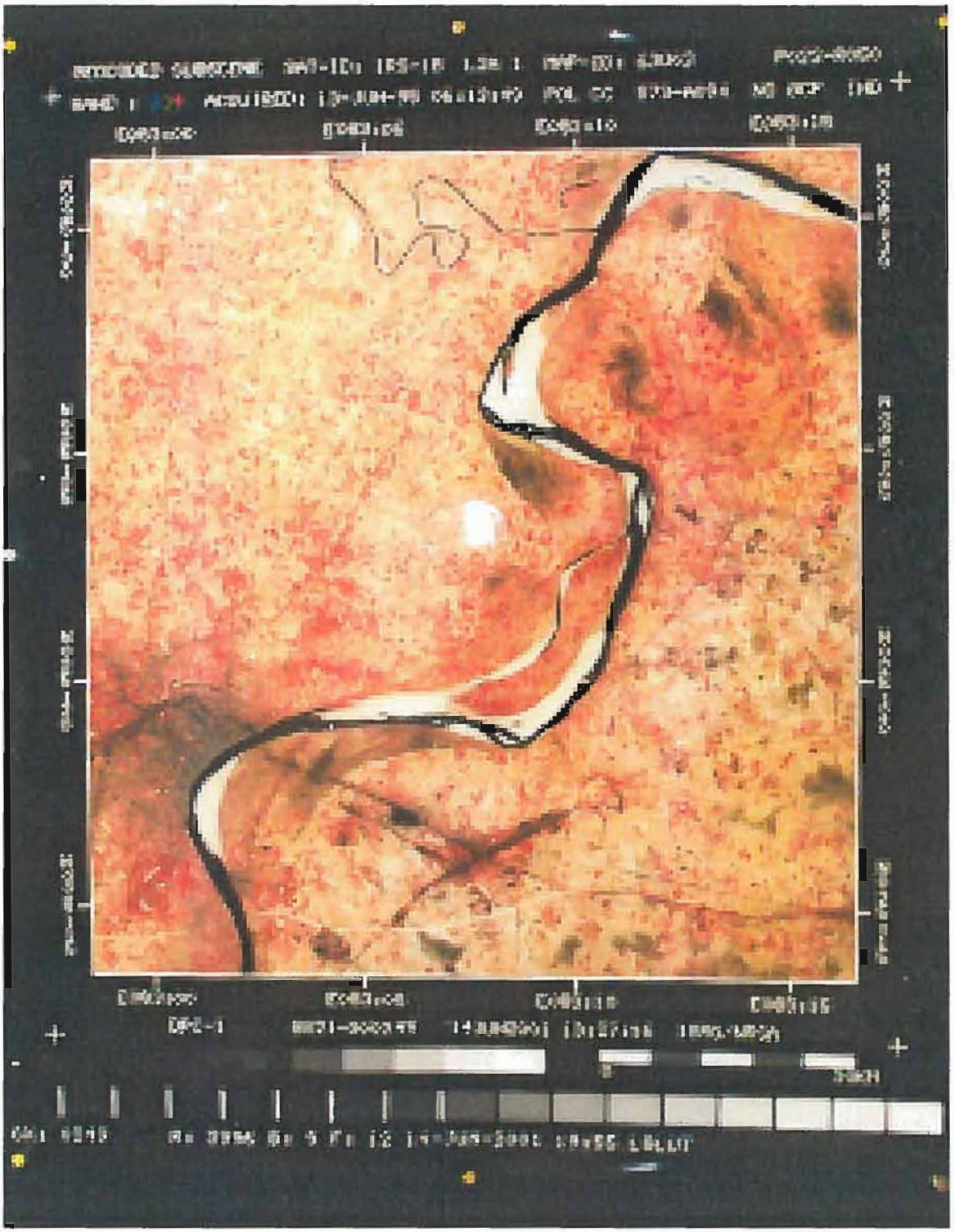


Plate 3.2 NRSA image of river Ganges at Varanasi during 1995

Superimposed deviation of the channel between December 1995 to December 1999 on the river Ganges between Mahahia and Kaithy is shown in Drg. MEC/11/17/Q079/SK-1. At New Ramnagar by pass bridge on the left bank there is deviation of the channel during the above period. But this change is negligible during the above period. Between Nagwa and Domri, initially the available width of river is small. Over a five years period (Dec 95 to Dec 99) the right bank has advanced and the river width has increased. At Domri there is small deposition on the right bank.

During 97 period small shoals have formed between Tantepur and sehbar. After two years (95-97) the length of the shoal has increased and became larger. At Tantepur the channel has become twin channel and the channel near the left bank is very thin. Over a years period this channel has gone under lot of siltation and navigation of the barges changed to right bank channel. Channel near to the right bank between Mawaikalan and Mahraunda lot of shoals have formed. Near Ramchandipur the left bank has advanced into the river and the channel has become narrow.

Between Mahwari khurd and Balua the shoals have moved place to place. There are small shoals in this stretch. Luthakund to Kaithi the river has changed to left bank. In this stretch Balua and Gaura initially the shoals are on the right bank. And these moved to left bank. Near Purabijai the right bank advances into the river. The bank is year to year during November, the bank is over topped and non-monsoon period the channel becomes narrow. At Kaithi on the right bank the change of the bank is negligible during the 95 to 99.

3.5.6 Shoals

A river section with an average reduced depth less than 2.0 m has been considered as a shoal and when a shoal reappears during successive sounding within 3 Km

from its original location it has been termed as permanent. However, this does not imply that such a shoal is stable.

There are four major shoals on the Patna- Balia Section . The shoals are :

Haldia Chapra / Sone confluence	Km 1067	1072
Hazaritola	Km 1102	1105
Piparpanti/ Saharanpur	Km 1116	1118
Gaderia/ Bhusaula	Km 1121	1126

The number of permanent and non-permanent shoals in 1988-89 are shown in Table 3.11

Table 3.11

The number of permanent and non-permanent shoals

(source : River Ganga Pilot_Project, March 1990)

Stretch	Length (Km)	No. of shoals (Permanent)	No. of shoals (non-permanent)
Allahabad-Mirzapur	153	13	1
Mirzapur – Varanasi	84	9	3
Varanasi – Gazipur	133	17	7
Gazipur – Balia	110	13	9
Balia – Patna	120	4	4

The details of shoals occurred during the season 2000-2001 on National Waterway No. 1 in the stretch of Triveni – Farakka, Farakka- Bhagalpur, Patna-Kaithy, Kaithy – Allahabad and Bhagalpur – Patna are shown in Annexure – I (8 sheets)

Total number of shoals in the stretches as per 1986, 1987 and 1989 survey are indicated in Table 3.12

Table 3.12

Number of shoals in the different stretches

(source : River Ganga Pilot Project, March 1990)

Stretch	1986	1987	1988-89
Allahabad-Mirzapur	-	16	14
Mirzapur – Varanasi	-	11	12
Varanasi – Gazipur	15	17	24
Gazipur – Balia	21	17	22
Balia – Patna	16	15	8

Number of shoals occurred during 2000-01 in NW1 in various stretches are shown in Table 3.13

Table 3.13

Number of shoals in NW1

(Ref. Annexure II)

Stretch	Sept.00		Oct.00		Nov.00		Dec.00		Jan.01		Feb.01	
Tribeni-Farakka									1	1		
Farakka-Bhagalpur							1	1	2	1		
Bhagalpur-Patna				13	3	2	-	4	3	-		
Patna – Kaithy			1	5	6	3	4	2	9	-		
Kaithy – Allahabad			8	10	16	26	32	-	36	-		

More number of shoal occurred in the stretch of Kaithy Allahabad. The total length of the shoals in this stretch is about 12600m mainly during the lean period. The least available depth can be monitored by executing frequent surveys based on an established chainage.

The least available depth between Tribeni and Bhagalpur is 1.9m, between Bhagalpur to Kaithy ranges between 1.3 to 1.9 m and Kaithy to Allahabad ranges between 1.0 to 1.9m. The shoal length for different stretches which occurred during season 2000-2001 are tabulated in Table 3.14

Table 3.14

The shoal length for different stretches

(Ref. Annexure II)

Stretch	Shoal length ranges in m	LAD ranges
Tribeni-Farakka	30 – 50	1.9
Farakka-Bhagalpur	100 – 225	1.9
Bhagalpur-Patna	50 – 300	1.6 – 1.9
Patna – Kaithy	50 – 750	1.3 – 1.9
Kaithy - Allahabad	20 – 1000	1.0 – 1.9

3.6 Meteorological conditions

3.6.1 Climate

Climate in the hinterland at Varanasi can be divided in four seasons viz.

The winter season starts from December and extends upto February. The Summer Season starts from March and extends upto May. The monsoon Season starts from June and extends upto September. During this period water level starts increasing. The transitional period is between October to November.

3.6.2 Rainfall

The monthly rainfall, nos. of rainy days and heaviest fall in 24 hours at Varanasi are tabulated in Table – 3.15.

Table – 3.15.

Rainfall details at Varanasi

(Source : IMD, Pune, Station : Varanasi, Period of Data : 1951-80)

Month	Rainfall In mm	No. of rainy days	Heaviest fall in 24 hours (In mm)
January	20.3	1.8	69.6
February	12.5	1.1	67.1
March	10.4	1.0	37.1
April	4.3	0.5	40.0
May	11.5	0.9	51.6
June	85.6	4.5	159.5
July	303.8	12.5	288.3
August	281.3	13.3	321.6
September	214.9	9.4	349.5
October	39.8	2.2	138.9
November	15.5	0.3	161.5
December	3.4	0.3	53.1
Total	1003.3	47.8	1761.8

The average annual rainfall is 1003.3mm having around 47.8 rainy days. The rainfall from the south-west monsoon (June-October) consists about 89% of the total average annual rainfall. The 24 hours heaviest rainfall is 349.5mm. Generally July to September are the wettest months in a year.

3.6.3 Temperature

The temperature details at Varanasi are shown in Table – 3.16. The table gives the mean of daily maximum, minimum, highest and lowest and extreme highest and lowest temperatures. The month of January is the minimum and May is maximum of mean of daily temperature. Mean of highest in the month recorded 44.3°C in the month of May and the lowest 5.3°C the month of January. The extreme highest and lowest temperature recorded 47.2 °C and 1.7°C for the month of May and February respectively. The minimum temperature slumped down to 1.7° C.

Table – 3.16

Temperature details at Varanasi

(Source : IMD, Pune, Station : Varanasi, Period of Data : 1951-80)

Month	Mean				Extreme	
	Daily Max.	Daily Min.	Highest	Lowest	Highest	Lowest
January	23.1	9.6	27.4	5.3	31.1	2.5
February	26.8	12.0	32.0	7.2	36.1	1.7
March	33.1	17.1	38.3	12.1	41.1	6.7
April	38.7	22.8	42.4	18.0	44.4	11.1
May	41.1	26.4	44.3	22.2	47.2	17.3
June	38.7	27.8	43.7	23.7	47.2	20.6
July	33.7	26.2	38.2	23.4	45.0	20.0
August	32.7	25.8	35.9	23.4	40.1	22.1
September	32.8	24.9	35.8	22.5	38.5	17.8
October	32.8	21.1	35.3	16.6	39.4	11.7
November	29.1	14.3	32.5	10.5	36.0	5.0
December	24.5	10.2	28.0	6.4	32.8	2.2

3.6.4 Humidity

The average monthly relative humidity recorded at 5.30 and 17.30 hrs at Varanasi are tabulated in Table – 3.17.

Table – 3.17

Relative humidity details at vanarasi

(Source : IMD, Pune, Station : Varanasi, Period of Data : 1951-80)

Month	Average Relative Humidity	
	5.30 hrs	17.30 hrs
January	75	51
February	64	39
March	49	28
April	40	24
May	47	27
June	62	47
July	82	72
August	85	78
September	82	73
October	71	57
November	65	50
December	73	53
Mean	66	50

During the summer season the relative humidity varies between 24% to 28%. The humidity in the monsoon season ranges between 50% to 85%. For the rest of the year, relative humidity generally varies 50 to 80%.

3.6.5 Weather phenomena

The average monthly number of days at Varanasi having the phenomenon of thunders, dust-storms, squalls and fog are given in Table – 3.18.

Table – 3.18

Weather phenomena at Varanasi

(Source : IMD, Pune, Station : Varanasi, Period of Data : 1951-80)

Month	Thunder	Fog	Dust-storm	Squall
January	0.5	4.2	0	0
February	0.5	1.1	0	0
March	0.6	0.1	1.2	0
April	0.5	0.0	0.5	0
May	0.4	0.0	0.9	0
June	1.2	0.0	0.7	0
July	2.2	0.0	0	0
August	2.2	0.0	0	0
September	1.6	0.0	0	0
October	0.2	0.0	0	0
November	0.0	0.3	0	0
December	0.1	1.3	0	0
Mean	10.0	7	2.3	0

It is evident that fog is very less in this region except in the month of January. Thunder rains occur generally only in the month of July and August. In other months thunders and rains are less. So it is quite suitable for navigation at Varanasi.

3.6.6 Visibility

The number of days with visibility is given in Table –3.19.

Table – 3.19

Visibility details at Varanasi

(Source : IMD, Pune, Station : Varanasi, Period of Data : 1951-80)

Month	Number of days with visibility in Km				
	Up to 1km	1-4 km	4-10 km	10-20 km	Over 20 km
January	3.1	12.6	13.5	1.8	0.0
February	1.2	5.9	17.6	2.6	0.7
March	0.0	3.0	23.3	3.1	1.6
April	0	1.1	25.0	3.3	0.6
May	0	1.7	26.6	2.7	0.6
June	0.0	2.4	20.3	7.3	0.0
July	0.1	4.1	18.0	8.8	0.0
August	0.1	3.0	19.8	8.2	0.0
September	0	2.0	20.3	7.7	0.0
October	0	2.8	22.0	5.7	0.5
November	0.3	7	19.2	3.2	0.3
December	1.9	12.9	15.0	0.9	0.3

Most part of the year the visibility is more than 4 kms. So it is quite suitable for navigation.

3.6.7 Wind

The details of the wind are given in Table –3.20.

Table – 3.20

Wind details at Varanasi

(Source : IMD, Pune, Station : Varanasi, Period of Data : 1951-80)

Month	Number of days with wind speed Km/h			
	> 62	20-61	1-19	4
January	0	0	21	10
February	0	0	20	8
March	0	0	23	8
April	0	0	23	7
May	0	0	25	6
June	0	0	23	7
July	0	0	23	8
August	0	0	22	9
September	0	0	22	8
October	0	0	19	12
November	0	0	16	14
December	0	0	21	10

Most part of the year wind speed is between 1-19 km/h.

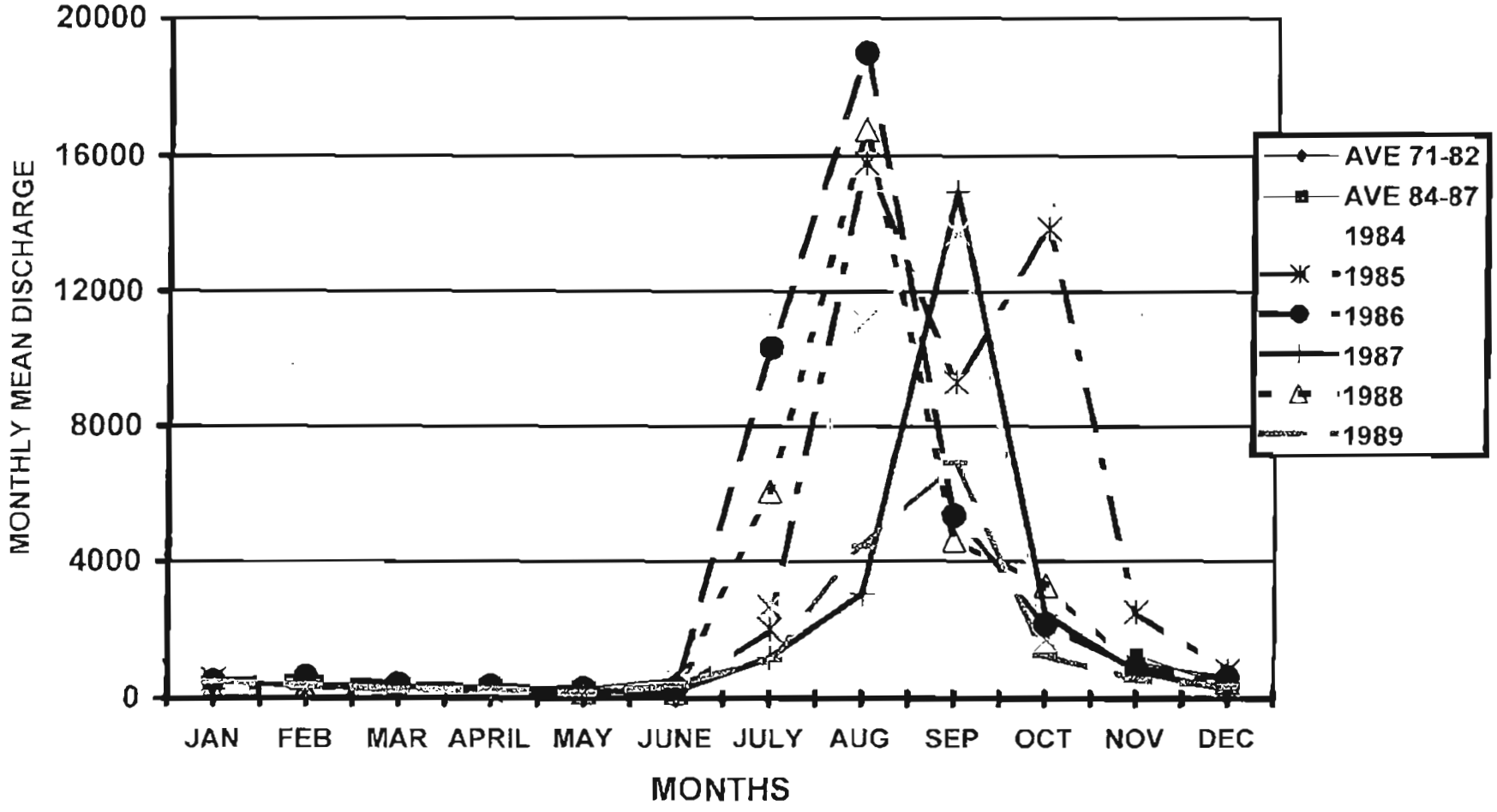
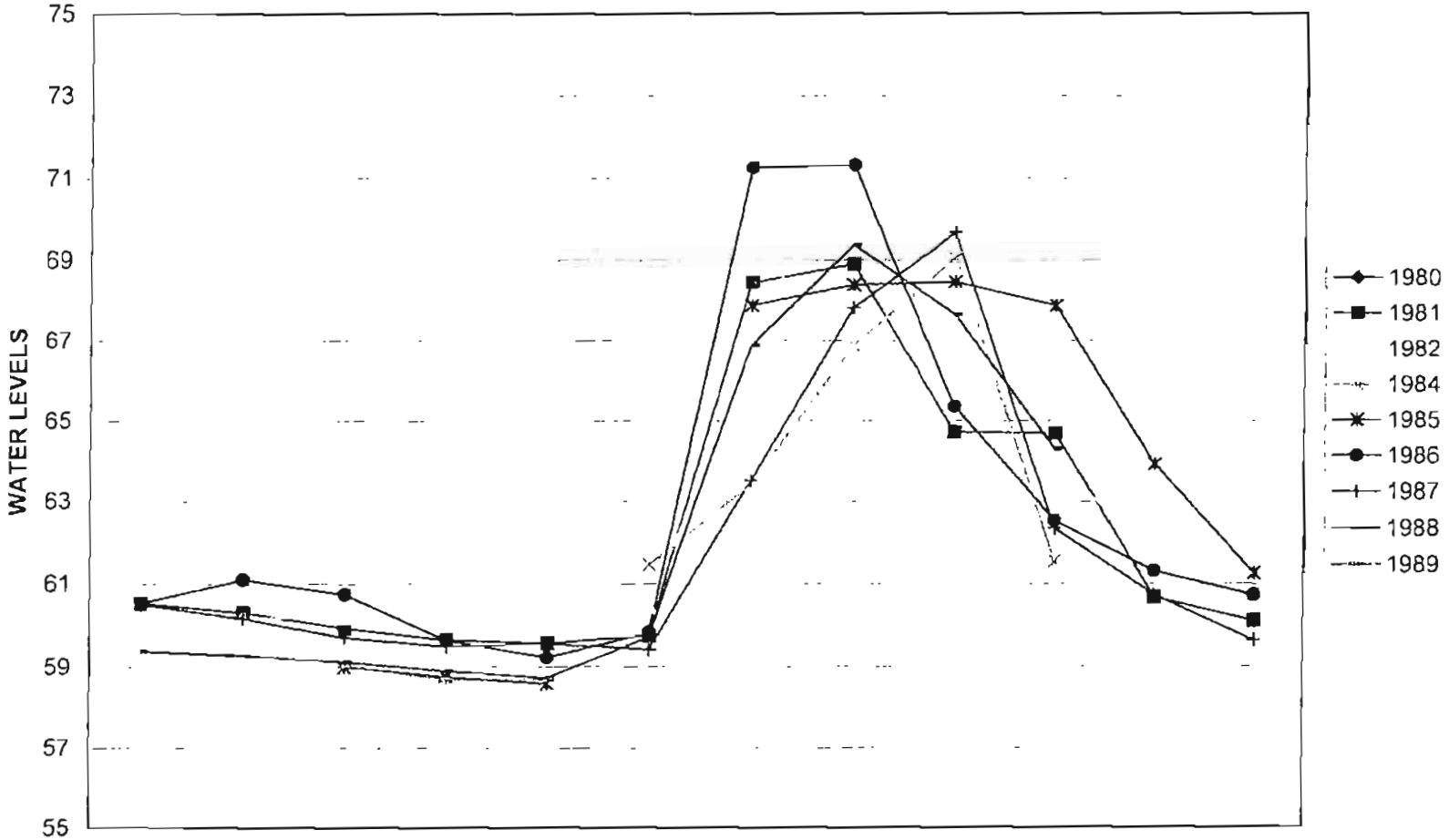


Fig. 3.1 MONTHLY MEAN DISCHARGE RATES (CUM/SEC) AT VARANASI

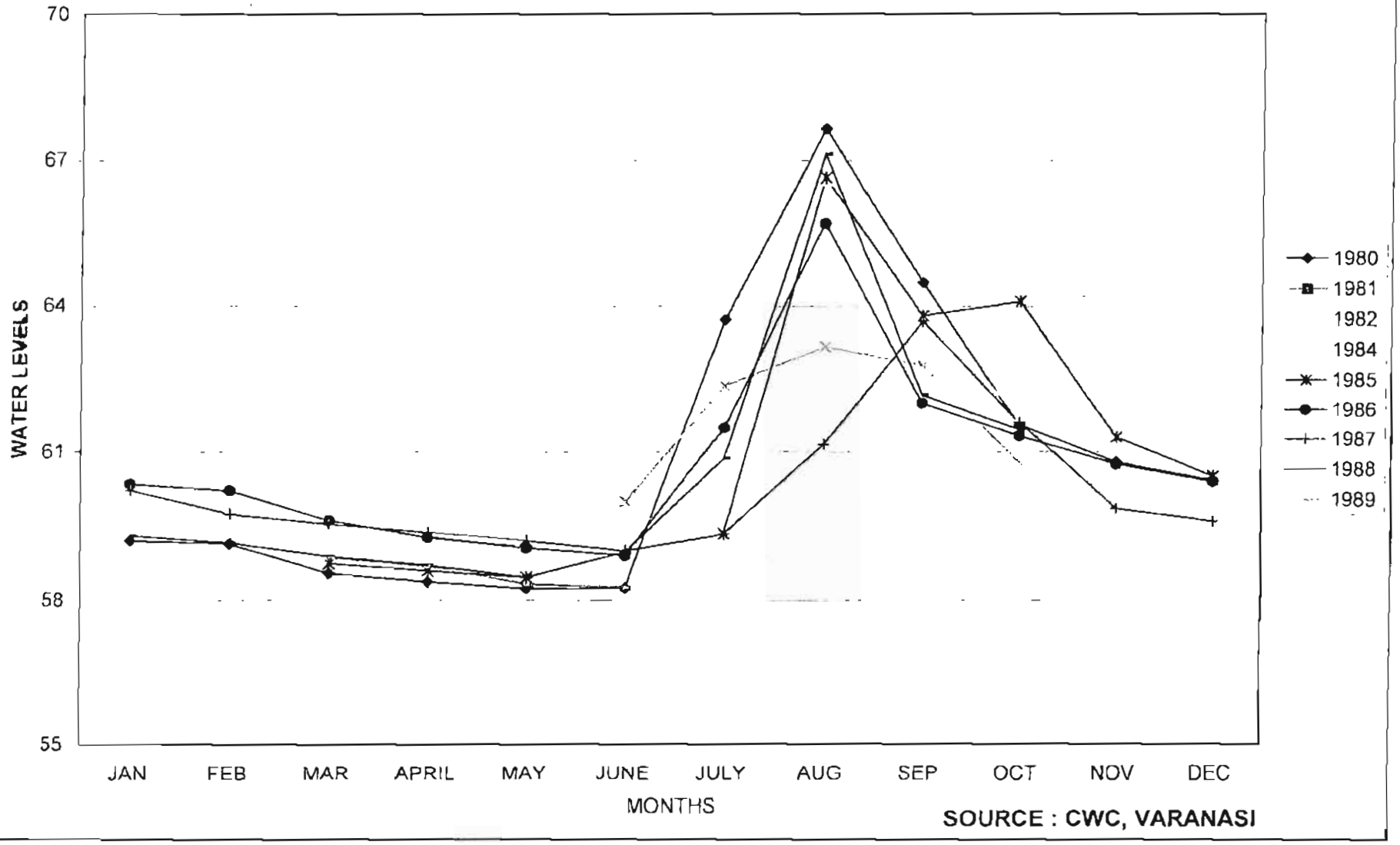
SOURCE : CWC, VARANASI

FIG. 3.2 MONTHLY MAXIMUM WATER LEVEL AT VARANASI



SOURCE : CWC, VARANASI

FIG. 3.3 MONTHLY MINIMUM WATER LEVEL AT VARANASI



SOURCE : CWC, VARANASI

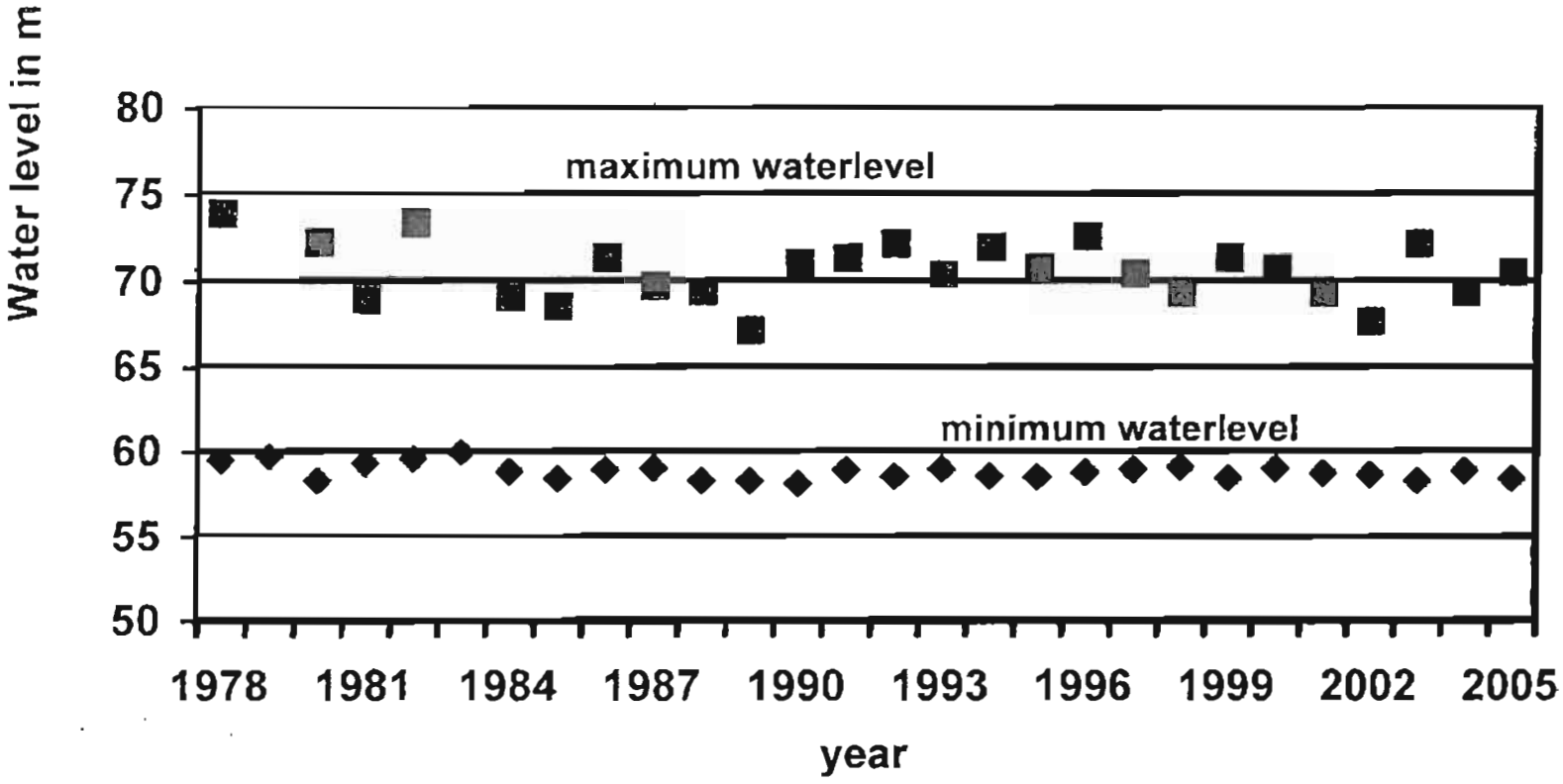


Fig.3.4 Maximum and minimum water levels at Varanasi

SOURCE : IWAI, KOLKATA

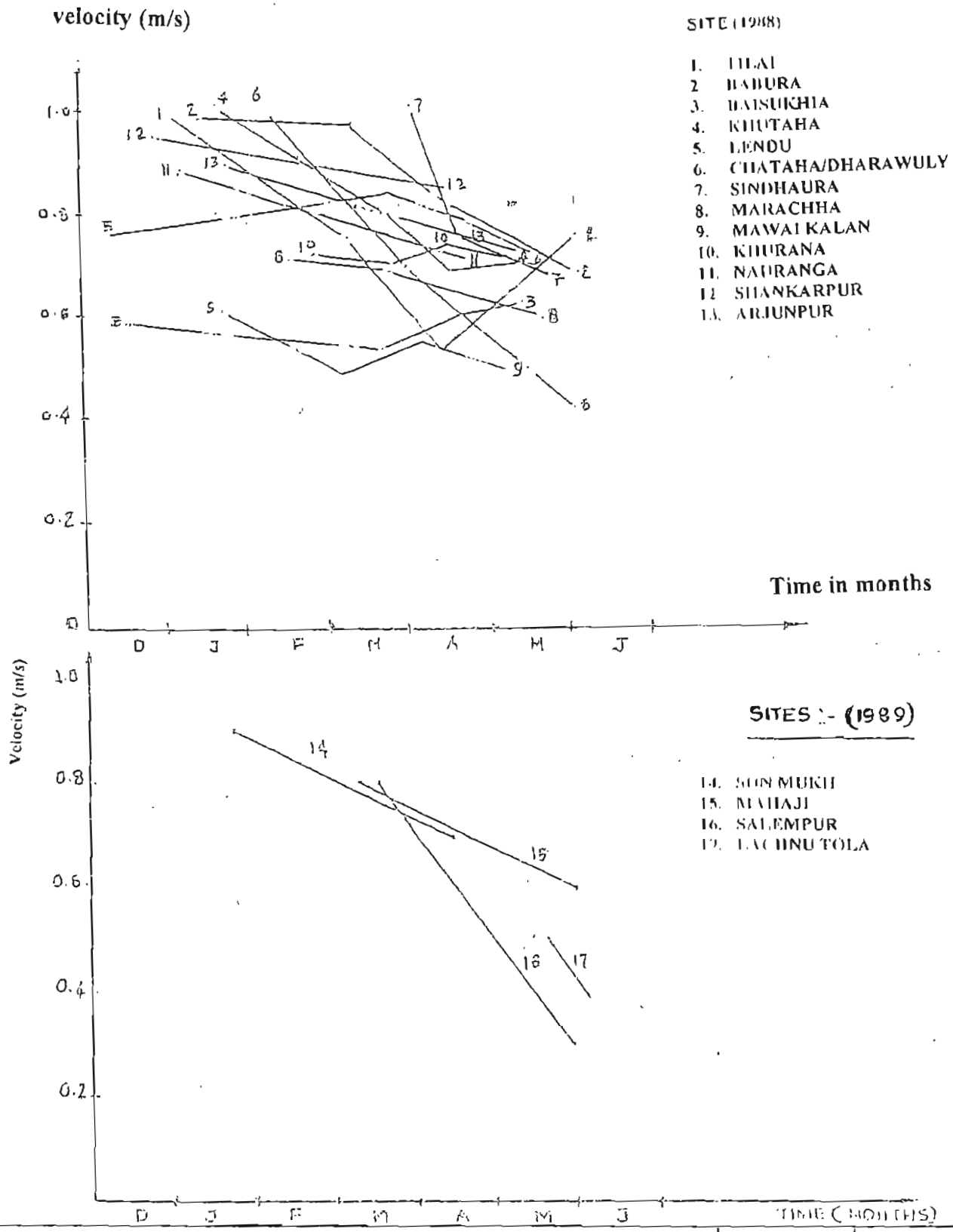


Fig 3.5 Current velocities for different months

FIGURE 3.6

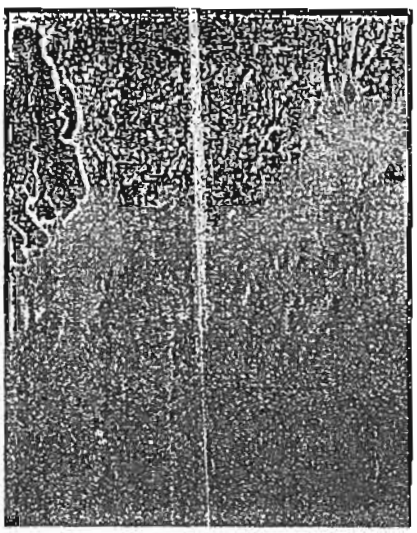
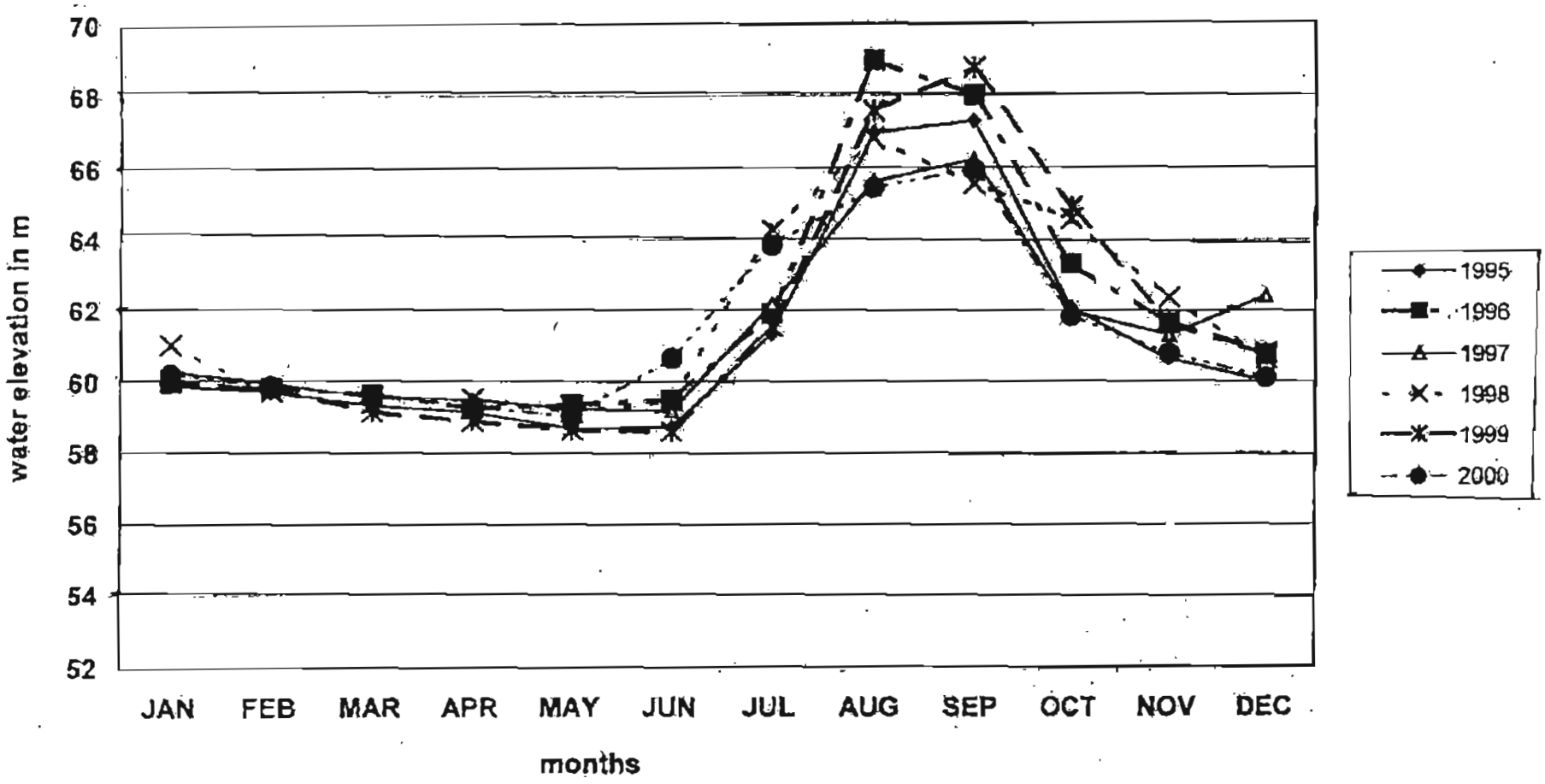
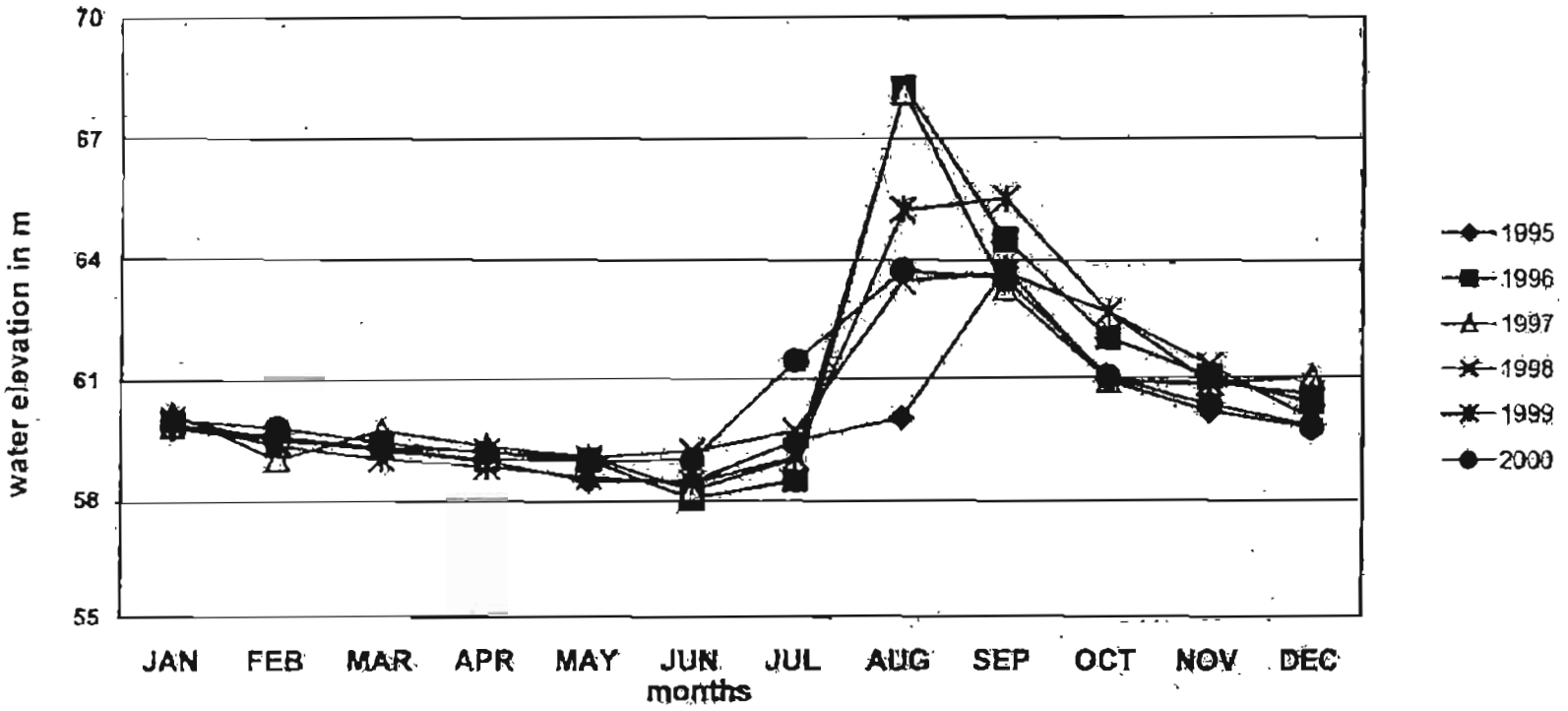


FIGURE 3.7

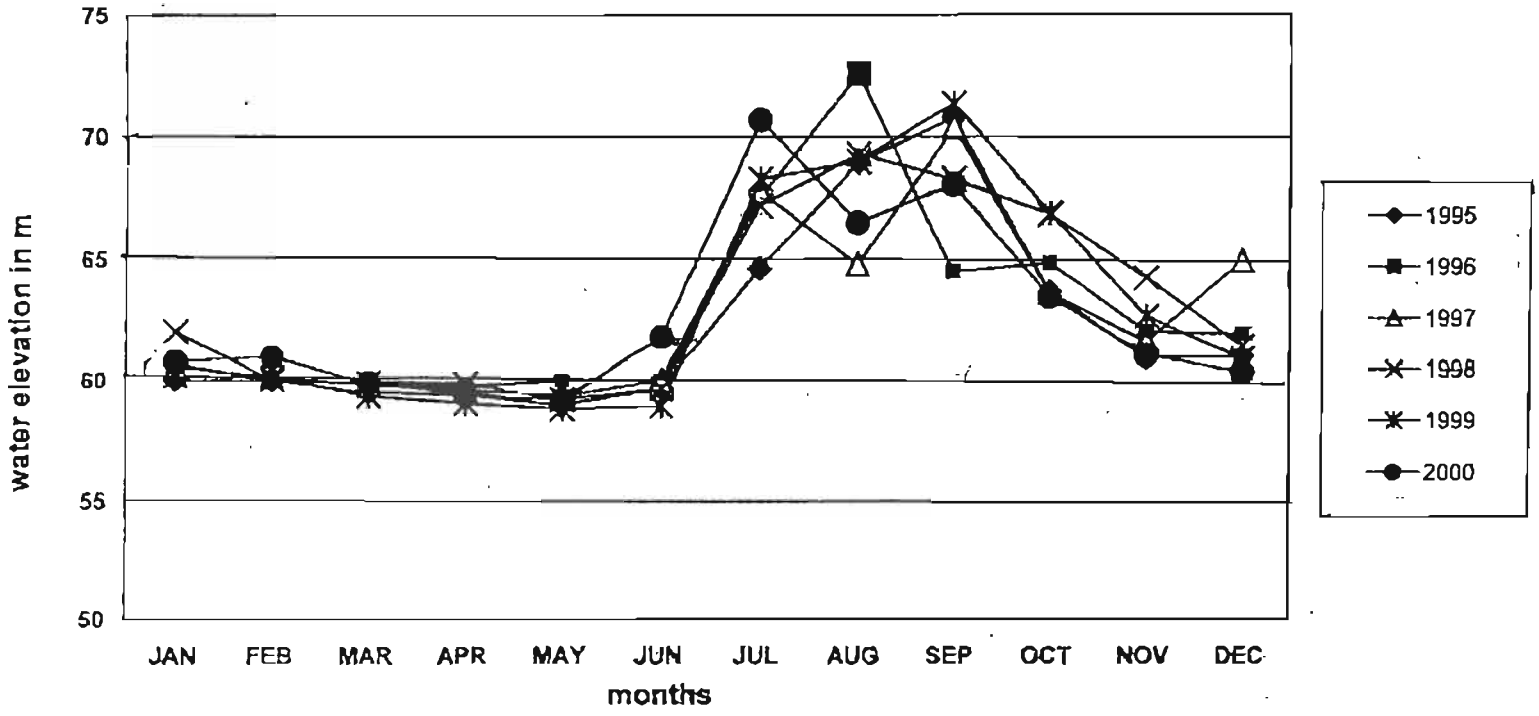


3.8 Average water level variation at Varanasi

(SOURCE, IWAI PATNA)



3.9 Minimum water wevel variation at Varanasi
(SOURCE : IWAI PATNA)



3.10 Maximum water level variation at Varanasi

(SOURCE : IWAI, PATNA)

ANNEXURE - I

Table 3.21

Monthly minimum water levels at Varanasi in m

	1995	1996	1997	1998	1999	2000
JAN	59.781	59.851	60.171	60.051	59.931	60.001
FEB	59.531	59.591	59.021	59.481	59.371	59.801
MAR	59.251	59.311	59.731	59.321	59.031	59.441
APR	58.966	59.017	59.351	59.226	58.831	59.201
MAY	58.486	59.001	59.081	59.061	58.576	58.971
JUN	58.461	58.041	58.261	59.231	58.436	59.001
JUL	59.481	58.506	59.021	59.721	59.061	61.491
AUG	60.041	68.261	68.151	63.491	65.261	63.761
SEP	63.811	64.531	63.311	63.696	65.531	63.551
OCT	61.001	62.076	61.001	62.731	62.741	61.091
NOV	60.211	61.101	60.911	61.381	60.936	60.391
DEC	59.801	60.436	61.101	60.016	60.671	59.841

SOURCE: (IWAI, PATNA)

Table 3.22

Monthly maximum water levels at Varanasi in m

	1995	1996	1997	1998	1999	2000
JAN	60.011	60.661	60.561	62.041	60.176	60.811
FEB	59.996	60.036	60.171	60.016	60.141	60.991
MAR	59.526	59.861	59.806	59.931	59.356	59.886
APR	59.411	59.737	59.591	59.871	59.061	59.436
MAY	58.961	59.996	59.346	59.221	58.831	59.181
JUN	59.686	59.996	59.996	59.666	58.936	61.821
JUL	64.621	67.561	67.796	67.231	68.301	70.661
AUG	68.991	72.541	64.801	69.301	69.011	66.526
SEP	70.731	64.511	70.381	68.316	71.331	68.091
OCT	63.671	64.871	63.631	66.881	66.931	63.481
NOV	60.961	62.056	61.651	64.271	62.691	61.071
DEC	60.981	61.941	64.971	61.441	60.901	60.371

SOURCE: (IWAI, PATNA)

Table 3.23

Monthly average water levels at Varanasi in m

	1995	1996	1997	1998	1999	2000
JAN	59.92	60.01	60.32	61.05	60.04	60.24
FEB	59.75	59.84	59.99	59.73	59.80	59.91
MAR	59.35	59.67	59.58	59.42	59.18	59.63
APR	59.16	59.27	59.50	59.54	58.92	59.32
MAY	58.71	59.37	59.27	59.15	58.65	59.06
JUN	58.74	59.50	59.19	59.48	58.61	60.66
JUL	61.35	61.91	62.16	64.28	61.55	63.83
AUG	66.98	68.97	65.63	66.82	67.57	65.46
SEP	67.30	68.02	66.24	65.56	68.76	65.98
OCT	62.06	63.30	61.98	64.58	64.90	61.84
NOV	60.64	61.62	61.31	62.36	61.67	60.80
DEC	60.03	60.75	62.39	60.64	60.79	60.12

SOURCE: (IWAI, PATNA)

Table 3.24

Maximum and Minimum water levels at Varanasi in m

Year	Maximum	Minimum
1995	70.731	59.411
1996	72.541	59.737
1997	70.381	59.346
1998	69.301	59.221
1999	71.331	58.831
2000	70.661	59.181

Table 3.25

Difference in water level at Varanasi in m

Year	difference in water level
1995	11.320
1996	12.804
1997	11.035
1998	10.080
1999	12.500
2000	11.480

SOURCE: (IWAI, PATNA)

ANNEXURE - I (a)

RANGE OF WATER LEVEL W.R.T NO OF DAYS

Range			Year																	
			1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
58.000	-	58.499	43	66	0	2	0	0	5	0	0	0	7	0	0	0	33	0	14	2
58.500	-	58.999	79	99	26	38	4	56	54	37	7	0	77	11	76	77	73	24	67	83
59.000	-	59.499	66	10	54	64	60	64	62	60	62	90	46	71	62	119	77	82	79	31
59.500	-	59.999	60	1	77	54	99	82	87	65	76	61	30	61	68	44	5	36	50	4
60.000	-	60.499	12	32	67	41	58	22	31	22	43	25	32	55	29	45	18	90	19	0
60.500	-	60.999	24	15	47	47	13	25	20	30	9	18	36	26	21	17	24	31	13	0
61.000	-	61.499	20	9	11	11	18	9	12	22	30	15	15	19	11	8	16	17	7	0
61.500	-	61.999	9	10	7	9	13	5	8	24	27	19	15	26	10	4	11	26	6	0
62.000	-	62.499	9	7	5	14	12	8	10	16	17	12	9	18	5	6	7	9	7	0
62.500	-	62.999	3	4	5	9	9	3	4	5	8	9	5	5	9	4	6	9	16	0
63.000	-	63.499	7	8	3	8	11	4	3	6	7	9	4	4	4	10	11	8	5	0
63.500	-	63.999	6	5	2	7	15	6	3	6	14	11	5	10	4	4	6	3	14	0
64.000	-	64.499	3	6	3	4	13	5	7	10	19	12	3	6	8	2	10	6	9	0
64.500	-	64.999	5	4	4	5	7	4	7	3	3	17	2	2	8	3	13	1	9	0
65.000	-	65.499	4	7	7	7	7	6	2	1	11	13	3	6	4	4	7	5	10	0
65.500	-	65.999	2	13	6	8	4	2	6	1	7	11	5	16	7	3	5	2	6	0
66.000	-	66.499	5	14	6	5	3	3	4	1	7	7	14	7	7	4	4	3	14	0
66.500	-	66.999	6	11	7	11	4	2	5	1	6	11	6	4	7	3	3	1	6	0
67.000	-	67.499	2	7	6	5	0	5	9	8	1	3	11	4	6	5	5	4	3	0
67.500	-	67.999	0	14	3	3	3	14	5	14	1	6	7	8	7	3	0	3	4	0
68.000	-	68.499	0	11	2	2	3	14	9	8	4	12	9	3	8	0	7	3	3	0
68.500	-	68.999	0	6	8	5	4	12	5	4	3	2	9	0	2	0	11	2	0	0
69.000	-	69.499	0	1	2	1	0	4	3	8	0	2	3	1	2	0	5	1	1	0
69.500	-	69.999	0	0	1	2	2	3	1	2	2	0	3	1	0	0	1	0	1	0
70.000	-	70.499	0	2	2	0	3	2	1	5	1	0	3	0	0	0	2	0	2	0
70.500	-	70.999	0	2	1	0	0	0	2	0	0	0	3	2	0	0	1	0	0	0
71.000	-	71.499	0	1	3	2	0	2	0	2	0	0	3	0	0	0	1	0	0	0
71.500	-	71.999	0	0	0	1	0	3	0	1	0	0	0	0	0	0	1	0	0	0
72.000	-	72.499	0	0	0	1	0	0	0	3	0	0	0	0	0	0	2	0	0	0
72.500	-	72.999	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
73.000	-	73.499	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
73.500	-	73.999	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
																				0
			365	365	365	366	365	365	365	366	365	365	365	366	365	365	365	366	365	120

(Source: CWC, Varanasi, collected from IWAI, Kolkata)

ANNEXURE – II

DETAILS OF SHOALS OCCURRED DURING SEASON 2000-2001

IN THE STRETCH TRIBENI (193) - FARAKKA (544) (N.W.- 1)

S. No	LOCATION	CHAINAGE	Sep-00		Oct. 00		Nov.-00		Dce. 00		Jan.001				Feb.01			
			IFN	II FN	IFN	II FN	I FN	IIFN	IFN	IIFN	IFN		IIFN		IFN		IIFN	
			LAD	Length	LAD	Length	LAD	Length	LAD	Length	LAD	Length	LAD	Length	LAD	Length	LAD	Length
		(KMS)	(m)	(m)	(m)	(m)	(m)	(m)	(m)	(m)	(m)	(m)	(m)	(m)	(m)	(m)	(m)	(m)
1	D/S PALASSEY FERRY	389.7									1.8	30	1.8	50				
	TOTAL										1.9	30	1.9	50				
	NO. OF SHOALS										1		1					

DETAILS OF SHOALS OCCURRED DURING SEASON 2000-2001

IN THE STRETCH FARAKKA (544) - BHAGALPUR(715) (N.W.- 1)

S. No.	LOCATIONS	CHAINAGE	Sep-00		Oct. 00		Nov. 00		Dce. 00				Jan.001				Feb.01			
			IFN		IIFN		IFN	IIFN	IFN		IIFN		IFN		IIFN		IFN		IIFN	
			LAD	Length	LAD	Length	LAD	Length	LAD	Length	LAD	Length	LAD	Length	LAD	Length	LAD	Length	LAD	Length
		(KMS)	(m)	(m)	(m)	(m)	(m)	(m)	(m)	(m)	(m)	(m)	(m)	(m)	(m)	(m)	(m)	(m)	(m)	(m)
1	U/S FARAKKA LOCK GATE	549.0							1.9	100	1.9	100	1.9	130	1.9	226				
2	U/S BATESHWAR STHAN	684.0											1.9	50						
	TOTAL								1.9	100	1.9	100	1.9	180	1.9	226				
	NO. OF SHOALS								1		1		2		1					

DETAILS OF SHOALS OCCURRED DURING SEASON 2000-2001
IN THE STRETCH BHAGALPUR (715) - PATNA (955) (N.W.- 1)

S No.	LOCATIONS	CHAINAGE	Sep-00		Oct. 00				Nov.-00				Dce. 00				Jan.001				Feb.01			
					I FN		II FN		I FN		II FN		I FN		II FN		IFN		IIFN		IFN		IIFN	
			LAD	Length	LAD	Length	LAD	Length	LAD	Length	LAD	Length	LAD	Length	LAD	Length	LAD	Length	LAD	Length	LAD	Length	LAD	Length
		(KMS)	(m)	(m)	(m)	(m)	(m)	(m)	(m)	(m)	(m)	(m)	(m)	(m)	(m)	(m)	(m)	(m)	(m)	(m)	(m)	(m)	(m)	(m)
1	TEKKAPUR	782.0															1.8	60						
2	TEKKAPUR	784.0													1.8	100								
	BELHAPUR	820.5																			1.8	150		
	NAYAGAON	822.0																			1.8	100		
3	MATHIHANI	833.0					1.6	300																
4	SEEMA	834.0															1.8	100						
5	RAMDIRI	837.0					1.7	250																
6	TEGHRA	863.6							1.7	250														
7	TEGHRA	867.0					1.7	300																
8	TEGHRA	869.0					1.8	300																
	U/S TEGHRA	870.0																			1.8	100		
9	U/S TEGHRA	871.0					1.9	100																
10	U/S BARH	892.0													1.8	50					1.8	100		
11	U/S BARH	896.0					1.7	200			1.8	60												
12	RUPAS (ATHMALGOLA)	897.0					1.7	250																
13	RUPAS	903.0					1.7	200	1.8	200														
14	U/S RUPAS(ATHMALGOLA)	906.0					1.8	150																
15	U/S RUPAS	909.0					1.8	200																
16	D/S MEHNAR	925.0													1.7	100								
17	U/S MEHNAR	928.0					1.8	150	1.7	250														
18	U/S MEHNAR	926.2									1.8	100												
	d/s CHECHAR	933																	1.9	60	1.8	150		
	d/s CHECHAR	933.8																			1.8	150		
	d/s CHECHAR	934.6																			1.7	200		
19	CHECHAR	936.6													1.9	60								
	Gopalpur	938																			1.9	100		
20	BAIDPUR	942.6															1.8	150						
21	BHAIROPUR	945.0					1.9	300																
22	BHAIROPUR	945.5					1.8	150																
	Bhairopur	946																			1.7	100		
	TOTAL						1.8	2850	1.7	700	1.8	150			1.8	300	1.8	300						
	NO. OF SHOALS						13		3		2				4		3							

DETAILS OF SHOALS OCCURRED DURING SEASON 2000-2001
IN THE STRETCH PATNA (955) - KAITHY(1263) (N.W.- 1)

NO	LOCATIONS	CHAINAGE	Sep-00		Oct.00				Nov.-00				Dec.00				Jan.01				Feb.01			
					IFN		II FN		IFN		IIFN		IFN		IIFN		IFN		II FN		IFN		II FN	
		(KMS)	LAD (m)	Length (m)	LAD (m)	Length (m)	LAD (m)	Length (m)	LAD (m)	Length (m)	LAD (m)	Length (m)	LAD (m)	Length (m)	LAD (m)	Length (m)	LAD (m)	Length (m)	LAD (m)	Length (m)	LAD (m)	Length (m)	LAD (m)	Lc
1	SALEMPUR	1043.0					1.8	50																
2	NAURANGA	1062.5											1.5	70										
3	NAURANGA	1063.0									1.6	450												
4	NAURANGA	1063.2							1.3	450														
5	NAURANGA	1064.0					1.5	800																
6	ARJUNPUR	1119									1.7	800	1.8	70	1.9	50	1.9	75						
7	ARJUNPUR	1120.5					1.8	350																
8	ARJUNPUR	1121.0							1.3	750														
9	U/S GAHMER	1151.0							1.8	100														
10	U/S KALLUPUR	1171.0					1.8	80																
11	KALUPUR	1172.0							1.8	100														
12	D/S KALUPUR	1172.5			1.3	80																		
13	U/S GHAZIPUR BRIDGE	1177.0															1.8	75						
14	U/S GHAZIPUR BRIDGE	1177.5									1.8	50												
		1177.3																	1.5	250				
15	U/S GHAZIPUR BRIDGE	1177.8															1.9	50						
16	U/S GHAZIPUR BRIDGE	1178.0											1.8	50										
17	U/S GHAZIPUR BRIDGE	1178.2							1.8	60														
18	GHAZIPUR BRIDGE	1178.3															1.7	300						
19	GHAZIPUR	1179.0															1.7	200						
20	BAIPUR	1185.2					1.8	400																
21	BAIPUR	1187.5							1.7	450														
22	RAFIPUR	1199.0															1.7	75						
23	BARHARIA	1200.0															1.9	50						
24	D/S ZAMANIA	1204.0															1.7	100	1.7	100				
25	U/S DEOCHANPUR	1247.5											1.8	50										
26	U/S DEOCHANPUR	1248													1.7	350								
27	DEOCHANPUR	1248.2															1.3	600	1.5	300				
	TOTAL				1.3	80	1.7	1480	1.6	1900	1.7	1100	1.7	240	1.8	400	1.7	1425						
	NO. OF SHOALS				1		5		6		3		4		2		9							

DETAILS OF SHOALS OCCURRED DURING SEASON 2000-2001

IN THE STRETCH KAITHY 1263) - ALLAHABAD (1547) (N.W.- 1)

S. No	LOCATIONS	CHAINAGE	Sep-00		Oct. 00				Nov.-00				Dec.-00				Jan. -01				Feb. 01			
					IFN		IIFN		IFN		IIFN		IFN		IIFN		IFN		IIFN		IFN		IIFN	
			LAD	Length	LAD	Length	LAD	Length	LAD	Length	LAD	Length	LAD	Length	LAD	Length	LAD	Length	LAD	Length	LAD	Length	LAD	Length
		(KMS)	(m)	(m)	(m)	(m)	(m)	(m)	(m)	(m)	(m)	(m)	(m)	(m)	(m)	(m)	(m)	(m)	(m)	(m)	(m)	(m)	(m)	(m)
1	GAURA	1272.5			1.6	450																		
2	U/S GAURA	1273.6					1.8	60																
3	U/S GAURA MAHU	1274.0			1.8	300																		
4	BHAUPALI	1290.8					1.4	400																
5	U/S BHAUPALI	1292.6					1.8	100																
6	KAILI	1293.6			1.6	300																		
7	NAKHAWA	1295.8							1.8	100														
8	D/S KHURANA/ NAKHWA	1298.0											1.6	400			1.0	200						
9	D/S KHURANA/ NAKHWA	1298.2									1.7	100			1.6	150								
10	D/S RAJGHAT BRIDGE	1304.2							1.8	250														
11	D/S RAJGHAT BRIDGE	1304.6									1.8	200												
12	D/S RAJGHAT BRIDGE	1304.8											1.8	200										
13	D/S RAJGHAT BRIDGE	1305.6													1.8	100	1.8	100						
14	D/S GANGPUR	1330.5					1.8	100																
15	D/S SHIVPUR	1334.7															1.6	300						
15	SHIVPUR	1334.8													1.9	100								
17	SHIVPUR	1335.6															1.9	150						
18	SHIVPUR	1336.5															1.5	150						
19	D/S MAJHAWA CHAK	1338.2															1.4	150						
20	SITLA TEMPLE	1339					1.8	100																
21	D/S MAJHAWA CHAK	1339.5															1.3	300						
22	SITLA TEMPLE	1339.8					1.8	60																
23	ADALPURA	1340			1.8	60									1.1	250								
24	MAJHWACHAK	1340.5													1.5	200								
25	MAJHWACHAK	1340.8															1.4	150						
26	BASHARATPUR	1341.2													1.7	600								
27	D/S SINDHAURA	1349.0													1.1	1000								
28	D/S SINDHAURA	1350.5					1.8	100									1.1	1500						
29	D/S SINDHAURA	1350.6					1.5	400																
30	D/S SINDHAURA	1350.7									1.1	450												
31	D/S SINDHAURA	1351.0							1.3	450														
32	D/S SINDHAURA	1351.3											1.1	400										
33	KATHNEI	1358.5													1.2	150								
34	KATHNEI	1356.6															1.2	150						
35	U/S SINDHAURA	1356.8									1.7	200												
36	KANURA	1361.5															1.2	150						
37	D/S DHARAMDEVA	1362.5					1.3	450							1.2	400								
38	DHARAMDEVA	1362.8							1.1	400	1.0	400	1.0	400										
39	DHARAMDEVA	1363.0			1.3	125																		
40	LEDU	1372.6							1.4	250							1.6	200						
41	LEDU	1373.0					1.6	200					1.5	300										
42	LEDU	1373.3			1.8	400																		
43	LEDU	1373.4													1.6	250								
44	LEDU	1373.5			1.4	75					1.4	250												
45	D/S BAISUKHIA	1384.0							1.6	250														
46	D/S BAISUKHIA	1384.5									1.6	250												

S. No	LOCATIONS	CHAINAGE	Sep-00		Oct. 00				Nov.-00				Dec.-00				Jan. -01				Feb. 01			
					I FN		II FN		I FN		II FN		I FN		II FN		I FN		II FN		I FN		II FN	
			LAD	Length	LAD	Length	LAD	Length	LAD	Length	LAD	Length	LAD	Length	LAD	Length	LAD	Length	LAD	Length	LAD	Length	LAD	Length
		(KMS)	(m)	(m)	(m)	(m)	(m)	(m)	(m)	(m)	(m)	(m)	(m)	(m)	(m)	(m)	(m)	(m)	(m)	(m)	(m)	(m)	(m)	(m)
47	D/S BAISUKHIA	1384.7									1.8	150												
48	D/S BAISUKHIA	1386.5													1.7	300	1.7	300						
49	D/S BAISUKHIA	1386.0					1.8	250																
50	D/S BAISUKHIA	1386.4											1.8	300										
51																								
52	U/S MIRZAPUR BRIDGE	1398.5															1.2	600						
53	U/S MIRZAPUR BRIDGE	1399.2											1.6	400										
54	U/S MIRZAPUR BRIDGE	1399.4													1.4	400								
55	U/S MIRZAPUR	1399.8															1.4	300						
56	VINDHYACHAL	1402.2											1.9	200	1.5	400								
57	D/S GOPALPUR	1425.0															1.2	300						
58	D/S GOPALPUR	1425.5							1.5	100	1.5	100			1.2	250								
59	D/S GOPALPUR	1425.7											1.5	300										
60	SITAMARHI	1447.5									1.7	400												
61	SITAMARHI	1448							1.5	460														
62	SITAMARHI	1448.2									1.5	800												
63	SITAMARHI	1448.5							1.3	500					1.5	350								
64	U/S SITAMARHI	1448.8					1.8	150					1.7	150			1.7	150						
65	U/S SITAMARHI	1449					1.5	500									1.7	150						
66	U/S SITAMARHI	1449.5											1.8	150			1.7	150						
67	U/S KHAIRA	1457.4									1.8	150												
68	U/S KHAIRA	1457.5							1.5	150			1.8	200										
69	U/S KHAIRA	1457.8													1.5	350	1.7	150						
70	U/S KHAIRA	1458.2													1.5	150								
71	U/S KHAIRA	1458.5											1.8	200										
	Total				1.3	1710	1.3	2860	1.1	2900	1.0	3450	1.1	3600	1.1	5400	1.0	5600						
	No. of Shoals				7		13		10.0		12		13		17		20							

DETAILS OF SHOALS OCCURRED DURING SEASON 2000-2001
IN THE STRETCH KAITHY 1263) - ALLAHABAD (1547) (N.W.- 1)

S.No.	LOCATIONS	CHAINAGE	Sep-00		Oct. 00				Nov. -00				Dec.00				Jan 01				Feb 01			
			IFN	II FN	IFN		II FN		I FN		IIFN		IFN		IIFN		IFN		II FN		IFN		II FN	
			LAD	Length	LAD	Length	LAD	Length	LAD	Length	LAD	Length	LAD	Length	LAD	Length	LAD	Length	LAD	Length	LAD	Length	LAD	Length
		(KMS)	(m)	(m)	(m)	(m)	(m)	(m)	(m)	(m)	(m)	(m)	(m)	(m)	(m)	(m)	(m)	(m)	(m)	(m)	(m)	(m)	(m)	(m)
72	D/S BAMPUR	1464.6					1.8	60																
73	D/S BAMPUR	1465.6			1.6	60																		
74	U/S SIRSA	1507.6											1.6	250										
75	SIRPUR	1508.6									1.4	800												
76	U/S TONS TIVER	1509.2-1510.8					1.6	500	1.8	150	1.7	600	1.6	1000	1	1600	1	1000						
77	RAMPUR	16110									1.7	300												
78	U/S TONS TIVER	1511.6													1.1	250								
79	D/S DUMDUMA	1512									1.7	200												
80	D/S DUMDUMA	1512.2											1.6	450	1.6	100								
81	D/S DUMDUMA	1512.6													1.4	300								
82	DUMDUMA	1513.3													1.7	100								
83	DUMDUMA	1513.6							1.6	200														
84	U/S DUMDUMA	1513.8							1.2	450														
85	U/S DUMDUMA	1513.9															1.9	150						
86	U/S DUMDUMA	1514.1															1.8	150						
87	U/S DUMDUMA	1514.2					1.2	500			1.4	600												
88	U/S DUMDUMA	1514.5															1.4	300						
89	U/S DUMDUMA	1515.5-1518.3			1.3	60	1.2	190	1.2	1000	1.6	1000	1	3600	1	650	1.2	900						
90	U/S DUMDUMA	1518.5					1.9	30	1.2	400					1.4	400								
91	SAHABAZ	1519															1.7	150						
92	SAHABAZ	1520.4									1.5	600												
93	U/S SHABAZ	1521													1.5	250								
94	RAMPUR	1521.8									1.5	300												
95	U/S SHABAZ	1522													1.5	250								
96	D/S DIHA	1522.2															1.5	150						
97	RAMPUR	1522.3											1.4	350										
98	D/S DIHA	1523.7													1.5	400								
99	D/S DIHA	1523.9											1.9	200										
100	DIHA	1525															1.8	150						
101	D/S RAWANKA	1527.8					1.2	100																
102	RAWANKA	1528.2													1.8	150								
103	U/S RAWANKA	1529.5			1.5	300			1.8	100					1.7	100								
104	D/S MANAIYA	1529.8					1.8	30																
105	D/S MANAIYA	1530															1.5	150						
106	MANAIYA	1530.2			1.8	150																		
107	MANAIYA	1530.5					1.4	150																
108	MANAIYA	1530.7													1.6	100								
109	MANAIYA	1530.8			1.5	150																		
110	MANAIYA	1531											1.8	400										
111	U/S MANAIYA	1531.5															1.5	300						
112	D/S LAWAIKALAN	1536.2							1.6	100	1.5	100												
113	D/S LAWAIKALAN	1536.8							1.7	100														
114	D/S LAWAIKALAN	1536.4											1.7	400										
115	D/S NIADKAR	1538.2							1.7	150														
116	D/S SIKURI	1538.5			1.8	150																		
117	D/S SIKURI	1538.7											1.8	450										
118	SIKURI	1539					1.9	20			1.7	150												
119	SIKURI	1539.4													1.2	1000								

S No	LOCATIONS	CHAINAGE	Sep-00		Oct. 00				Nov. -00				Dec 00				Jan.01				Feb.01			
			I FN	II FN	I FN		II FN		I FN		II FN		I FN		II FN		I FN		II FN		I FN		II FN	
		(KMS)	LAD	Length	LAD	Length	LAD	Length	LAD	Length	LAD	Length	LAD	Length	LAD	Length	LAD	Length	LAD	Length	LAD	Length	LAD	Length
			(m)	(m)	(m)	(m)	(m)	(m)	(m)	(m)	(m)	(m)	(m)	(m)	(m)	(m)	(m)	(m)	(m)	(m)	(m)	(m)	(m)	(m)
120	TIKURI	1539.6											1.9	150			1.2	1600						
121	U/S LAWAIKALAN	1540			1.9	60																		
122	BHADKAR	1540.6							1.7	50	1.9	150			1.6	250								
123	BHADKAR	1540.7											1.5	400										
124	U/S BHADKAR	1641.2							1.8	100	1.8	100			1.8	100	1.5	300						
125	D/S CHATNAG	1641.5															1.5	150						
126	U/S BHADKAR	1641.6											1.9	100										
127	D/S BIRLA MANDI	1642.6											1.7	200										
128	CHATNAG	1643											1.6	150										
129	U/S CHATNAG	1643.4											1.3	100			1.4	600						
130	U/S CHATNAG	1643.8											1.6	100										
131	U/S CHATNAG	1644							1.4	450	1.4	300			1.4	300								
132	U/S CHATNAG	1644.2					1.2	460					1.1	200										
133	U/S CHATNAG	1644.5			1.5	250			1.6	460														
134	D/S SANGAM	1644.7													1.1	600								
135	SANGAM	1645							1.6	100			1.2	400										
136	SANGAM	1646.2							1.5	100			1.5	200			1.2	150						
137	D/S SANGAM	1646.4															1.6	150						
138	SANGAM	1645.6					1.4	200			1.1	300												
	TOTAL					1160		1365		4500		8950		12600		12300		12650						
	NO OF SHOALS				8		10		16		26		32				36							

CHAPTER – 4

SITE SELECTION

4.0 SITE SELECTION FOR THE NEW INTERMODAL TERMINAL

4.1 Introduction

The Ganges River forms an important part in the development of an integrated inland water transport in the country. Recognising the multipurpose role of this river, 1620 Km long stretch of Ganga between Haldia and Allahabad has been declared as National Waterway No.1. In order to promote inland navigation, the need of which has been reinforced after declaration of Ganga as National Waterway No.1, IWAI has plans to develop Varanasi as major Intermodal River Terminal.

The Ganges waterway however suffers from many navigational hazards like shallow water, narrow width during dry season, siltation and bank erosion. Also there is large seasonal variation in water level between monsoon and dry season. This chapter discusses in detail the basis of site selection for proposed Intermodal Terminal at Varanasi.

The Ganga from Allahabad to Patna over a distance of 600 km flows predominantly along the right bank between Allahabad and Mirzapur (153kms). When it swings towards east between Mirzapur and Patna (447km), admittedly while this is the general swing of the river. The lengths are covered by sub-meanders within these reaches with the deep channel also sympathetically changing banks. Naturally for selection of site for a jetty the overall pattern of the meanders has to be reckoned.

A suitable site is required to be examined at Varanasi between Kaithi (1264 km Chainage) and Ramnagar (1318 km chainage). From the overall plan it would appear that stable deep depths may generally be available on the right bank

upstream of Varanasi and left bank down stream of Varanasi. The site to be selected based on other infrastructure facilities, which are discussed separately in subsequent para.

Terminals are the centers of receipt, export, storage, distribution of cargo and embarkation of passengers. Terminals form the hub of connection at transit through various means and modes of transportation. They are the shelters where vessels can berth and load or unload cargo and get its supplies. With development of waterway transport many small and big cities have been built on the banks of river. These terminals and cities at the same time have grown into political, cultural, economic and trade centers. Many such important cities have developed on the river route.

In order to meet the need of rapid economic development in the country and in the Gangatic Plain in particular and also in view of congestion faced in other modes of transport like road and railway the capacity of inland water transportation has to be increased and many terminals have to be built. At present there are a number of major and minor Ghats at Ganges. However, existing wharf's are of marginal type. For historical reasons as well as convenience of connection with towns for cargoes and passengers all the terminals are located near the town and distributed along the riverbank.

Lack of terminal and handling facilities and infrastructure has limited the expansion of inland water transportation rate and full utilisation of waterways and fleets. Construction of terminals on Ganges River is difficult as well as expensive due to large fluctuation in river levels in different seasons.

Huge investment involved in development of terminals reinforces the need of proper selection of location of terminals. Inland Terminals should be strategically placed in such a way that it serves dual purpose. Enough traffic passes through the terminal and associated hinterland also develops side by side.

The facilities provided at the terminal should meet the traffic demand and should be utilised to the maximum extent possible. As the resources are scarce the investment made should be economically viable.

Planning for inland terminals and other associated development works should take in to account changes in pattern of trade, future expansions, increase in size of vessels etc. Terminal development work while being implemented should ensure proper rehabilitation of people displaced by the project.

4.2 Criteria for site selection

Proper site selection keeping in view all associated natural hazards and man made problems will go in a long way towards development of commercially viable inland water transport.

These sections analyse in detail the basis of site selection for the proposed intermodal terminal at Varanasi.

Ideally, selection of sites for establishing Inland River terminal should have following basis:

a) Stability of river bank
b) Available draft in natural situation
c) Availability of adequate water front
d) Adequate width of waterway
e) Road connection to site
f) Approach distance to deep water
g) Capital dredging and bund
h) Nearness to city/ town
i) Ecological/ Environmental Impact
j) Operating and maintenance cost of all facilities

k) Nearness to railhead

l) Current in lean season

m) Discharge at selected site

n) Cost of foundation

o) Variability of channel near terminal

p) Availability of essential services

q) Availability/ acquisition of adjoining back up land for locating Terminal

Each of the above criteria for selecting terminal site have been described in detail in the following paragraphs:

a) Stability of river bank

Stable water front is an important navigational aspect, which plays a key role in deciding the location of an inland water terminal. It could be further divided as below. For the ratings and weightage of each sub-criterion please refer Table –4.I

- Stable coast/ river bank
- Erosion arrested or partly occurs, bank protection work exists
- Large erosion occurs, bank protection work required
- Low siltation, marginal quantity of dredging required
- Large siltation, large quantity of dredging required.

b) Available draft in natural situation

Self-propelled vessels need adequate minimum depth of water to ply smoothly in the river. The depth of water in the navigational channel should be sufficient to ensure safe navigation, berthing and handling operations of design vessels. The projected depth below design low water level should be equal to the full-loaded draft plus net under keel clearance

Available draft at each of the proposed sites forms an important criteria in site selection. Within this criteria five sub criteria have been chosen and each of the proposed sites rated, based on weightage give to each subcriteria. The five subcriteria are

- Available draft > 3.0m
- Available draft 2.5 – 3.0 m
- Available draft 2.0 – 2.5 m
- Available draft 1.5 – 2.0 m
- Available draft > 1.5 m

c) **Availability of adequate water front**

This criterion is an important consideration for finalisation of site selection. The nature of land holding whether private, government or being used for religious purpose decides the case of availability of land for terminal construction and operation. Availability of adequate water front will decide the ultimate design of water front and on shore facilities. Adequate water front length has been split in to three sub-criteria and each of the proposed sites rated based on weightage given to each sub-criterion:

- Water front available for 2 terminals
- Water front available for 1 terminal
- Water front available for < 1 terminal

d) **Adequate width of waterway**

The waterway should have adequate width at the proposed site to facilitate the vessels docking and levelling. The width of water area in front of wharf for docking vessel is generally 3-4 times the width of the design vessel and this water

area should not occupy any portion of main navigational channel. In order to facilitate the vessels docking and leveling, approach at an angle of 30 to 45 degrees with the wharf is required. For the purpose of proper evaluation, width of waterway has been divided into three sub-criteria as given below:

- Width naturally available for ferry in 2 barges
- Width naturally available for ferry in 1 barge
- Width naturally available for less than 1 barge

e) Road connection to site

The proposed terminal being of intermodal type the road linkage plays a very crucial role in deciding the site location. An efficient road linkage system will facilitate optimal utilisation of site. If road connections are not well developed and clearing capacity from port area of these modes of transport is inadequate the expected benefits from these ports can not be achieved. An efficient systems of intermodal linkage ensures that cargo is brought in or evacuated from the terminal without delay and achieves speedy turnaround of vessels and less storage provisions have to be made at terminal.

Like previous criteria this has also been broken up in to five subcriteria for optimal evaluation. The sub-criteria are:

- Metalled road connection
- Conversion of un-metalled road < 2 km to metalled road/ new road < 1 Km
- Conversion of un-metalled road 2-4 Km to metalled road/ new road < 1 Km
- Conversion of un-metalled road 4-6 Km to metalled road/ new road 1-2 Km
- Conversion of metalled road >6 Km construction of new road >2 Km

f) Approach distance to deep water

The approach distance to –2.0m LAD from shoreline in the lean season also is a deciding factor from development cost point of view.

The five sub-criteria within these criteria are:

- Approach distance < 5m
- Approach distance 5-10m
- Approach distance 10 - 15m
- Approach distance 15-20m
- Approach distance > 20m

g) Capital dredging and Bund

The quantum of dredging required to be carried out at coast of the proposed sites is an important criterion from capital cost point of view. Four sub criteria have been chosen for these criteria and weightage given are:

- Capital dredging not required
- Capital dredging low quantity
- Capital dredging medium quantity
- Capital dredging high quantity

h) Nearness to city/ town

The distance of proposed site from Varanasi/ Mughalsarai would also be a deciding factor in finalisation of the location of site. Nearness to city will obviously be an advantageous feature.

Five subcriteria have been chosen for this criteria and weightage given:

- City/ town nearby, infrastructure available (within 7.5 Km)
- City/ town nearby, infrastructure available (within 7.5-15 Km)
- City/ town nearby, infrastructure available (within 15-20 Km)
- City/ town nearby, infrastructure available (within 20-25 Km)
- City/ town nearby, infrastructure available (>25 Km)

i) Ecological/ Environmental Impact

The location of terminal can have impact on the environment in the form of deforestation, noise, air or water pollution, pollution due to handling, aggravated drainage of land/ sub-soil as well as aesthetics. For the disturbed drainage of land, deforestation and air or water pollution an additional cost element shall be applied to the cost of infrastructural works.

The environmental impact of noise is measured by the number of individuals suffering considerable annoyance at a certain level of exposure. Although Inland Waterways is considered to produce the lowest level of noise annoyance and the road transport the most.

Air pollution another most important environmental aspect depends on the mode of transportation. The more energy is used, the more pollution in terms of obnoxious emissions is expected.

In case of Inland Water Transport, water pollution is relevant when calamities occurs with POL transport in particular.

The construction of new intermodal terminal as proposed sites may have a direct / indirect effect on the immediate surrounding ecology/ environment. This criteria has been divided into five sub-criteria's are:

- Least impact on ecology
- Marginal impact on ecology
- Medium impact on ecology
- Large impact on ecology
- Very large impact on ecology

j) Operating and maintenance cost of all facilities

When the proposed terminal starts functioning there has to be certain operational and maintenance cost towards basic infrastructure facilities for vessel handling and for cargo specific activities. This criteria has been divided into five such criteria's which are listed below:

- Too Low O & M cost
- Low O & M cost
- Medium O & M cost
- High O & M cost
- Too high O & M cost

k) Nearness to Rail head

The basic requirement of an access railway head to terminal is that distance should be short, occupy less space and track capacity should match the capacity of different lines in the cargo handling chain. The access of railway to terminal consists of terminal yard and handling tracks loop, roads should be laid out in the terminal area and road connection should not interfere with traffic.

This criteria has been divided into five such criteria's which are listed below:

- Available within 10 Km
- Available within 10-15 Km

- Available within 15-20 Km
- Available within 20-25 Km
- Available at >25 Km

l) Current in lean season

The velocity of currents in the lean season at a particular location is also an important navigational aspect, which plays a key role in deciding the location of an inland water terminal. It could be further divided as below. For the ratings and weightage of each sub-criterion please refer Table –3.I

- Current velocity < 1 knot
- Current velocity 1 –2 knot
- Current velocity 2 - 3 knot
- Current velocity 3 - 4 knot
- Current velocity > 4 knot

m) Discharge at selected site

Discharge at the sites under study in Varanasi is more or less varying within close ranges for the particular period. As such although this criteria is one of the important considerations for the terminal location, however considering that the sites under study around Varanasi have almost identical discharge at a given point of time.

n) Cost of foundation

The cost of construction of foundation at the particular location is an important criteria from the development cost point of view.

This criteria has been sub-dived into three headings for the evaluation of the various sites. The three sub-criterias are:

- Low construction cost
- Medium construction cost
- High construction cost

Which are also dependent on soil conditions

o) **Variability of channel near terminal**

The variation in the width and meandering of river channel during lean season and flood season is an important criteria from navigational aspect point of view.

This criteria has been sub-dived into five headings for the evaluation of the various sites. The five sub-criteria's are:

- <15 m in flood season
- 15 – 20 m in flood season
- 20 – 25 m in flood season
- 25 – 30 m in flood season
- >30 m in flood season

p) **Availability of essential services**

Availability of essential services like, electricity, medical facilities, potable water supply, communication, water craft repair facilities and sewerage disposal system also become a deciding factor in finalsation of the proposed terminal site. The five sub criterias under this heading chosen to evaluate the site is given below:

- Nearness to : electricity, medical facilities, potable water supply, communication, water craft repair facilities and sewerage disposal system
- Nearness to : electricity, medical facilities, potable water supply, and water craft repair facilities
- Nearness to : electricity, medical facilities, and water craft repair facilities
- Nearness to: electricity and medical facilities.
- All facilities are to be built.

q) Availability/ acquisition of adjoining back up land for locating Terminal

This is also an important criteria for deciding the location of an intermodal terminal. Five sub-criteria have been chosen to evaluate each site. The sub-criteria are:

- Land available/ No rehabilitation
- Land with little ground improvement/ rehabilitation least
- Land available but requires medium ground improvement/ rehabilitation comparatively more
- Land available but requires substantial ground improvement/ rehabilitation comparatively more
- Land available but costly or after substantial rehabilitation

4.3 Locations considered

General

A joint visit to locate the proposed intermodal terminal at Varanasi was made alongwith IWAI Officials. The discussion held with IWAI officials at Delhi and Varanasi backed up by a study of survey of topographical map of Survey of India - Gazipur and Varanasi districts and close examination of site conditions resulted

in identifying 7 possible locations as follows with their relative merits and demerits:

a) New Ramnagar By Pass Bridge (Right Bank)
b) New Ramnagar By Pass Bridge (Left Bank)
c) Ramnagar Fort Pontoon Bridge (Left Bank)
d) Ramnagar Fort Pontoon Bridge (Right Bank)
e) Gaura (Left bank)
f) Kaithi site 1 (Left bank)
g) ABC Jetty (Kaithi site 2) 9 Left bank)

All considered site locations are shown in Fig 4.1 to Fig 4.3.

The description of each of these probable sites has been given in the following paragraphs:

4.3.1 New Ramnagar By Pass Bridge (Right Bank)

Upstream of New Ramnagar By Pass Bridge (Right Bank) site is located on the right side bank of Ganges at a distance of 9 Km upstream of Malviya road cum Railway Bridge connecting Varanasi to Mughalsarai. Recently constructed (Opened to traffic in July1999) Pt. Deendayal Setu which is bypass to Mughalsarai,Ramnagar & Varanasi towns is hardly 500 metres from the proposed site. This site is shown in Plate 1 and 2.

The bye pass bridge is on NH2, which is also a part of the Delhi-Kolkata part of the Golden Quadrilateral. The left side of the right bank (coming from NH7 to Allahabad along new bypass road) is a suitable site for the proposed terminal. A metalled service road connecting NH7 & left flank of bypass road is situated at a distance of about 500m only from the proposed site. The site is having connectivity to both NH2 and NH7. The land is coming under Ralhupur revenue

village and is owned by Advocate Gopal Singh who is also The Chaiman of Kashi Naresh' fort. A small temple like stucture was seen near approach to site.

A wide drain which is normally dry but gets flooded by the river during monsoon season flows adjacent to the site. The approach road to the proposed terminal can be planned in such a way that there is no need to cross the drain thereby avoiding the need to build a culvert. However during detailing if it is found that some portion of the proposed site goes beyond the drain, then the existing drain can be diverted to avoid building of any culvert.

New Ramnagar by pass (Chainage 1318) Bridge is located across Ganga River new Malahia. It is seen that near New Ramnagar Bridge adequate water frontage with draft is available. On the right bank a public boarding school is located. This school is shown in Plate 4.1(a). Right bank has firm stable bank with deep slope. It is noticed that top of land to water level at present is ~20m and the distance between edge of the land to shoreline at present is ~ 30m. We were given to understand that water level during HFL rises to ~12m from the present level. The water does not cross the top edge of the bank during high flood season. The draft available on the right bank is ~5m close to the shore (i.e. approx. at a distance of 3m from shore). The cross section of the river at down stream Ram nagar road bridge (1317.5km) and up stream Ram nagar road bridge (1317.8km) are shown in Fig. 4.4 and 4.5 respectively.

The advantage of this location is that NH-7 is passing close by. Highway to Allahabad is also passing close by this location. The site is close to town and about 10 Km from Railway station.

Northern railway main line (electrified) passes at a distance of 6 km from the site. The bank is in its natural state made up completely with flurical deposits and devoid of any man made protective measures.

While assessing the draw-down effect of the constructed bridge it is found that the effect is within limits and thus do not restrict the terminal location near to the bridge.

4.3.2 New Ramnagar By Pass Bridge (Left Bank)

New Ramnagar By Pass Bridge (Left Bank) site is located on the left side bank of Ganges at a distance of 9 Km upstream of Malviya road cum Railway Bridge connecting Varanasi to Mughalsarai. The onshore site presently belongs to Government and most of them is Diara land. This site is shown in Plate 3.

At present no metalled road connect the site. A non-metalled road is in existence. However National Highway NH-7 is passing at a distance of only 2 Km from the site. The approach to NH-7 is through a newly constructed bridge on river Ganges near Malahia.

New Ramnagar by pass (Chainage 1318) Bridge is located across Ganga River new Malahia. It is seen that on the left bank of the river near New Ramnagar Bridge adequate water frontage with draft is available. On the left bank a residential cum school is located. On the left bank lot of siltation is noticed with flat embankment. During high flood , water course takes away sand and a fresh deposit is seen in the next season. Sufficient Diara land on left bank of the river is seen.

The draft available on the left bank is ~ 2.0m approx. at a distance of 10m from the present shoreline. The bank is in its natural state made up completely with fluvial deposits and devoid of any man made protective measures.

The advantage of this location is that NH-7 is passing close by. Highway to Allahabad is also passing close by this location. The site is close to town and about 10 Km from Railway station.

The railway connection for the left bank is through a single BG line connecting Allahabad and Varanasi at a distance of about 6 to 7 kms.

The river emerges from a comprehensively narrow width at Malahia and becomes wider at the pontoon bridge. The left bank experiences sedimentation near the new Ramnagar bridge during the dry season. This is also evidenced by the slight recession of river on the left bank.

4.3.3 Ramnagar Fort Pontoon Bridge (Left bank)

Ramnagar Pontoon Bridge site is located on the left bank of river Ganges at a distance of 7 Km upstream of Malviya road cum railway bridge. The site presently belong to Government/Municipality. This is located on the concave part of the Ganges at the chainage of 1315km. The cross section of the river at up stream Ram nagar pontoon bridge (1316 km) is shown in Fig. 4.6.

The site is connected by all season-metalled road. National Highway NH-7 is located at a distance of 2 Km (if measured from pontoon bridge). The pontoon bridge is open for traffic only from November to June.

Northern railway main line (electrified) passes at a distance of 9 km from the site. The left riverbank at Ramnagar Pontoon Bridge site is partly stable. The navigation channel is 2 to 3m deep and 500 m wide and lies at a distance of 15-20m from the riverbank during May. The bank is in its natural state made up completely with flurical deposits and devoid of any man made protective measures.

This pontoon bridge maintained by PWD is located close to Ramnagar Fort. Every time a barge is required to move the portion of the floating pontoons are required to be moved along with the top platforms for allowing Safeway.

Earlier with temporary provisions and ramp some loading has been carried out on the left bank of the river for IWAI. However, there is a bathing ghat close by. Slope is gentle. Approachability by road is existing. However Road meanders through busy market place.

Approach to the right bank just opposite the fort is somewhat difficult. One approach is over the Pontoon otherwise we have to lay a ~4-5 Km road from the nearby road connecting Varanasi to Mughalsarai. There is a stiff slope bank. Draft of ~2m is available at a distance of 10m from the shoreline. There is no adequate land available for construction of onshore facilities and the maintaining any ground open or closed storages.

4.3.4 Gaura

Gaura is located on northern (left side) bank of river Ganges downstream of Varanasi. The site presently belongs to Government. This is located on the concave part of the Ganges at the chainage of 1272km. This site is shown in Plate 4 and 5.

Gaura site is connected to National Highway No. NH-29 by un-metalled cart track. The approximate distance is 10 Km From Varanasi. North Eastern Railway line is located at a distance of 2.5 Km from the site.

The riverbank at Gaura site is quite stable. The navigation channel is 3.0-4.0. M deep, 200 m wide and lies close to riverbank. The bank is in its natural state made up completely with flurical deposits and devoid of any man made protective measures. The cross section of the river at Gaura (1272.5 km) is shown in Fig. 4.7.

While ferrying by launch from Balua left bank to Kaithi the team had a close look on the banks between Gaura to Chandrawati. Some places have gentle slope but at some it has stiff slope. Water depth available on the left bank is sufficient almost through the season for safe navigation. There is a shift in shoreline to about 50m on the left bank and about 10Km on the right bank during high flood level from the present position. NH-29 runs close to Chandrawati.

Because of braiding of the channel near Gaura the shoals have changed place to place over a period of 5 years (1995 to 1999).

4.3.5 Kaithi site 1

Kaithi site1 is located on the left side bank of Ganges at a distance of 35 Km downstream of Malviya road cum Railway Bridge. A part of the kaithy site presently belongs to private owners. This is located on the convex part of the Ganges at the chainage of 1264km. This site is shown in Plate 6 and 7.

The site is connected by all season-metalled road to National Highway NH-29.

Rajwani railway station of North-Eastern Railway line is located at distance of 8 Km from Kaithy site.

The riverbank at Kaithy site is stable. The navigation channel is 2.0 m deep and 400 m wide and lies close to the riverbank. The bank is in its natural state made up completely with flurical deposits and devoid of any man made protective measures. The cross section of the river at Kaithi (1263 km) is shown in Fig. 4.8.

Adequate water depth is available close to shore through the lean season for safe navigation and berthing. Slope of the bank is gentle with firm and stable ground on the left bank. Adequate back up spaces for on-ground facilities are available. There is a famous Markandya temple close by. Approach road to exiting Kaithi .

Ghat from the NH-29 through the village is there. It is metalled but narrow and runs through semi densely populated region. It will be advisable to avoid this road if the traffic of inflow and outflow cargoes by road is high. Approx. road distance from NH-29 is ~3 Km.

4.3.6 ABC Jetty (Kaithy site 2)

At Kaithi the team also inspected another site where earlier ABC had unloaded ODC consignments in HFL for Jagdishpur Plant. This site is shown in Plate 8. A high level RCC Jetty on piles is existing but not in operation and maintenance for several years. If two/three level jetty is required to be planned at the location then this could be utilised. The depth in elevation between the top of Jetty and the water level at the moment appears to be ~22m and the horizontal distance between the edge of the shore line and the edge of the existing jetty is approx. 50m. Water depth of 2m is available at an approx. distance of 15m from the existing shoreline. The site is very close to NH-29.

4.4 Decision matrix

After assessing the individual details and pros and cons of the candidate sites, the Ram Nagar Pontoon Bridge (Right Bank) was not considered further for the following reasons:

- Inadequate approach
- Non availability of firm and stable bank
- Poor road lengths
- High Capital investment required for the development of infrastructure
- Inadequate water depth close to the shore.

Balance six sites were evaluated based on the criteria/ sub-criteria considered essential from riverine conditions, navigational aspects, developmental cost,

availability of infrastructure, availability of back up land, operational and maintenance aspects.

Each of these criterions was further developed with a weightage matrix. The results of each site against the matrix are given in Table 4.2 to 4.3.

4.5 Recommended site

After the detailed study of hydrological, morphological and meteorological study, site at New Ram Nagar by pass bridge right bank is more suitable for development of intermodal terminal.

It has been observed from the calculation that the site at Ramnagar Bridge near Malahiya on the Right Bank of river Ganges has the maximum score of 89.5 points. This is followed by the site at Kaithy, Gaura, ABC Jetty (Kaithy site 2), New Ramnagar Fort Pontoon Bridge (left bank) and New Ramnagar bypass Bridge (left bank) with score of 82, 65.25, 62, 58.5, and 49.75 respectively.

The above analysis consolidates the location of the intermodal terminal on the Right Bank of river Ganges near New Ramnagar Bypass Bridge.

The recommended site near New Ram Nagar by pass bridge dipicting the infrastructure facilities, road, railway connections have been shown in Drg. no. MEC/11/17/Q079/SK-2

The consultant made further in depth study followed by site visit to ascertain the availability of land and water front from the statutory authorities.

Further development and details of approach road, terminal planning, on shore works, open storage and warehousing details have been dealt in Chapter – 6.

Table 4.1

CRITERIA FOR SHORT LISTING OF INTERMODAL TERMINAL AT VARANASI

SL. NO.	CRITERIA/SUB CRITERIA	MAXIMUM CRITERIA SCORES	MAXIMUM SUB CRITERIA SCORES
1.	**Riverine condition/Navigational Aspects**	50	
1.1	Adequate width of water way		5.0
1.2	Currents		2.5
1.3	Stability of riverbank		10.0
1.4	Available draft (natural)		12.5
1.5	Availability of adequate water front		10.0
1.6	Discharge		5.0
1.7	Variability of channel near terminal		5.0
2.	**Development Cost & Availability of Infrastructure**	30	
2.1	Foundation cost		2.5
2.2	Capital Dredging & Bund		7.5
2.3	Approach distance to –2.0m LAD from shore line (lean season)		5.0
2.4	Nearness to city/town		2.5
2.5	Road connection to site		7.5
2.6	Nearness to rail head		2.5
2.7	Availability of essential services		2.5
3.	**Availability /acquisition of adjoining backup land for locating terminal**	5	
4.	**Ecology & environmental impact**	5	
5.	**Cost of operating & maintenance of all facilities**	10	
	Total	100	100

A detailed description of the criteria/sub-criteria with ratings and percentage score (Poor:20%, Fair:40%, Good:60%, Very Good:80%, Excellent:100%) is presented Table 4.2

Table 4.2

CRITERIA –RATINGS & SCORE

SL. NO.	CRITERIA/SUB CRITERIA	RATINGS	PERCENTAGE
1.	**Riverine condition/Navigational Aspects**		
1.1	**Adequate width of water way**		
	▪ Naturally available for ferry in 2 barges	Excellent	100
	▪ Naturally available for ferry in 1 barge	Very good	80
	▪ Width for < 1 barge	Good	60
1.2	**Current in lean season**		
	▪ < 1 knot	Excellent	100
	▪ 1-2 knots	Very good	80
	▪ 2-3 knots	Good	60
	▪ 3-4 knots	Fair	40
	▪ > 4 knots	Poor	20
1.3	**Stability of River Bank**		
	▪ Stable riverbank	Excellent	100
	▪ Erosion arrested or party occurs, bank protection works exists	Very good	80
	▪ Large erosion occurs, bank protection work required	Good	60
	▪ Low siltation, marginal quantity of dredging required	Fair	40
	▪ Large siltation, large quantity of dredging required	Poor	20
1.4	**Available draft (Natural situation) close to shore**		
	▪ > 3m	Excellent	100
	▪ 2-3m	Very good	80
	▪ 1.5-2m	Good	60
	▪ 0.5 – 1.5m	Poor	20

SL. NO.	CRITERIA/SUB CRITERIA	RATINGS	PERCENTAGE
1.5	**Discharge at selected site**		
	• More than 10000 m^3/sec at all seasons	Excellent	100
	• Between 1000-10000 m^3/sec at all seasons	Very good	80
	• Between 200-1000 m^3/sec at all seasons	Good	60
	• Less than 200 m^3/sec at all seasons	Poor	20
1.6	**Adequate water front**		
	• Available for 2 terminals	Excellent	100
	• Available for 1 terminal	Good	60
	• Available for < 1 terminal	Poor	20
1.7	**Variability of channel near the terminal**		
	• <15 m in flood season	Excellent	100
	• 15-20 m in flood season	Very good	80
	• 20-25 m in flood season	Good	60
	• 25-30 m in flood season	Fair	40
	• >30 m in flood season	Poor	20
2.	**Development Cost & Availability of Infrastructure**		
2.1	**Foundation cost**		
	• Low	Excellent	100
	• Medium	Very good	60
	• High	Poor	20
2.2	**Capital Dredging & Bund**		
	• Not required	Excellent	100
	• Low quantity	Very good	80
	• Medium quantity	Good	60
	• High quantity	Poor	20

SL. NO.	CRITERIA/SUB CRITERIA	RATINGS	PERCENTAGE
2.3	**Approach distance to –2.0m LAD from shore line (lean season)**		
	▪ < 5m	Excellent	100
	▪ 5-10m	Very good	80
	▪ 10-15m	Good	60
	▪ 15-20m	Fair	40
	▪ > 20m	Poor	20
2.4	**Nearness to city/town**		
	▪ <7.5 Km	Excellent	100
	▪ 7.5-15 Km	Very good	80
	▪ 15-20 Km	Good	60
	▪ 20-25 Km	Fair	40
	▪ >25 Km	Poor	20
2.5	**Road connection to site**		
	▪ Metalled road connection	Excellent	100
	▪ Conversion of unmetalled road < 2 Km to metal road/ new road <1 Km	Very good	80
	▪ Conversion of unmetalled road 2-4 Km to metal road/ new road <1 Km	Good	60
	▪ Conversion of unmetalled road 4-6 Km to metal road/ new road 1-2 Km	Fair	40
	▪ Conversion of unmetalled road >6 Km to metal road/ new road >2 Km	Poor	20
2.6	Nearness to rail head		
	▪ Available within 10 Km	Excellent	100
	▪ Available within 10-15 Km	Very good	80
	▪ Available within 15-20 Km	Good	60
	▪ Available within 20-25 Km	Fair	40
	▪ Available at >25 Km	Poor	20

SL. NO.	CRITERIA/SUB CRITERIA	RATINGS	PERCENTAGE
2.7	Availability of essential services a)Electricity b)Medical/Police (c) Watercraft repair facility (d) Potable water (e) Communication (f) Sewage disposal system		
	▪ Nearness to (a), (b), (c), (d), (e) & (f)	Excellent	100
	▪ Nearness to (a), (b), (c), (d)	Very good	80
	▪ Nearness to (a), (b), (c)	Good	60
	▪ Nearness to (a), (b)	Fair	40
	▪ Facilities are to be built	Poor	20
3.	**Availability /acquisition of adjoining backup land for locating terminal**		
3.1	▪ Land available/ No rehabilitation	Excellent	100
3.2	▪ Land with little ground improvement/ rehabilitation least	Very good	80
3.3	▪ Land available but requires medium ground improvement/ rehabilitation comparatively more	Good	60
3.4	▪ Land available but requires substantial ground improvement/ rehabilitation comparatively more	Fair	40
3.5	▪ Land available but costly or after substantial rehabilitation	Poor	20
4.	**Ecological & environmental impact**		
4.1	▪ Least impact	Excellent	100
4.2	▪ Marginal impact	Very good	80
4.3	▪ Medium impact	Good	60

SL. NO.	CRITERIA/SUB CRITERIA	RATINGS	PERCENTAGE
4.4	▪ Large impact	Fair	40
4.5	▪ Very large impact	Poor	20
5.	**Cost of operating and maintenance of all facilities**		
5.1	▪ Too low	Excellent	100
5.2	▪ Low	Very good	80
5.3	▪ Medium	Good	60
5.4	▪ High	Fair	40
5.5	▪ Too high	Poor	20

Table 4.3

EVALUATION OF SITE
NEW RAMNAGAR BY PASS BRIDGE (LEFT BANK)

SL. NO.	CRITERIA/SUB CRITERIA	RATINGS	SCORE
1.	**Riverine condition/Navigational Aspects**		
1.1	Adequate width of water way		
	Width available for 2 barges	Excellent	5
1.2	Currents		
	< 1 knot	Excellent	2.5
1.3	Stability of riverbank		
	Large siltation, marginal quantity of dredging required	Poor	2
1.4	Available draft (natural)		
	0.5 – 1.5 m	Poor	2.5
1.5	Availability of adequate water front		
	Available for 2 terminals	Excellent	5
1.6	Discharge		
	Between 200 – 1000m^3/sec	Good	3
1.7	Variability of channel near terminal		
	> 30m	Poor	1
2.	**Development Cost & Availability of Infrastructure**		
2.1	Foundation cost		
	High	Good	1.25
2.2	Capital Dredging & Bund		
	High quantity	Poor	2
2.3	Approach distance to –2.0m LAD from shore line (lean season)		
	10-15m	Good	3
2.4	Nearness to city/town,		
	<7.5 Km	Excellent	2.5
2.5	Road connection to site		
	Conversion of 1 Km from unn-metalled to metal and new road is < 1 Km	Very good	4
2.6	Nearness to rail head		
	< 10 Km	Excellent	2.5
2.7	Availability of essential services		
	All services available	Excellent	2.5
3.	**Availability /acquisition of adjoining backup land for locating terminal**		
	Land is available but requires medium ground improvement/ rehabilitation comparatively more	Fair	1
4.	**Ecological & environmental impact**		
	Marginal impact	Very good	4
5.	**Cost of operating & maintenance of all facilities**		
	Medium	Good	6
	Total		**49.75**

Table 4.3(Cont.)

EVALUATION OF SITE
NEW RAMNAGAR BY PASS BRIDGE (RIGHT BANK)

SL. NO.	CRITERIA/SUB CRITERIA	RATINGS	SCORE
1.	**Riverine condition/Navigational Aspects**		
1.1	Adequate width of water way		
	Width available for 2 barges	Excellent	5
1.2	Currents		
	< 1 knot	Excellent	2.5
1.3	Stability of riverbank		
	High and firm bank	Excellent	10
1.4	Available draft (natural) close to shore		
	>3 m	Excellent	12.5
1.5	Availability of adequate water front		
	Available for 2 terminals	Excellent	10
1.6	Discharge		
	Between 200 – 1000m^3/sec	Good	3
1.7	Variability of channel near terminal		
	< 15m in flood season	Excellent	5
2.	**Development Cost & Availability of Infrastructure**		
2.1	Foundation cost		
	Medium	very good	1.5
2.2	Capital Dredging & Bund		
	Not required	Excellent	7.5
2.3	Approach distance to –2.0m LAD from shore line (lean season)		
	<5m	Excellent	5
2.4	Nearness to city/town, infrastructure		
	<7.5 Km	Excellent	2.5
2.5	Road connection to site		
	Conversion of 1 Km from un-metalled to metal and new road is < 1 Km	Very good	6
2.6	Nearness to rail head		
	< 10 Km	Excellent	2.5
2.7	Availability of essential services		
	All services available	Excellent	2.5
3.	**Availability /acquisition of adjoining backup land for locating terminal**		
	Land with little ground improvement	Very good	4
4.	**Ecological & environmental impact**		
	Marginal impact	Very good	4
5.	**Cost of operating & maintenance of all facilities**		
	Medium	Good	6
	Total		**89.5**

Table 4.3(Cont.)

EVALUATION OF SITE
RAMNAGAR FORT PONTOON BRIDGE (LEFT BANK)

S.NO.	CRITERIA/SUB CRITERIA	RATINGS	SCORE
1.	**Riverine condition/Navigational Aspects**		
1.1	Adequate width of water way		
	Width available for 2 barges	Excellent	5
1.2	Currents		
	< 1 knot	Excellent	2.5
1.3	Stability of riverbank		
	Large erosion occurs, bank protection work reqd.	Good	6
1.4	Available draft (natural) close to shore		
	0.5 – 1.5 m	Poor	2.5
1.5	Availability of adequate water front		
	Available for 2 terminal	Good	6
1.6	Discharge		
	Between 200 – 1000m^3/sec	Good	3
1.7	Variability of channel near terminal		
	25- 30m in flood season	Fair	2
2.	**Development Cost & Availability of Infrastructure**		
2.1	Foundation cost		
	High	Poor	0.5
2.2	Capital Dredging & Bund		
	Medium quantity	Good	4.5
2.3	Approach distance to –2.0m LAD from shore line (lean season)		
	15-20m	Fair	2
2.4	Nearness to city/town, infrastructure		
	<7.5 Km	Excellent	2.5
2.5	Road connection to site		
	Conversion of 1 Km from un-metalled to metal and new road is < 1 Km	Very good	6
2.6	Nearness to rail head		
	< 10 Km	Excellent	2.5
2.7	Availability of essential services		
	All services available	Excellent	2.5
3.	**Availability /acquisition of adjoining backup land for locating terminal**		
	Land is available but requires medium ground improvement/ rehabilitation comparatively more	Good	3
4.	**Ecological & environmental impact**		
	Marginal impact	Very good	4
5.	**Cost of operating & maintenance of all facilities**		
	High	Fair	4
	Total		58.5

Table 4.3(Cont.)

EVALUATION OF SITE
GAURA (LEFT BANK)

SL. NO.	CRITERIA/SUB CRITERIA	RATINGS	SCORE
1.	**Riverine condition/Navigational Aspects**		
1.1	Adequate width of water way		
	Width available for 2 barges	Excellent	5
1.2	Currents		
	1-2 knot	Very good	2.0
1.3	Stability of riverbank		
	Large erosion occurs, bank protection reqd.	Good	6
1.4	Available draft (natural) close to shore		
	>3 m	Excellent	12.5
1.5	Availability of adequate water front		
	Available for 2 terminals	Excellent	5
1.6	Discharge		
	Between 200 – 1000m^3/sec	Good	3
1.7	Variability of channel near terminal		
	> 30m	Poor	1
2.	**Development Cost & Availability of Infrastructure**		
2.1	Foundation cost		
	High	Good	1.25
2.2	Capital Dredging & Bund		
	Low quantity	Very good	6
2.3	Approach distance to –2.0m LAD from shore line (lean season)		
	<5m	Excellent	5
2.4	Nearness to city/town, infrastructure		
	15-20 Km	Good	1.5
2.5	Road connection to site		
	Conversion of >6 Km from un-metalled to metal and new road is >2 Km	Poor	1.5
2.6	Nearness to rail head		
	<10 Km	Excellent	2.5
2.7	Availability of essential services		
	Nearness to a) and b)	Fair	1.0
3.	**Availability /acquisition of adjoining backup land for locating terminal**		
	Land with little ground improvement/ rehabilitation least.	V. Good	4
4.	**Ecological & environmental impact**		
	Marginal impact	Very good	4
5.	**Cost of operating & maintenance of all facilities**		
	High	Fair	4
	Total		65.25

Table 4.3(Cont.)

EVALUATION OF SITE
KAITHY (LEFT BANK)

SL. NO.	CRITERIA/SUB CRITERIA	RATINGS	SCORE
1.	**Riverine condition/Navigational Aspects**		
1.1	Adequate width of water way		
	Width available for 2 barges	Excellent	5
1.2	Currents		
	< 1 knot	Excellent	2.5
1.3	Stability of riverbank		
	Firm and stable	Excellent	10
1.4	Available draft (natural)		
	>3 m	Excellent	12.5
1.5	Availability of adequate water front		
	Available for 2 terminals	Excellent	10
1.6	Discharge		
	Between 200 – 1000m^3/sec	Good	3
1.7	Variability of channel near terminal		
	<15m	Excellent	5
2.	**Development Cost & Availability of Infrastructure**		
2.1	Foundation cost		
	Medium	Very good	1.5
2.2	Capital Dredging & Bund		
	Low quantity	V. Good	6
2.3	Approach distance to –2.0m LAD from shore line (lean season)		
	<5m	Excellent	5
2.4	Nearness to city/town, infrastructure		
	20-25 Km	Fair	1
2.5	Road connection to site		
	Conversion of 4-6 Km from un-metalled to metal and new road is 1-2 Km	Fair	3
2.6	Nearness to rail head		
	<10Km	Excellent	2.5
2.7	Availability of essential services		
	Nearness to a, b,c	Fair	1
3.	**Availability /acquisition of adjoining backup land for locating terminal**		
	Land with little ground improvement/ rehabilitation least.	Fair	4
4.	**Ecological & environmental impact**		
	Marginal impact	Very good	4
5.	**Cost of operating & maintenance of all facilities**		
	Medium	Good	6
	Total		**82**

Table 4.3(Cont.)

EVALUATION OF SITE
ABC JETTY (LEFT BANK)

SL. NO.	CRITERIA/SUB CRITERIA	RATINGS	SCORE
1.	**Riverine condition/Navigational Aspects**		
1.1	Adequate width of water way		
	Width available for 2 barges	Excellent	5
1.2	Currents		
	< 1 knot	Excellent	2.5
1.3	Stability of riverbank		
	Large erosion occurs and bank protection reqd.	Excellent	6
1.4	Available draft (natural)		
	0.5-1.5 m	Good	2.5
1.5	Availability of adequate water front		
	Available for 2 terminals	Excellent	10
1.6	Discharge		
	Between 200 – 1000m^3/sec	Good	3
1.7	Variability of channel near terminal		
	20-25m	V. Good	4
2.	**Development Cost & Availability of Infrastructure**		
2.1	Foundation cost		
	High	Good	0.5
2.2	Capital Dredging & Bund		
	Medium quantity	V. Good	4.5
2.3	Approach distance to –2.0m LAD from shore line (lean season)		
	15-20m	Fair	2
2.4	Nearness to city/town, infrastructure		
	>25 Km	Poor	0.5
2.5	Road connection to site		
	Conversion of <2 Km from un-metalled to metal and new road is <1 Km	Very good	6
2.6	Nearness to rail head		
	<10 Km	Excellent	2.5
2.7	Availability of essential services		
	Nearness to a and b	Fair	1.0
3.	**Availability /acquisition of adjoining backup land for locating terminal**		
	Land available /no rehabilitation.	Fair	5
4.	**Ecological & environmental impact**		
	Marginal impact	Very good	4
5.	**Cost of operating & maintenance of all facilities**		
	High	Fair	4
	Total		**62.00**

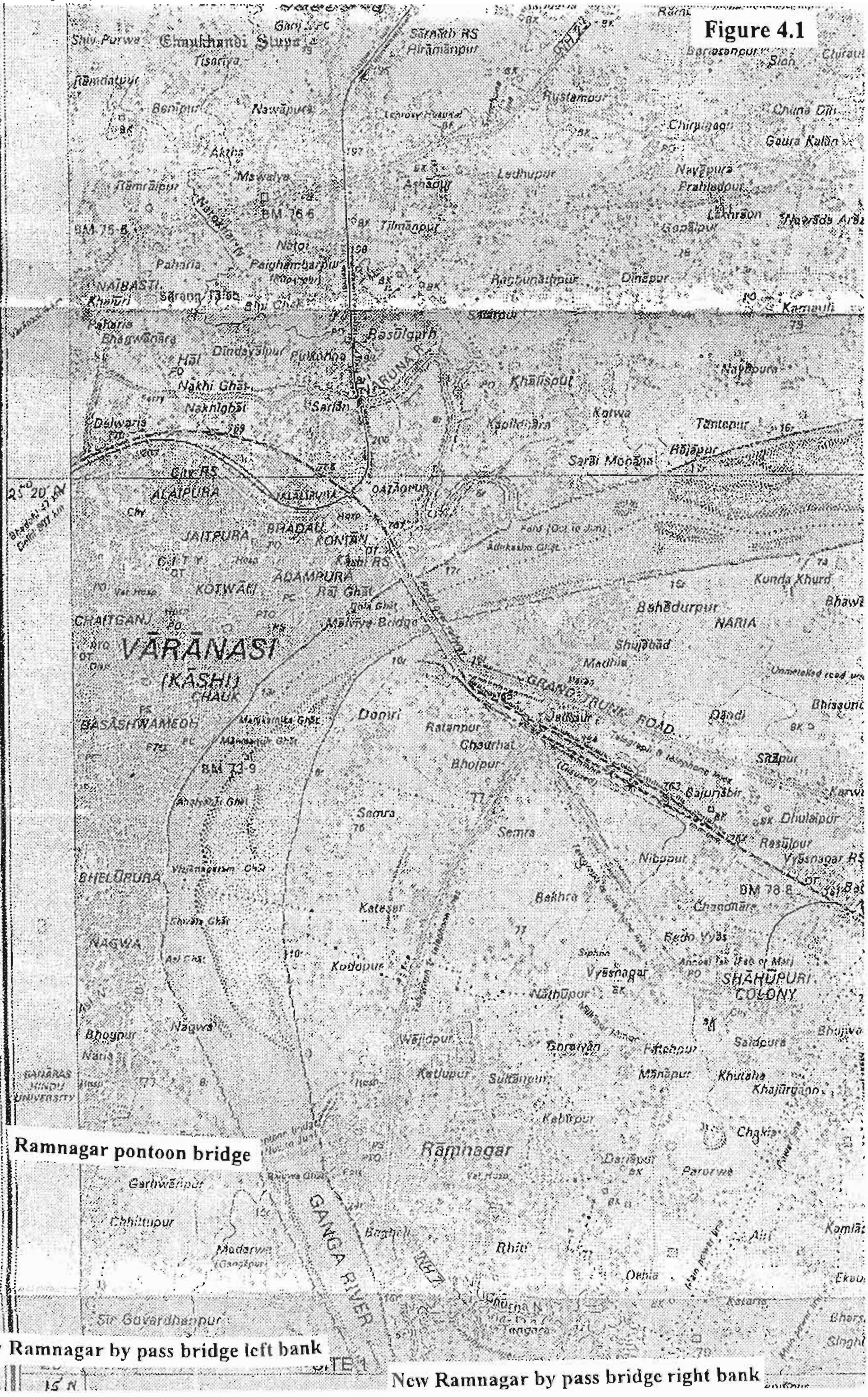


Figure 4.1
VĀRĀNASI
(KĀSHI)
CHAUK
GRAND TRUNK ROAD
GANGA RIVER
VARUNA R.
Rāmnagar
SHĀHŪPURI COLONY
BANARAS HINDU UNIVERSITY
Malviya Bridge
Ramnagar pontoon bridge
New Ramnagar by pass bridge left bank
New Ramnagar by pass bridge right bank

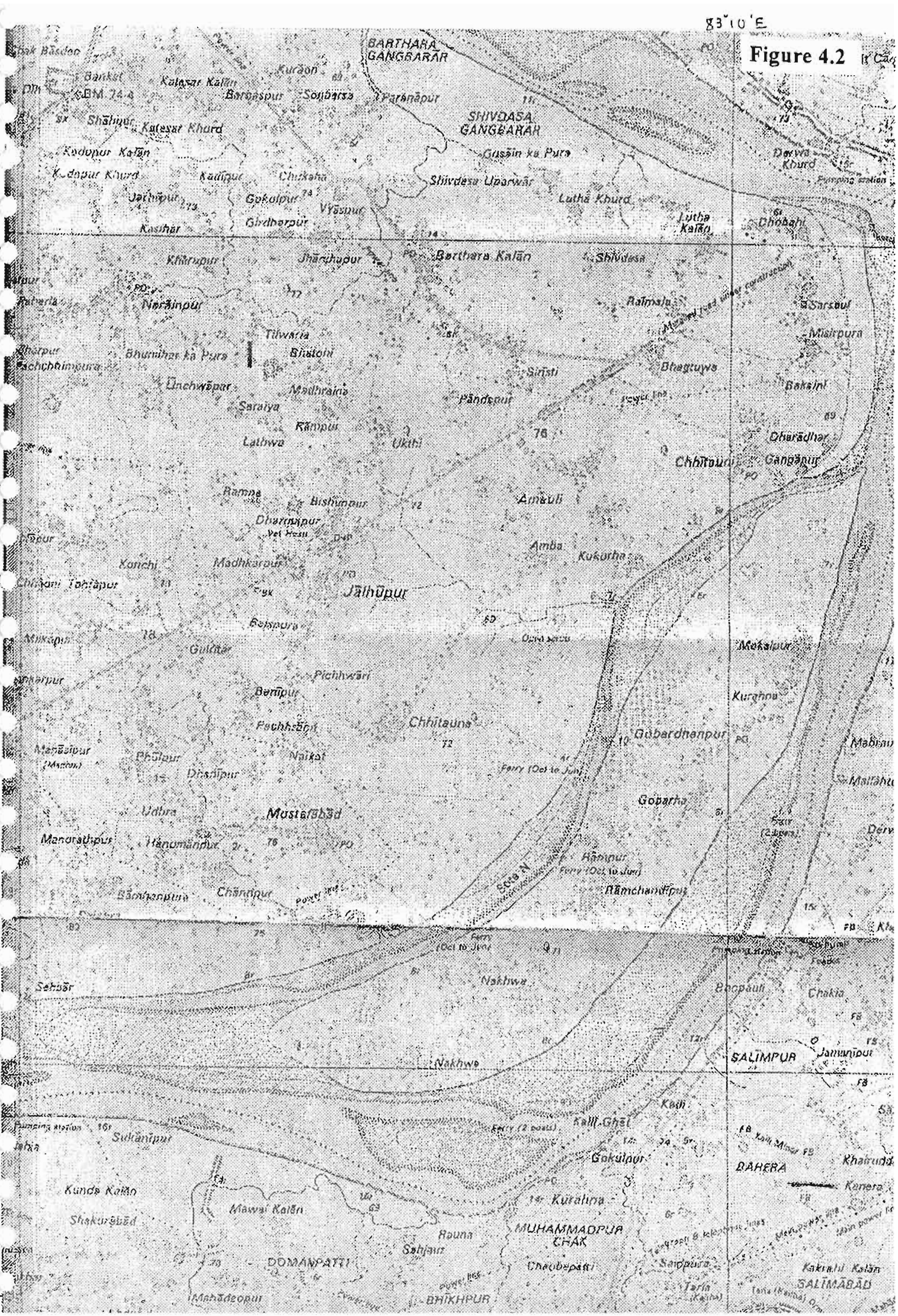
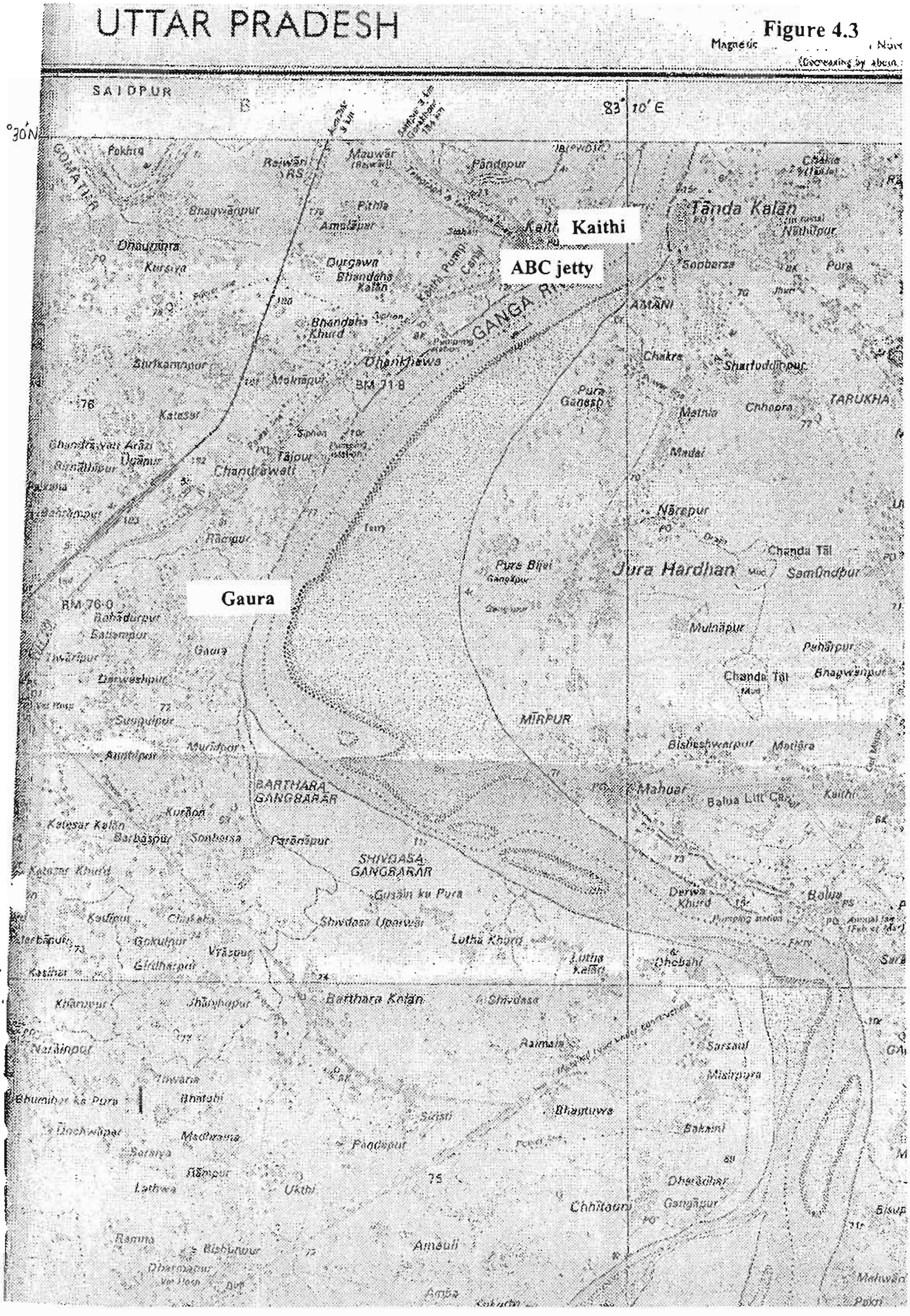

83°10'E
BARTHARA GANGBARAR
Kurāon
Katesar Kalān
Barnaspur
Sonbarsa
Parānpur
SHIVDASA GANGBARAR
Shāhpur
Katesar Khurd
Kadupur Kalān
Kadupur Khurd
Kadipur
Chuksha
Gussāin ka Pura
Shivdasa Uparwār
Jarhipur
Gokulpur
Vyāspur
Latha Khurd
Lutha Kalān
Girdharpur
Kasihar
Khairupur
Jhānjhapur
Barthara Kalān
Shivdasa
Narāinpur
Tilwaria
Ralmalu
Sarsaul
Misirpura
Bhumihar ka Pura
Bhatolni
Siristi
Bhagtuwa
Pachchhimpura
Unchwāpar
Madhraina
Pāndepur
Baksini
Saraiya
Rāmpur
Lathwa
Ukthi
Dharādhar
Gangāpur
Chhitauni
Ramna
Bishunpur
Ambuli
Dharmpur
Konchi
Madhkarpur
Amba
Kukurha
Tohtāpur
Jālhūpur
Mekalpur
Gulitar
Pichhwāri
Bānipur
Kurahna
Pachhāpur
Chhitauna
Gobardhanpur
Mahrau
Naikot
Mallāhu
Phūlpur
Dhāripur
Ferry (Oct to Jun)
Udhra
Mustafābād
Gobarha
Manorathpur
Hanumānpur
Rāmpur
Ferry (Oct to Jun)
Rāmchandipur
Bāndhanpura
Chāndpur
Power line
Ferry (Oct to Jun)
Nakhwa
Chakia
SALĪMPUR
Jamunipur
Nakhwa
Kathi
Pumping station
Sukhānipur
Ferry (2 boats)
Kalli Ghāt
Gokulpur
DAHERA
Khairuddi
Kunda Kalān
Kurahna
Mawai Kalān
Shakurābād
Rauna
MUHAMMADPUR CHAK
Sahjaur
DOMANPATTI
Chaubepatti
Saidpura
Kakrahi Kalān
SALĪMĀBĀD
Mahādeopur
BHIKHPUR
Tarla
Figure 4.2

Figure 4.3


UTTAR PRADESH
SAIDPUR
83° 10' E
Kaithi
ABC jetty
Gaura
GANGA
Tānda Kalān
Jura Hardhan
MIRPUR
Chanda Tāl
BARTHARA GANGBARAR
SHIVDASA GANGBARAR
Barthara Kalān
Chandrāwati
Dhānkhewa
BM 71·8
BM 76·0
Mahuar
Balua
Dhobahi
Chhitauni
Ambali

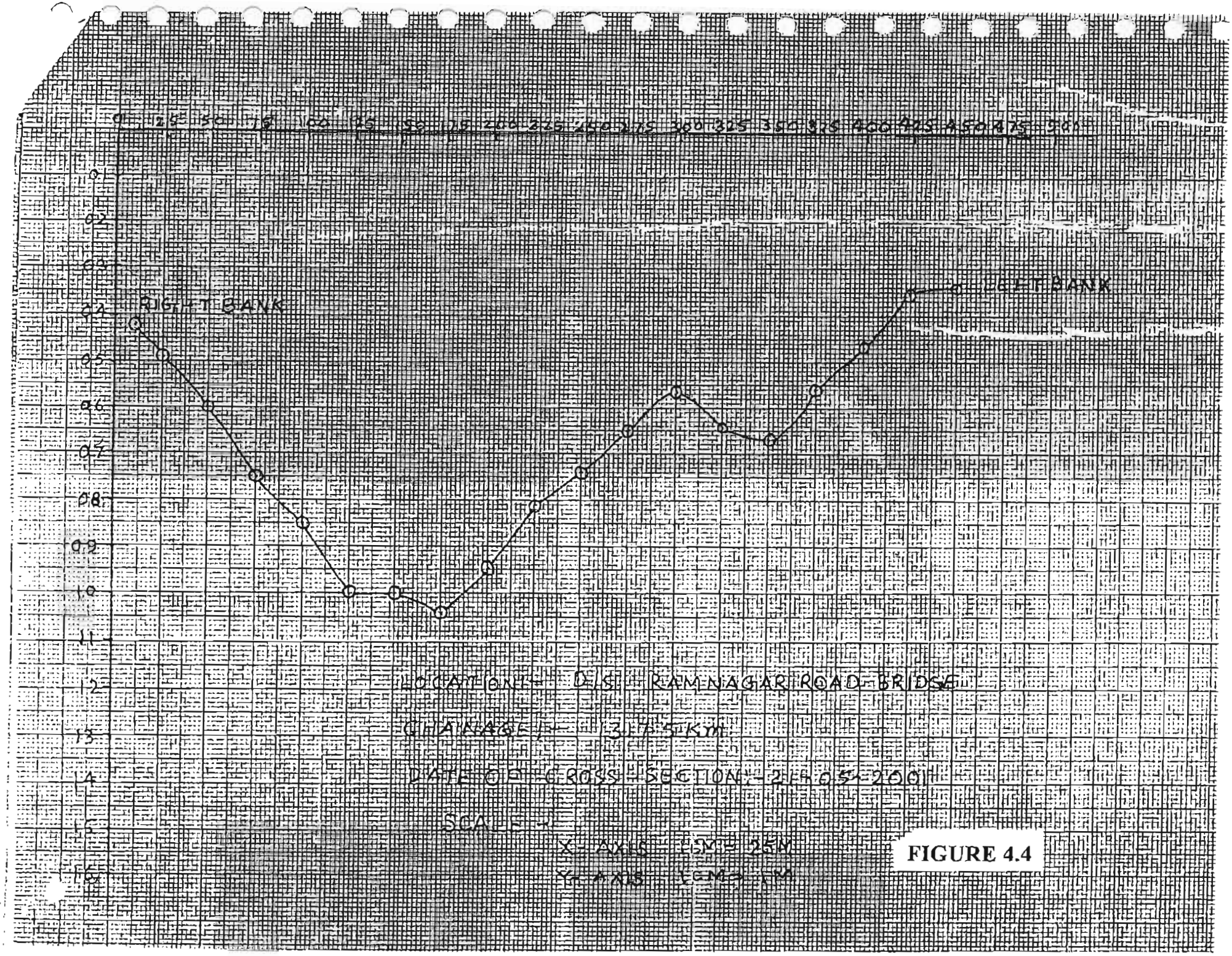

RIGHT BANK
LEFT BANK
LOCATION :- D/S - RAMNAGAR ROAD BRIDGE
CHAINAGE :- 3.5 KM
DATE OF CROSS SECTION :- 2.6.2001
SCALE :-
X - AXIS 1 CM = 25M
Y - AXIS 1 CM = 1M

FIGURE 4.4

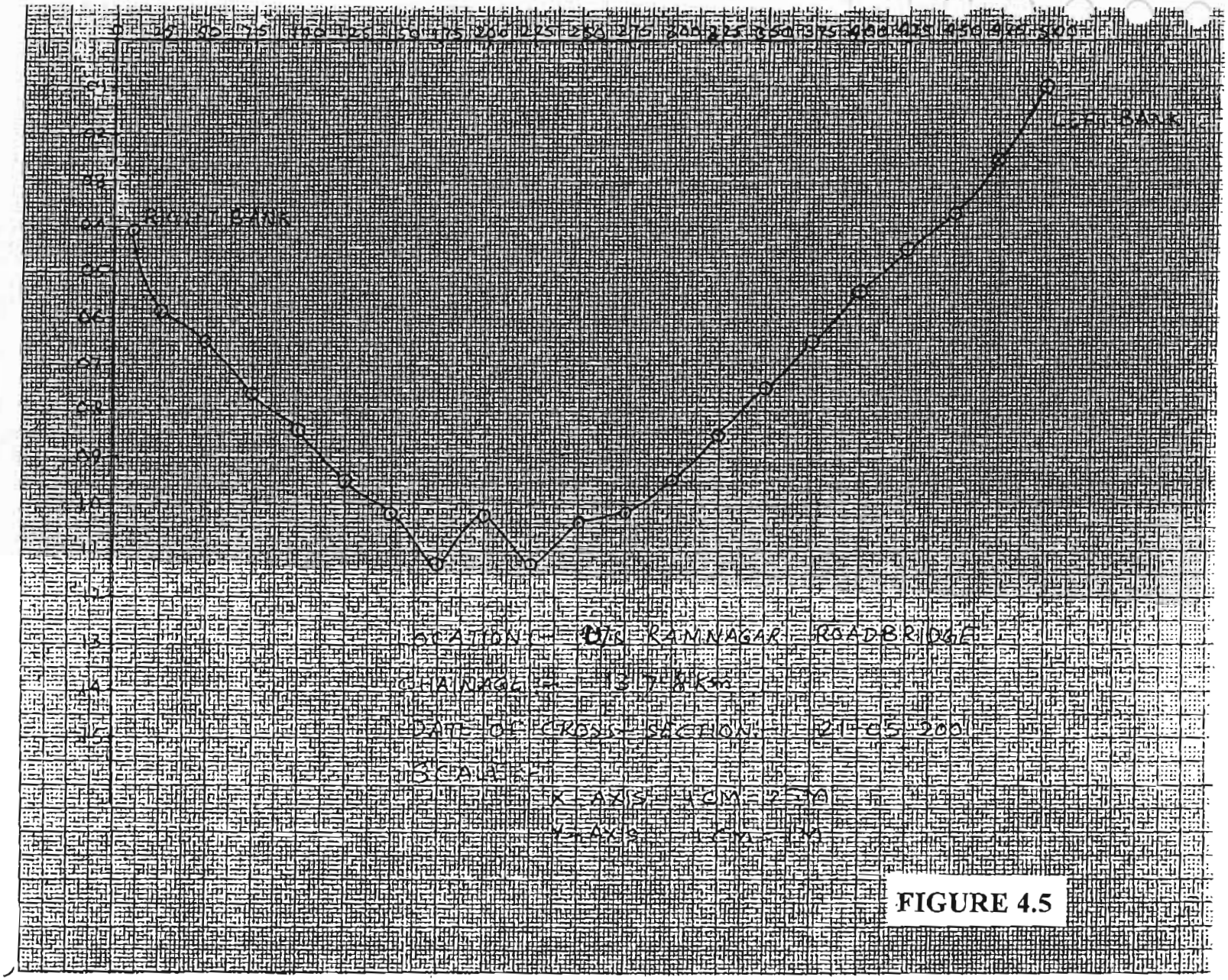

LEFT BANK
RIGHT BANK
LOCATION :- KANNAGAR - ROADBRIDGE
CHAINAGE :- 137.8 Km
DATE OF CROSS - SECTION :- 21-05-200
SCALE :-
X - AXIS 1 CM = 2 M
Y - AXIS 1 CM = 1 M

FIGURE 4.5

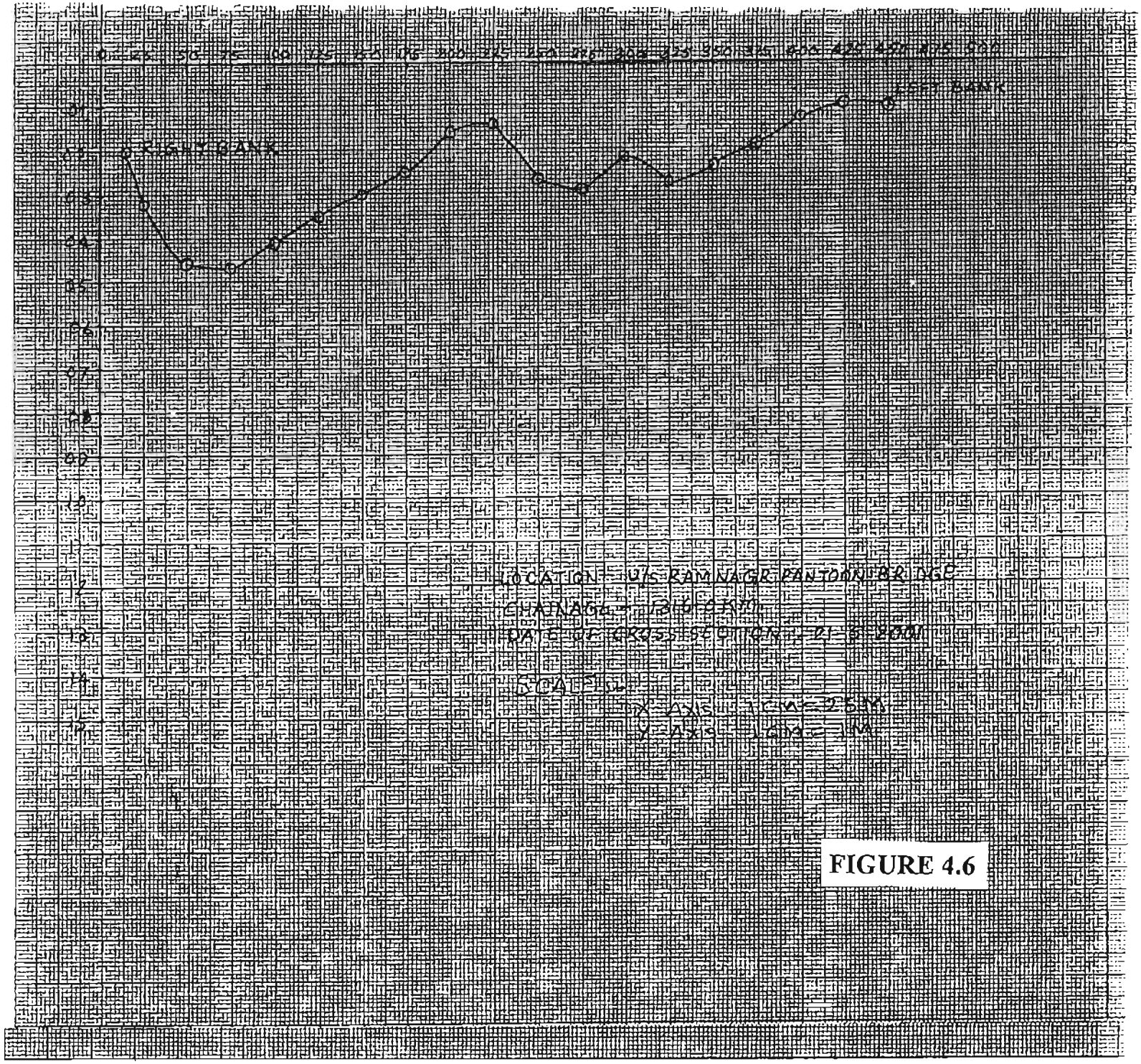

LOCATION - U/S RAMNAGR PANTONNI BRIDGE
CHAINAGE - 1210.0 KM
DATE OF CROSS SECTION - 21-8-2004
SCALE
X AXIS 1 CM = 25 M
Y AXIS 1 CM = 1 M

FIGURE 4.6

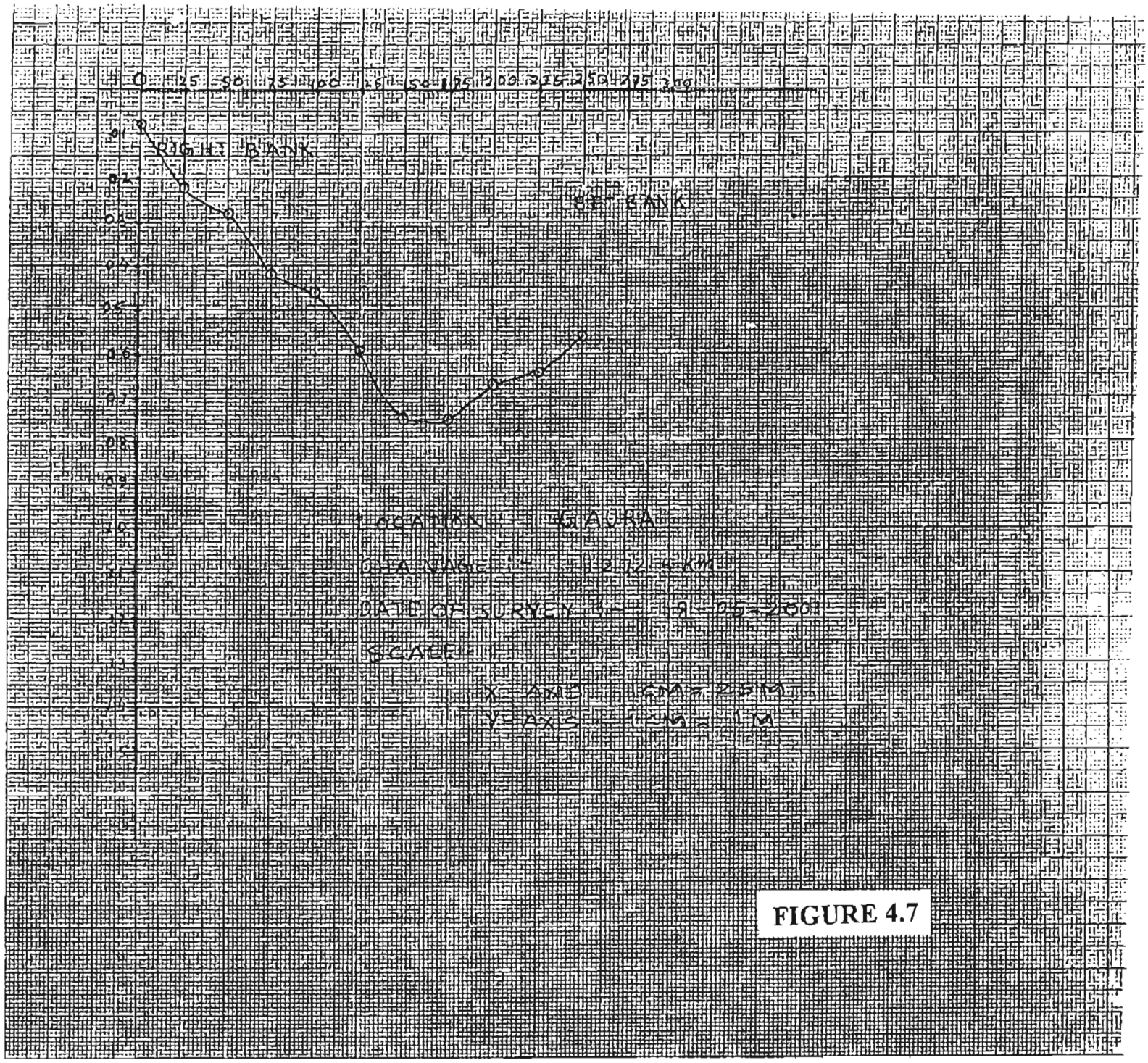

0 25 50 75 100 125 150 175 200 225 250 275 300
RIGHT BANK
LEFT BANK
LOCATION :- GAURA
DATE OF SURVEY :- 9-05-2001
SCALE :-
X- AXIS 1CM = 25M
Y- AXIS 1CM = 1M

FIGURE 4.7

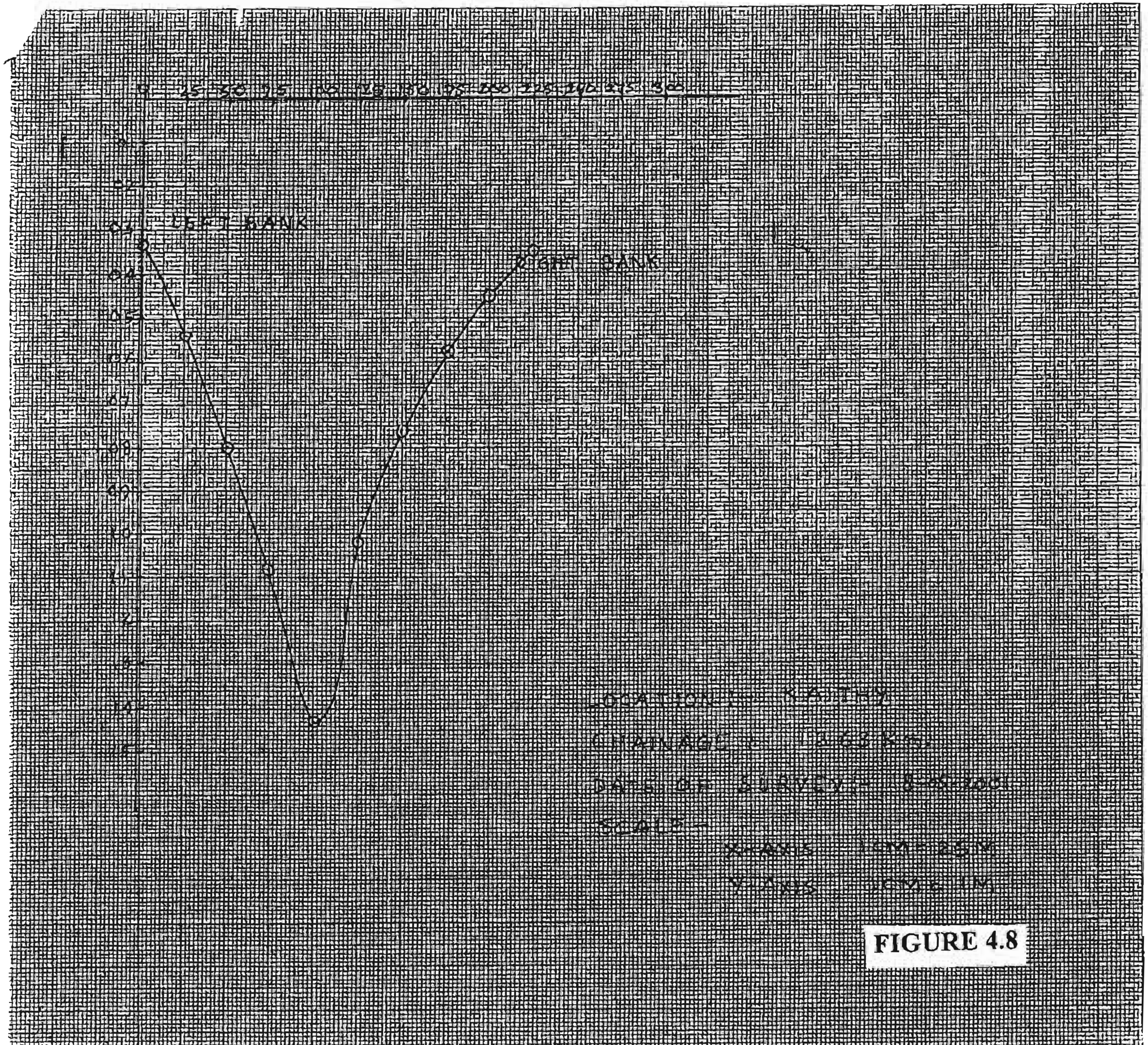

LEFT BANK
RIGHT BANK
LOCATION :-
CHAINAGE :-
DATE OF SURVEY :-
SCALE –
X-AXIS
Y-AXIS

FIGURE 4.8

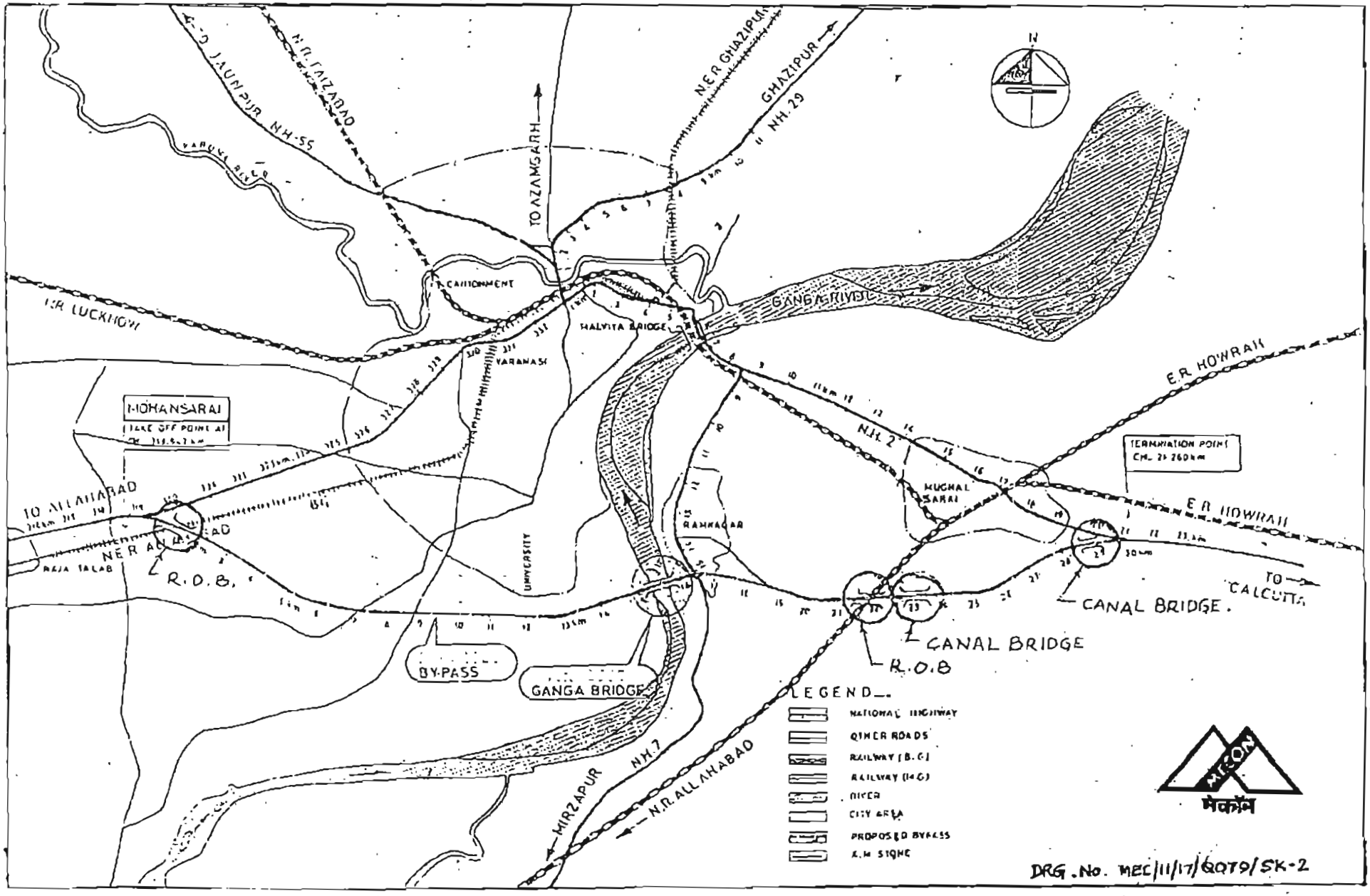

TO AZAMGARH
N.H. FAIZABAD
A-D JAUNPUR NH-55
VARUNA RIVER
N.E.R GHAZIPUR
GHAZIPUR
NH. 29
CANTONMENT
GANGA RIVER
MALVIYA BRIDGE
VARANASI
N.R. LUCKNOW
E.R. HOWRAH
MOHANSARAI
TAKE OFF POINT AT
TO ALLAHABAD
N.H. 2
MUGHAL SARAI
RAMNAGAR
TERMINATION POINT
CH. 21·260 km
E.R. HOWRAH
TO CALCUTTA
UNIVERSITY
RAJA TALAB
R.O.B.
BY-PASS
GANGA BRIDGE
CANAL BRIDGE.
CANAL BRIDGE
R.O.B
MIRZAPUR
NH.7
N.R. ALLAHABAD
LEGEND
NATIONAL HIGHWAY
OTHER ROADS
RAILWAY (B.G.)
RAILWAY (M.G.)
RIVER
CITY AREA
PROPOSED BYPASS
K.M. STONE
MECON
मेकॉन
DRG. No. MEC/11/17/GOT9/SK-2

Plate 4.1 New Ram Nagar By pass bridge (Right bank)

Plate 4.1 (a) Public Boarding School at New Ram Nagar By pass bridge (Right bank)

Plate 4.2 New Ram Nagar By pass bridge (Right bank)

Plate 4.3 New Ram Nagar By pass bridge (Left bank)

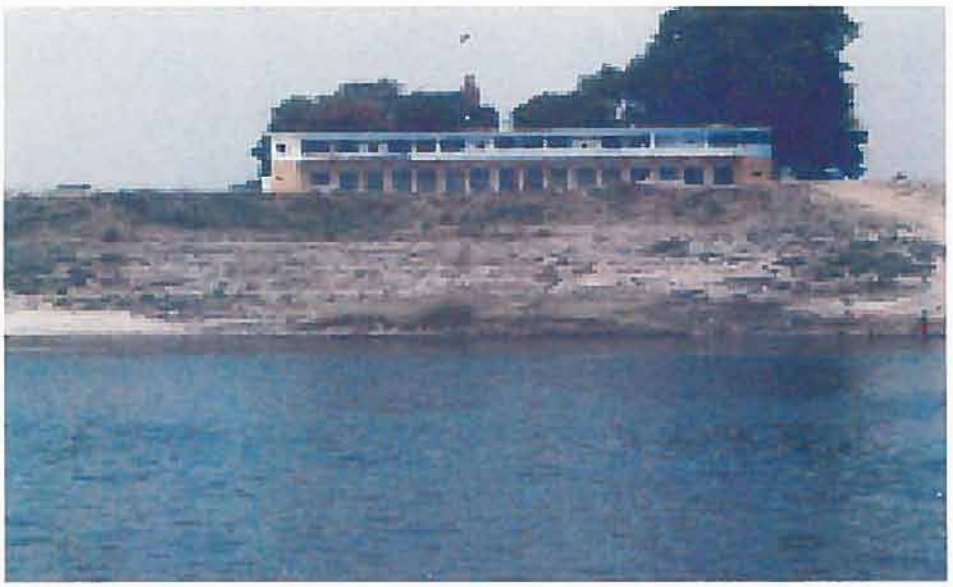


Plate 4.4 Gaura left bank

Plate 4.5 Gaura left bank

Plate 4.6 Kaithi (site 1) left bank

Plate 4.7 Kaithi (site 1) left bank

Plate 4.8 ABC jetty (Kaithi site 2) left bank

CHAPTER – 5

DESIGN VESSEL AND FLEET COMPOSITION

5.0 DESIGN VESSEL ANALYSIS

5.1 Inland transport vessel operating on NW-I

MECON had detail discussion with Manager CIWTC Kolkata for the vessels operating on river Ganges on NW-I.

Central Inland Water Transport Corporation (CIWTC) : -

Central Inland Water Transport Corporation Ltd. was established as a Government of India undertaking in the year 1967 to look after the assets and liabilities of the River stream navigation co.

CIWTC Ltd. has three functional units viz. :

1. River services division
2. Rajabagan dockyard
3. Deep sea ship repair division

River services division is maintaining and operating IWT services in eastern and north-eastern sectors. It has its main terminal at Kolkata and branch offices at Haldia, Patna, Kahalgaon, Karimganj, Badarpur, Dhubri, Pandu and Guwahati. IWT services of the corporation are essential from the strategic point of view of maintaining supply to North-Eastern states. Hence the corporation has been brought under the memorandum of understanding scheme.

CIWTC is an autonomous body based in Kolkata, transporting cargo on several river routes. They own Rajabaghan ship building and repair yard at Kolkata, which is engaged in ship repairing, ship building and general engineering

activities. They have regular sailing in Ganges. The various types of cargo crafts that are in use for transportation over inland water on National Waterway No. 1 by CIWTC are given below.

The deep sea ship repair division undertakes repair of ocean going vessels for outside agencies and has two establishments one at Kolkata and other at Port Blair.

Presently on Ganges the cargo fleet is mainly operated by Central Inland Water Transport Corporation (CIWTC). The different types of cargo vessels and the details of the vessels owned by CIWTC are:-

- Heavy duty push cum side towing tugs with bollard pulls
- Light duty tugs
- Power water carriers
- Self propelled tankers
- Self propelled carriers
- 750t dumb barges

The different types of vessel and details of the vessels available with CIWTC Kolkata, operating on Ganges NW-1 are listed in Table 5.1 to 5.3.

On detail discussions with CIWTC officials in Kolkata the following analysis and their present status as on June 2001 is ascertained.

1. Tug flotilla

Length	-	28.5m / 27.50m
Breadth	-	7.60m / 7.50m
Depth	-	2.50 m / 2.60 m

Table – 5.1

HEAVY DUTY PUSH-CUM SIDE TOWING TUGS WITH BOLLARD PULL

Name of vessel	Bollard Pull (t)	Official No. (WB)	Job Code No.	Year of built	Type of propulsion	Total power (BHP)	G R T.	Dimension (m)	Loaded Drat (m)	Min. H'way above keel (m)	Builder's Name/ place	ME Eng. Make & Type	Aux. Eng. Make & Type
Saptagram	13	1157	220	1983	Twin Screw	950	219	28.50X7.92 X 2.50	1.66	13.00	Y.Y.C Ltd., Yokehma, Japan	YANMARS 185T	YANMAR 6-CHN-N
Sarnath	13	1156	221	1983	Twin Screw	950	219	28.50X7.92 X 2.50	1.66	13.00	Y.Y.C Ltd., Yokehma, Japan	YANMARS 185T	YANMAR 6-CHN-N
Shibsagar	13	1155	223	1983	Twin Screw	950	219	28.50X7.92 X 2.50	1.66	13.00	Y.Y.C Ltd., Yokehma, Japan	YANMARS 185T	YANMAR 6-CHN-N
Koshal	12	1179	235	1985	Twin Screw	1236	214	28.50X7.60 X 2.50	1.72	10.85	H.D.P.E, Salkia/How	GRSE R 8V 16/18TLS	ASHOKE LEYLAND ALU 470
Kannauj	12	1189	233	1985	Twin Screw	1236	214	28.50X7.60 X 2.50	1.72	10.85	H.D P.E, Salkia/How	GRSE R 8V 16/18TLS	ASHOKE LEYLAND ALU 470
Kakdwip	12	1199	239	1985	Twin Screw	1236	214	28.50X7.60 X 2.50	1.72	10.85	H.D P.E, Salkia/How	GRSE R 8V 16/18TLS	ASHOKE LEYLAND ALU 470
Tanjore	12	1188	237	1985	Twin Screw	1236	214	28.50X7.60 X 2.50	1.72	10.85	Rajabagan D/Y CIWTC/Cal	GRSE R 8V 16/18TLS	ASHOKE LEYLAND ALU 470
Tamralipta	12	1203	240	1986	Twin Screw	1236	214	28.50X7.60 X 2.50	1.72	10.85	Rajabagan D/Y CIWTC/Cal	CUMMINS KTA 1150M	ASHOKE LEYLAND ALU 470
Tnhut	12	1210	241	1987	Twin Screw	1236	214	28.50X7.60 X 2.50	1.72	10.85	Rajabagan D/Y CIWTC/Cal	GRSE R 8V 16/18TLS	ASHOKE LEYLAND ALU 470
Sri Biswajit	10	1195	236	1982	Twin Screw	944	185	27.50X7.50 X 2.60	1.72	11.12	Rajabagan D/Y CIWTC/Cal	KOEL W8V BSLM	ASHOKE LEYLAND ALU 470
Aoudh	12	1247	242	1991	Twin Screw	940	208	27.50X7.50 X 2.60	1.70	11.75	Sesa Goa Ltd., Goa	CUMMINS KTA 1150M	RUSTON 4Y DAX
Avanti	12	1248	243	1991	Twin Screw	940	208	27.50X7.50 X 2.60	1.70	11.75	Sesa Goa Ltd., Goa	CUMMINS KTA 1150M	RUSTON 4Y DAX
Ambala	12	1249	245	1992	Twin Screw	940	208	27.50X7.50 X 2.60	1.70	11.75	Sesa Goa Ltd., Goa	CUMMINS KTA 1150M	RUSTON 4Y DAX
Anantapur	12	1250	244	1992	Twin Screw	940	208	27.50X7.50 X 2.60	1.70	11.75	Sesa Goa Ltd., Goa	CUMMINS KTA 1150M	RUSTON 4Y DAX
Mathura	12	1250	246	1993	Twin Screw	940	208	27.50X7.50 X 2.60	1.70	11.75	P. Das & Co. Guwahati	CUMMINS KTA 1150M	RUSTON 4Y DAX
Tamluk	12	1980	242	1993	Twin Screw	940	228	27.50X7.50 X 2.60	1.70	11.75	Rajabagan D/Y CIWTC/Cal	CUMMINS KTA 1150M	RUSTON 4Y DAX
Tiruchi	12	1281	248	1995	Twin Screw	940	228	27.50X7.50 X 2.60	1.70	11.75	Rajabagan D/Y CIWTC/Cal	CUMMINS KTA 1150M	ASHOKE LEYLAND ALU 470

(Source : CIWTC, Kolkata)

Table 5.1 (Cont.)

LIGHT DUTY TUGS

Name of vessel	Official No. (WB)	Job code No.	Year of built	Type of propulsion	Total power (BHP)	G.R.T.	N.R.T	Dimension (m) (LXBxH)	Loaded Drat (m)	Min. H'way above keel (m)	Builder's Name/ place	ME Eng. Make & Type
PT Ganga	WBG 17	232	1959	Twin Screw	300	78.18		20.85 X6.93 X 1.62	1 20	8.80	Rajabagan D/Y CIWTC/Cal	MAN W5V 17.5/22A (P) KOEL W6V 17.6/22A (S)

POWER WATER CARRIERS

Name of vessel	Official No. (WB)	Job code No.	Year of built	Type of propulsion	Total power (BHP)	G.R.T.	N.R.T	Dimension (m) (LXBxH)	Loaded Drat (m)	Min. H'way above keel (m)	Builder's Name/ place	ME Eng. Make & Type
ML Bahika II (80 t)	WB 1197	200	1965	Twin Screw	210	107.11		25.15X 7.62 X1 83	1 22	5.18	P.E.M.W Ltd. Salkia/ Howrra	PERKINGS T6

SELF PROPELLED OIL TANKERS

Name of vessel	Official No. (WB)	Job code No.	Year of built	Type of propulsion	Total power (BHP)	G.R.T.	N.R. T	Dimension (m) (LXBxH)	Loaded Drat (m)	Min. H'way above keel (m)	Builder's Name/ place	ME Eng. Make & Type	Aux. Eng. Make & Type
MT Barauni (1200t)	WB 1227	120	1988	Twin Screw	940	1058	412	87.00X 13.00 X 3.00	1.85	11.60	Rajabagan D/Y CIWTC/Cal	CUMMINS KTA 1150M	AE-CUMMINS N495 G
MT Naharkatia (1500t)	WB 1254	127	1991	Twin Screw	960	1315	456	85.00X 16.00 X 3.00	1.85	11.00	Alcock Ashdown Ltd., Bhavnagar	KOEL W4 AM	AE-RUSTON 6YDAX CD-MWM TBD 232 V6

OLD BARGES

Name of vessel	Official No (WB)	Brand ed No. (CPT)	Job code No.	Year of built	Loaded Drat (m)	Carrying Cap (MTS)	Regd. Tonnage	Max. hatch opening (LXB) (m)	Ht. From Fl. Bd. To Hatch cover (m)	Builder's Name/ place
CF 3	WBI 3005	S258	723	1960	0.84	57	70	-	-	Rajabagan D/Y CIWTC/Cal

(Source : CIWTC, Kolkata)

Table – 5.2

SELF PROPELLED CARRIERS

Name of vessel	DWT (t)	Official No. (WB)	Job code No.	Year of built	Type of propu-ision	Total power (BHP)	G.R. T.	Dimension (m)	Loaded Dral (m)	Min. H'way above keel (m)	Builder's Name/ place	ME Eng. Make & Type	Aux. Eng. Make & Type
Prakriti	550	1139	107	1983	Twin screw	672	470	55.00X10.00 X 2.80	1.85	9.30	Chowghle & Co. Bhavnagar	KOEL W6V BSM	KOEL RD42
Prafulla	550	1141	118	1987	Twin screw	672	470	56.00X10.00 X 2.80	1.85	9.30	Chowghle & Co. Bhavnagar	KOEL W6V BSM	KOEL RD42
Nazrul	600	1153	105	1983	Twin screw	600	750	56 05X10.15 X 3.00	1.85	12 42	Alcock Ashdown/ Bhavnagar under order from MDL	KOEL W6V BSM	KOEL RB 33
Rabindranath	600	1152	109	1983	Twin screw	600	750	56.05X10.15 X 3.00	1.85	12.42	- do -	KOEL W6V BSM	KOEL RB 33
Tulsidas	600	1163	113	1984	Twin screw	600	750	56.05X10.15 X 3.00	1.85	12.42	- do -	KOEL W6V BSM	KOEL RB 33
Jawahar	600	1154	114	1984	Twin screw	600	623.6	56.60X10.00 X 3 00	1 85	10.95	Rajabagan D/Y CEWTC, Calcutta	KOEL W6V BSM	KOEL RB 33
Subhas	600	1174	115	1984	Twin screw	600	623.6	55.00X10.00 X 3.00	1.85	10.95	- do -	KOEL W6V BSM	KOEL RB 33
Moulana Azad	600	1175	117	1985	Twin screw	600	623.6	55 00X10.00 X 3.00	1.85	10.95	- do -	KOEL W6V BSM	KOEL RB 33
Atulprasad	600	1222	123	1989	Twin screw	620	582	55.00X10.00 X 3.00	1.85	9.3	Sesa Goa Ltd.	MWM IBD 232V12	KOEL RB 33M
Tansen	600	1223	125	1990	Twin screw	620	582	55.05X10.00 X 3.00	1.85	9.3	- do -	KOEL W6V BSM	KOEL RB 33
Ranapratap	600	1220	121	1989	Twin screw	620	594	55.00X10.45 X 3.00	1.85	10 85	Alcock Ashdown/ Bhavnagar	KOEL W6V BSM	KOEL RB 33
David Hare	600	1221	122	1989	Twin screw	620	594	55.00X10.45 X 3.00	1.85	10.85	- do -	KOEL W6V BSM	KOEL RB 33
Wazed Ali	600	1234	124	1990	Twin screw	620	594	55.00X10.45 X 3.00	1.85	10.85	Alcock Ashdown/ Bhavnagar	KOEL W6V BSM	KOEL RB 33
Dwijendralal	600	1238	126	1991	Twin screw	620	582	55.00X10.00 X 2.55	1.85	9.30	Bharati Shipyard Ltd., Bombay	KOEL W6V BSM	KOEL RB 33
Rajanikanta	600	1239	128	1991	Twin screw	620	582	55.00X10.00 X 2.55	1.85	9.30	Bharati Shipyard Ltd., Bombay	KOEL W6V BSM	KOEL RB 33
Pragati	400	1107	106	1979	Twin screw	436	512.3 1	49.12 X 8.75 X 2.55	1.85	11.31	Goa Shipyard Ltd., Goa	CUMMINS NHRS-6-M	KOEL RB 33

(Source : CIWTC, Kolkata)

Table – 5.3

750 T DUMB BARGES

Name of vessel	Official No. (WB)	Branded No. (CPT)	Job code No.	Year of built	Dimension (LXBXD)	Loaded Draf (m)	Carrying Cap. (MTS)	Regd. Tonnage	Max. hatch opening (LXB) (m)	Ht. From Fl. Bd. To Halch cover (m)	Builder's Name/ place
DB Pranam	4039	S 52	507	1982	65.0X 10.00 X 2.90	1.83	750	655	4-holds 7.47X7.90-3 12.97X7.90-1	3.00	Rajabagan D/Y CEWTC, Calcutta
DB Pranati	4040	S386	506	1982	- do -	1.83	750	655	- do -	3.00	- do -
DB Prasad	4041	S 25	508	1988	- do -	1.83	750	655	- do -	3.00	- do -
DB Prasanti	4042	S 514	510	1988	- do -	1.83	750	655	- do -	3.00	- do -
DB Rupnarayan	4047	S 250	509	1987	- do -	1.83	750	655	- do -	3.00	- do -
DB Jaldhaka	4058	S 23	513	1985	- do -	1.83	750	655	- do -	3.00	- do -
DB Phalgu	4059	S 546	520	1986	- do -	1.83	750	655	- do -	3.00	- do -
DB Manu	4060	S 577	521	1986	- do -	1.83	750	655	- do -	3.00	- do -
DB Amanat	4063	S 593	522	1987	- do -	1.83	750	655	- do -	3.00	- do -
DB Haldi	4064	S 605	523	1987	- do -	1.83	750	655	- do -	3.00	- do -
DB Usri	4065	S 610	524	1987	- do -	1.83	750	655	- do -	3.00	- do -
DB Sanju	4052	S 231	511	1984	- do -	1 83	750	655	- do -	3.00	- do -
DB Silai	4056	S 22	512	1985	- do -	1.83	750	508.2	- do -	3.00	PS & Co., Vizag
DB Sone	4057	S 569	519	1986	- do -	1.83	750	508 2	- do -	3.00	- do -
DB Kansabati	4053	S 125	515	1985	- do -	1 83	750	508.2	- do -	3.00	- do -
DB Khowai	4054	S 124	514	1985	- do -	1.83	750	512.07	- do -	3.00	Bharati S/Y Ltd., Calcutta
DB Koel	4055	S 123	516	1985	- do -	1.83	750	512.07	- do -	3 00	- do -
DB Dwarka	4046	S 584	505	1983	- do -	1.83	750	512.07	- do -	3.00	- do -
DB Dwarakeswar	4048	S 5	504	1983	- do -	1.83	750	508.2	- do -	3.00	BB Paul & Co. Calcutta
DB Barak	4043	S 562	500	1983	- do -	1.83	750	508.2	- do -	3.00	BB Paul & Co. Calcutta
DB Bipasa	4044	S 273	502	1983	- do -	1.83	750	508.2	- do -	3.00	AC Roy & Co. Calcutta
DB Baitarani	4045	S 217	501	1983	- do -	1.83	750	508.2	- do -	3.00	BN Bose & Co. Howrah
DB Barakar	4049	S 474	503	1983	- do -	1 83	750	508.2	- do -	3.00	BN Bose & Co. Howrah

(Source : CIWTC, Kolkata)

Name of vessel	Official No. (WB)	Branded No. (CPT)	Job code No.	Year of built	Dimension (LXBXD)	Loaded Drat (m)	Carrying Cap. (MTS)	Regd. Tonnage	Max. hatch opening (LXB) (m)	Ht. From Fl. Bd. To Hatch cover (m)	Builder's Name/ place
DB Tista	4050	S 230	527	1985	- do -	1.83	750	508	- do -	3.00	Uran S/Y Bombay
DB Tapti	4051	S 162	518	1985	- do -	1.83	750	508	- do -	3.00	Uran S/Y Bombay
DB Mandakini	4069	S 283	527	1989	- do -	1.83	750	616	- do -	3.00	Hindustan S/Y, Vizag
DB Manjun	4070	S 280	528	1989	- do -	1.83	750	616	- do -	3.00	Hindustan S/Y, Vizag
DB Mundeswari	4071	S 211	526	1989	- do -	1.83	750	616	- do -	3.00	Hindustan S/Y, Vizag
DB Mahanadi	4072	S 228	525	1989	- do -	1.83	750	616	- do -	3.00	Hindustan S/Y, Vizag
DB Matla	4078	S 367	531	1989	- do -	1.83	750	616	- do -	3.00	Hindustan S/Y, Vizag
DB Argo	4079	S 298	530	1989	- do -	1.83	750	616	- do -	3.00	Hindustan S/Y, Vizag
DB Raimongal	4407	S 29	532	1988	- do -	1.83	750	682	- do -	3.00	AC Roy & Co. Calcutta
DB Ravi	4075	S 42	529	1988	- do -	1.83	750	682	- do -	3.00	AC Roy & Co. Calcutta
DB Rapti	5000	S 172	538	1989	- do -	1.83	750	682	- do -	3.00	AC Roy & Co. Calcutta
DB Retlam	5001	S 614	537	1989	- do -	1.83	750	682	- do -	3.00	AC Roy & Co. Calcutta
DB Bidyabati	4084	S 377	543	1989	- do -	1.83	750	682	- do -	3.00	AC Roy & Co. Calcutta
DB Bitasta	4085	S 378	534	1989	- do -	1.83	750	682	- do -	3.00	BN Bose & Co Calcutta
DB Betwa	4036	S 403	535	1989	- do -	1.83	750	682	- do -	3.00	BN Bose & Co. Calcutta
DB Bhadra	4087	S 435	544	1989	- do -	1.83	750	682	- do -	3.00	BN Bose & Co. Calcutta
DB Bhima	4088	S 467	539	1989	- do -	1.83	750	682	- do -	3.00	BN Bose & Co. Calcutta
DB Burhan	4090	S 472	540	1989	- do -	1.83	750	682	- do -	3.00	BN Bose & Co. Calcutta
DB Kopai	4082	S 106	542	1989	- do -	1.83	750	682	- do -	3.00	BB Paul & Co. Calcutta
DB Koshi	4083	S 119	541	1989	- do -	1.83	750	682	- do -	3.00	BB Paul & Co. Calcutta
DB Jhilam	4097	S 157	551	1991	- do -	1.83	750	682	- do -	3.00	BB Paul & Co. Calcutta
DB Kosai	4099	S 49	553	1991	- do -	1.83	750	682	- do -	3.00	BB Paul & Co Calcutta
DB Kaveri	4098	S 112	554	1993	- do -	1.83	750	682	- do -	3.00	BB Paul & Co. Calcutta
DB Subarnrekha	4080	S 152	545	1990	- do -	1.83	750	682	- do -	3.00	Shalimar Works Ltd, Howrah

(Source : CIWTC, Kolkata)

Loaded draft - 1.7m / 1.72m

Propulsion - Twin screw

2 X 470 BHP each (approx.)

Total number of tugs with CIWTC	19 nos.
Total number of tugs which can not operate in NW1	3 nos.
Number of tugs which are in break down condition and requires huge investment to make them operational	6 nos.
No. of tugs under repair or awaiting moderate repair	3nos.

2. Dumb barge

Length - 65.0 m

Breadth - 10.0 m

Depth - 2.90 m

Loaded draft - 1.83 m

Load carrying capacity - 750t

Total number of dumb barges with CIWTC	58 nos.
Number of operating dumb barges	30 nos.
Number of dumb barges which require extensive repair to make them operational	20 nos.
Under repair or awaiting moderate repair	8nos.

3. Self Propelled Carrier (SPC)

Length - 56.6m / 55.0m

Breadth - 10.45m / 10m

Depth - 3.0m / 2.8m / 2.55m

Loaded draft - 1.85 m

Propulsion	-	Twin screw
Engine power	-	2 X 300 BHP each (approx.)
Load carrying capacity	-	600 T/ 550 T

Total number of SPC's with CIWTC	16 nos.
Total number of SPC's under repair /awaiting for repair	6 nos.
Number of SPC's which are in break down condition and requires extensive repair	6 nos.
Number operating SPC's at present, which can operate in NW I.	4nos.

4. Oil tankers

- Total number of oil tankers - 3 nos.

	1	2	3
Length	87 m.	85 m.	55 m.
Breadth	13 m	16 m	10 m
Depth	3 m	3 m	2.8 m
Carrying capacity	1200 t	1500 t	600 t
Loaded draft	1.85 m	1.85 m	1.85 m
Engine power	2X470 BHP (approx.)	2xX480 BHP (approx.)	2X330 BHP (approx.)
Remarks	Not in operation, awaiting repair	Not in operating condition	Not in operating condition

Further to the above, IWAI is now planning to operate container vessels on NW2. CIWTC have presently one container vessel 'RABINDRANATH TAGORE' which is suitable for carrying 300 tonnes in all weather conditions in the National Waterways NW-1 and NW – 2.

5.2 Design Vessel

5.2.1 Vessel characteristics

Inland Waterways involves so many different types of vessels that it is difficult to identify certain type of vessel with a view to standardisation.

The vessel characteristics to be determined are the following:

Length = L
Beam = B
Draft = T
Air draft = H_v

Of these parameters especially draft, but also beam and air draft are of importance in open water sections.

For commercial navigation, the beam is the most important variable for standardisation, since barges can adapt their draft to a certain extent of off-loading or ballasting.

The main factors influencing the selection of design vessel are

- Type of cargo e.g bulk | break bulk | Unit loads | Container | General | Bagged | -Dry cargo vessels
  Liquids |- Liquid

- Cargo flow characteristics
    - Regular flow
    - Irregular flow

- Threat perceptions viz. pilferage etc

- Crew members social characteristics

A close relationship exists between the navigable clear dimensions of the vessels which will navigate on it. It is imperative to assess and stipulate the length, beam, and draft of the waterway vessels or combinations of vessels in conformity to the width of channel for navigation.

5.2.2 Vessel dimensions

In order to optimise the vessel dimensions the consultants have followed the following methodology;-

Reviewed the

1) Existing fleet on the National waterway no 1 CIWTC fleet
2) Master plan studies for navigation on National waterway No1 –June 1990
3) River Ganga pilot project (Patna-Allahabad) to identify constraints and measures to introduce regular navigation -March 1990
4) NCAER report on economic viability of inland water transport in the Ganga corridor between Haldia and Allahabad

In addition to the guiding features of IWT fleet design as indicated above viz. river characteristics, cargo demand, the physical constraints along the river course

such as bridge clearance etc shall also be determined. All the above and the ongoing studies have indicated that the design fleet for IWT operations along the National waterway no 1 should be capable of operating in shallow drafts at reasonably high speeds and reliability to meet the cargo inflow and outflow.

The Inland water transport fleet currently deployed by CIWTC consists of self-propelled vessels & push & side towing flotilla. As already discussed there are number of operating parameters that will influence the fleet design parameters if it is to be improved viz. channel width, speeds, blockage coefficient, terminal infrastructure, cargo handling rates, vessel maintenance etc.

The availability of shallow drafts along the river has compounded problems in the operation of CIWTC vessels. As already recommended by the consultants in the NCAER report schottel propulsion system could be adopted in line with the state of art propulsion system being used in most of the developed countries. Further rudder type propulsion system is an ideal propulsion system for IWT vessels operating under the shallow draft of 1.0 to 1.5 m on river Ganges.

According to the studies prepared by a Dutch Mission on the navigability of river Ganga between Allahabad and Farakka, it can be seen that cost per ton for barges smaller than 300t is very high. While the relative advantage of using larger barges is quite obvious. However, bigger size of the barge more than 1000t results diminishing benefits.

Self-propelled barge of 300t needs a LAD of 1.5m and a fairway, which is 27m wide, while, as SPB of 600 t requires a LAD of 2.0m, and a fairway width of 30m. Thus there will be a slight increase in infrastructure costs with the use of self propelled barges of 600 t instead of 300t but this are compensated by a reduction in fleet operating costs.

Earlier studies on this route both upstream and downstream have optimized the vessel size around 600t.

The barge characteristics their dimensions and possibility of formation depends on the cargo and its quantum. Following two modes are considered possible in the short and long term planning, which are:

(i) Self propelled vessels

The self-propelled vessels can be designed for the rough weather conditions. These are expensive crafts and therefore demand very fast turn-round at the loading and unloading points.

(ii) Push tug barge combinations

Technically this system has slight advantage of lower horsepower requirement. This type of mode of transport is economical if the productivity of the push tug is substantially high. This can be achieved by the following ways:

- Using extra number of push barges with each push tug, and
- Using a push barge that can operate without a crew on board.

Push tug barge combination may not be a profitable proposition in the short term planning and operationally cumbersome system, not advisable on a river with bends, tides and other ship movements. In the long-term there can be a market for push barge system where large quantities of cargo become available in future for regular and continuous transport.

Self propelled vessels could be cost effective in the earlier phases of the developments and having less operational cost.

The design vessel details are given below Table –5.4

Table – 5.4

DETAILS OF VESSEL

	LOA (M)	Beam (M)	Loaded draft(M)	Load carrying capacity (DWT)
Self propelled barges	55.5	10.45	1.85	600
750t dumb barges	64.936	9.966	1.83	750
Pusher Tug	28.50	7.6	2.50	-
Container vessel	54.56	9.59	1.20	352

The details of the self-propelled carrier and dumb barges shown in Fig 5.1 and Fig. 5.2.

5.3 Fleet composition

The fleet requirement depends on type of cargo, travelling distance, navigation facilities, facilities of handling at loading and unloading terminal, type and capacity of the craft, number of days available for safe navigation.

The details of the least available depth have been discussed in Chapter 3.0. The detail of the vessels operating on National Waterway no. 1 has been discussed in clauses 5.1 and 5.2 of this chapter. The projected traffic details have been discussed in chapter 2.0.

The various types of cargoes to be carried on this route can be divided very broadly into two categories.

a. General cargo
b. Petroleum products

These cargoes can be carried by dumb barges of 750 t capacity of different shapes and sizes available at present with CIWTC.

CIWTC is presently owing and operating heavy duty push cum side towing tugs to pull two dumb barges of 750 t capacity each. Similarly the dumb barges of such capacity are presently operated, on the route by CIWTC and as such no further investment is required for barge and towing tugs. It is worth while analysing the requirement and fleet composition for handling cargoes whether inflow or outflow.

The preliminary assessment of fleet requirement, the cargo potential for the terminal at Allahabad is taken as within the command area hinterland of Varanasi terminal. The import and export of the cargo at Varanasi is almost same. So, assuming that barges which are coming from Patna to unload the cargo at Varanasi, the same barges will be loading again and going back to Patna.

Coal

The projected traffic for the coal is 78,423t. Coal is mainly loading at Patna and unloading at Varanasi. The details of the barge trips and other details are given below.

Cargo throughput	:	78,423 t
Dumb barges size (2 nos.)	:	1500 t

Parcel size	:	1200 t
Unloading rate at jetty (Varanasi)	:	500 tph
Berthing time at jetty	:	10 min
Time required to unload the barge	:	144 min
Deberthing time at jetty	:	10 min
Total time req. at berth / barge trip	:	164 min
Number of barge trips required	:	65 nos.

Analysing the cargo movement through the terminal at Varanasi it is seen that the total inflow of traffic is 518184t and the total cargo outflow is 531735t. It is therefore for possible that the barges, which are bringing cargoes to Varanasi can be loaded with the outflow traffic for onward movement from Varanasi. The above analysis has been carried out and shown in Table 5.5. From the above it can be seen that the total barge trips (each barge trip consisting of 2 nos. 750t dumb barges) will be 435.

Fleet requirement

On an average 85 hours are required for one barge trip including the travel time from Varanasi to Patna and vice versa and also loading, unloading, berthing, deberthing at Varanasi and Patna. Patna is 364 kms from Varanasi. It takes approximately 6.0 days to travel to and fro between Varanasi and Patna considering an average speed of barges as 10 kmph and with out any night navigation. Total number of operating days is 300 days in a year.

Time required for one barge trip (Patna -Varanasi - Patna)

Distance between Varanasi to Patna	:	364 km
Speed of the barge	:	10 kmph
Navigation hours per days	:	12 hrs
Time required for reaching Varanasi to Patna vice versa	:	3.03 days
Loading / Unloading rate at Varanasi / Patna	:	500 tph
Berthing time at Varanasi / Patna	:	10 min
Time required to load / unload the barge at Varanasi / Patna	:	144 min
Deberthing time at Varanasi / Patna	:	10 min

Time required for one barge trip to reach Varanasi to Patna and Patna to Varanasi, loading at Varanasi / Patna, unloading at Patna/ Varanasi, berthing and deberthing at Varanasi and Patna is 88 hrs. With the above considerations the number of dumb barges required are 40 and the total number of tugs required assuming each tug is capable of pushing two dumb barges simultaneously is 20.

The details of the barge trips for different commodities

Table 5.5

Description	unit	Coal	Fertilizer	Food grains	POL	Iron & steel	Cement	Total
Cargo throughput	t	78423	248092	283643	296868	25226	117667	1049919
Dumb barges size (2 nos.)	t	1500	1500	1500	1500	1500	1500	
Parcel size	t	1200	1200	1200	1200	1400	1200	
No of barge trips	nos	65	207	236	247	18	98	871
Distance from Varanasi to Patna	kms	364	364	364	364	364	364	
Velocity of the barge	kmph	10	10	10	10	10	10	
Time required to reach Varanasi (12hrs a day)	days	3.03	3.03	3.03	3.03	3.03	3.03	
Loading/unloading rate at jetty	tph	500	275	275	350	500	275	
Berthing time at jetty	min	10			10	10	10	
Time required to unload the barge	min	144			206	168	262	
Time required to load the barge	min		262	262				
Deberthing time at jetty	min	10			10	10	10	
Time at berth per barge	min	164	262	262	226	188	282	
Total time required at berth								
1 shift operation (6 hrs a day)	days	30	151	172	155	9	77	594
2 shift operation (13 hrs a day)	days	14	70	79	72	4	35	274
Total time required for one barge trip (Patna - Varanasi- Patna)								
1 shift operation (6 hrs a day)	days	6.97	7.52	7.52	7.32	7.10	7.63	
2 shift operation (13 hrs a day)	days	6.48	6.73	6.73	6.64	6.54	6.78	

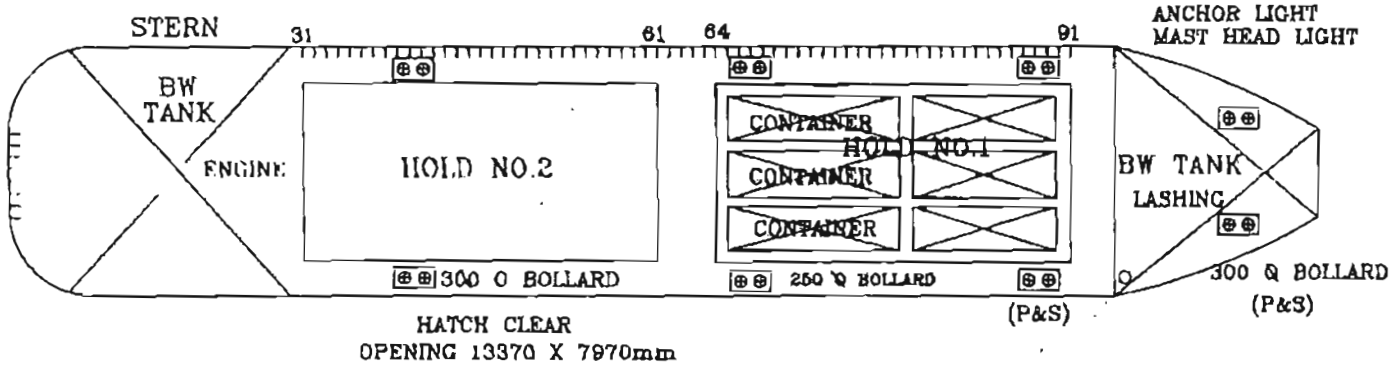
Loading at Varanasi (Fertilizer and Food grains) t 531735

Unloading at Varanasi (coal, POL, cement and Iron & steel) t 518184

* Assuming that the barge coming from patna which will be unloading at Varanasi, same will be loading again and go back to Patna.

Loading and unloading traffic is almost equal. So, the number of barge trips(Patna - Varanasi- Patna) will be 435

600 DWT SELF PROPELLED GENERAL CARGO CUM CONTAINER VESSEL



LEGEND:-

1 LENGTH OVERALL 56.5m
2 BREADTH (MLD) 10.45m
3 DEPTH (MLD) 3.0m
4 DRAUGHT (DESIGN) 1.85m
5 DRAUGHT (SCATING) 2.20m
6 FRAME SPACINGS 600mm
7 DEAD WEIGHTO 600 TONNES
8 NO.OF COPLEMENTS 15

HOLDING CAPACIY:-

HOLD NO. 1 482.6 m^3 UP TO TOP OF HATCH COAMING

HOLD NO.2 462.2m^3 UP TO TOP OF HATCH COAMING

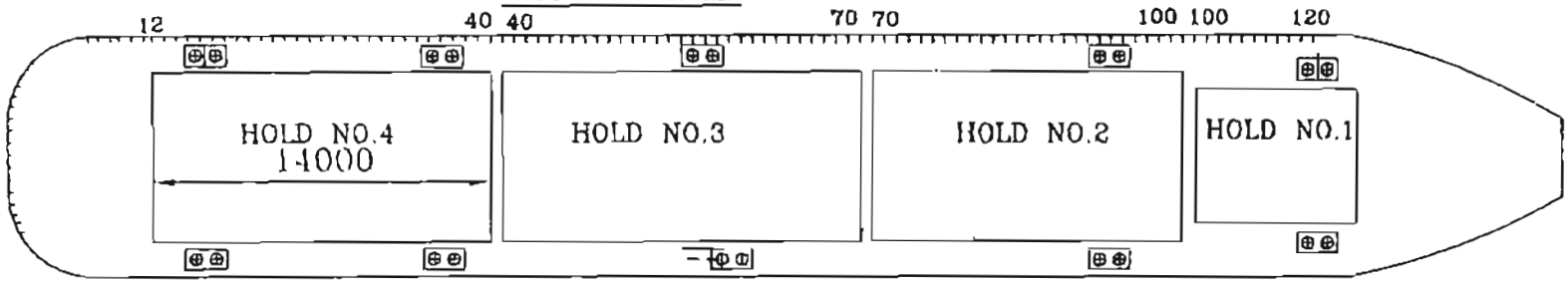
TANK CAPACITY:-

1 F.O.TANK (P&S) 27 TONNES (APPROX.)
2 F.W. TANK (P&S) 21 TONNES (APPROX.)
3 B.W. TANK 230 TONNES (APPROX.)

FIG. 5.1 DETAIL OF THE SELF PROPELLED CARRIER.

CUSTOMER	IWAI, NOIDA
	मैकन लिमिटेड
	MECON LIMITED
	SELF PROPELLED CARRIER.
	DRG No MEC/

DUMB BARGE



LEGEND:–

1 LENGTH OVERALL 64.936m
2 BREADTH (MLD) 9.966m
3 DEPTH (MLD) 2.67m
4 DRAUGHT (DESIGN) 1.83m
6 FRAME SPACINGS 500mm
7 DEAD WEIGHT 826 TONNES
8 NO.OF COPLEMENTS 4 CREW
9 SCANTLING DRAUGHT 2.20m

FIG.5.2 DETAILS OF THE DUMB BARGE

FILE NAME- Q079B
DRAWN BY PRS

NOTES :

IWAI, NOIDA.
मेकन लिमिटेड
MECON LIMITED

DUMB BARGE

CHAPTER – 6

PLANNING OF TERMINAL FACILITIES

6.0 PLANNNING OF TERMINAL

6.1 Terminals

Within the broad National strategy, the development of each individual terminal on the river Ganges must be comprehensively planned. The development of the Intermodal Terminal at Varanasi will consist of a combination of medium-term and long-term planning of new facilities. Waterway terminals are centres of receipt, outflow, storage and distribution of various cargoes such as bulk, break-bulk, POL, liquid, unitised and containerised.

In order to enhance the rapid economic development of the villages along the coast and near saturated condition of other modes of transport like road and railway, the onus is now on Inland Waterways to share a burden. With a view to this the present terminal at Varanasi is being planned on National Waterway No.1. Construction of the terminal on River Ganges has to be planned taking into consideration the large fluctuation in river levels in different seasons, highly erodable beds and banks and the resultant siltation and shift of river channel during monsoon and lean season.

Judicious selection and location of terminals are required to be planned to ensure that enough traffic from the hinterland passed through the terminal and also acts as a catalyst in the development of terminal hinterland.

Terminal planning will take into considerations future expansion, changes in pattern of trade, increase in technology for design ship, and possibly a Master Plan to take care of future provisions for 15-20 years although the construction may be envisaged in phases.

In view of the level of present and future traffic projections as discussed under Chapter 2.0 the following criteria have been carefully examined under Chapter 4.0 while selecting for terminal site:

- Stable water front
- Adequate depth of water near shore to the high bank
- Availability of adequate back-up area
- Road and Railway linkage
- Availability of water supply and electric supply

It is needless to point out that an important consideration for terminal site is the water side area which will provide safe and suitable accommodation for vessels. Terminals constructed in suitable water side areas where the river bed is stable, will ultimately lead to a low construction and maintenance cost. In an unstable river bed the perennial problem of scouring and sedimentation will be faced.

6.2 Basic Criteria

The requirement of terminals for movement of goods whether in-flow or out-flow has been established as in Chapter 2.0. Stand alone terminal will not be a viable solution. We need to supplement it with efficient handling system to quickly load or unload the IWT vessels. The handling system envisaged shall be able to meet the variety of cargoes. There can be several logistics of handling and also several modes of arrival of goods pattern and out-flow of cargoes from the terminal. Economics of terminal operation will depend upon fast reliable method of transfer of cargoes.

Besides the terminal proper and related material handling equipments, there will be a requirement of on shore land area for:

a) Storage of goods – open and covered
b) Operational building and other amenities
c) Handling area
d) Parking sheds and circulation of vehicles and equipment
e) Infrastructure facilities check post, Power supply arrangement, water supply, fire fighting and communication etc.
f) Fuel storage, container storage and road network
g) Office building cum electrical sub station
h) Expansion provisions

Having established the location, size of fleet, navigational requirements, size of cargo required to be handled, we are discussing in subsequent paras the features of the alternative terminal schemes in detail including the method of handling in each of the alternatives. The size of the jetty is based on the criteria that it is required to handle only one vessel at a time.

After assessing all the pros and cons and versatility and adaptability of handling in all seasons it is proposed to carry out further analysis for the following three alternative schemes which have been discussed in Chapter 7.0.

Alternative – I : Use of structural girder with overhead crane for loading / unloading

Alternative – II : Unloading / loading on proposed high level jetty with diaphragm wall

Alternative – III : Mechanised unloading / loading on proposed high level jetty

6.3 Guidelines and design criteria

While planning the alternatives the following general guidelines and design criteria have been adopted.

6.3.1 Navigational criteria

One of the important criteria at the terminal site is the water front, which provide safe berthing vessels. Economics of cost dictates that terminals shall be constructed where adequate water depth and stable river bed is available. Unstable river bed will have problem of scouring and sedimentation. In case of scouring bank, suitable bank protection measures need to be adopted. If sedimentation occurs in the particular bank then capital as well as maintenance dredging will be more and recurring. Planning of the terminal will be closely associated with the channels on which it is located.

6.3.2 Navigational channel

A certain amount of water has to flow through the river to maintain the water level in the navigational channel to a desired LAD referred to the Chart Datum or reference level, leaving the natural cross-profile of the river undisturbed. Depending on the design vessel a desired width and a depth of water level is required to be maintained in the navigation channel of the river with river conservancy work wherever necessary. The discharge at that location through the entire natural cross section of the river including the navigable channel is the "minimum – discharge" required to maintain a desired LAD in the channel. This will vary from location to location on the axis of the river in an ascending order from the upstream to down stream directions as the river undergoes braiding and widening as it flows down.

With a velocity of flow (during the lean season) in the order of 0.5 m/sec., the dredged channel of 30m bottom width, 1.5m depth and 1:4 side slope would require a discharge of 27 m^3/sec. Assuming entire water is channelised through it.

In reality, the cross-section of the river cannot be completely remodelled to above criteria. Cross sections of the river at shoals show that the wet sections outside the fairway normally exceed 8, so remodeling will imply enormous increase in dredging work.

With earlier studies conducted on river Ganges with the assistance of the NEDECO i.e. Netherlands Engineering Consultants, the Netherlands & Delft Hydraulics Laboratory, Delft, Netherlands it is observed that the position of water during summer months (May and June) in the river is very critical but navigation with a depth of 1.5m of water is feasible all through the year up to Gomti confluence (50 Km short of Varanasi) and above this limit up to Allahabad the navigation channel needs to be improved during May and June when the discharge in the river falls below the minimum required to maintain the fairway.

River Ganges is in alluvial plain. The Ganges at the proposed terminal location is meandering towards the right with a large convex radius. Discharge ratio between flood and low water is 286. Range of water level is 13.0m. As the bend of the curved channel is gentle, the river bed will have sandy soil and banks resistance to scouring will be high. The water flows slowly in low water period at ~ 0.2m/sec. However during flood period it floods the beaches and the current velocity increases to 3.5m/sec. The discharge value and the current velocity considered in the design of the New Ramnagar by pass bridge close by the proposed site are 46,186 m^3/sec and 4.5 m/sec respectively.

Main considerations to safe navigation is to determine

- Minimum dimensions and configurations of fairway for the design vessel with the required draft availability for the full season.
- Vessel required draft availability for the full season.

The main waterway parameters, which have to be taken into consideration while designing the navigation system are:

(i) Dimensions
- Depth of navigable channel
- Width of navigable channel
- Radius of curvature of channel bends
- Ratio of wetted cross section of the channel and the mid ship form of the design vessel.

(ii) Alignment
- One-way / Two-way navigation
- Radius of curvature of channel bends

(iii) Flow conditions
- Current velocity
- Discharge
- Water elevation

(iv) Environmental conditions

(v) Obstacles
- Vertical clearance under structures such as bridges above High flood level (HFL).
- Vertical clearance under overhead power cables extending across channels, above HFL.

- Horizontal clearance between vertical, fixed structures flanking navigation channels.

(vi) Design Vessel

- Maximum length
- Maximum width
- Maximum draft (load)
- Maximum height above water line (light condition)
- Hull form of vessel and its mid ship cross section
- Speed while proceeding upstream
- Speed wile proceeding downstream
- Squat of vessel at full speed.

A government of India committee had recommended that a channel of 45m width and 1.5m depth should be the minimum for national waterway. Cross sections may be expected to satisfy four requirements:

i) The water way must be deep enough to prevent vessels from running aground or being difficult to steer.

ii) The waterway must be sufficiently wide to enable the standard traffic flow to pass safely and speedily.

iii) Vessels must be able to reach a reasonable speed to keep down the cost of transport.

iv) The cross section must not be too large and therefore uneconomical.

Typical cross sections of the river U/S New Ram Nagar by-pass bridge as surveyed by IWAI on 21.5.2001 have been given in Chapter 4.0.

6.3.3 Channel Width

The minimum width of the channel as observed from the sketch No. 6.3 is 400 m. The width of the channel plays an important role in deciding the safe maneuverability of the vessel plying on it. During the dry season the ratio of the wetted cross section of the fairway to the wetted area of mid ship cross section of the vessel i.e. "n" ratio is a significant factor.

When a vessel is navigating in a narrow and shallow channel its movements and manoeuvrability are effected inter-alia, by hydrodynamic effects of a close bank line, the ratio between the cross section of the channel and the vessel and the clearance between the keel and the channel bed. These also affect another vessel which may be parallel in an overtaking or passing situation simultaneously.

Channel width should comprise of the following elements:

	Minimum	Maximum
Bank clearance lane	0.8 W	1.6W
Manoeuvring lane	1.3 W	1.8W
Ship clearance lane	1.0 W	1.2W
Manoeuvring lane	1.3 W	1.8W
Bank clearance lane	0.8 W	1.6W
Total	5.2 W	8.0 W

For two way navigation the channel width should be between 5 to 8 times width of the design vessel. For one way channels this would reduce to between 3 to 5 times the width of the vessel depending on its manoeuvrability.

The ratio of channel width to vessel width is an important factor for deciding the channel width.

In first stage, channel of 4 times the width, which would amount to a channel width of 4.0 x 10 = 40m is recommended.

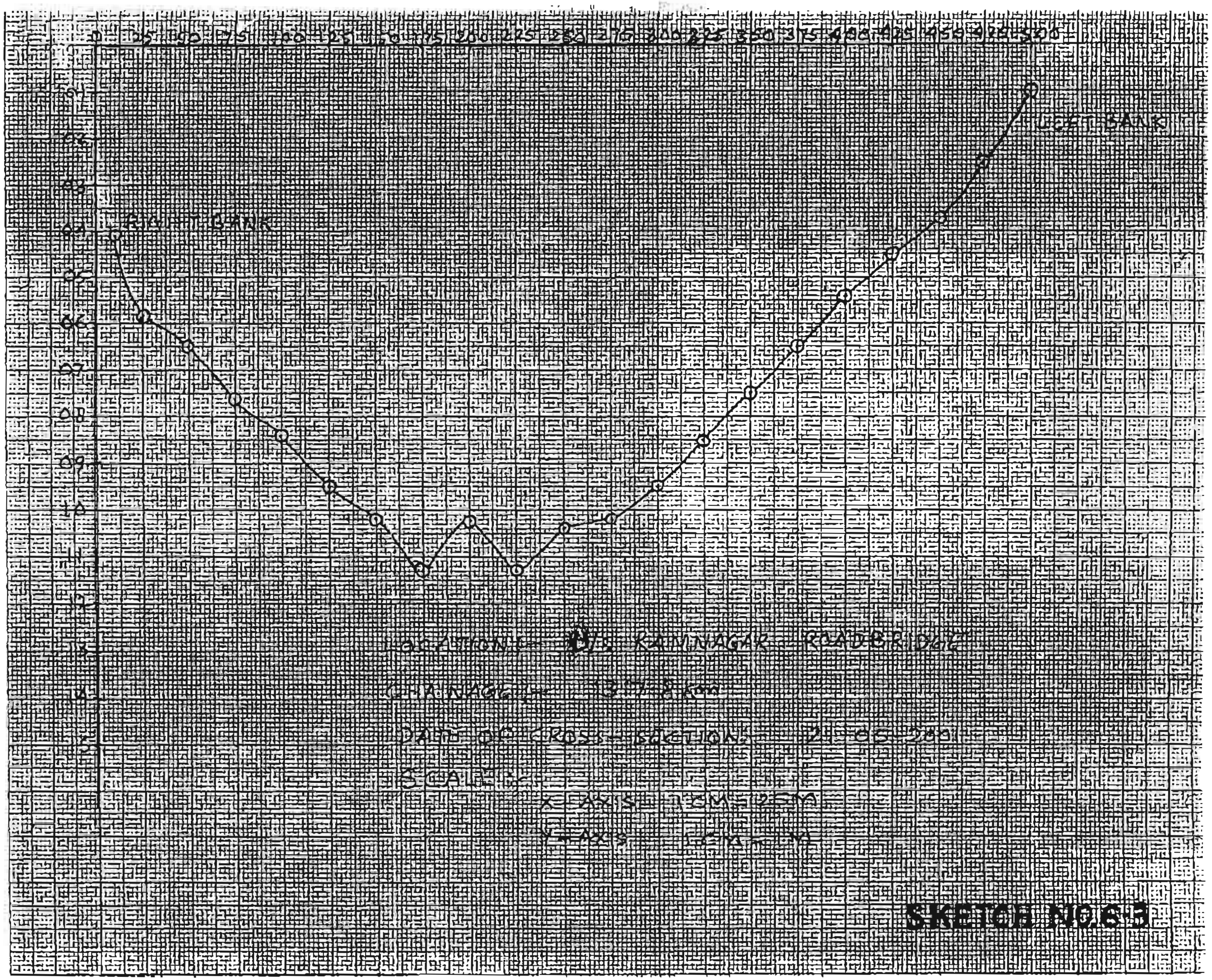
6.3.4 Channel Depth

The channel depth must be more than the maximum of draft of the vessel and under keel clearance. In inland waterways the ship motion is relatively small since water are in tranquil condition.

The maximum loaded draft of the design vessel is 1.85m. The channel depth of 2.0 meters will permit passage of the design vessel. It is therefore recommended that the channel be designed for a depth of 2.0 m below the level of the lowest low water. It can be deepened further in stages as the traffic and vessel sizes grow.

The recommended value of the ratio of water depth/ship draught (h/t=1.3) is difficult to be met in the Ganges channels. Small keel clearance is detrimental for steering and has to be compensated by increasing the navigable width. A small keel clearance also inter-alia dictates reduced speed, so as to avoid the bottom touching due to squat.

When we look at the stretches of Ganges between Haldia to Allahabad the following facts emerges: -


RIGHT BANK
LEFT BANK
LOCATION :- U/S RAMNAGAR ROADBRIDGE
CHAINAGE :- 137.8 km
DATE OF CROSS-SECTION :- 21-05-2001
SCALE :-
X-AXIS 1CM=25M
Y-AXIS 1CM=1M

SKETCH NO.6.3

- Haldia –Calcutta stretch has the desired channel depth for the movement of IWT vessel . This section therefore poses no major problems for achieving the desired channel depth dimensions.
- Calcutta- Patna sections the channel depth is inadequate in several sections near shoals. The channel depth within these sections is near about 1.2 m.
- Patna- Allahabad section – A restriction of depth to 2.0 m with necessary conservancy activities exists during the lean season for about 50 km, for the design vessel of 600 t and a restriction of depth of 1.5m during the lean season for the design vessel of 300t for about 20 km, in the total stretch of 600km between Patna and Allahabad.

We recommended that regular Thalweg survey associated with hydrographic survey in stretches be conducted.

Hydrographic survey is a basic investigation and the chart resulting therefrom is essential information for any kind of vessel. The hydrographic survey chart is put to many other uses such as for civil/marine works, dredging, scientific investigations including model studies. Hydrographic surveying is an elaborate and time consuming operation since each and every square meter of navigable area has to be gone over in a survey vessel and the best channel is to be found out and delineated.

6.3.5 River Bends

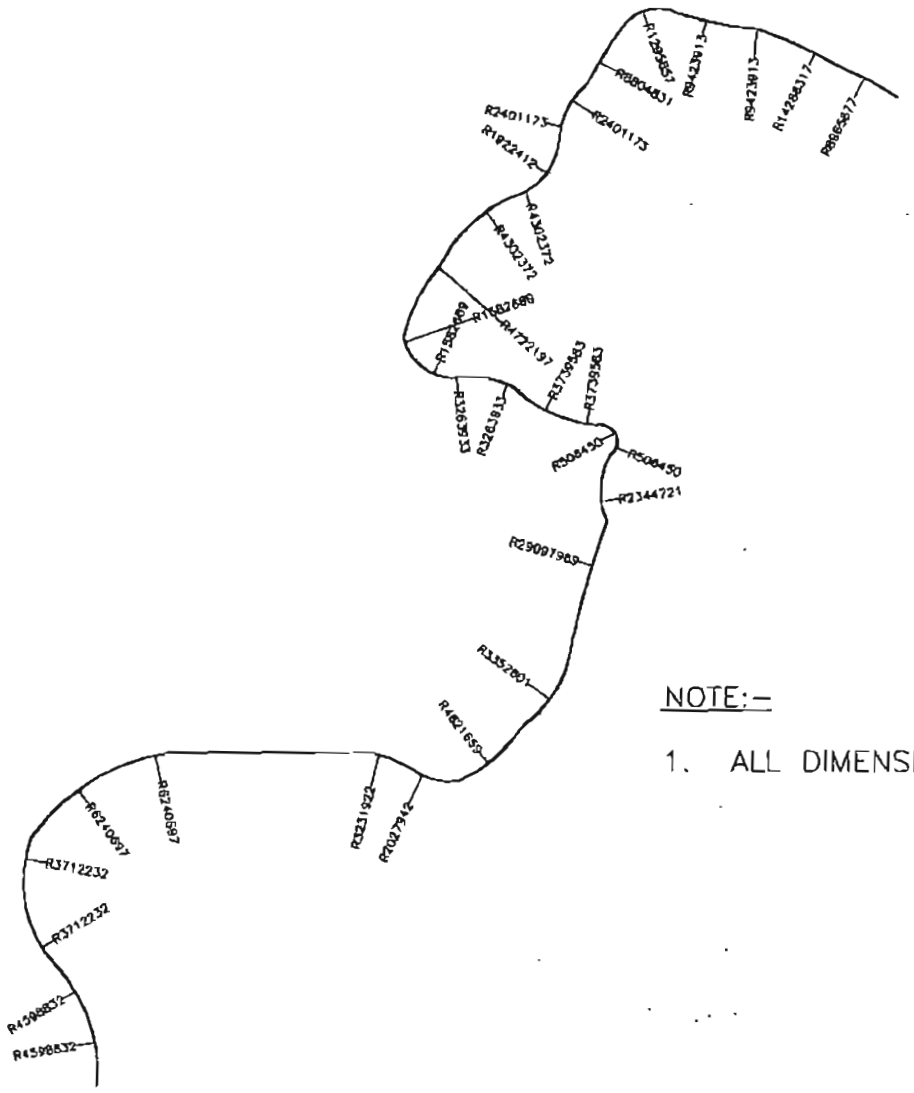
Bends / curves are especially decisive for the admitted length of the craft. When passing a curve, the craft comes into a drift position which generates eddies. Where turbulence is caused by motor ships the propeller wash may have a significant impact on the banks. The length of the boat determines also the possibility of a turning.

For the design vessel of 600t, the length is 60m and as per Dutch guidelines the minimum permitted radius of bends shall be six times the length of vessel for "normal cross section" and four times the length of vessel for "narrow" and "one way traffic" cross section . Analysing latest satellite imageries of March/ April 1989, for the stretch Patna-Allahabad and as assessed in the River Ganga Pilot Project by Netherlands Engineering Consultants and Delft Hydraulics Laboratory, the minimum radius of bend is about 500 m. With this radius the design vessel plying on the stretch will have no problem.

We reproduce below the stretches having the least bend radii in the Patna - Allahabad sector.

Sl. No.	Stretch	Chainage (km)	Radius of bends (m)	Length (m)	Remarks/ Place
1.	Allahabad-Mirzapur	1615	500	750	Allahabad
		1600	500	850	Maniaya
		1585	500	750	
		1498	500	750	Jagdishpur
2.	Ballia-Patna	1120	1000	1250	Saharanpur/Gaderiya
		1032	1500	2250	Digha (via Pahleza ghat)

In all the remaining stretches the bend radii are larger. Radii of bends at various stretches of the river in Varanasi are shown in Drg. MEC/11/17/Q079/SK-4.



N

W E

S

NOTE:-

1. ALL DIMENSIONS ARE IN mm.

RADIUS OF BENDS AT VARIOUS STRETCHES
OF THE RIVER GANGES AT VARANASI
DRG. NO. MEC/11/17/Q079/SK-4

MECON
ISO 9001 Company

6.4 Offshore requirements

6.4.1 Required number of berths phase wise

The number of berths depends on the cargo throughput, parcel size, cargo handling rate, equipment used for loading and unloading of cargo and service time required for the barges.

The projected traffic has been discussed in Chapter-2. The planning of terminal and other facilities has been made in Phase I for 1.02 Mt/yr and Phase – II from 1.02 to 1.624 Mt/yr.

Apart from the actual time required for loading/ unloading of cargo, additional time is required for barges for appurtenant operations manoeuvring of barge at berth, obtaining customs clearance surveys, initiating the mechanical equipment and on completion of cargo handling activities, another survey, ballasting, bunkering, and sailing off the berth.

The water area required for berthing/ deberthing of barge are dependent upon the following:

- LOA of vessel
- Number of vessel to be accommodated simultaneously
- Cargo type
- Type of berth construction i.e. whether alongside berth or finger piers.

While assessing the requirement of number of berths it is assumed that terminal are operative on 300 days in a year as required LAD not available in the lean season for various stretches.

6.4.2 Size of the berth

The length of the berth has been decided based on the mooring study and the LOA of presently operating barges on river Ganges. The berth length of 38m for Alternative II & III is enough for loading/ unloading operation and berthing of the single barge at a time. The width has been decided taking into account mechanical handling system on the berth. The width of the berth has been kept at 15 m considering the mechanical equipment on the berth. The details of the berth occupancy phasewise are given in Table no. 6.1. The berth occupancy calculations considering individual cargoes in Phase I and Phase II are shown in Table 6.2 to 6.3.

Table 6.1

Description	unit	Phase I	Phase II
Cargo throughput	t	1,049,919	1,624,000
Dumb barges size (2 nos.) (750t each)	t	1500	1500
Parcel size (two way)	t	2400	2400
No of barge trips	nos.	435	677
Loading/unloading rate at jetty (ave)	tph	275	350
Berthing time at jetty	min	10	10
Time required to unload the barge (ave)	min	262	205
Time required to load the barge (ave)	min	262	205
De berthing time at jetty	min	10	10
Time at berth per barge (ave)	min	544	430
Number of working days	days	300	300
Berth occupancy	%	59	76

Berth occupancy with 2 no. 25/5t crane (Phase 1) **Table 6.2**

Description	unit	Coal	Fertilizer	Food grains	POL	Iron & steel	Cement	Total
Cargo throughput	t	78423	248092	283643	296868	25226	117667	1049919
Dumb barges size (2 nos.)	t	1500	1500	1500	1500	1500	1500	
Parcel size	t	1200	1200	1200	1200	1400	1200	
No of barge trips (Varanasi to Patna or Patna to Varanasi)	nos	65	207	236	247	18	98	871
Loading/unloading rate at jetty	tph	500	275	275	350	500	275	
Berthing time at jetty	min	10			10	10	10	
Time required to unload the barge	min	144	262	262	206	168	262	
Time required to load the barge	min							
Deberthing time at jetty	min	10			10	10	10	
Time at berth per barge	min	164	262	262	226	188	282	
Berth occupancy (300 days)	%	2.96	15.07	17.18	15.51	0.94	7.68	59.34

Loading at Varanasi (Fertilizer and Food grains) - Inflow cargoes t 531735
Unloading at Varanasi (coal, POL, cement and Iron & steel) - Outflow t 518184
* Assumed that the barges coming from say Patna and unloading at Varanasi, same barges will be loaded again with outflow cargoes go back to Patna.
Loading and unloading traffic is almost equal. So, the number of barge trips will be 435

Berth occupancy with 2 nos. 25/5t crane (Phase II) **Table 6.3**

Description	unit	Coal	Fertilizer	Food grains	POL	Iron & steel	Cement	Total
Cargo throughput	t	150000	330000	370600	586444.5	32942	153731	1623718
Dumb barges size (2 nos.)	t	1500	1500	1500	1500	1500	1500	
Parcel size	t	1200	1200	1200	1200	1400	1200	
No of barge trips (Varanasi to Patna or Patna to Varanasi)	nos	125	275	309	489	24	128	1350
Loading/unloading rate at jetty	tph	500	275	275	700	500	275	
Berthing time at jetty	min	10			10	10	10	
Time required to unload the barge	min	144	262	262	103	168	262	
Time required to load the barge	min							
Deberthing time at jetty	min	10			10	10	10	
Time at berth per barge	min	164	262	262	123	188	282	
Berth occupancy (300 days)	%	5.69	20.01	22.49	16.71	1.25	10.03	76.18

Loading at Varanasi (Fertilizer and Food grains) - Inflow cargoes t 700600
Unloading at Varanasi (coal, POL, cement and Iron & steel) - Outflow t 923118
* Assumed that the barges coming from say Patna and unloading at Varanasi, same barges will be loaded again with outflow cargoes go back to Patna.
Loading and unloading traffic is almost equal. So, the number of barge trips will be 725

So, one berth is adequate to handle the above traffic in Phase I and II, however the capacity of loading / unloading is increased in Phase II with the above handling facilities as per requirement. The capacity of unloading of POL is increased by addition of another pump.

A meeting was held on 21st December'2006 at Kolkata between IWAI, MECON, CIWTC & IWT Officers/Operators wherein the detail methodology of berthing / deberthing was discussed in detail. Also IWAI vide comments furnished in letter no. IWAI/PR/1/97 dated 4.10.07 indicated the requirement of 2/3 of length of vessel to be abreast against pier while berthing. To meet the above mentioned basic minimum operational requirement, it is proposed to construct all the three piers in Phase I itself under Alternative I. The same is described in subsequent chapters and cost analysis worked our accordingly.

6.4.3 Riverine Accessories

Riverine accessories comprise of fenders and bollards.

6.4.3.1 Fenders

Fendering is the important item in the design of the unloading/loading platform. Variation in the water level, barge sizes, approach velocity and maneuver are the important parameters in designing the suitable system. The berthing structures are proposed to be provided with high energy absorption fenders to enable berthing of 750 DWT barges with an approach velocity of 0.45 m/sec, the energy to be absorbed is 8.0 T-m .

6.4.3.2 Bollards

Calculated mooring force is 20t. By considering the current force on the barge total pull is equal to 36t. The bollards will be of cast iron type. The 15t capacity bollard will be placed on the berthing face of 38m length with 10m centre to centre distance.

6.5 Onshore requirements

6.5.1 Land availability

Detail discussions were held with General Manager, District Industries centre, Town planner, Varanasi Development authority, Asst Director and Asstt town planner in UP town and country planning department, Superintendent Engineer and other senior officials regarding the land availability and the land owner ship around the proposed site.

It is concluded that required land is available at New Ramnagar by Pass Bridge on Right Bank of the Ganges. At present the land is owned by Mr Gopal singh, advocate. Gopal singh is the son of the ex-chairman of Raja saheb of Ramnagar fort.

Total storage for container, open storage and other administrative offices for phase I and Phase II can be located on the backup area available behind the jetty.

The land required in phase – I is 2.0 ha and Phase II is 2.5ha. However IWAI has acquired about 6.0ha for development of the proposed terminal.

6.5.2 Shore protection

The right-bank of river Ganges at New Ramnagar by Pass Bridge is very stable but the bank may undergo some erosion on the upstream of the terminal and deposition on the down stream of the terminal. So, riverbank in front of the terminal will be protected by revetment for a total distance of 150m of the terminal or more after detail study during detail engineering. It can also be done after observing the phenomena after some years of operation.

6.5.3 Road connectivity

Varanasi is well connected by road to major cities in Uttar Pradesh and NH7, NH28 and NH29 is passing through Varanasi. The proposed site is about 500m from NH7 and Pt Deendayal setu bridge is a by pass to Mughalsarai and Varanasi on NH2 is close to the site. The road connectivity map of Varanasi is shown in Fig. 6.1.

It is required to prepare a road length of 500m from the site to connect to NH7.

6.5.4 Rail connectivity

Varanasi is well connected by electrified broad gauge railway line. The proposed site is nearer to the Varanasi main railway line, which connects Mughalsarai and Varanasi.

The rail connectivity map of Varanasi is shown in Fig. 6.2.

FIGURE 6.1


Road Network of
Uttar Pradesh
HIMACHAL
PRADESH
CHINA
(TIBET)
N
NEPAL
HARYANA
RAJASTHAN
MADHYA PRADESH
BIHAR
LUCKNOW
Uttar Kashi
Badarinath
Dehra Dun
Okhimath
Chamoli
Karnaprayag
Pithoragarh
Pauri
Saharanpur
Nakur
Haridwar
Almora
Didihat
Bijnor
Nainital
Dhura
Meerut
Tarakpur
Sonipat
To Delhi
Rampur
Moradabad
Pilibhit
Bareilly
Banbirpura
Bulandshahr
Khaga
Budaun
Shahjahanpur
Alipur
Khari
Etah
Simpur
Bahraich
Balrampur
Mainpuri
Kaimganj
Hardoi
Fatehpur
Gonda
Maharajganj
Etawah
Kanpur
Unao
Gorakhpur
Rae Bareli
Sultanpur
Azamgarh
Deoria
Gwalior
Jalaun
Kalpi
Fatehpur
Pratapgarh
Kunda
Ballia
Ghazipur
Jhansi
Hamirpur
Varanasi
Mahoba
Banda
Allahabad
Manikpur
Mirzapur
Robertsganj
Lalitpur
Mandawra
Rewa
Oudhnagar
Map not to Scale
State Capital
International Boundary
Other Roads
National Highway
with Number
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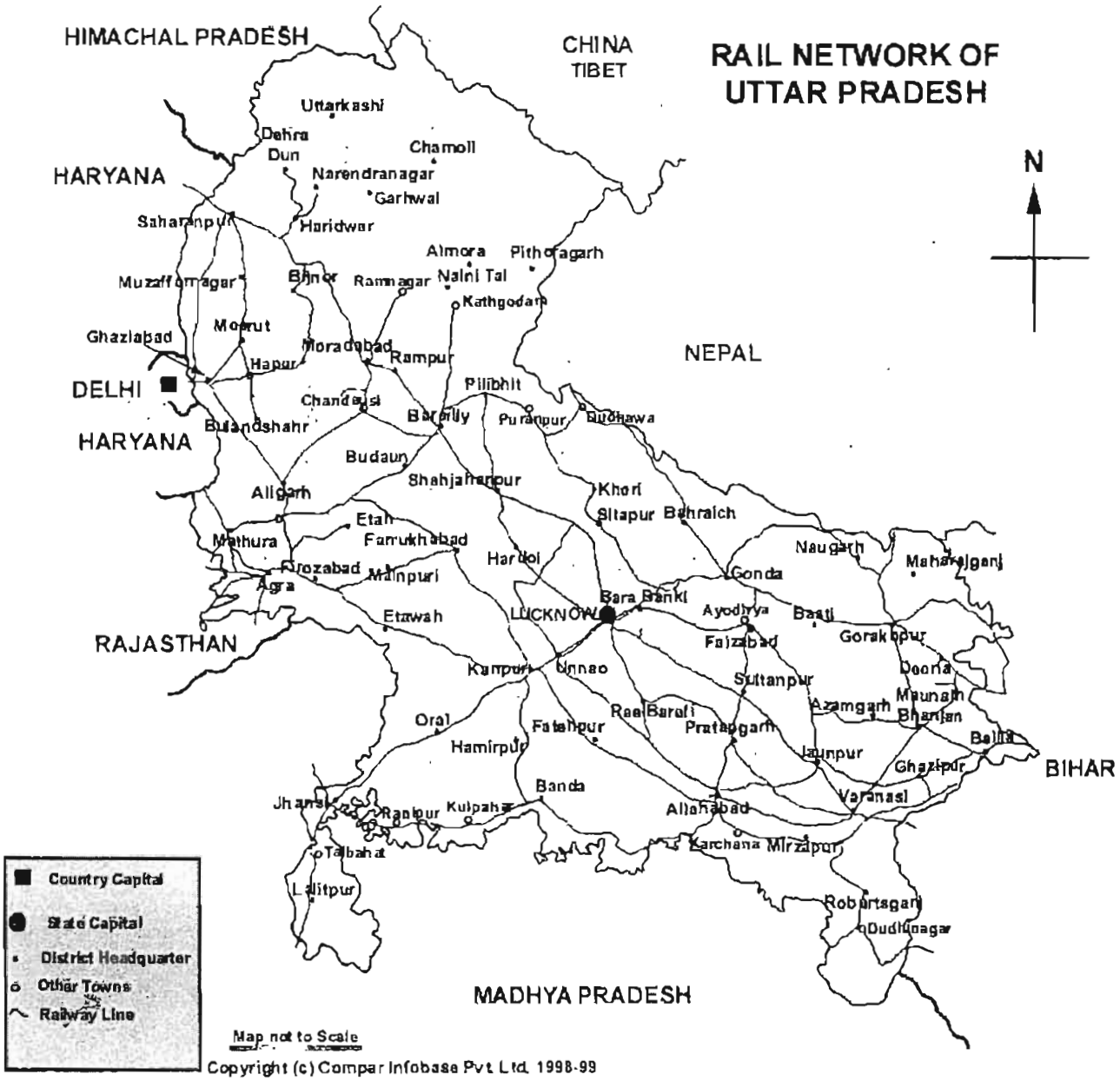
FIGURE 6.2



6.5.5 Power Supply and Distribution

6.5.5.1 Purchaser Obligation :

Inland Waterways Authority will arrange 6.6 kV OH line within battery limit of 50m. for providing power supply to the proposed mechanized loading / unloading system. The overhead line is to be terminated at end structure, complete with line arrestors in each phase. Scope of work for electrics of this project will start from downstream of this end structure. IWA will furnish the fault level, details of system earthing, voltage and frequency variations at the time of detailing.

6.5.5.2 Distribution of Power Supply System :

For feeding the entire illumination load and shop load one number 250 kVA, 6.6 kV / 415V, 3Ø, Dry type transformer and one number 6.6 kV indoor panel mounted HT isolator is envisaged.

One number floor mounted, compartmentalized construction, PMCC, three phase, 4 wire system, with Horizontal bus bar on the top and TPN vertical bus bar at the back, cable alley with each vertical is envisaged for feeding the various loads provided at various locations / premises. PMCC will have one incomer of suitable rating MCCB as incomer and requisite numbers of outgoing feeders, minimum 20% spare feeders will be provided for future use. This PMCC will cater phase-I & phase-II loads for all the three proposed alternatives.

For illuminating the open storage area one number 22m. high flood light tower with 400W HPSV Flood light luminare is envisaged to cover both phase-I & II open storage area. Street lighting inside the proposed complex and lighting in open storage area centralised switching from switchgear room will be provided. 9

to 11m high steel tubular pole will be provided at an interval of 30m apart for road lighting.

Lighting distribution boards will have TPN MCB of suitable rating at I/C and number of outgoing feeders of 20A, SP MCB, 20% spare feeders will be provided as spare in each LDB.

Individual control in office buildings shall be provided through single pole tumbler switches. In those areas where group controls are required, rotary switches will be provided.

The minimum size of the cable used will be 4.0 sq.mm. Aluminium for power loads and 1.5 sq.mm. copper cable for point wiring and 2.5 sq.mm. copper for circuit wiring and maximum size of cable used will be limited to 3.5x240 sq.mm. AYFY type as incomer to PMCC.

For power supply to 25/5 t EOT crane under alternate-I one no. 250A MCCB each have also been envisaged for receiving end.

6.5.5.3 Illumination Levels and Type of Lamps

The level of illumination and types of lamps selected shall generally conforming to the following :

- Open storage area, (area lighting) : 20 lux - HPSV. Flood light fitting through tower light.
- Road lighting : 20 lux - HPSV. Street light fitting
- Transit shed, maint. Shed, garage etc. : 100 lux - HPSV low bay fitting.
- Disel store, Security office : 100 lux. - Flourescent fitting.
- Office building, switch gear room : 200 lux. - Flourescent fitting.

-	Jetty platflorm	:	60 lux. - HPSV / HPMV street light fitting.
-	Crane operating shed	:	100 lux. HPSV / HPMV well glass fitting

6.5.5.4 Ceiling Fans :

1400 mm sweep ceiling fans shall be provided for office building. Generally one no. of fan shall be provided for every 10 sq.m. area. The fan shall be complete with electronic regulator.

6.5.5.5 Miscellaneous Items :

Items such as brackets, hangers, clamps, junction boxes, earthing wire / flat etc. which are required to make the lighting installations complete in all respect are also considered.

6.5.5.6 Earthing :

Earthing electrodes of medium duty GI pipes 50 mm dia, length 3m in one piece as per IS:3043 - 1987 will be provided as per requirement around switchgear room for grounding of the electrical equipment in the switchgear room. 2 Nos. of earthing electrodes will also be provided for grounding the flood light tower. Lighting poles will be considered grounded. Separate earthing 2 Nos. will be provided for transformer neutral earthing.

6.5.5.7 Conductor sizes for ground connections :

For equipment ground connections, the minimum conductor sizes used will be as follows:

6.5.5.8 High voltage system

75x5 mm GI flat for etc.	:	Main earthing ring, transformer, HT isolator

6.5.5.9 LT System :

50x6 mm GI flat for	:	PMCC. Motor and starter over 37 kW. LDB's Bonds to crane gantries.
25x3 mm GI flat for	:	Motor and starters above 15 kW and upto 37 kW.
6 sq.mm stranded GI wire for :		Motors and starters upto 2.2 kW, push buttons, light fittings, JB etc.

6.5.5.10 HT Power Cable

6.6 kV XLPE Cable

6.6 kV heavy duty power cable, 3 core, aluminium conductor 3x95 sq.mm, XLPE insulated, extruded inner sheath, galvanized round steel wire armoured and PVC outer sheath will be provided for connecting the transformer to the overhead end structure.

6.5.5.11 LT Power Cable

1.1 kV, Grade PVC Aluminium Conductor Armoured Power Cables.

1.1 kV, heavy duty power cable, multicore stranded aluminium conductor PVC insulated galvanized round steel wire armoured and PVC outer sheath

6.5.6 Water supply

A terminal needs potable quality water for drinking and sanitation needs of the working personnel. In addition water is required for fire fighting purposes.

Required quantity of water will be made available from the near by municipal lines. The water shall be stored in an overhead water tank of 25000 litres capacity.

6.5.7 Fire fighting facilities

Fire protection facilities would have to be provided to both onshore and offshore facilities in the terminal in accordance with recommendations of the Tarrif Advisory Committee (TAC), India and the National Fire Protection Association (NFPA) USA. Where TAC regulations are not specific, NFPA or Indian Standard Codes would have to be adopted.

In order to combat any occurrence of fire in different units of the proposed terminal following fire protection facilities have been envisaged:

— Portable Fire Extinguishers

— Fire Hydrants and water monitors.

6.5.7.1 Portable Fire Extinguishers

All plant units will be provided with adequate number of portable fire extinguishers of appropriate type suitable for the class of fire in the premises. The selection and distribution of portable fire extinguishers will be in accordance with the requirement of IS 2190-1992.

In order to protect the equipment and machineries from any damage or loss due to fire all plant units, stores, maintenance shed, diesel store, transit stores and offices etc. will be provided with adequate nos. of portable fire extinguisher to be used as first aid. Depending on the type of fire hazards the following portable extinguishers have been envisaged to be distributed in the various premises.

Phase – I

- 5 kg capacity dry chemical power (DCP) type extinguisher – 6 nos.
- 4.5 kg capacity carbon di-oxide (CO_2) type extinguisher – 10 nos.

Phase – II

- 5 kg capacity dry chemical power (DCP) type extinguisher – 2 nos.
- 4.5 kg capacity carbon di-oxide (CO_2) type extinguisher – 8 nos.

6.5.7.2 Water based fire-fighting system

River water will be used for fire fighting network in the berth and storage area. One number electric motor driven pump of 144 m^3/hr capacity at 7 kg/cm^2 pressure and one diesel engine driven pump of same capacity and head will be provided. One number electric driven jockey pump of 10 m^3/hr capacity at 7 kg/cm^2 pressure will be provided to take care of pressure losses due to leakage in the piping system. All these pumps will be connected through common delivery

header for pumping fire-fighting water into the fire water piping network. A separate pump house would have to be provided within the system for pumping river water in which these pumps are located.

6.5.8 Drainage system

6.5.8.1 Storm water drainage system

Suitable storm water drainage system for drainage of the onshore area shall be with open drains of rectangular cross section. Wherever the drains cross roads suitable pipe culverts will be provided. Drainage system will be designed for maximum intensity of rainfall.

Effective storm water drainage system along the proposed road network and in and around different units shall be provided. The drains are of rectangular shape of size 300 mm X 350mm (D) and 600 mm X 800 mm (D) and total length of about 1050 m.

Pipe culverts using 2 numbers of 300Ø pipes of total length of about 15 m and using 2 numbers of 400Ø pipes of total length of about 25 m shall be provided below the road for drain cross over.

6.5.8.2 Sewerage disposal system

For disposal of sanitary sewerage septic tanks and soak pits have been planned for the office premises. To treat the faecal sewage from the toilets two numbers of septic tanks suitable for the use of 10 persons each shall be provided made of

brick work and R.C.C cover and man hole. Two numbers of soak pits of dia 1500 mm made of bricks shall also be provided.

6.5.9 Auxiliary buildings and other infrastructure

On-shore facilities are common to any of the 3 alternatives of off-shore facilities. These are mainly of two parts i.e., provision of different buildings and storage area for different activities of the terminal and enabling facilities like ground improvement, levelling, roads around different units, boundary walls, fencing, drainage etc. This also includes an approach road to connect the NH-7.

The broad description of different structures are as follows:

6.5.9.1 Garage

One number garage meant for parking mobile crane shall be of size 18m x 12m X 6m height. The same shall be of R.C.C. frame construction with shell roof in order to have 12 m wide clear space. There will be external brick in filled wall alround upto the full height with sufficient windows and ventilators shall be provided with protective grills for proper ventilation and light. The flooring shall be of R.C.C. over well compacted boulder soling and chequered ironite finish.

Necessary plastering and cement based paint on outer faces and white washing on inside face of walls shall be provided. Garage shall be alround drain.

6.5.9.2 Maintenance Shed

One number maintenance shed for dumpers and other machineries shall be provided of size 24m x 12m 2.5m high. This is a structural building with G.I.

sheeting and roofing. Necessary R.C.C foundation for structural column and flooring shall be provided. Other facilities like drainage and collection of oil etc. shall be provided.

6.5.9.3 Diesel Store

One number diesel store building of size 15m X 9m X 4m shall be provided. This will be of R.C.C. framed construction with brick in fill wall with a structural roofing.

Necessary flooring and finishing work like plastering, painting etc. shall be provided. Proper ventilation has to be ensured. Limited number of doors and windows shall be provided for safety reason.

6.5.9.4 Office Building cum-Electrical sub-station

This building is intended to provide office space as well as Electrical premises.

The total size of the building shall be about 40m x 15m X 4m high of which GF shall be made under Phase-I while the 1st floor will be taken up in Phase-II.

This will be of R.C.C. framed structure with in filled brick wall. Flooring shall be of P.C.C. with different types of floor finishes to suit the requirement. While the office and other utility areas will have terrazzo finish, the electrical premises shall have ironite finishes. The plastered walls shall have different internal finishes such as colour distemper for offices rooms and toilets, washable synthetic enamel paint for canteen pantry area where as white wash shall be applied for electrical premises. The toilets shall have tiles on the floor and around walls upto 1.5m

height. Outside of the building shall be painted with waterproof cement based paint of approved shade.

Sufficient number of steel doors, windows and ventilators shall be provided to suit functional requirement such as movement, natural light and ventilation. Wooden flush doors shall be provided for toilets and canteen area. Synthetic enamel paint shall be provided for all steel and wooden members. All other necessary fitting and fixtures for various usage shall be provided.

The substation area shall have R.C.C foundation for transformer switch panels. R.C.C. cable trenches shall also be provided for laying cables. Precast R.C.C. cover slab shall be provided for cable trench with necessary M.S. inserts for fixing trays and wall mounted brackets etc.

Effective rain water drainage system shall be done with proper roof water proofing treatment and rain water pipes. Alround drains shall also be provided along with slopped P.C.C. apron to clear off the surface run off.

6.5.9.5 Security Office

A security office in front of the main gate of the complex of size 3m x 3m shall be made of R.C.C framed structure with brick wall and all necessary finishes like IPS flooring, plastering, painting etc..

6.5.9.6 Enabling Facilities

Roads: A road network in and around different units of Terminal area, loading and unloading area near jetty and approach towards NH-7 of total length about 1500 m shall be provided. The same shall be of 7m wide of 1150m and of heavy

duty type. Necessary berms of 1.5 m wide on either sides of the approach road towards NH-7 shall also be provided. Four lane road for a length of 350m shall be provided.

6.5.9.7 Boundary wall

The entire units inside the terminal area shall be enclosed with boundary wall of height of 3m made of brickwork. The approximate length is 980 metres. Boundary wall is proposed to be made in Phase-I.

6.5.10 storage sheds / Ware houses

The ware houses and storage yard of the terminal will be mostly laid out on the shore terraces. With a view to optimisation of the terrace area rationally, they are mostly laid out in linear pattern parallel to the wharf frontage

The warehouse, storage yards, repair shops service and utility buildings are envisaged in the onshore area. Every means has been investigated to determine the best method of handling the specific incoming or outgoing material before placing it into storage. The design of storage facilities requires consideration of the various functions and the effect of material characteristics on each function. These functions include receiving, handling, storage, protection and reclaiming for either shipping or use.

The period of storage is crucial in deciding the storage area requirement. It is envisaged to keep storage space considering retention time of seven (7)days for all types of cargoes excepting bulk cargoes which are handled in bulk by mechanical means. For bulk cargo, depending on the nature and type of cargo

and intermodal connectivity out of the terminal. Storage period from 21 days to 40 days could be provided as per requirement.

The cargoes which needs protection from weather i.e. food grains, Fertilisers, cement etc will be stored inside the covered sheds. A structural covered shed of 30m X 12m X 6m has been envisaged in Phase – I which can be further extended by 30m X 12m X 6m in Phase II. The covered storage space will be of structural steel frame work, with abound brick walls, concrete flooring and necessary finishing such as floor finishing, plastering and painting etc. The floor of the covered sheds will be 150mm above the surrounding ground level and it will have platforms on either side to facilities loading and unloading directly to or from the trucks. A manually operated under slung crane of 3t capacity has been envisaged within the shed for handling of bags in fishnet along with 5t capacity battery operated fork lift truck..

6.5.11 Open storage

General and miscellaneous cargoes not effected by weather will be stored in open area. In Phase – I around 2500 t of cargo are planned to be kept in open storage. In phase – II with the increase in cargo volume additional area requirement for storing 2500 t of cargo has been envisaged. Area will be planned with adequate circulation area and road connection.

Two Nos. of storage yards of size 75m x 30m will be provided one each under Phase-I and Phase-II. The yards shall be made at an elevation of about 150mm from the road level. These will be made of well boulder soling well compacted sand to achieve proper compactness to withstand load of storage material. In addition, a layer of sand cement mortar (3:1) shall be laid to ensure that soling material does not come out.

The earthen sub-box earth below the loading shall be very well compacted as the nature of soil being soft near the river bank so as to stop any settlement under the heavy load placed on it. Ground improvement for an area of 6.0Ha, has been considered due to soft nature of oil so that consolidation takes place in due course.

6.5.12 Container storage yard

IWAI now intends to handle container cargo through the proposed terminal at Varanasi. In Phase – I around 32 numbers of containers with 600t of cargo are planned to be kept in open storage. In phase – II with the increase in cargo volume additional area requirement for another 16 number of containers storing 300t of cargo has been envisaged. Area will be planned with adequate area for movement and road connection.

Storage yards of size 60m x 30m will be provided under Phase-I and 60m x 15m under Phase-II. The yards shall be made at an elevation of about 150mm from the road level. These will be made of RCC / PCC flooring to withstand load of storage material.

6.5.13 Pipe lines

The water for the proposed terminal will be mainly for drinking and sanitary purpose. The drinking water shall be made available at an overhead tank. Drinking water front in over head tank shall be supplied to various consumer points of the terminal by means of drinking water piping network, complete with valves, fittings and appurtenances

The drinking water comprises of GI pipe network, valves, etc complete in all respects. The drinking water will be supplied at various office buildings, electrical sub station ,pump house and security offices. Service pipe lines approximately 200m length for drinking water from shore and other building shall be provided.

Service pipe lines for POL from shore (loading to barges) of approximately 220 m length with flexible hose for a length of 30m will be provided for loading to barges.

Pipe lines for edible oil approximately of 250 m lengths from Barges to shore with flexible hose for a length of 30m.

6.5.14 Classification of cargoes by storage facility type

An analysis of the various types of inflow and outflow likely cargo movement through the terminal is carried out and it is planned to provide storage facility for the cargoes as follows.

1). Inflow cargoes

Inflow cargoes are classified into the following four items

a. Cargoes which use transit sheds
b. Cargoes which use open storage yards
c. Cargoes which use transit sheds / open storage yards
d. Cargoes which are directly transferred to outside of the terminal

Major commodities of the above items are as follows

i. Cement, Sugar, Foodgrains
ii. Iron and steel, Machinery, Fertiliser / raw materials, stone, Marble, Limestone, coal

iii. Chemical, POL products

iv. Salt, Oil

The various volumes of the respective classified items are as follows

Item	Cargo Volume	Percentage	Remarks
i)	393750 t	38.60 %	Shed
ii)	343500 t	33.68 %	Yard
iii)	282750 t	27.72 %	Shed yard
Total	1020000 t	100 %	

6.5.15 Geotechnical investigation

Geotechnical investigation of the area to know the sub-soil characteristics, properties and strength has been carried out. Total 4 Nos. of boreholes in which two in the river bed and other two on the bank have been drilled for the purpose, in order to ascertain strength & deformation potential of soil. Generally hard clayey silty soil is encountered with SPT values in the range of about 38 – 60 at 4m below GL in the bank & about 48 at 15m below the bed level in the river. (Volume III - The Geo-technical investigation report by M/s Cengrs Geotechnica Pvt Ltd, New Delhi)

Type of foundation

Terminal structure is an open piled one supported on piles. This is a beam slab construction resting on piles or steel structural girder. Piles have to be taken to about –25m below the bed level. While planning piles due consideration has been given for scouring action of the river. In on shore all structures shall have open foundation.

CHAPTER – 7

SCHEME OF HANDLING AND DESIGN CRITERIA

7.0 SCHEME OF HANDLING AND DESIGN CRITERIA

7.1 General

Inland Waterways have always served as integrated transport facilities and centers of distribution in European countries, China etc. They serve as the interchange between land and river transport, and for the assembly and breaking down of commodities moved in bulk. Their need for good access was recognised by developers world over. Improvements in the road network have given priority to waterway access. Inland waterways facilities can be exploited to promote sustainable distribution objectives and the challenges we face specially on shifting freight from our roads. Inland waterways are important to this task. Efficient and forward – thinking Inland Waterway terminal will therefore play an important part in the success of integrated transport policy.

The government proposes a partnership approach working together with the industry at National, Regional and local level – and with other related interests. The partnership will be practical. The Government is already working with industry on a range of measures like tax holiday, incentives etc. Integrated transport network is an opportunity for Inland waterways. The aim of the Varanasi terminal will be to help the industry, user and consumer to make the best of this opportunity at national and regional level. Inland waterways are all important to the local community and they and local authorities working together will help each other.

Waterways have always had an important function for the economy and wealth. As existing witnesses of historical development and bearing in mind their indispensable function as drainage canals, it is necessary to make use of them as a cultural heritage with economic and ecological benefits. The waterways have to be developed sensibly now with clear prospects for the future. To become the life veins of the regions again and to be able to

contribute to the economic growth by creating jobs. Due to their prominent position, they can be brought in as catalysts and engines for a new boom.

7.2 Cargo handling

Optimisation and choice of appropriate cargo handling techniques is key to terminal design. A rational terminal design in the present day context necessarily has advanced handling techniques.

While planning cargo handling techniques due considerations need to be given to quantum of cargo, type of cargo, handling requirements, flow of cargo, variations in the water level in the river, extent of mechanisation for transportation to and from the terminal.

Cargo traffic whether inflow or outflow from / to the terminal will grow with development and there will be corresponding increase in barge / carriers. The capacity and dimensions of these are already discussed under chapter 5.0. Handling on National Waterway No.1 at present is mostly manual or semi mechanised.

There could be various types of handling equipment's which could be envisaged to handle each type of cargo i.e. whether it is bagged, containerised, unit loads, bulk, break bulk and POL products etc.

The cargo handling at the terminal has to be considered as a unified system and not in a piecemeal fashion, and it can not be really be divided into individual stages (from / to barge, at apron, between and storage area and loading / unloading to / from truck or trailer). The handling at each stage is only one step in the total handling system. If we hope to maintain high throughput at the terminal, the cargo passing through the terminal must flow smoothly.

7.2.1 Alternative – I: Use of structural girder with overhead crane for loading / unloading

Under this alternative, 2 no electric overhead travelling crane of 25/5t capacity and 15.0m span have been envisaged under Phase I on structural girders. The structural girder will be placed on piers with pile foundation as shown in Drg.no. MEC/11/17/Q079/01. It is noticed that high water level (Flood level) reaches at RL + 73.90m and low water level is RL +58.220m. The variation of water level is about 15m.

25/5t EOT crane with grab attachment will be used for loading and unloading of bulk cargo. The hook will be used for bagged and unit cargo. Handling of 20 feet containers would need separate spreader beam type attachment .The crane will unload the material from barge and load directly to the truck/trailer. It will be possible to lift or load the material from / onto the barge under any condition. For loading / unloading, the crane travel will be extended for a distance of 15m on the shore side as shown in the above drawing. The crane girder will have an overhang of 15m towards the river side so as to enable the crane from operating in that zone for lifting / loading at all levels of river Ganges (between high flood level +73.9m and low water level of 58.220m). The crane shall be able to load / unload cargo at the rate of average 275 tph considering the two EOT cranes. These two cranes in unison will be in a position to load / unload from the design vessel at a rate of average 275 tph. The extension of the girder and the travel of the crane towards the river have been kept as approximately 15m from the high bank so that the minimum depth available is 2.5m at all seasons. The extra depth provided to account for inaccuracies in sounding, any possibility of silting up and the under keel clearance.

MECON, IWAI and the barge operators had a meeting at IWAI Kolkata to assess the technical feasibility of this alternative. It was concluded that this alternative does not have problem in loading and unloading operation and the barges can be berthed alongside with suitable mooring facilities.

In order to minimize the impact of the barge to the proposed terminal vessel slowly comes to the berth and hit the fender. The complete mooring of the barge shall be finished by tying the ropes to the bollards and the mooring rings provided on the pier/ bank. Mooring rings are provided at four locations at three different levels.

RCC steps of adequate width shall be provided on the bank of the river for the movement of the crew and access to the vessel at three different locations. Suitable number of supply lines for water, fuel and electricity to the vessel and crane shall be envisaged. The lines shall be supported from crane girders / columns. Flexible pipes shall be used at the vessel area for smooth operation during different water levels.

Proposed structural steel girder supporting EOT crane of 25/5t capacity is resting on RCC piers with pile foundation. Entire supporting system consists of three deep piers resting on pile foundation & shallow foundations supported on piles. Deep piers are on 1200 dia piles and shallow foundations are on 600 dia piles. 1200 dia piles will be about 25 m long with full embedment the river bed. Length of the pile has been determined based on maximum scour depth at the jetty site. 600dia piles supporting shallow foundations are nearly of 20m length. This alternative apparently looks very neat and simple.

As already indicated in Chapter 6.0 ,to meet the above mentioned basic minimum operational requirement, it is proposed to construct all the three piers in Phase I itself under Alternative I. Accordingly cost of offshore works

considered under Alternative I includes all three piers, fenders, staircases, structural steel girder etc.

If the flow of bulk cargoes increase in future compared to the unitised or break bulk cargoes then loading by crane on to the belt conveyor system for transportation up to the open stockyard can be planned. Land level and road level shall be at RL +77.00m. Suitable parking space of the crane towards the shore side will be provided.

The embankment protection shall be provided for a total length of 150m with stone boulder pitching with cement pointing over well compacted granular soil in proper line and shape along the bank.

The scour depth details shall be based on soil investigation report prepared by M/s Cengers Geotechnical Pvt Ltd.

Merits

1. The scheme allows for loading and unloading operation through a common handling system and also facilitates use of the crane at any level of water in river Ganges
2. The scheme allows for direct loading and unloading into and from the barges by the overhead crane and there by minimises labour intensive manual work.
3. The crane can handle both unit loads and bulk volume cargoes.
4. Loading/unloading can be done for average 300 days per annum.

Demerits

1. Structural steel work will cause corrosion and needs to be maintained with proper painting periodically.

2. The system has a fixed handing capacity per annum with the crane envisaged. Any increase in traffic beyond the capacity will call for a duplication of this module by the side of this proposed structure.
3. The cargo handling capacity mainly dependent on cranes.
4. Operational difficulty in handling containers with cranes and add on attachments is envisaged.
5. During low tide the fenders have to be cleaned by high pressure water system.

Onshore facilities

Adequate onshore facilities have been envisaged to take care of storages of incoming and outgoing cargoes. The onshore facilities also include office building, electric substation, water sump, garages etc. The phase wise facilities envisaged are given below.

Phase I

1. Open storage area (30m x 75m)
2. Transit shed (structural) closed (30m x 12m)
3. Fencing
4. Office building and Electric substation (40m x 15m)
5. Check post (3m x 3m)
6. Overhead water tank
7. Service pipe lines
8. Container yard (60m x 30m)
9. Pump House (15m x 8m)
10. Necessary road work in the terminal area

Phase II

1. Open storage area (30m x 75m)
2. Transit shed (structural) closed (30m x 12m)
3. Office building – second floor
4. Boundary wall
5. Garage for parking of mobile cranes (18m X 12m)
6. Garage for parking of trucks (18m x 12m)
7. Diesel store
8. Maintenance shed (structural column, shed and side sheeting) 24m X 12m X 8m
9. Container yard (60m x 15m)

7.2.2 Alternative – II: Unloading / loading on proposed high level jetty with diaphragm wall

It is proposed to have a diaphragm wall in the front to be located in between low water level and high water level with top level of the jetty as +77.0m. Suitable gravel fill with earthwork / PCC works is proposed behind the diaphragm wall up to the shoreline (top bank). The proposed layout is shown in Drg. MEC/11/17/Q079//02.

Mobile crane of 25t capacity at 15m radius will be working on the platform to load the barges from the jetty and also to unload the barges from the jetty in Phase I. The total traffic handled by this mobile crane will be about 0.87mt. In order to take care of the balance 0.15mt of cargoes in Phase I a 6t mobile crane has been additionally envisaged. With the increase in traffic inflow / outflow additional one number of 25t capacity mobile cranes will be provided in Phase II. The top of the jetty will be of precast RCC slab. The top level of the jetty will be +77.0m and will be adequately designed to allow 2 numbers of mobile cranes operating simultaneously.

This proposal envisages a diaphragm wall of about 1200mm thickness with anchorage's and tie back. Diaphragm wall shall be taken down to below maximum scour depth needing the wall depth of about 45m from top. Intermittent tie beams shall be provided at an interval of 2.5m and shall be anchored to a continuous anchorage system. Tie beams are supported on two nos. 600 dia piles each. Piles are provided in between the diaphragm wall and anchorage blocks. On the back of the diaphragm wall back filling is done using sand gravel mixture of granular materials to ensure minimum thrust on the diaphragm wall. To protect granular fill from being removed due to flow of flood water both ends of the jetty shall be made to slope and protected with boulder pitching. This is not a very workable proposition from the point of view it works out costly due to high cost of construction of diaphragm wall and anchorage system.

Merits

1. The scheme allows for loading and unloading operation to be done by the same mobile crane at all levels of water in river Ganges.
2. Allows direct access of trucks on the jetty within the reach of the mobile crane.
3. The plane diaphragm wall with pre-stressed tie rod presents many advantages
   - Construction speed
   - Limited area required for the work
   - Possibility of with standing large vertical and horizontal loads
   - Great rigidity
   - Executions without soil bulk dozing.
   - Depth down to 50m
4. No dredging is necessary in area between diaphragm wall and shore line and in front of diaphragm wall.

Demerits

1. Possibility of siltation on the upstream of the terminal. However these could be studied for certain years before any action is initiated.
2. Diaphragm wall construction requires specialised and skilled contractors
3. Diaphragm wall needs to be built on land i.e. filling shall be done before construction of the diaphragm wall.
4. Limitations arise both from the wall itself and from the tie rods/ anchoring arrangement.
5. Operational difficulty in handling containers with cranes and add on attachments is envisaged.
6. Highly heterogeneous ground with a disturbed stratigraphy or quite freshly worked soil will not make easy the wall construction.
7. During low tide the fenders have to be cleaned by high pressure water system.

Onshore facilities

Adequate onshore facilities have been envisaged to take care of storages of incoming and outgoing cargoes. The onshore facilities also include office building, electric substation, water sump, garages etc. The phase wise facilities envisaged are given below.

Phase I

1. Open storage area (30mx75m)
2. Transit shed (structural) closed (30mx12m)
3. Boundary wall and fencing
4. Office building and Electric substation (40mx 15m)
5. Check post (3m x 3m)

6. Garage for parking of mobile cranes (18m X 12m)
7. Service pipe lines
8. Container yard (60m x 30m)
9. Overhead water tank
10. Pump House (15m x 8m)
11. Necessary road work in the terminal area

Phase II

1. Open storage area (30mx75m)
2. Transit shed (structural) closed (30mx12m)
3. Office building – second floor
4. Garage for parking of trucks (18m X 12m)
5. Maintenance shed (structural column, shed and side sheeting) 24mX 12m X 8m .
6. Diesel storage
7. Container yard (60m x 15m)

7.2.3 Alternative – III: Mechanised unloading / loading on proposed high level jetty

In this alternative it is proposed to construct the approach way of length 5.0m and width of 7.5m with T shaped jetty of 15m width and length of 38m at RL of +77.0m. The jetty face will be 20m from the bank. 1 no. Mobile crane of 25t capacity at 15m radius is envisaged to load the barges from the jetty and also unload the barges from the jetty in Phase I in combination with 6t mobile crane as in Alternative II. The proposed layout is shown in Drg. MEC/11/17/Q079/03. This alternative is a beam slab construction resting on piles. Total 25 nos. of 1500mm dia piles has been envisaged. Lengths of the piles are approximately 45m in view of the maximum scour depth. A frame work of beams and piles with precast / RCC slabs will be made for decking.

This is a very simple system with no extra work apart from bank protection, for a total length of 150m on either side of the jetty. Since a substantial length of pile at top will be unsupported, horizontal system of bracing may have to be used to reduce buckling and resulting moment in pile.

Merits

1. It will be possible to bring in direct trucks on the jetty at +78.0m level for loading and unloading operation.
2. Loading/unloading can be done for an average 300 Days per annum.
3. Future expansion of the berth is possible and economic if traffic increases and to accommodate two barges simultaneously.
4. Indian contractors are acquainted with this method of construction.
5. Allows free flow of river water.

Demerits

1. Lift of the cargo is more during lean season. It may be difficult in operation during this period.
2. Operational difficulty in handling containers with cranes and add on attachments is envisaged.
3. Entire length of the berth and beyond stone pitching will be required which performs dual function of retaining backfill earth and scour protection.
4. During low tide the fenders have to be cleaned by high pressure water system.

Onshore facilities

Adequate onshore facilities have been envisaged to take care of storages of incoming and outgoing cargoes. The onshore facilities also include office

building, electric substation, water sump, garages etc. The phase wise facilities envisaged are given below.

Phase I

1. Open storage area (30mx75m)
2. Transit shed (structural) closed (30mx12m)
3. Boundary wall and fencing
4. Office building and Electric substation (40mx 15m)
5. Check post (3m x 3m)
6. Garage for parking of mobile cranes (18m X 12m)
7. Service pipe lines
8. Container yard (60m x 30m)
9. Pump House (15m x 8m)
10. Overhead water tank
11. Necessary road work in the terminal area

Phase II

1. Open storage area (30mx75m)
2. Transit shed (structural) closed (30mx12m)
3. Diesel storage (15mx9m)
4. Office building – second floor
5. Garage for parking of trucks (18m X 12m)
6. Maintenance shed (structural column, shed and side sheeting) 24mX 12m X 8m
8. Diesel storage
9. Container yard (60m x 15m)

7.3 Evaluation of alternatives

The alternative wharf structures developed in the preliminary design are functionally adequate to meet the requirement of the terminal for loading and unlading facility for the inflow/outflow cargoes. In order to select the preferred alternative, the main characteristics of these structures are summarised and evaluated in subsequent paras. After evaluation and considering the results of the cost estimated, the preferred construction type is recommended.

7.3.1 Main characteristics of alternative structures

Diaphragm wall

This type of structure is probably most significant innovations in the construction of terminals in recent years. Diaphragm wall technique has become a conventional approach to construction of terminals, water proof bulkheads etc. But as a permanent part of riverine works it is still rather new.

The reasons are

- Marine conditions are corrosive
- Engineers have to choose between –piling(bored or driven type) sheet piling and diaphragm walling.
- Diaphragm wall needs to be built on land before dredging.

For riverine works, designed to with stand a given height of water table behind the bulk head, special attention must be paid to the joint water proofness, entailing further precautions.

Construction of the diaphragm wall is briefly enumerated below.

A trench to the required depth is first excavated by a specially developed grab operated from a standard crane by means of a purpose designed attachment including a Kelly bar and Kelly bar guide. The use of Kelly bar ensures correct alignment and verticality of construction.

During excavation the trench is kept filled with bentonite suspension which stabilises the trench walls are preventing caving in. Bentonite suspension is mixed on site and into the excavation as digging proceeds. Density and viscosity are carefully checked during excavation and concreting. The guide walls usually 600 to 900 mm deep or more, depending on ground conditions are constructed before excavation begins and also serve as top retaining walls or trench collars.

Reinforcement is made up on site and formed into three dimensional cages for each panel. The cage is positively located in the trench, spacers being used to ensure accurate centering and cover blocks fixed to ensure adequate concrete cover. Since the film of bentonite on the steel is removed by mechanical contact with the concrete and reinforcement is completely encased by concrete. Large cages are usually spotted welded to maintain their shape during handling and placing.

Before concreting takes place a steel stop end pipe is placed in position at one end of the trench and this acts as a form of shutter. In certain cases pipes are placed at both ends of the trench. The pipe is subsequently removed when concrete has partially cured leaving a semicircular joint between panels. Concrete is poured through a tremie pipe in a continuous operation, the mix being designed to flow easily and with out any tendency to segregate. The slump is usually 180mm to 200mm to allow adequate fluidity. Rate of concreting shall be usually 15 to 23m3 per hour. The bentonite slurry being displaced and the excess stored for treatment prior to reuse or disposal.

Deck on cast-in-situ concrete bored piles

This type of structure is widely used around the world and is well known construction practice in India.

Installation of cast in situ bored piles of about 1500mm diameter shall be done. Following different methods of advancing, the bore hole is commonly made using either of the following methods.

1. Chisel and bailer method
2. DMC (Direct mud circulation)/RMC (Reverse mud circulation) method
3. Rotary drill
4. Continues flight auger

In all the above methods and cleaning of bore holes is most important. DMC method of construction of cast in situ bored piling using bentonite slurry is given below.

1. Initial boring shall be done for about 1.5 to 2 m using bailer. Temporary guide casing shall then be lowered down the bore hole. Dia of cutting tool / chisel shall be 7 to 8cm less than the outside dia of casing / guide pipe. The out side dia of casing / guide pipe for each size of pile will be the same as nominal shaft dia of pile. Working level / ground level shall be minimum 1.5m above water level / high tide level.
2. The centre line of the guide casing shall be checked with respect to the reference points before continuing further boring.
3. Bore hole is then filled with bentonite slurry fed from bentonite installation. Specification for bentonite and bentonite slurry are as under:

a) Bentonite power used in the process should be tested for its Liquid Limit (LL) of more than 300 %, sand content in bentonite slurry should not be more than 7 %.

b) Bentonite slurry should be made by mixing it with fresh water using pump for circulation. The specific gravity of solution shall be 1.05 to 1.1 depending on site condition. The viscosity as tested by marsh cone should be approximately 35secs.

4. Further boring is done with the use of DMC chisel upto the founding strata.
5. Bentonite slurry is pumped by high pressure reciprocating pumps / vertical pumps into the boreholes through the cutting tool and the same is allowed to over flow the bore hole. Material, which comes out along with the bentonite slurry, is passed through channels and is collected in a sediment tank where sediments settle and bentonite can be reused. If necessary bentonite may be passed through the disander to remove sand particles before it is reused.
6. After founding strata is reached, the bore is flushed by bentonite slurry for about 15 mins with DMC chisel. Pumping for flushing is done by use of mud circulation. Pump. During flushing, the chisel is kept resting on the founding strata to remove all the loose sediments which might have accumulated on the founding strata. The DMC chisel and connecting rods are removed from the bore hole thereafter.
7. Reinforcement bars may be tack welded to rings to provide more rigidity to the cage. Roller cover blocks may be provided to the cage at approximately 2m interval and suitably staggered.
8. Reinforcement cage in suitable lengths is lowered then and bore shall be flushed once again by bentonite slurry through tremie to ensure that bottom is cleaned after placing the reinforcement.
9. Concreting is to be done by tremie method as per clause 6.3.3 of IS 2911 – 1979 tremie dia being 200mm. Concrete mix should have a slump of about 150mm to 180mm and maximum aggregate size shall not exceed 20-25mm.
10. Before pouring concrete through tremie, bottom of concreting funnel shall be closed with a steel plate. After the funnel is filled with concrete plate, is removed and first load of concrete is discharged. There after concreting is done in a continuos manner. It should always be ensured that the bottom of

tremie pipe is minimum 2m within concrete to avoid mixing of fresh concrete with bentonite slurry.

Concrete shall be filled approximately 600 to 900 mm above cut off level of pile so that good concrete will be available at the cut off level. In case cutoff level of pile is same as top of guide casing the concrete shall be allowed to overflow till good concrete is visible. After concreting upto required level is done guide casing is withdrawn.

7.4 Recommended alternative

Considering all the above discussions on different type of terminal structure. We have analysed three different alternatives

Alternative I - Piled structure with pier works
(Ref. Drg. no. MEC/11/17/Q079/01)

Alternative II - Diaphragm wall on the front side with intermediate piles
(Ref. Drg. no. MEC/11/17/Q079/02)

Alternative III - Open pile type berthing structure.
(Ref. Drg. no. MEC/11/17/Q079/03)

On analysis of the various alternatives considering construction speed, area required for the work, possibility of withstanding large vertical and horizontal loads, depth down to 50m, stone pitching requirements, Construction flexibility and construction cost the recommended alternative is alternative –I (Drg. no. MEC/11/17/Q079/01)

7.5 Design Criteria for Terminal Structures

7.5.1 Introduction

In this chapter describes the design criteria for Terminal structures.

7.5.2 Civil/ Structural Design Criteria

The following load and/ or load combinations shall be used in the design of the facilities:

i) Berthing impact from barges

ii) Mooring loads

iii) Self weight on account of loading / unloading equipment

iv) Self weight of jetty structure

v) Vehicular loads.

vi) Wind load and Seismic loads

vii) Earth pressure and surcharge load

viii) Secondary stresses due to shrinkage, creep, temperature etc.

7.5.2.1 Permanent load and dead load

Dead load comprises the self-weight of the structure with specific weight of the concrete as 25 KN/m^3 plus superimposed loads of a permanent nature as in Alt II and Alt III. In Alt I the load transferred from the structural girder and crane on the piles will be considered.

7.5.2.2 Live load

A uniformly distributed load of 30kN/m^2 on open deck areas of the jetty shall be used for Alt II and Alt III.

7.5.2.3 Wind loads

Design wind speed shall be calculated as per IS:875-1987 (part 3). Wind forces for the structure as a whole shall be determined with due consideration for wind shielding, shape co-efficient and variation of wind velocity with height. For operational conditions, a basic wind speed of 47 m/sec shall be considered.

As per IS 875 –1987 (part3) definition of basic wind speed shall be peak gust velocity average over 3 sec time interval at 10m height above mean ground level with 50 years mean return period.

7.5.2.4 Current loads

The currents in Ganges at Varanasi are mainly influenced by the general weather climate. Minimum current velocity as observed / analysed from past data is 0.2m/sec and the maximum current velocity is 3.5 m/sec. The current velocity for the design considered that as 3.5 m/sec. The current force on barges is 16.0t considering the design current velocity. However this current force is transferred to terminal structure as an additional mooring force.

7.5.2.4 Temperature load

The temperature variation of ± 20° C between super-structure and sub-structure with reference to the temperature at the time of the construction shall be considered. A linear temperature difference between top and bottom of deck of 10° C shall be considered.

7.5.2.6 Seismic load & Earthquake Resistant Design

Varanasi is located in the seismic zone – III as per IS 1893-2002. Seismic analysis shall be carried out based on the stipulations of structures in zone – III. The design of the structures shall be in accordance with the requirements of the said standard. The design seismic shear, V_B is given by the following equation.

$V_B = A_h W$

Where A_h = Design horizontal acceleration spectrum.

$A_h = ZI S_a W / 2 R g$

Z = Zone factor

I = Importance factor

R = Response reduction factor

S_a / g = Average response acceleration coeff.

W = Seismic weight of the structure

Whenever earthquake forces are considered along with other design loading, the following load combination shall be adopted in the design for strength criteria in limit state of collapse.

U = 1.2 (DL+IL ± EL), 1.5 (DL+IL), 1.5 (DL ± EL), 1.9 DL ± 1.5 EL

DL = Dead Load of structure

IL = The imposed load on the structure considering its modified values as specified in IS 1983 - 2002

EL = The value of earthquake load adopted for design.

U = Ultimate limiting design load

7.5.2.7 Berthing Energy

The berthing energy of barges shall be calculated based on provisions of IS 4651 (Part-III) – 1974 (Reaffirmed in 1997) and 14238 - 1995, according to the barge characteristics of 750 DWT. The berthing transverse approach velocity, during berthing is 0.45 m/sec (max allowable) consequently, the berthing energy works out to 8.0 t-m.

Fenders shall be designed for the most critical berthing energy of the laden vessels to be handled at the jetty. Fenders have to be checked for forces from the vessel on account of wind, wave and current forces when the vessel is moored along side the berth. Friction forces shall be taken into account in accordance with the selected fender system.

7.5.2.8 Mooring loads.

The mooring forces shall be calculated based on provisions of IS: 4651 (Part-III). These forces can also be selected as per the recommendations of BS 6349.

Calculated mooring force is 20t. By considering the current force on the barge total pull is equal to 36t.

7.5.2.9 Construction loads

Construction loads shall be taken as per norms.

7.5.3 Material of Construction

7.5.3.1 Concrete

The reinforced concrete in foundations and super structure for onshore units shall be of M-25 grade using Portland slag cement conforming to IS:455-1989. However for all offshore structures the grade of RCC shall be M-30. All materials for plain / RCC works shall be of high quality conforming to Indian Standards with respect to cement content, admixture, water cement ratio and slump etc. Design mix shall be adopted for getting correct proportion of ingredients.

Coarse and fine aggregates for concrete shall conform to IS:383 ("Specification of coarse and fine aggregates from Natural sources for concrete"). They shall be chemically inert, hard strong, dense, durable, clean and free from veins, adherent coating and shall be of limited porosity. Coarse aggregates shall be generally retained on 4.75 mm IS sieves. Fine aggregate normally shall pass through 4.75 mm sieve but not more than 10% will pass through 150 micron IS sieve. These shall comply with the requirements of grading zones I, II and III as given in Table –III of IS: 383-1970.

Water used for concrete shall be clear and free from injurious amounts of oil, acid, alkali, organic maters or other harmful substances, which may impair the strength, and durability of concrete. Potable water shall generally be considered satisfactory for mixing and curing concrete with maximum chloride of 600mg/litre and sulphate content of 500 mg/litre.

7.5.3.2 Reinforcement bars

Generally high strength deformed bars of minimum grade Fe415 conforming to IS1786-1985 shall be used. However TMT bars of grade Fe 500 & Fe 550 may also be used having percentage elongation 14.5%.

Cover to reinforcement shall be provided as follows:

Nominal clear cover to outer reinforcement shall not be as per IS provisions for reinforced concrete structures exposed to environmental hazard. Clear cover to offshore structure piles shall be 75mm. Welding of reinforcement shall be done in accordance with the recommendations of IS: 2751-1979.

7.5.3.3 Steel

General

Steel Structural work will cover all building structures viz. columns, roof structures ,wall structures ,crane girders ,crane rails ,platforms ,monorails ,flood light towers ,ladders ,staircases ,handrails ,etc. for handling of cargoes from the barge and their storage. The work also include CGI sheeting for roofing and side cladding in different areas as required. Total structural work shall be complete in all respects for proper functioning of plant and equipment.

Design parameters

Steel Structures will be designed as per IS: 800-1984 or any latest relevant international standards and codes of practices.

Loading will be taken as per IS:875-(parts 1,2,3 and 5)-1987 in addition to the technological loads indicated by the equipment manufacturer/supplier.

For design of towers IS802(part1/sec1),1995 and (part1/sec2),1992 shall be adopted.

Materials

The material for structures to be designed shall be as follows:

a) All steel rolled sections and plates will conform to IS 2062-1992.
b) Crane rails will conform to IS-3443-1980
c) CGI sheet will conform IS-277-1992

Method of construction

Steel Structures to be fabricated will generally be of welded construction. Covered electrodes will conform to IS:814-1991.Elements will be fabricated in largest possible dimensions optimal with the transport requirement so as to minimize site work. Site connection will be either by permanent bolts or by erection bolts followed by site welding.

Fabrication

Fabrication of structures will conform to IS:800-1984 and other relevant standards mentioned therein. Appropriate sequence and procedure of welding will be followed during fabrication of structures so that distortions/deviations in the fabricated structures are kept to a minimum.

Inspection

All structures will be offered for inspection. Material Certificate for the fabricated structures will also be provided.

Erection

Erection will be carried out as per applicable standards , drawings , specifications and regulations. The erection tolerance will be within the standard specified limits.

Painting

All steel structures will receive one coat of Red Oxide zinc chromate primer of 40 microns dft per coat after surface preparation to grade ST2 as per Swedish Standard SIS 055900. Subsequently 2 coats of synthetic enamel / aluminum finish paint of 30 micron dft per coat will be applied.

Codes & Standards (latest) will be used in the design, engineering, constructing.

7.6 Bill of Quantities

Bill of Quantities of all the three alternatives are enclosed as Appendix - A

ANNEXURE - A

BOQ Details - Offshore Facilities

Sl	Items	Unit	Alt-I		Alt-II		Alt-III	
			BOQ / Vol. of Work		BOQ / Vol. of Work		BOQ / Vol. of Work	
			Ph-I	Ph-II	Ph-I	Ph-II	Ph-I	Ph-II
A	Material Handling Equipment							
1	25 t x 15 m EOT crane	no	1.00	1.00	0.00	0.00	0.00	0.00
3	25t capacity at 15m radius mobile crane	no	0.00	0.00	1.00	1.00	1.00	1.00
	Sub-total (A)							
B	Structural Work							
1	Crane girder for 25 t EOT crane							
	- Steel structure	t	420.00	0.00	0.00	0.00	0.00	0.00
	- CGI sheeting	m^2	200.00	0.00	0.00	0.00	0.00	0.00
C	Civil Engineering Work for Offshore Facilities							
1	RCC (M 30)	m^3	1860.00	0.00	250.00	0.00	800.00	0.00
2	1200 mm dia. x 25 m long piles (M 35 grade)	no	30.00	0.00	0.00	0.00	0.00	0.00
3	600 mm dia. x 20 m long piles (M 35 grade)	no	26.00	0.00	40.00	0.00	0.00	0.00
4	1500 mm dia. x 45 m long piles (M 35 grade)	no	0.00	0.00	0.00	0.00	25.00	0.00
5	Shore protection	m	150.00	0.00	0.00	0.00	150.00	0.00
6	RCC (M 30) for diaphragm wall 1200 mm thick	m^3	0.00	0.00	2500.00	0.00	0.00	0.00
7	Earthwork for filling	m^3	0.00	0.00	21000.00	0.00	0.00	0.00
8	15 t Bollards	nos	0.00	0.00	4.00	0.00	4.00	0.00
9	Fender	set	3.00	0.00	5.00	0.00	5.00	0.00
10	Dredging	cu m	0.00	0.00	5000.00	0.00	0.00	0.00

BOQ Details - Onshore Facilities (Common for Alt-I, II & III)

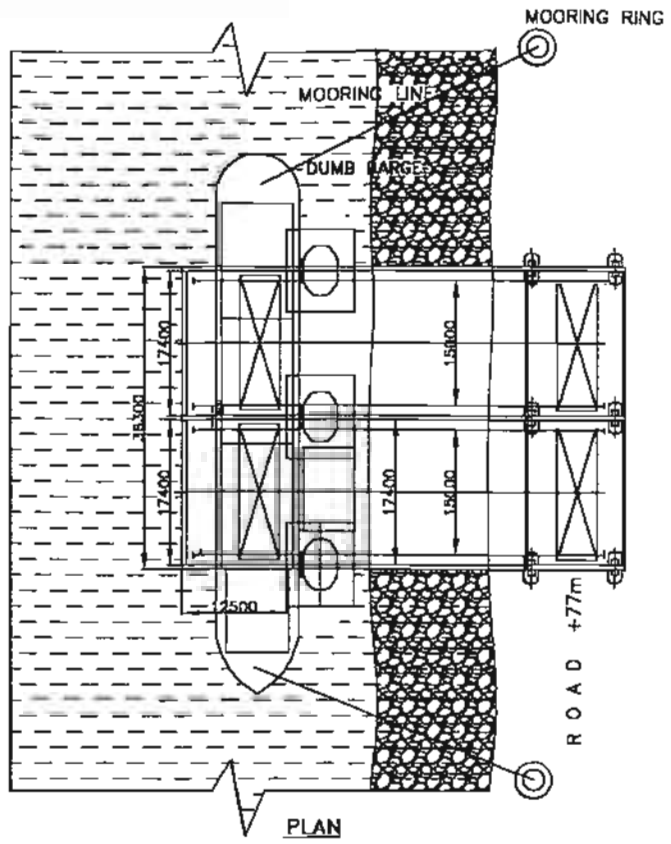
Sl	Items	Unit	BOQ / Vol. of Work	
			Ph-I	Ph-II
A	Material Handling Equipment			
1	5t battery op. fork lift truck in closed storage	nos	1.00	1.00
2	Underslung crane in closed storage - 3t x 12m	nos	1.00	0.00
3	6t x 6m radius mobile tyre mounted crane for loading/unloading from open & closed storage	nos	1.00	1.00
B	Electrical items			
1	250kV Dry Type Transformer	No	1	0.00
2	6.6kV HT Isolator	No	1	0.00
3	PMCC consisting of 5 panels (Multitier configration)	Set	1	0.00
4	MCCB - 250 Amp. (Column mounted)	No	2	0.00
5	Illumination	Lot	1	0.00
6	Cables	Km	5	0.00
7	Earthing system	Lot	1	0.00
8	Erection Materials	Lot	1	0.00
C	Fire Fighting System			
1	4.5 kg CO_2 type fire extinguishers	no	10.00	8.00
2	5 kg DCP type fire extinguishers	no	6.00	2.00
3	Water hydrant system :			
	- Hydrants	no	7.00	7.00
	- Water monitor	no	2.00	2.00
	- Discharge water from hydrant, 600-900 lpm			
4	- Fire fighting pumps, 144 cumph	no	2.00	2.00
	2 nos (1 electric + 1 diesel)			
	- Jockey pumps, 10 cumph	no	2.00	2.00
	2 nos (1 main + 1 standby)			
D	Maintenance Workshop Equipment			
1	Welding set	no	1.00	-
2	Lathe	no	1.00	-
3	Pedestal grinder	no	1.00	-
4	Hand tools	lot	1.00	-
E	Air conditioners	nos	2.00	-
	Water coolers	nos	1.00	
F	Telecommunication / Telephone Sets	nos	3.00	-
G	Structural Work			
1	Transit Shed			
	- Steel structure	t	36.00	36.00
	- CGI sheeting	m^2	1327.00	1327.00

Sl	Items	Unit	BOQ / Vol. of Work	
			Ph-I	Ph-II
2	Maintenance Shed			
	- Steel structure	t	0.00	20.00
	- CGI sheeting	m^2	0.00	680.00
3	Diesel Store			
	- Steel structure	t	0.00	7.00
	- CGI sheeting	m^2	0.00	150.00
4	Garage for repairing trucks			
	- Steel structure	t	0.00	25.00
	- CGI sheeting	m^2	0.00	200.00
5	Flood light towers	t	4.50	4.50
H	Civil Engineering Work for Onshore Facilities			
1	Office building			
	RCC (M - 25)	m^3	300.00	200.00
	RCC (M - 20)	m^3	100.00	0.00
2	Security post			
	RCC (M - 25)	m^3	15.00	
3	Maintenance shed			
	RCC (M - 25)	m^3	0.00	80.00
	RCC (M - 20)	m^3	0.00	50.00
4	Transit shed			
	RCC (M - 25)	m^3	100.00	100.00
	RCC (M - 20)	m^3	60.00	60.00
5	Diesel shed			
	RCC (M - 25)	m^3	0.00	75.00
	RCC (M - 20)	m^3	0.00	20.00
6	Garage			
	RCC (M - 25)	m^3	0.00	135.00
	RCC (M - 20)	m^3	0.00	40.00
7	Pump house			
	RCC (M - 25)	m^3	130.00	0.00
	RCC (M - 20)	m^3	20.00	0.00
8	Overhead tank			
	RCC (M - 25)	m^3	50.00	0.00
9	Container storage area			

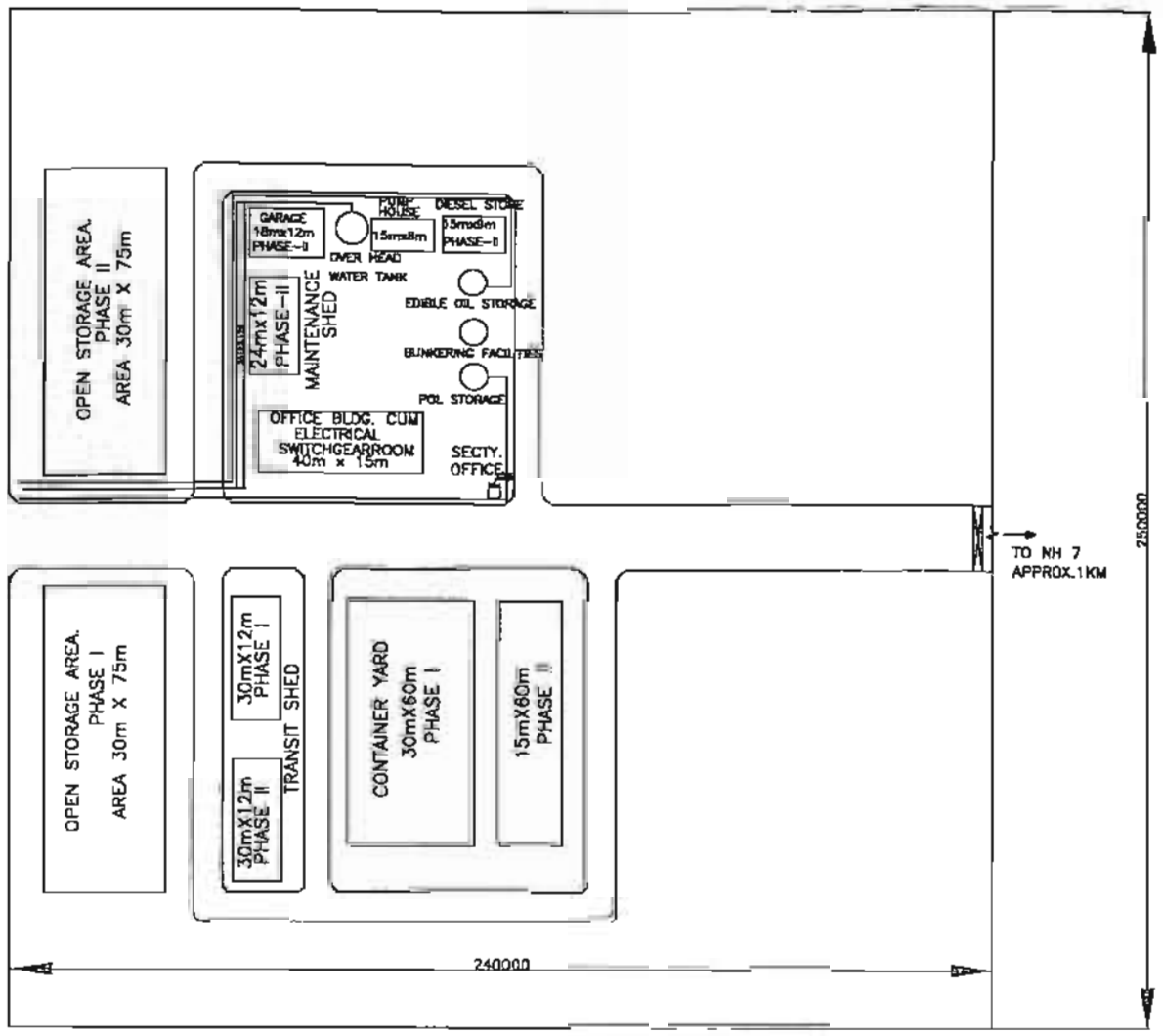
Sl	Items	Unit	BOQ / Vol. of Work	
			Ph-I	Ph-II
	PCC paved area	sqm	1800.00	900.00
10	Open storage			
	PCC paved area	sqm	2250.00	2250.00
11	Boundary wall	met	980.00	0.00
12	Septic tank	no	2.00	0.00
13	Storm water drainage open drains			
	RCC open drains (300 X 350)	m	550.00	0.00
	RCC open drains (600 X 800)	m	500.00	0.00
14	Pipe culverts			
	300 dia x 15m long	nos	2.00	0.00
	400 dia x 25m long	nos	4.00	0.00
15	RCC culvert	nos	1.00	0.00
16	Pedestal for pipe supports			
	PCC (M-20)	m3	50.00	0.00
17	Road inside complex	sqm	13650.00	0.00
18	Ground improvement	hec	6.00	0.00
I	Water supply facilities			
1	GI pipe DN 50mm (60.8 x 4.5)	rm	50.00	50.00
2	GI pipe DN 40mm (48.8 x 4.0)	rm	100.00	50.00
3	GI pipe DN 32mm (42.9 x 4.0)	rm	50.00	50.00
4	GI pipe DN 25mm (34.2 x 4.0)	rm	50.00	50.00
5	GI pipe DN 15mm (21.8 x 3.2)	rm	50.00	50.00
6	Gate valve DN 50 mm	nos	5.00	5.00
7	Globe valve DN 40 mm	nos	5.00	3.00
8	Globe valve DN 32 mm	nos	2.00	2.00
9	Globe valve DN 25 mm	nos	2.00	2.00
10	Globe valve DN 15 mm	nos	10.00	10.00
11	Float valve DN 25 mm	nos	1.00	0.00
12	Valve pit	nos	5.00	5.00
13	Supporting structure	ton	2.00	2.00
J	Pipe line for edible oil	rm	250.00	0.00
	Flexible hose	rm	30.00	0.00
K	Pipe line for POL oil	rm	220.00	0.00
	Flexible hose	rm	30.00	0.00

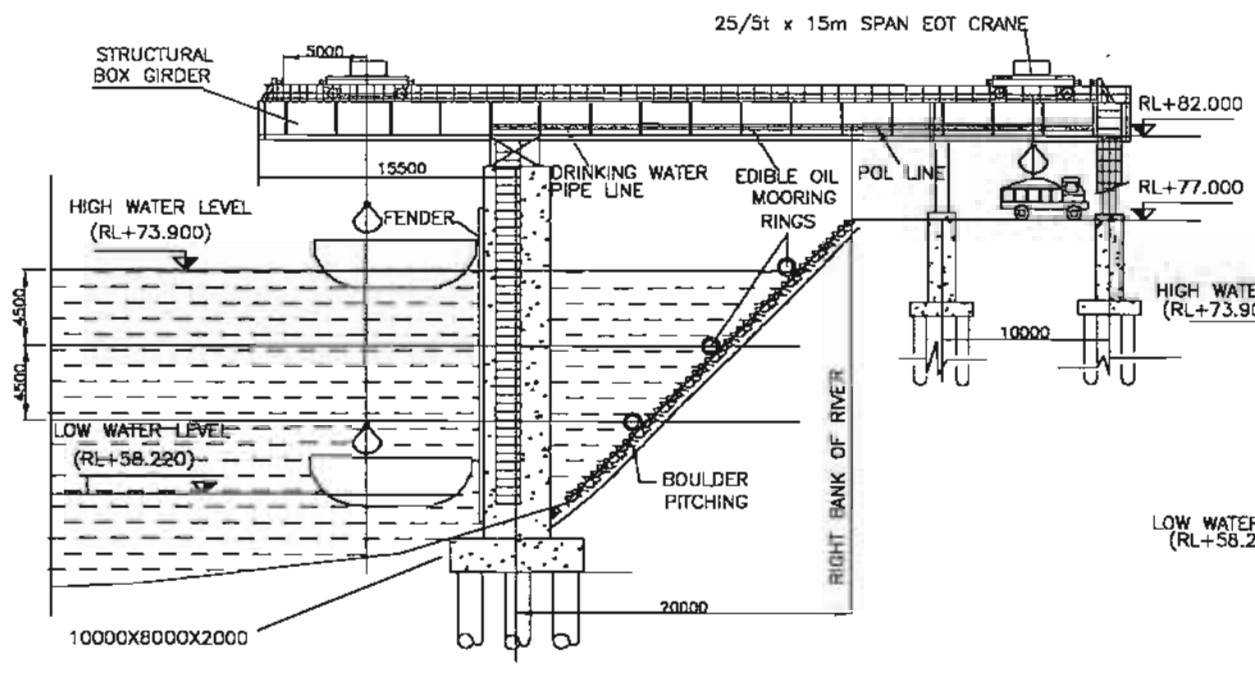
Note : Excludes pumps for drinking water, edible oil and POL etc

DRG.No.MEC/11/17/0079/01

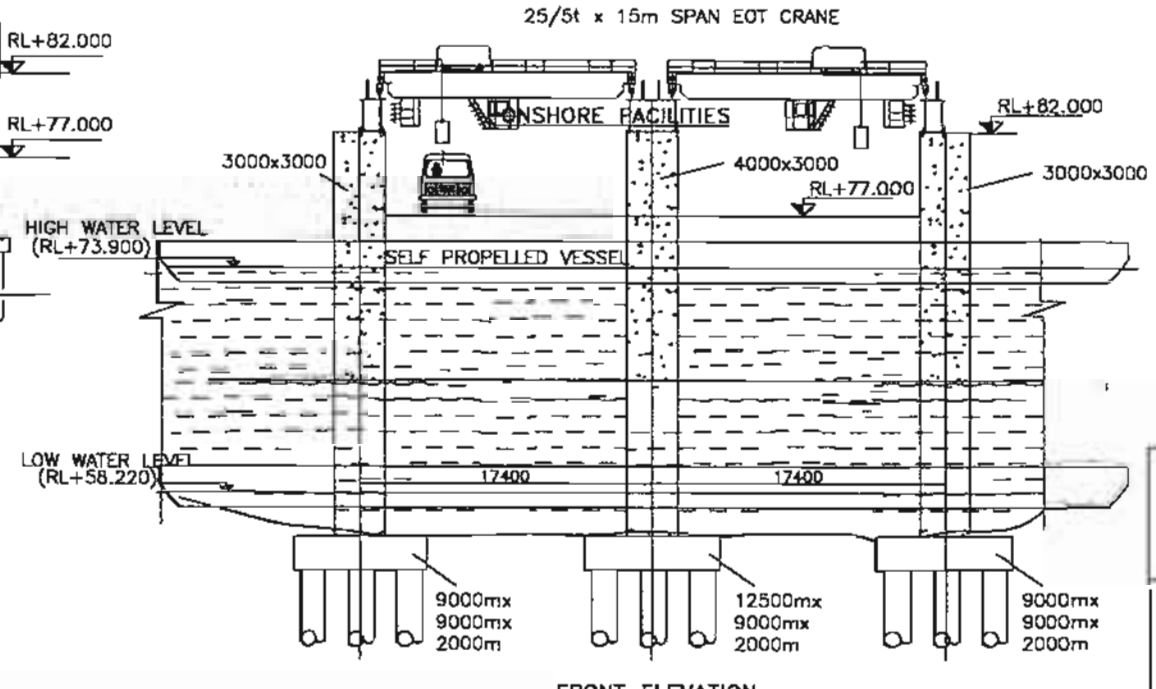


PLAN





ELEVATION



FRONT ELEVATION

NOTES :

1. ALL DIMENSIONS ARE IN mm & LEVELS ARE IN m.

REV. NO.	DATE	ZONE	DESCRIPTION	BY	VERIFIED
			REVISIONS		

REFERENCES — DRG. NO.

REV/SEC — CONCURRED BY

INLAND WATERWAYS AUTHORITY OF INDIA
MINISTRY OF SHIPPING
GOVT. OF INDIA

मेकन लिमिटेड

MECON LIMITED

SECTION	MAT. HAND
LOCATION	RANCHI
DESIGNED	GLN
DRAWN	GLN
CHECKED AND VERIFIED	
APPROVED	SIG.
	DATE

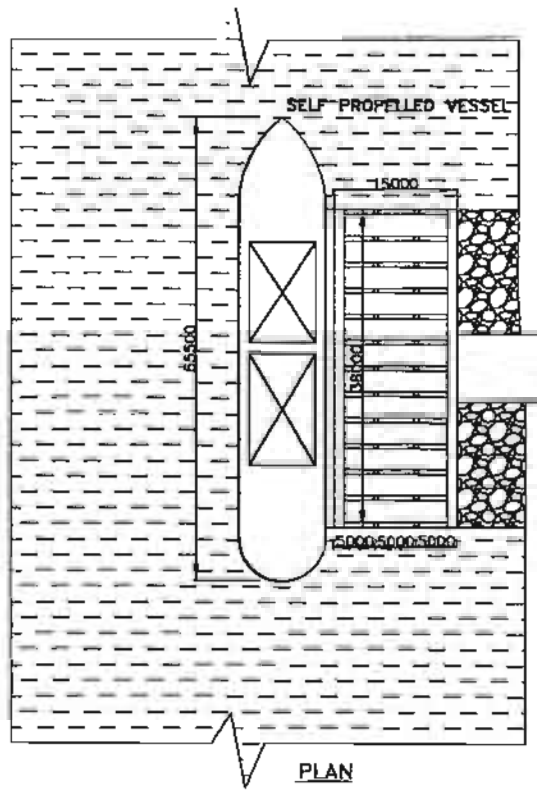
INTERMODAL TERMINAL, VARANASI

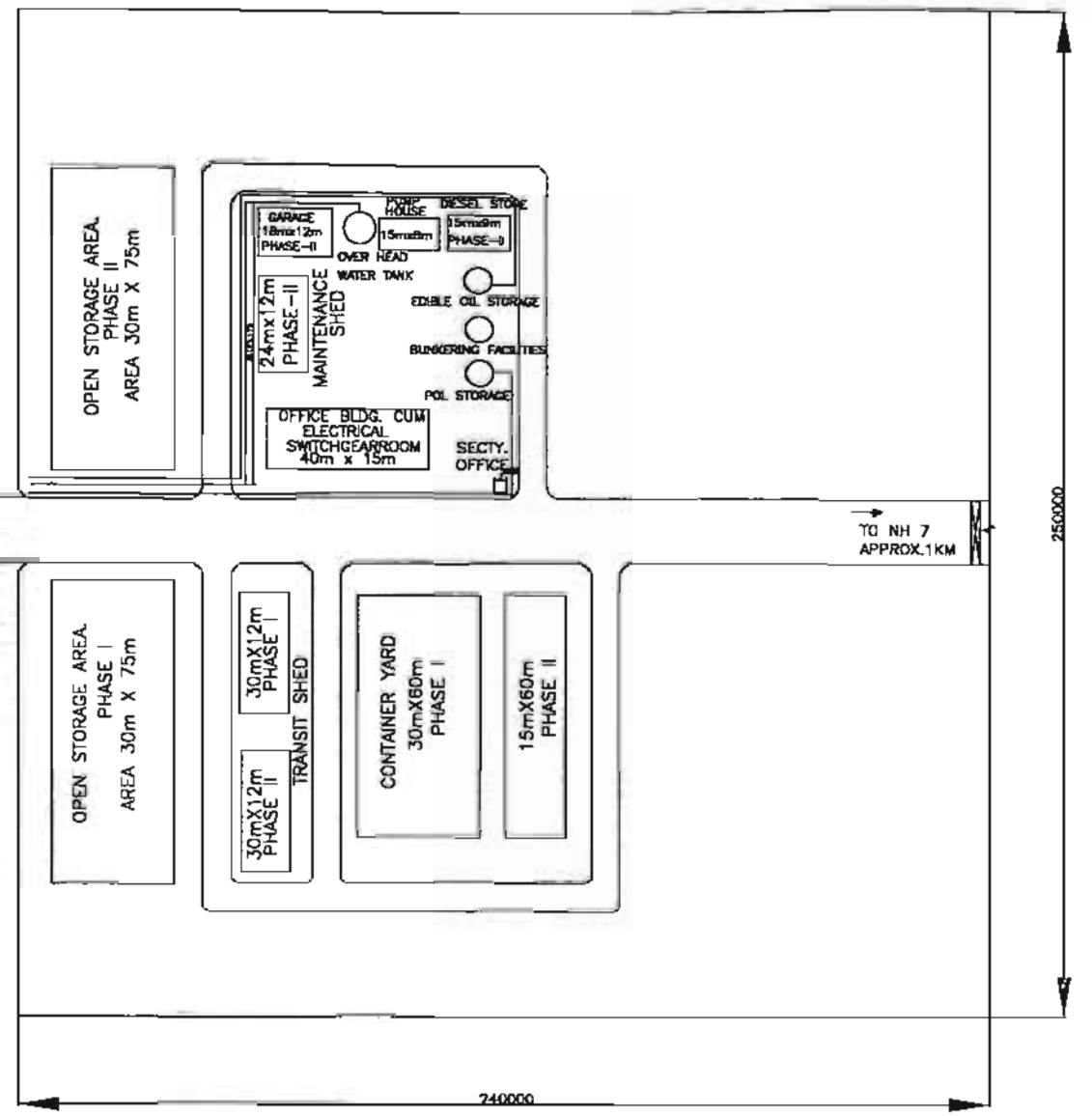
LOADING / UNLOADING SYSTEM WITH E.O.T. CRANE ON STRUCTURAL GIRDER ALT. – I

SCALE – AS SHOWN | SHEET 1 OF 1 | REV 0

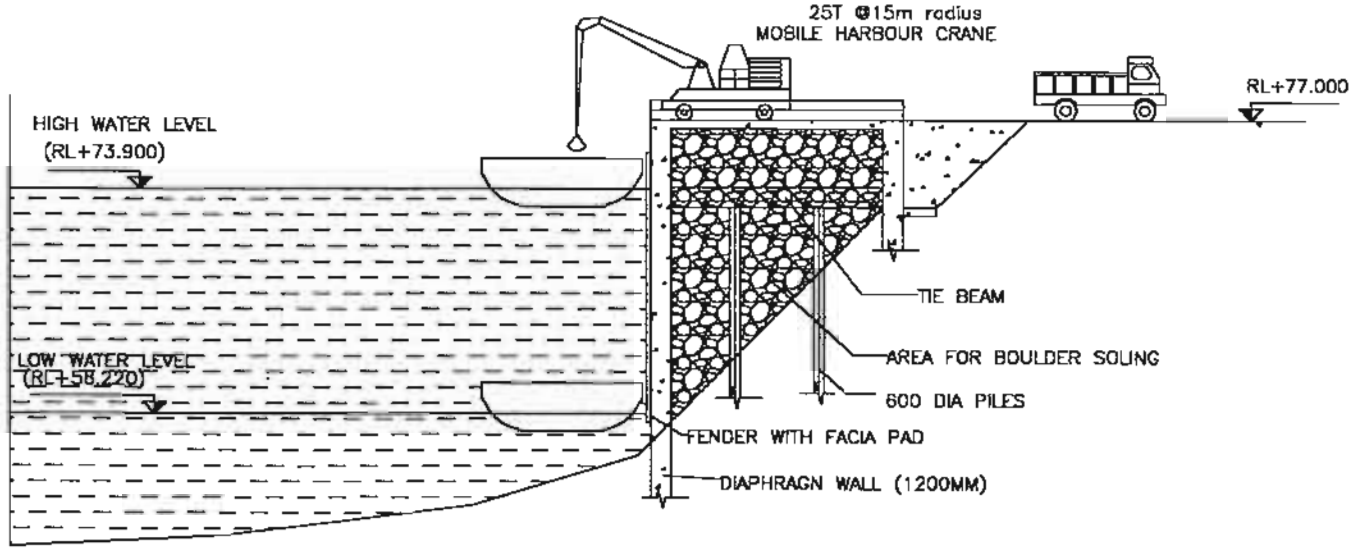
DRG.No.MEC/11/17/0079/01

DRG.No.MEC/11/17/0079/02





ONSHORE FACILITIES



ELEVATION

NOTES :

1. ALL DIMENSIONS ARE IN mm & LEVELS ARE IN m.

REV./SEC						

CONCURRED BY

REV.NO.	DATE	ZONE	DESCRIPTION	BY	VERIFIED

REVISIONS

REFERENCES — DRG. NO.

IWAI

INLAND WATERWAYS AUTHORITY OF INDIA
MINISTRY OF SHIPPING
GOVT. OF INDIA

मेकन लिमिटेड

MECON LIMITED

SECTION	MAT. HAND
LOCATION	RANCHI
DESIGNED	GLN
DRAWN	GLN
CHECKED AND VERIFIED	SK
APPROVED	Sr.
	DATE

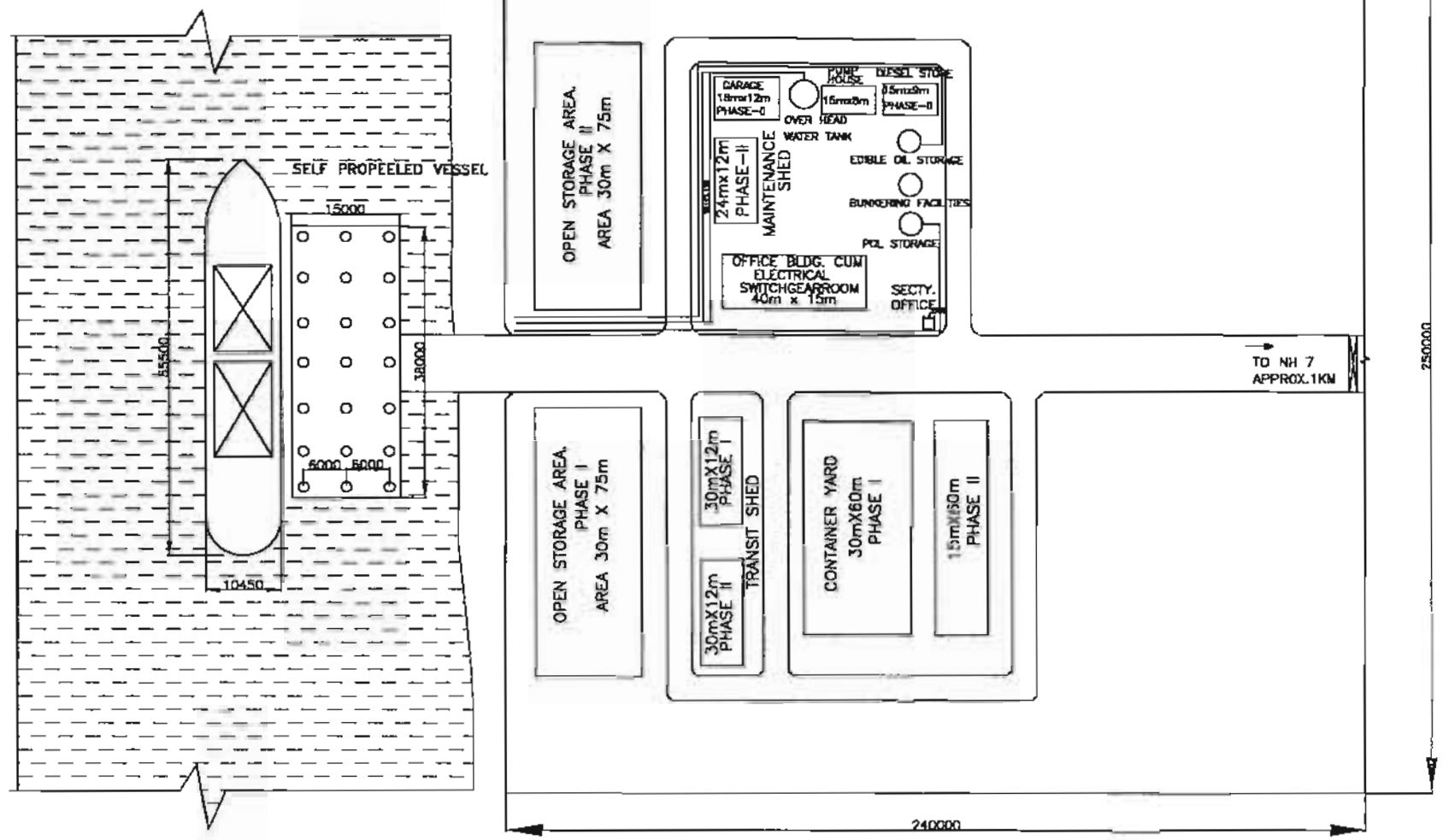
INTERMODAL TERMINAL, VARANASI

MECHANISED UNLOADING / LOADING ON PROPOSED HIGH LEVEL JETTY WITH DIAPHRAGM WALL ALT. – 2

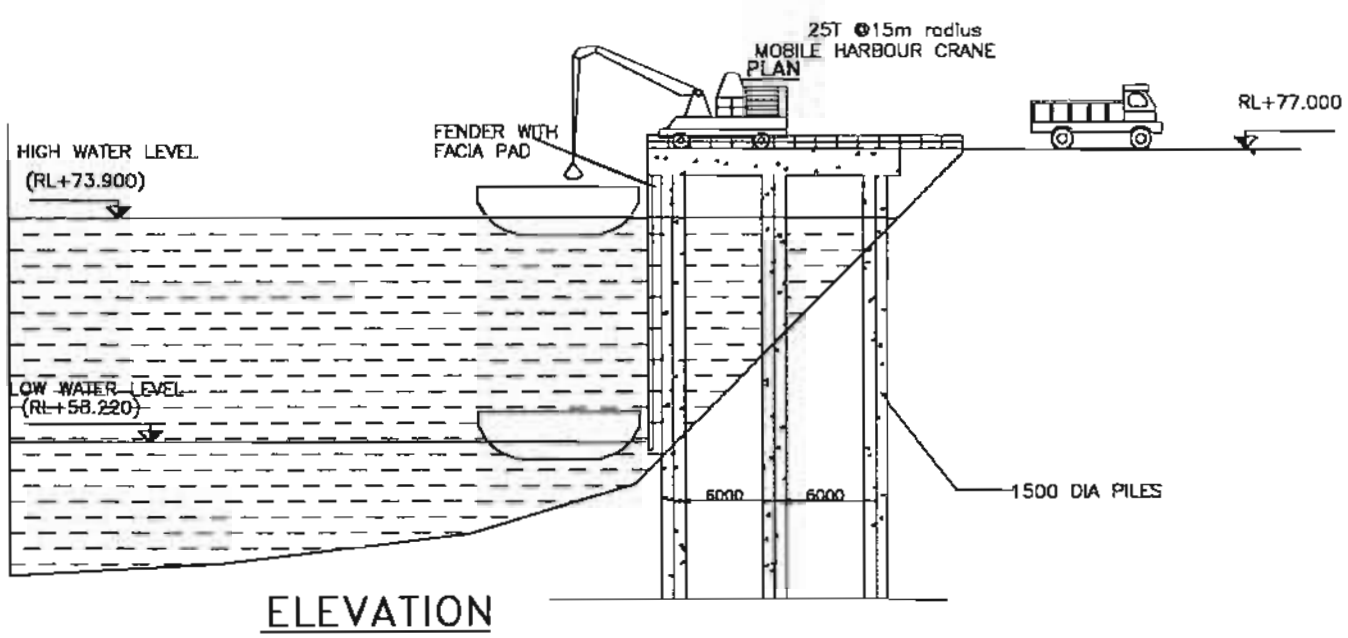
SCALE:- AS SHOWN | SHEET 1 OF 1 | REV 0

DRG.No.MEC/11/17/0079/02

DRG.No.MEC/11/17/0079/03



ONSHORE FACILITIES



ELEVATION

NOTES :

1. ALL DIMENSIONS ARE IN mm & LEVELS ARE IN m.

REV/SEC						
CONCURRED BY						

REV.NO.	DATE	ZONE	DESCRIPTION	BY	VERIFIED
REVISIONS					

REFERENCES | DRG. NO.

SECTION	MAT. HAND
LOCATION	RANCHI
DESIGNED	GLN
DRAWN	GLN
CHECKED AND VERIFIED	SK
APPROVED	SIG.
	DATE

IWAI

INLAND WATERWAYS AUTHORITY OF INDIA
MINISTRY OF SHIPPING
GOVT. OF INDIA

मेकन लिमिटेड

MECON LIMITED

INTERMODAL TERMINAL, VARANASI

MECHANISED UNLOADING / LOADING ON PROPOSED HIGH LEVEL JETTY WITH OPEN PILE ALT. –3

SCALE– AS SHOWN | SHEET 1 OF 1 | REV 0

DRG.No.MEC/11/17/0079/03

CHAPTER – 8

TECHNO-ECONOMIC ANALYSIS

8.0 TECHNO-ECONOMIC ANALYSIS

8.1 Capital Investment

The estimated capital investment for setting up the proposed intermodal terminal at Varanasi has been worked out under three alternatives (as elaborated in the technical chapters) as follows:

(Rs lakhs)

Sl No	Item	Alt-I		Alt-II		Alt-III	
		Ph-I	Ph-II	Ph-I	Ph-II	Ph-I	Ph-II
1	On-shore facilities	770	1075	770	1075	770	1075
2	Off-shore facilities	1187	1187	1413	2263	1334	2184
	Total	**1957**	**2262**	**2183**	**3338**	**2104**	**3259**

Note : Phase-II is inclusive of Phase-I.

Further details of capital cost estimates are furnished in table-8.01.

The project cost estimates include all facilities and work within the boundary of the proposed system for intermodal terminal at Varanasi including installation of material handling equipment, electrics, air conditioning & ventilation equipment, maintenance workshop equipment, fire fighting facilities, telecommunication equipment, water / fuel supply network and associated civil & structural work including offshore structures. The cost estimates include all direct and indirect costs such as procurement of equipment, spares, building structures, execution of civil engineering works, erection of plant & machinery/building structures, provision for contingencies, freight, insurance, duties & taxes, engineering, project

management and site works, cost towards acquisition of 6 hectares of land, preliminary and pre-operative expenses, etc. which are involved in setting up the proposed intermodal terminal at Varanasi along with supporting services facilities. Since the project would be entirely funded through equity, no provision has been kept in the estimate towards interest during project implementation period. Cost towards infrastructure facilities outside the project boundary such as external water supply line, external power supply line, external road / rail link, township, etc. are also not considered in the estimates. The above estimates are towards fixed assets and do not include any provision towards margin money for working capital.

8.1.1 Basis of estimate

Major considerations made while arriving at the project cost estimates are as follows :

- All cost data are computed based on I Quarter, 2007 prices and do not include any provision towards forward escalation in costs.

- The capital cost estimates are based on the following prevailing foreign exchange rate :

  1 US $ = Rs 45.00

- Costs adopted in the estimates are generally based on available inhouse information, current budgetary quotations and costs extracted from similar projects, suitably adjusted to reflect current prices.

8.1.2 **Methodology and cost criteria**

The criteria adopted for the project cost estimates are given hereunder:

- 100% new equipment has been envisaged for procurement and use in the project. No second hand and revamped equipment is envisaged while estimating the project cost.

- 100 % equipment are envisaged to be procured indigenously.

- An amount of 5% of the supply prices of equipment is included in the estimate towards cost of spare parts required during initial two years of operation.

- The cost of building structure has been estimated based on the quantities of structural steel as derived from the layout drawings. All structural steel would be procured and fabricated locally. The rates for fabrication of building structure as prevailing in the region have been adopted for the purpose of estimation.

- Erection costs for equipment are based on percentage factors applied to equipment supply costs. These percentages are derived from historical data obtained from similar projects. Rates for erection of building structure as prevailing in the region have been adopted for the purpose of estimation.

- The cost of civil engineering works has been estimated based on the quantities of concrete / piles as derived from the layout drawings, equipment / off-shore structure design and prevailing soil conditions and

the local labour rates and prices of construction materials as prevailing in the region.

- Adequate provision has been made in the estimate to account for inland transportation and handling at site.

- Central sales tax on indigenous plant and equipment (including spares), is provided at concessional rate of 3 %.

- Provision is also made in the estimate towards engineering, project management and site works, which consists mainly of preparation of project reports and technical specifications, detailed engineering, tender evaluation, procurement and inspection services, project management and support services during project implementation stage, enabling works, etc.

- A contingency provision @ 5% has been kept in the estimate to account for unforeseen aspects of the project. However, provision towards contingency does not cover escalation in price levels.

- Cost towards acquisition of land and ground improvement of 6 hectares as required for this project.

- Pumps for the handling POL, edible oil and water are not considered in the capital cost estimate. Space provision is only kept for bunkering and POL storage facilities in planning of onshore facilities

- Approach road from the plant boundary to NH7 is not considered.

- Provision towards preliminary & pre-operative expenses have been made in the estimate towards establishment, rent, rates & taxes, travelling, legal expenses, expenses on postage, advertisement, printing, stationary, insurance during construction including erection insurance and other miscellaneous expenses likely to be incurred during implementation of the project.

- The total project is envisaged to be constructed / implemented in two phases with implementation of phase-I facilities over a period of 24 months (in years 2007 & 2008) and subsequent implementation of phase-II facilities over a period of ten years (in year 2018).

- Project cost has been assumed to be 100% financed through equity fund. Therefore, the interest accrued during construction period shall be nil.

- No provision has been kept in the estimate towards margin money for working capital. It is assumed that the entire working capital requirement of the project would be met through bank borrowings.

The estimates are based on certain assumptions and available in-house data. Nevertheless, these figures represent a fair estimate of the scale of investment required.

It is observed from the capital cost estimates that Alternative-I emerges as the least cost option. Further, in order to achieve better berthing of the vessel all the three piers are required to be constructed in phase-I. Thus, in case of Alternative-I, the entire off-shore requirement has been envisaged under Phase-I only.

8.2 Annual Operating & Maintenance (O & M) Cost

Annual cost of operation for the proposed intermodal terminal at Varanasi has been worked out taking into account the annual cargo traffic to be handled at the terminal, requirement of operational and supervisory manpower, power & fuel, repair & maintenance expenses, expenses towards stevedoring, annual tax on land / buildings, expenses towards embankment protection, dredging and maintenance of channel and other miscellaneous expenses.

The annual cargo traffic proposed to be handled in the terminal years 2009 and 2019 after commissioning of Phase-I and Phase-II facilities of the project respectively and in the terminal year 2023 would be as follows :

Projected Annual Cargo Traffic

('000t/yr)

S. No	Commodity / Terminal Year	2009	2019	2023
1	Coal	90	142	178
2	Fertilizer	261	327	339
3	Food grains	300	363	392
4	POL	344	559	679
5	Iron & Steel	27	32	35
6	Cement	124	151	163
	Total	**1146**	**1574**	**1786**

Year-wise / commodity-wise details of projected cargo traffic is furnished in table-8.02. The operating & maintenance (O & M) cost (excluding depreciation & interest charges) works out to as follows :

Operating & Maintenance (O & M) Cost

(Excluding depreciation & interest charges)

Sl No	Item	Alt-I		Alt-II		Alt-III	
		Ph-I	Ph-II	Ph-I	Ph-II	Ph-I	Ph-II
1	Annual O & M cost (Rs lakhs)	750	1024	774	1076	772	1075
2	Equivalent cost per tonne of cargo (Rs/t)	65.42	65.06	67.51	68.36	67.34	68.30

Notes

1. Phase-II is inclusive of Phase-I.
2. Phase-I & II figures correspond to Year 2009 and Year 2019 respectively.

Details of annual O & M cost are shown in table-8.03.

The cost estimates are based on I Quarter, 2007 price levels and do not take into account any forward escalation in prices of consumable, stores, fuel, etc. and labour rates.

8.2.1 **Criteria / Basis for annual O & M cost**

Manpower

Provision for labour & supervision is based on the assessed operational & maintenance manpower requirement for the proposed intermodal terminal at Varanasi and category-wise wage rates (including fringe benefits).

The category-wise break-up of manpower and annual wage rates are shown in table-8.03.

Power & Fuel

The costs of major utilities such as power & fuel have been calculated / adopted based on their assessed annual requirement and considering the following unit rates (as prevailing during I Quarter, 2007) :

Electricity	:	Rs 4.70 per kWh
HSD oil	:	Rs 35.00 per litre

Repair & Maintenance

Provision for repair & maintenance includes cost of stores & spares, repair shop expenses, repair & maintenance of mechanical & electrical equipment, mobile equipment, buildings / structures, off-shore structures and other civil engineering work.

In addition to the above, expenses towards stevedoring operation, annual tax on land / buildings, embankment protection, dredging / maintenance of channel etc. have also been included in the O & M cost estimates.

While estimating the O & M cost estimates, it has been assumed that the project authority (IWAI) would not be operating any barge or tug themselves. Therefore, expenses towards its operation have not been included in the above estimates.

8.3 Profitability Analysis

From the foregoing sections, it can be observed that in case of Alt-II and Alt-III both capital investment and O & M costs are higher as compared to the scheme envisaged under Alt-I. Thus, Alt-I proposal emerges as techno-economically the best alternative. Therefore, profitability analysis has been carried out for Alt-I proposal only.

Based on the capital investment and annual O & M costs as elaborated in the preceding sections and annual revenue earnings indicated in section 8.3.1, the financial analysis for the proposed inter-modal terminal at Varanasi has been carried out for Alt-I proposal. The projections have been made based on phase-wise implementation of the overall project and considering 15 years of operation (2009-2023). The salient techno-economic indices are presented in table-8.04 as follows.

Table-8.04

Salient Techno-Economic Indices

Sl No	Item	Unit	Phase-I + Phase-II
1	Cumulative retained profit after tax over 15 years of operation	Rs lakhs	5977
2	Average retained profit after tax per year based on 15 years of operation	Rs lakhs	398
3	Cumulative cash surplus over 15 years of operation	Rs lakhs	7182
4	Internal rate of return over 15 years of operation		
	- Pre-tax	%	24.1
	- Post-tax	%	18.1

Sl No	Item	Unit	Phase-I + Phase-II
5	Pay-back period after tax	Year	5.51
6	Break-even capacity (Average for 15 years of operation)	%	30
7	Cash break-even capacity (Average for 15 years of operation)	%	20

Details of various financial statements / detailed computation sheets for various economic indicators are furnished in the following tables.

Statement	Table No.
Profit & loss statement	Table-8.05
Cash-flow statement	Table-8.06
Computation of Internal Rate of Return (IRR)	Table-8.07
Computation of Pay Back Period	Table-8.08
Computation of Break-even Capacity	Table-8.09
Estimation of Annual Requirement of Working Capital	Table-8.10

8.3.1 Annual revenue earnings

Presently, the cargo handling charges at various ports / jetties in India are in the range Rs 25 - 50 / t for manual handling and Rs 50 – 150 / t for mechanised handling depending on the type of commodity to be handled.

The major ports in India are of quite old vintage. The incidence of capital recovery charges in case of these ports is very low. The proposed inter-modal terminal at Varanasi is equipped with mechanised handling facilities. The proposed tariff for cargo handling has been adopted based on the above

considerations, taking into account the prevailing rates of IWAI for inter-modal transport of various commodities in the country within an average radius of 400 km and considering the green-field nature of the present project. The following average cargo handling charges have been considered for the purpose of examining the financial viability of the proposed inter-modal terminal project at Varanasi:

Average Cargo Handling Charges

(Rs/t)

Sl No	Commodity	Average Cargo Handling Charge
1	Coal	460
2	Fertilizer	80
3	Food grains	85
4	POL	63
5	Iron & steel	80
6	Cement	100

Additionally revenue accrued to IWAI from container handling has been considered @ Rs 1300 per container.

The year-wise annual revenue projections (2009-2023) are furnished in Table-8.11.

It is seen from the profitability projections that the project emerges as techno-economically viable and merits favourable consideration for implementation.

8.3.2 **Assumptions**

The major assumptions made while carrying out the financial analysis for Alt-I option is furnished as follows.

Sl No	Item	Value / Remarks
1	Capital cost of fixed assets	
	- Phase-I	Rs 1957 lakhs
	- Phase-II (Total)	Rs 2262 lakhs
2	Annual cargo traffic (projected)	
	- Phase-I (in Year 2009)	11,46,426 tonnes
	- Phase-II (Total) – (in Year 2019)	15,73,939 tonnes
	- In Terminal Year 2023	17,86,148 tonnes
3	Annual revenue expenditure at 100% operating rate (O & M cost)	
	- Phase-I (in Year 2009)	Rs 750 lakhs
	- Phase-II (Total) – (in Year 2019)	Rs 1024 lakhs
	- In Terminal Year 2023	Rs 1137 lakhs
4	Annual net revenue earnings at 100% operating rate	
	- Phase-I (in Year 2009)	Rs 1237 lakhs
	- Phase-II (Total) – (in Year 2019)	Rs 1755 lakhs
	- In Terminal Year 2023	Rs 2047 lakhs
5	Financing of capital investment	
	- Debt – equity ratio	100% financing through equity fund
6	Annual working capital requirement at 100% operating rate	

Table-8.01

Estimated Capital Cost of Intermodal Terminal at Varanasi

(Base Date : I Quarter, 2007)

(In Rs Lakhs)

Sl	Items	Onshore Facilities (Alt-I, II & III)			Offshore Facilities (Alt-I)			Offshore Facilities (Alt-II)			Offshore Facilities (Alt-III)			Total (Alt-I)			Total (Alt-II)			Total (Alt-III)		
		Phase-I	Phase-II	Total	Phase-I	Phase-II	Total	Phase-I	Phase-II	Total	Phase-I	Phase-II	Total	Phase-I	Phase-II	Total	Phase-I	Phase-II	Total	Phase-I	Phase-II	Total
1	Equipment																					
	- Material Handling Equipment	49.75	60.00	109.75	200.30	0.00	200.30	520.00	520.00	1040.00	520.00	520.00	1040.00	250.05	60.00	310.05	569.75	580.00	1149.75	569.75	580.00	1149.75
	- Plant Lighting / Illumination	11.00	0.00	11.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	11.00	0.00	11.00	11.00	0.00	11.00	11.00	0.00	11.00
	- Power Distribution Equipment	38.28	0.00	38.28	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	38.28	0.00	38.28	38.28	0.00	38.28	38.28	0.00	38.28
	- Fire Fighting Equipment	15.30	15.10	30.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	15.30	15.10	30.40	15.30	15.10	30.40	15.30	15.10	30.40
	- Maintenance Workshop Equipment	7.40	0.00	7.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	7.40	0.00	7.40	7.40	0.00	7.40	7.40	0.00	7.40
	- Air Conditioner / Water Coolers	0.82	0.00	0.82	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.82	0.00	0.82	0.82	0.00	0.82	0.82	0.00	0.82
	- Telecommunication Equipment	0.12	0.00	0.12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.12	0.00	0.12	0.12	0.00	0.12	0.12	0.00	0.12
	- Water supply & fuel piping system	7.92	2.54	10.46	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	7.92	2.54	10.46	7.92	2.54	10.46	7.92	2.54	10.46
	Sub-total (1)	130.59	77.64	208.23	200.30	0.00	200.30	520.00	520.00	1040.00	520.00	520.00	1040.00	330.89	77.64	408.53	650.59	597.64	1248.23	650.59	597.64	1248.23
2	Spares	6.53	3.88	10.41	10.02	0.00	10.02	26.00	26.00	52.00	26.00	26.00	52.00	16.55	3.88	20.43	32.53	29.88	62.41	32.53	29.88	62.41
3	Building Structures	28.21	51.09	79.30	213.70	0.00	213.70	0.00	0.00	0.00	0.00	0.00	0.00	241.91	51.09	293.00	28.21	51.09	79.30	28.21	51.09	79.30
4	Erection	11.80	6.39	18.19	15.02	0.00	15.02	39.00	39.00	78.00	39.00	39.00	78.00	26.82	6.39	33.21	50.80	45.39	96.19	50.80	45.39	96.19
5	Civil Engineering Work	325.61	89.05	414.66	461.40	0.00	461.40	445.75	0.00	445.75	370.25	0.00	370.25	787.01	89.05	876.06	771.36	89.05	860.41	695.86	89.05	784.91
6	Freight, Insurance, Duties & Taxes	30.98	18.41	49.39	47.52	0.00	47.52	123.35	123.35	246.70	123.35	123.35	246.70	78.50	18.41	96.90	154.33	141.76	296.11	154.33	141.76	296.11
7	Engineering & project management	70.00	30.00	100.00	130.00	0.00	130.00	130.00	63.00	193.00	130.00	63.00	193.00	200.00	30.00	230.00	200.00	93.00	293.00	200.00	93.00	293.00
8	Contingencies	30.19	13.82	44.01	53.90	0.00	53.90	64.21	38.57	102.78	60.43	38.57	99.00	84.09	13.82	97.91	94.40	52.39	146.79	90.62	52.39	143.01
	Total Plant Proper	633.91	290.28	924.19	1131.86	0.00	1131.86	1348.31	809.92	2158.23	1269.03	809.92	2078.95	1765.77	290.28	2056.05	1982.22	1100.20	3082.42	1902.94	1100.20	3003.14
9	Cost of Land (area 6 ha)	101.00	0.00	101.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	101.00	0.00	101.00	101.00	0.00	101.00	101.00	0.00	101.00
10	Preliminary & pre-operative expenses	35.00	15.00	50.00	55.00	0.00	55.00	65.00	40.00	105.00	65.00	40.00	105.00	90.00	15.00	105.00	100.00	55.00	155.00	100.00	55.00	155.00
	Capital Cost of Fixed Assets	769.91	305.28	1075.19	1186.86	0.00	1186.86	1413.31	849.92	2263.23	1334.03	849.92	2183.95	1956.77	305.28	2262.05	2183.22	1155.20	3338.42	2103.94	1155.20	3259.14

Table-8.02

Projected Traffic (t/yr)

Sl	Commodity	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
1	Coal	78423	82002	85745	89658	93750	97232	100843	104588	108472	112500	119163	126220	133695	141613	150000	158884	168294	178261	188818
2	Fertilizer	248092	252512	257011	261590	266250	275356	284772	294511	304583	315000	317944	320916	323916	326944	330000	333085	336198	339341	342513
3	Food grains	283643	289141	294745	300458	306281	312175	318183	324306	330548	336909	343393	350001	356737	363602	370600	377732	385001	392410	399962
4	POL	296868	311691	327254	343594	360750	378711	397567	417361	438141	459956	482857	505898	532136	558631	586445	615644	646297	678476	712257
5	Iron & steel	25226	25712	26207	26711	27225	27749	28283	28828	29382	29948	30524	31111	31710	32320	32942	33576	34222	34880	35551
6	Cement	117667	119875	122124	124416	126750	129250	131800	134400	137051	139755	142445	145186	147980	150828	153731	156690	159706	162780	165913
	TOTAL	1049920	1080933	1113085	1146426	1181006	1220473	1261448	1303995	1348178	1394068	1436326	1480333	1526175	1573939	1623718	1675611	1729718	1786148	1845014

Table-8.03

Annual Operation and Maintenance Costs (Rs lakhs)

Sl	Item	Unit	Unit rate (Rs/unit)	Alternative-I				Alternative-II				Alternative-III			
				Phase-I (2009)		Phase-II (2019)		Phase-I (2009)		Phase-II (2019)		Phase-I (2009)		Phase-II (2019)	
				Quantity	Cost	Quantity	Cost	Quantity	Cost	Quantity	Cost	Quantity	Cost	Quantity	Cost
1	Manpower														
	- Director	nos	761000	1	8	1	8	1	8	1	8	1	8	1	8
	- Manager	nos	457000	3	14	3	14	3	14	3	14	3	14	3	14
	- Technical Assistant	nos	304000	3	9	3	9	3	9	3	9	3	9	3	9
	- Supervisors	nos	183000	5	9	6	11	5	9	6	11	5	9	6	11
	- Crane Operators	nos	183000	1	2	2	4	1	2	2	4	1	2	2	4
	- Customs Officer	nos	152000	1	2	1	2	1	2	1	2	1	2	1	2
	- Security Officers	nos	152000	1	2	1	2	1	2	1	2	1	2	1	2
	- Clerks	nos	107000	5	5	9	10	5	5	9	10	5	5	9	10
	- Drivers	nos	91000	1	1	2	2	1	1	2	2	1	1	2	2
	- Watchman / Peon	nos	76000	5	4	7	5	5	4	7	5	5	4	7	5
	Sub-total (1)			26	56	35	67	26	56	35	67	26	56	35	67
2	Electricity	kWh	4.70	310800	15	551600	26	120000	6	170000	8	120000	6	170000	8
3	Diesel (HSD)	litres	35.00	36000	13	72000	25	93320	33	150700	53	93320	33	150700	53
4	Repair & Maintenance														
	- Plant & Equipment	-	5.00%		17		20		33		62		33		62
	- Building structures	-	2.00%		5		6		1		2		1		2
	- Civil engg work (including berth & approach)	-	1.00%		8		9		8		9		7		8
	Sub-total (4)	-	-		30		35		42		73		41		72
5	Stevedoring Expenses														
	- Bulk cargo				516		707		516		707		516		707
	- Containers				-		2		-		2		-		2
	Sub-total (5)				516		709		516		709		516		709
6	Annual Tax of land & buildings				6		6		5		5		4		5
7	Embankment protection, dredging and maintenance of channel				46		63		46		63		46		63
8	Miscellaneous operating cost				68		93		70		98		70		98
	Total Annual O & M Cost				750		1024		774		1076		772		1075
	Equivalent O & M Cost (Rs per tonne of cargo handled)				65.42		65.06		67.51		68.36		67.34		68.30

NB It is assumed that IWAI is not operating any barge or tug.

Table-8.05

PROFIT & LOSS STATEMENT (ALT-I)

(Rs lakhs)

Sl	Items \ Years	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
1	Annual revenue expenditure	0	0	750	768	789	810	833	856	880	902	925	949	1024	1051	1078	1107	1137
2	Annual net revenue earnings	0	0	1237	1280	1322	1367	1413	1461	1510	1564	1625	1685	1755	1822	1894	1968	2047
3	Gross profit	0	0	487	512	533	557	580	605	630	662	700	736	731	771	816	861	910
4	Interest																	
	- On term loan	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	- On working capital	0	0	7	7	7	7	7	8	8	8	8	8	9	9	10	10	10
	- On overdraft	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Total Interest	0	0	7	7	7	7	7	8	8	8	8	8	9	9	10	10	10
5	Depreciation	0	0	76	76	76	76	76	76	76	76	76	76	89	89	89	89	89
6	Operating profit	0	0	404	429	450	474	497	521	546	578	616	652	633	673	717	762	811
7.	Taxation	0	0	87	105	120	135	149	162	175	190	207	222	210	228	247	265	284
8	Profit after tax	0	0	317	324	330	339	348	359	371	388	409	430	423	445	470	497	527
9.	Dividend on equity	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10.	Retained profit :																	
	(i) Current	0	0	317	324	330	339	348	359	371	388	409	430	423	445	470	497	527
	(ii) Cumulative	0	0	317	641	971	1310	1658	2017	2388	2776	3185	3615	4038	4483	4953	5450	5977

Table-8.06

CASH-FLOW STATEMENT (ALT-I)

(Rs lakhs)

Sl	Items \ Years	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
A.	SOURCES OF FUNDS																	
1	Equity capital	1174	783	0	0	0	0	0	0	0	0	0	305	0	0	0	0	0
2	Gross profit	0	0	487	512	533	557	580	605	630	662	700	736	731	771	816	861	910
3	Increase in term loan	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	Increase in working capital	0	0	55	1	2	1	2	2	2	1	2	2	6	2	2	2	2
5	Overdraft	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Cash Inflow (A)	1174	783	542	513	535	558	582	607	632	663	702	1043	737	773	818	863	912
B.	DISPOSITION OF FUNDS																	
1	Capital expenses	1174	783	0	0	0	0	0	0	0	0	0	305	0	0	0	0	0
2.	Repayment of term loan	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3.	Repayment of overdraft	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4.	Interest																	
	- On term loan	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	- On working capital	0	0	7	7	7	7	7	8	8	8	8	8	9	9	10	10	10
	- On overdraft	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Total interest	0	0	7	7	7	7	7	8	8	8	8	8	9	9	10	10	10
5	Increase in working capital	0	0	55	1	2	1	2	2	2	1	2	2	6	2	2	2	2
6	Taxation	0	0	87	105	120	135	149	162	175	190	207	222	210	228	247	265	284
7.	Dividend on equity	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Cash Outflow (B)	1174	783	149	113	129	143	158	172	185	199	217	537	226	239	259	277	296
	Net Cash Accrual (A-B)	0	0	393	400	406	415	424	435	447	464	485	506	512	534	559	586	616
	Cumulative Cash Surplus	0	0	393	793	1199	1614	2038	2473	2920	3384	3869	4375	4887	5421	5980	6566	7182

Table-8.07

IRR CALCULATION (ALT-I)

(Rs lakhs)

Sl	Items \ Years	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
1.	Capital cost excl. IDC	1174	783	0	0	0	0	0	0	0	0	0	305	0	0	0	0	-113
2.	Interest on working capital	0	0	7	7	7	7	7	8	8	8	8	8	9	9	10	10	10
3.	Interest on overdraft	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4.	Gross profit	0	0	487	512	533	557	580	605	630	662	700	736	731	771	816	861	910
5.	Taxation	0	0	87	105	120	135	149	162	175	190	207	222	210	228	247	265	284
6	Net inflow																	
	- Post-tax	-1174	-783	393	400	406	415	424	435	447	464	485	201	512	534	559	586	729
	- Pre-tax	-1174	-783	480	505	526	550	573	597	622	654	692	423	722	762	806	851	1013
7.	Internal rate of return, %																	
	- Post-tax	18.1																
	- Pre-tax	24.1																

Table-8.08

PAY BACK PERIOD CALCULATION (ALT-I)

(Rs lakhs)

Sl No	Items \ Operating Years	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
1.	Gross profit	487	512	533	557	580	605	630	662	700	736	731	771	816	861	910
2.	Total interest	7	7	7	7	7	8	8	8	8	8	9	9	10	10	10
3.	Taxation	87	105	120	135	149	162	175	190	207	222	210	228	247	265	284
4.	Net inflow	393	400	406	415	424	435	447	464	485	506	512	534	559	586	616
5.	Cumulative inflow	393	793	1199	1614	2038	2473	2920	3384	3869	4375	4887	5421	5980	6566	7182
6	Total fixed capital	2262														
7.	Pay back period (Years)	6.61														

Table-8.09

BREAK-EVEN CAPACITY (ALT-I)
(Average over 15 years)

(Rs lakh)

Sl.	Item	Amount
1	Net annual revenue earnings	1597
2	Variable expenses	764
3	Contribution	833
4	Fixed expenses	
	-Annual revenue expenditure	160
	-Depreciation	80
	-Interest	8
	Sub-total (4)	248
5	**Break-even Capacity (%)**	**30**
6	**Cash Break-even Capacity (%)**	**20**

Table-8.10

Annual Working Capital Requirement (Rs lakhs)

Sl	Item	No of Days	Alternative-I		Alternative-II		Alternative-III	
			Phase-I	Phase-II	Phase-I	Phase-II	Phase-I	Phase-II
1	Salaries & wages	30	5	6	5	6	5	6
2	Power & fuel	30	2	4	3	5	3	5
3	Repair & maintenance	30	2	3	3	6	3	6
4	Stevedoring expenses	30	42	58	42	58	42	58
5	Embankment protection, dredging etc.	30	4	5	4	5	4	5
	Annual Working Capital		**55.00**	**76.00**	**57.00**	**80.00**	**57.00**	**80.00**

Table-8.11

Projected Annual Revenue Earnings (Rs lakhs)

Sl	Commodity	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
1	Coal	361	377	394	412	431	447	464	481	499	518	548	581	615	651	690	731	774	820	869
2	Fertilizer	198	202	206	209	213	220	228	236	244	252	254	257	259	262	264	266	269	271	274
3	Food grains	241	246	251	255	260	265	270	276	281	286	292	298	303	309	315	321	327	334	340
4	POL	187	196	206	216	227	239	250	263	276	290	304	319	335	352	369	388	407	427	449
5	Iron & steel	20	21	21	21	22	22	23	23	24	24	24	25	25	26	26	27	27	28	28
6	Cement	118	120	122	124	127	129	132	134	137	140	142	145	148	151	154	157	160	163	166
	Sub-total (1-6)	1125	1162	1200	1237	1280	1322	1367	1413	1461	1510	1564	1625	1685	1751	1818	1890	1964	2043	2126
7	Revenue earning from container handling														4	4	4	4	4	4
	TOTAL	1125	1162	1200	1237	1280	1322	1367	1413	1461	1510	1564	1625	1685	1755	1822	1894	1968	2047	2130