INLAND WATERWAYS AUTHORITY OF INDIA (IWAI)

CONSULTANCY SERVICES FOR PREPARATION OF DETAILED PROJECT REPORT INCLUDING TECHNICAL & FINANCIAL STUDY IN DELHI TO ALLAHABAD STRETCH OF YAMUNA RIVER (NW110)

FINAL DETAILED PROJECT REPORT
VOLUME–I (MAIN REPORT)

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VOLUME-II: DRAWINGS

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Abbreviation

IWT	-	Inland Water Transport
IWAI	-	Inland Waterway Authority of India
SWOT	-	Strength, Weaknesses, Opportunities and threats
IRR	-	Internal rate of return
FIRR	-	Financial Internal Rate of Return
HFL	-	Highest Flood Level
MSL	-	Mean Sea Level
DGPS	-	Differential Global positioning system
DWT	-	Deadweight tonnage
O & M	-	Operation and maintenance
NPV	-	Net Present Value
WYC	-	Western Yamuna Canal
EYC	-	Eastern Yamuna Canal
BCM	-	Billion cubic metres
G	-	Gauge
GD	-	Gauge and Discharge
GQ	-	Gauge and Water Quality
GDQ	-	Gauge, Discharge and Water Quality
GDSQ	-	Gauge, Discharge, Sediment, and Water Quality
U/s	-	Upstream
D/s	-	Downstream
CWC	-	Central Water Commission
WYC	-	Western Yamuna Canal
EYC	-	Eastern Yamuna Canal
MLD	-	Million Litres per Day
CPCB	-	Central Pollution Control Board
NRSA	-	National Remote Sensing Agency
LWL	-	Lowest Water Level
WL	-	Water Level
NA	-	Not Available
PG	-	Poiaghat
JB	-	Jawahar Bridge
CH	-	Chainage
NLL	-	Northern Coal Field Limited
UPRVUNL	-	Uttar Pradesh Rajya Vidyut Utpadan Nigam
SGRL	-	Singrauli
JWK	-	Jawahar Kanjan Halt
TPP	-	Thermal Power Plant
NKCF	-	Northern Karanpura Coal Field
FGTP	-	Firoz Gandhi Thermal Project siding
BCSR	-	Bachra Railway Siding at Ray
TTPH	-	Tanda Thermal Power House

MJA	-	Meja Raod
BVAR	-	Bevara
IFFCO	-	Indian Farmers Fertiliser Cooperative
NCR	-	National Capital Region
JNPT	-	Jawaharlal Nehru Port Trust
HDCB	-	Haldia Dock Comp Bulk
OBS	-	Okhla Bird Sanctuary
DTC	-	Delhi Transport Corporation
DIMTS	-	Delhi Integrated Multi-Modal Transit System
mnT	-	Million Tonnes
km	-	Kilometre
m	-	Metre
T/Hr	-	Tonnes per Hours
TPH	-	Tonnes per Hours
Hr	-	Hours
L	-	Length
B	-	Width
DWT	-	Dead Weight Tonnage
MMT	-	Million Metric Tonnes
MMTPA	-	Million Metric Tonnes per Annum
KW	-	Kilowatt
Rd	-	Road
NH	-	National Highway
SH	-	State Highway
UNESCO	-	The United Nations Educational, Scientific and Cultural Organization
TTZ	-	Taj Trapezium Zone
EFC	-	Eastern Freight Corridor
DPCC	-	Delhi Pollution Control Committee
SPCP	-	State Pollution Control Board
DO	-	Dissolved Oxygen
BOD	-	Biochemical Oxygen Demand
GOI	-	Government of India
FSL	-	Full Supply Level
ABN	-	ASEA Brown Boveri
DPCL	-	Dhamra Port Company Ltd

EXECUTIVE SUMMARY

0.1 Introduction

The Govt. of India desires to explore the commercial navigation potential on year round basis in inland waterways. Ministry of Shipping (MoS), Govt. of India through Inland Waterways Authority of India (IWAI) intend to identify the viable waterways in India for their phased development.

To make provisions for existing national waterways and to provide for the declaration of certain inland waterways to be national waterways and also to provide for the regulation and development of the said waterways for the purposes of shipping and navigation, National waterway act, 2016 has received the assent of the President on the 25th March, 2016 declaring a total of 111 National Waterways. All the River stretches/Canals have been divided in different clusters for carrying out the study.

IWAI intends to explore transportation potential of National Waterway (NW) – 110. The proposed route is along the River Yamuna, stretching from Jagatpur (6 km upstream of Wazirabad Barrage) in Delhi to the confluence of Ganges and Yamuna rivers at Sangam, Prayagraj, in the state of Uttar Pradesh (UP). This Delhi-Prayagraj stretch is 1,089 km long, and passes through Delhi, Haryana and UP.NW 110 is proposed to be developed as alternate mode of transportation for cargo and passenger movement. This development would help to decongest traffic of road and railway by shifting it to waterway. Developing and maintaining NW – 110 is an opportunity to improve sustainable development of this waterway and the hinterland.

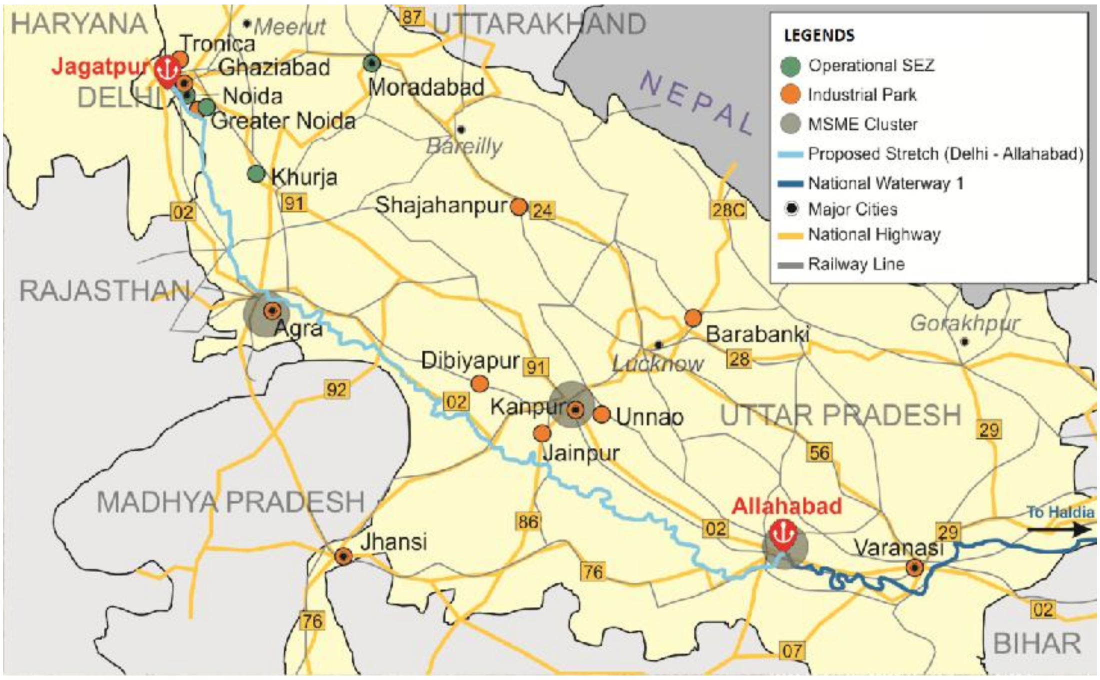


Fig.1 National Waterway-110 along with prominent locations

0.2 Site Conditions

The River Yamuna is the biggest tributary of the River Ganga. River Yamuna originates in the Tehri Garhwal district of Uttarakhand from the Yamunotri glacier. The important tributaries falling in Yamuna River NW 110 are the Hindon, the Chambal, the Betwa, the Ken and the Sindh. The average annual rainfall in the region varies between 400 to 1100 mm. Mean maximum and mean Minimum temperature varies between 42°C and 7°C respectively. The mean wind speed prevailing in the area is varying around 1.2 m/s to 1.5 m/s. The average relative humidity varies 53% to 55% in the project area. The general topography of the River Yamuna NW 110 is plain with levels varying from 70–200m above msl. In River Yamuna stretch NW 110 the river flattened gradually with an average slope varying from 0.04% to 0.011%. The average rate of fall is 0.11 m/km. The majority of soil type is alluvial and covers about 42% of the basin area. River Yamuna NW 110 is significantly mobile and changes flowing pattern in one season to another.

There are 4 nos. of barrage over River Yamuna NW 110 namely Wazirabad Barrage, ITO Barrage, Okhla Barrage, and Gokul Barrage. There are 78 nos. of bridges on River Yamuna NW 110 including 49 existing road bridges, 15 under construction road bridges, 12 existing rail bridges and 2 under construction rail bridges. There are 44 nos. of HT lines crossing over River Yamuna NW 110.8 nos. of pontoons is installed on River Yamuna NW 110.

0.3 Technical Analysis

All relating project data for River Yamuna NW 110 stretch was collected from various departments/organisations Viz. IWAI, CWC and State Irrigation Department/Flood Control Departments, NRSA, SOI etc. The hydrological data collected from CWC for 14 gauging stations on River Yamuna NW 110 and analyzed for water availability in river reach.

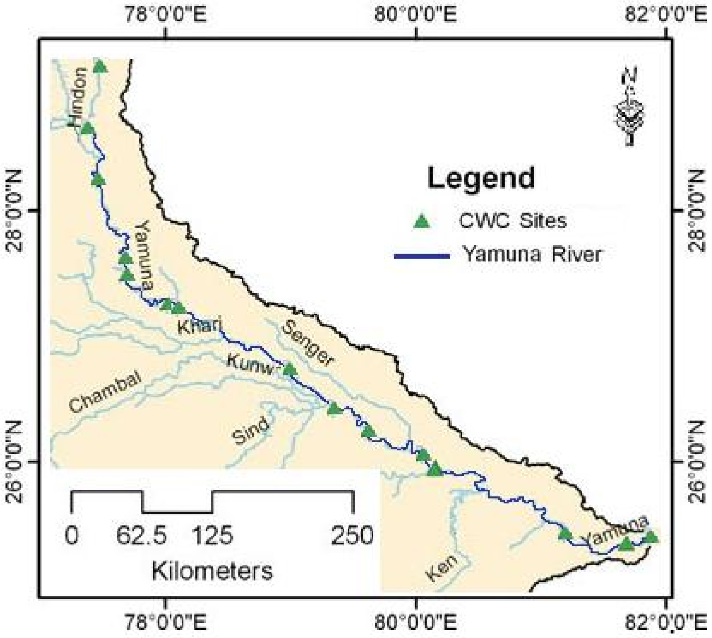


Fig. 2 Locations of CWC Gauge Stations on River Yamuna NW 110

Table 1 Observed Min and Max Water Level and Discharge at each Gauge Station

S. No.	Station Name	Ch. (Km)	Zero of the Gauge (m)	Chart Datum (m)	Minimum		Maximum	
					Min WL (m)	Min Q (m^3/s)	Max WL (m)	Max Q (m^3/s)
1.	Delhi R. B.	1068.00	197.00	201.85	199.35	8.99	207.13	3466.00
2.	Mohana	991.00	185.00	187.04	186.78	2.25	192.26	7981.00
3.	Mathura (Prayaghat)	848.27	160.00	163.57	161.02	9.78	167.34	1776.00
4.	Gokul Barrage (U/S)	842.29	160.00	163.21	162.90	NA	166.17	NA
	Gokul Barrage (D/S)		157.65	158.92	156.80	NA	166.07	NA
5.	Agra (Poiyaghat)	752.00	146.00	147.21	146.79	3.15	152.52	6063.00
6.	Agra (JB)	746.45	145.00	146.18	145.01	NA	152.08	NA
7.	Etawah	531.84	114.00	114.91	114.16	5.97	122.40	3999.00
8.	Auraiya	417.51	99.00	99.98	99.75	56.49	114.35	21004.0
9.	Kalpi	349.60	90.00	94.01	91.96	75.63	109.55	25749.0
10.	Hamirpur	280.53	88.00	88.40	88.24	3.09	106.38	30019.0
11.	Chillaghat	213.78	75.00	84.60	84	NA	103.32	NA
12.	Rajapur	95.51	65.00	74.83	73.37	44.94	93.01	37603.0
13.	Pratappur	33.13	70.00	72.43	71.81	66.94	89.25	30000.0
14.	Naini	13.34	70.00	71.82	71.39	NA	86.60	NA

It has been analysed that the overall water level variation to the tune of 3m to 9m in upstream Etawah and 15m to 20min downstream Etawah has been observed. Similarly, the overall discharge variation to the tune of 1765 m^3/s to 6000 m^3/s in upstream Etawah and 21000 m^3/s to 37600 m^3/sin upstream Etawah has been observed.

It is also analsyed that the annual variation of minimum water level itself is in the range of 0.2 m to 3.1 m and maximum water level is in the range of 2.4 m to 17.8 m. Similarly, the variation of minimum discharge is in the range of 12m^3/s to 417m^3/s and maximum discharge in the range of 1744m^3/s to 3717m^3/s. The annual variation in the minimum& maximum water level, the average of the annual minimum water level and annual maximum water level at each gauge station is presented in graph given below:

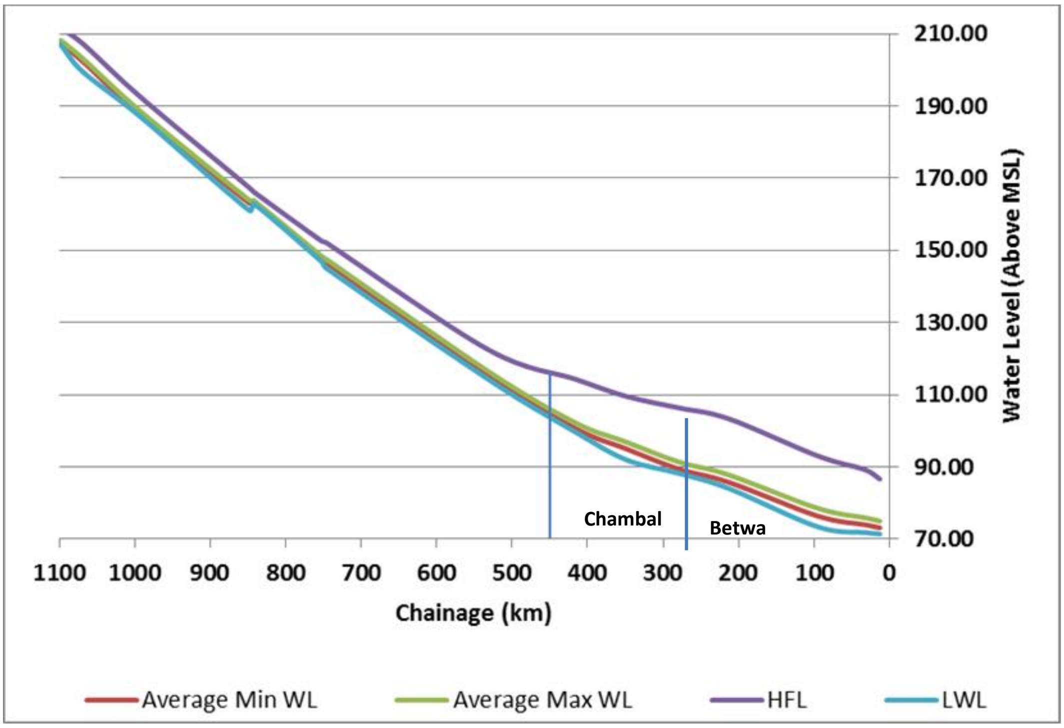


Fig. 3 Average Water Level Variation

Monthly Maximum and minimum water level data for various CWC gauge stations has been further analyzed to compute monthly average minimum and monthly average maximum water level. These data depict minimum and maximum depth available with respect to chart datum during different months of the year. A typical graph of monthly water level variation is given below:

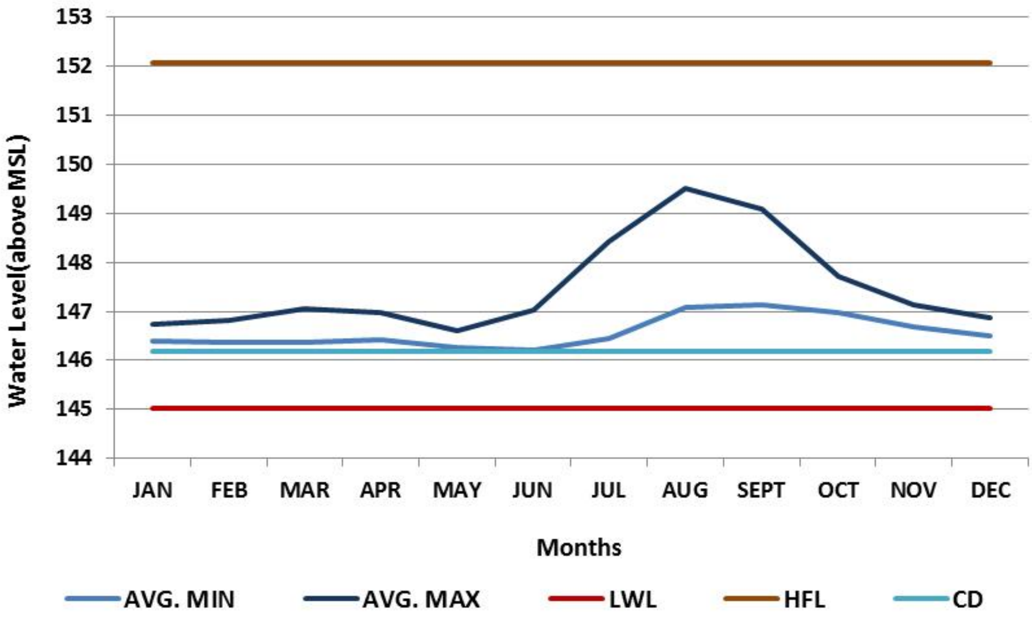


Fig.4 Monthly water level variation at Agra (JB) (Typical)

The daily gauge discharge data for five major stations namely Agra (P.G.), Etawah, Auraiya, Hamirpur and Pratappur has been analysed for computation of ten daily average flow and has been summarized as follows

Table 2 Summary of Ten Daily Discharge

Gauge Station	June	July to September	October to January	February to May
Agra (PG)	Begins at 22 and increase to 82 m^3/s	Begins at 85 m^3/s and increase to 670 m^3/s	Begins at 280 m^3/s and decrease to 43 m^3/s	Begins at 38 m^3/s and decrease to 21 m^3/s
Etawah	Begins at 17 m^3/s and increase to 83 m^3/s	Begins at 92 m^3/s and increase to 487 m^3/s	Begins at 290 m^3/s and decrease to 45 m^3/s	Begins at 40 m^3/s and decrease to 18 m^3/s
Auraiya	Begins at 133 m^3/s and increase to 213 m^3/s	Begins at 1100 m^3/s and increase to 3366 m^3/s then decreases to 1005 m^3/s	Begins at 787 m^3/s and decrease to 223 m^3/s	Begins at 211 m^3/s and decrease to 134 m^3/s
Hamirpur	Begins at 90 m^3/s and increase to 540 m^3/s	Begins at 1375 m^3/s and increase to 1735 m^3/s	Begins at 1097 m^3/s and decrease to 170 m^3/s	Begins at 173 m^3/s and decrease to 84 m^3/s
Pratappur	Begins at 310 m^3/s and increase to 675 m^3/s	Begins at 2596 m^3/s and increase to 5280 m^3/s	Begins at 2080 m^3/s and decrease to 417 m^3/s	Begins at 408 m^3/s and decrease to 300 m^3/s

Gauge-Discharge Data Analysis

The daily gauge discharge data for five major stations namely Agra (P.G.), Etawah, Auraiya, Hamirpur and Pratappur has been analysed. These gauge discharge relationship are useful for estimation of flood discharge for different water levels. Graphs are useful for estimation of discharge required to maintain 2.5 m flow depth under the existing conditions of river channels. A typical gauge discharge curve is shown below

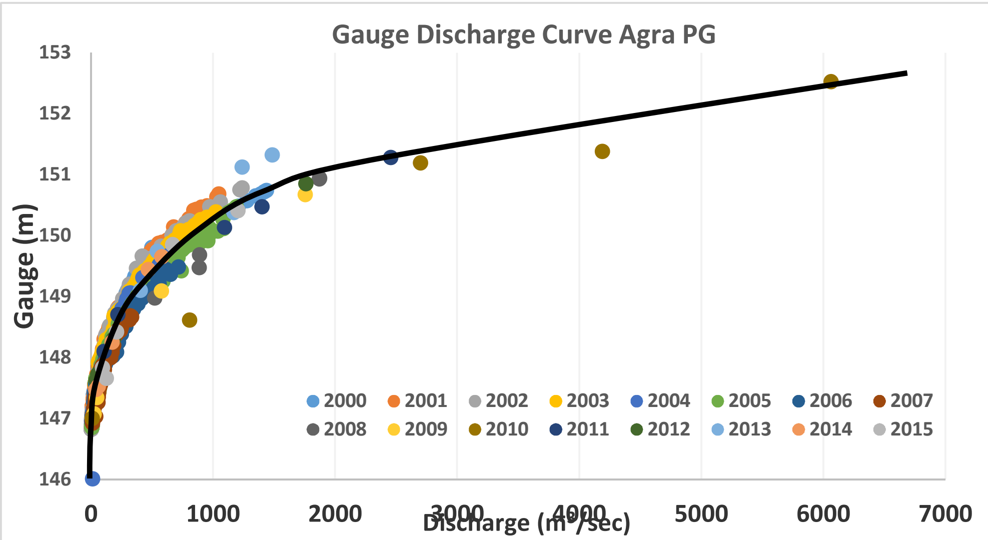


Fig. 5 Gauge Discharge Curve at Agra (PG)

Sediment Data Analysis

The suspended sediment data for five major stations namely Agra (P.G.), Etawah, Auraiya, Hamirpur and Pratappur was analysed to establish relationship between discharge and suspended sediments. From the discharge sediment concentration analysis it is depicted that during non-monsoon period almost entire sediment was fine sand & silt/clay and during monsoon 80 to 90 % sediment is fine sand.

Assessment of Water Availability

Statistical analysis has been carried out by computing average monthly water level value from the available hydrological data to assess the water availability round the year in the River Yamuna NW 110. The duration curves of cumulative monthly elevation has been plotted to find out the duration of availability of 2.5m water depth throughout the year and the minimum water depth available for 330 days as summarized below:

Table 3 Summary of Water Availability

Gauge Station / Chainage	Approx. No. of days for which minimum 2.5 m water depth available (Days)	Minimum Water depth available for 330 days (m)
Delhi Railway Bridge (Ch. 1068km)	30	0.7
Mohana (Ch. 991km)	30	0.3
Gokul Barrage (Ch. 842.29km)	30	0.6
Agra (Poiyaghat) (Ch. 752km)	40	0.2
Etawah (Ch. 531.84km)	50	0.3
Auraiya (Ch. 417.51km)	80	0.5
Kalpi (Ch. 349.60km)	100	0.5
Hamirpur (Ch. 28.53km)	100	0.7
Chillaghat (Ch. 213.78km)	110	0.6
Rajapur (Ch. 95.51km)	120	1.1
Pratappur (Ch. 33.13km)	110	1.0
Naini (Ch.13.34km)	130	0.9

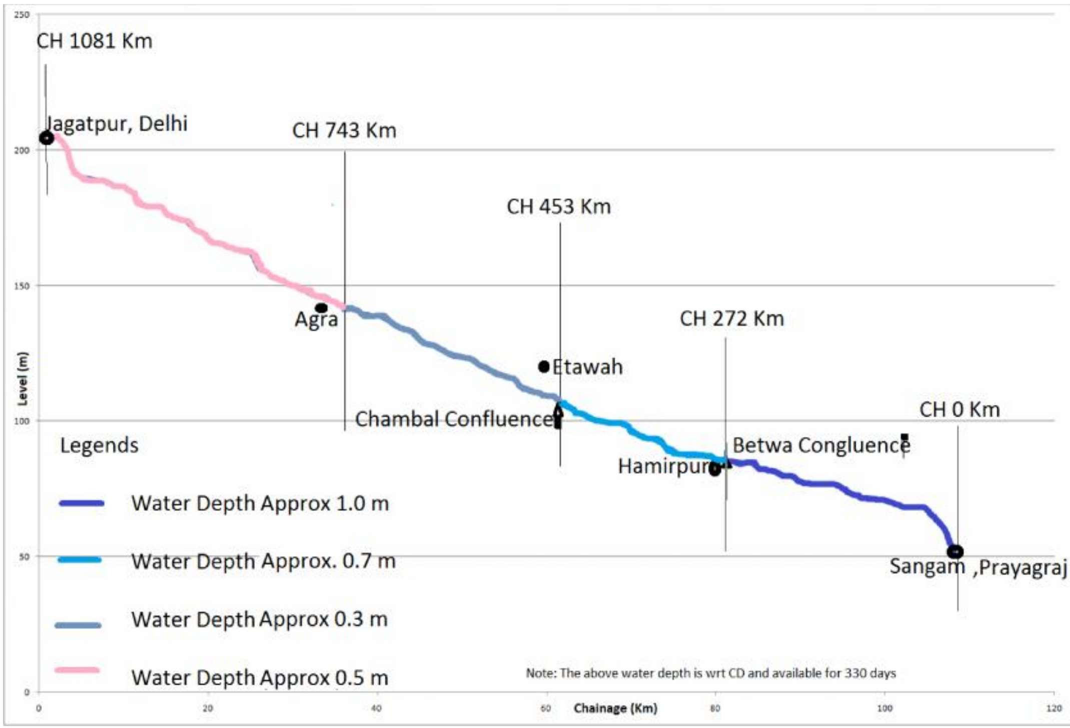


Fig. 6 Stretches wise water availability for 330 days

Flow Frequency Analysis

The flow frequency curves to daily mean discharges have been plotted followed by estimation of 50%, 75% and 90% dependable flow. The following discharge duration curve at each gauge stations give the understanding about the base flow.

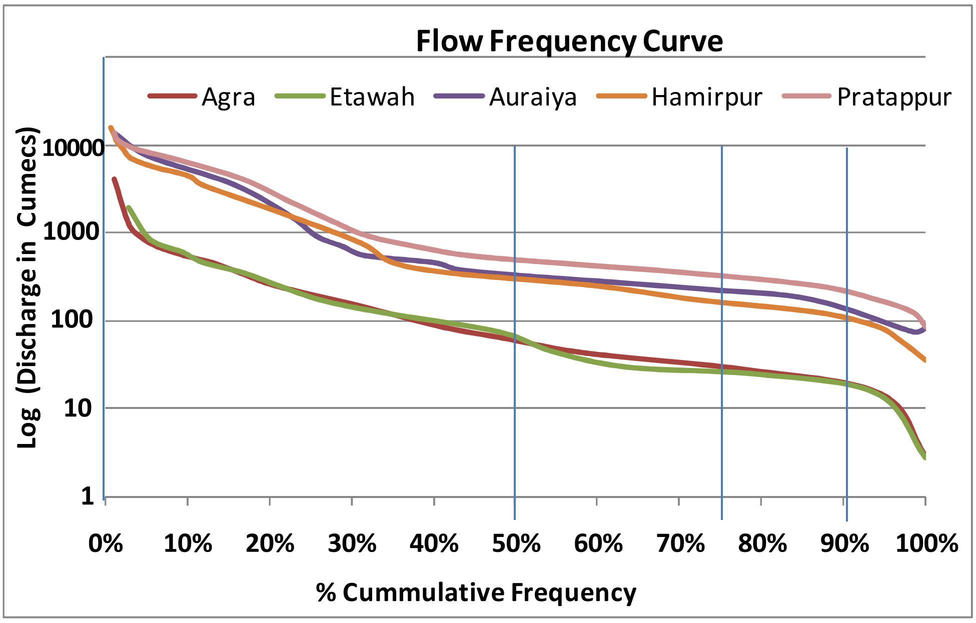


Fig. 7 Flow Frequency Curve

Table 4 Discharge availability at different location in the River Yamuna

Gauge Station	Dependable Flow (m^3/s)		
	50 %	75 %	90 %
Agra(Ch.752 km)	60	30	20
Etawah(Ch.531.84 km)	70	30	20
Auraiya(Ch.417.51 km)	325	200	120
Hamirpur(Ch.280.53 km)	290	160	100
Pratappur(Ch.33.13 km)	500	320	210

On comparing the water availability and discharge required it is found that from Prayagraj Sangam at Ch. 0 Km up to u/s Kalpi at Ch. 371 km minimum targeted depth for navigation can be maintained with dredging only. The remaining portion of the NW110 above Ch. 371 up to New Delhi at Ch. 1081 Km Barrages with Navigation Locks would be required to store the water and to maintain the required depth for navigation due to non-availability of requisite discharge throughout the year

River Course Change Analysis

Satellite Imageries Landsat05, Landsat07 and Landsat08 imageries of 30m spatial resolution were collected from National Remote Sensing Centre Hyderabad for the past 10 years from the year 2008 to year 2017. Route of Yamuna River from Delhi to Prayagraj has been analyzed. Satellite imagery of two seasons July to

September and October to December has been analyzed for each of the years. The analysis depicts that there is no major planform changes in river course. Increase in river channel width at few locations viz. from Ch. 975 km to Ch 982 km, from Ch. 995 km to Ch1005 km and from Ch.1020 km to Ch1038 km post 2010 flood due to bank erosion.Except for year 2010 and that too at few locations pre and post monsoon imageries do not indicate any morphological changes for remaining years.Though the analysis shows some changes or shift in plan form of deep channel course, these movements of deep channel are either within Khadir or within high banks that is within the normal flood plain where there is no habitation but seasonal agricultural land. Such locations are between Okhla barrage and Gokul Barrage. In rest of the reach after confluence with Chambal River, the deep channel meanders within Khadir.

River Yamuna cross sections Analysis

River cross sections for different years in entire reach were analysed. The cross sections of different years at a given site were superimposed to study changes in bed and bank profiles over the period of data. Analysis of data in general indicates that major changes in bed profile were in year of high floods. Except for some bank erosion in some years, minor shift in deep channel position and bed level changes to the tune of 1 to 2 m the river sections were nearly stable.

0.4 Field Surveys and investigations

WAPCOS undertook cross section surveys up to +2m above High Flood Level at every 200m interval (excluding Bathymetric survey, the data for the same has been provided by IWAI) and additional survey necessary to fill data gaps and record details after physical verification, wherever necessary. WAPCOS also carried out Geotechnical Investigations at the locations of proposed structures. In order to present survey data and results in detail the whole River Yamuna NW 110 Course has been divided in following 4 stretches with considering Chaiange 0.0 Km at Prayagraj increasing towards Delhi and Ch. 1089 Km at Delhi

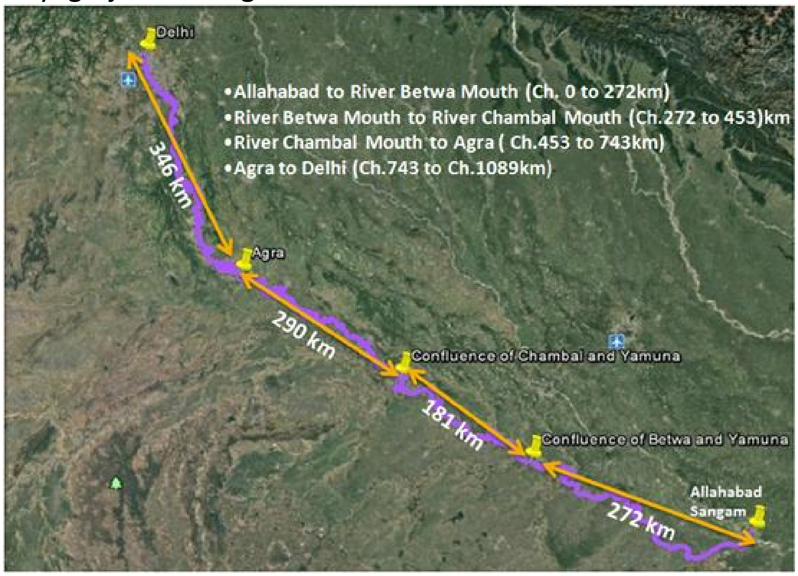


Fig. 8 Location of Stretches

During field survey the observed water depth has been reduced w.r.t Chart Datum (CD) and the graphs has been plotted to show the variation of bed level, sounding datum, water level & high flood level to correlate each other and ascertain water availability. The following graphs depict the same.

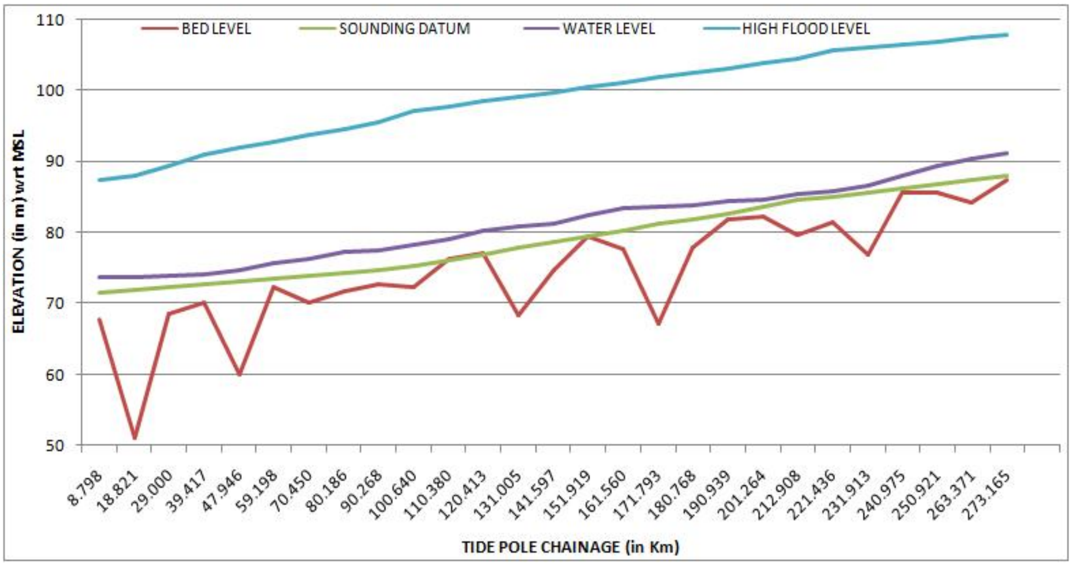


Fig. 9 Water Depth Variation in Stretch 1

From the above graph it seen that the water depth variation in stretch-1 (Prayagraj to Betwa Mouth) are to the tune of 0.8 m 3.2 m.

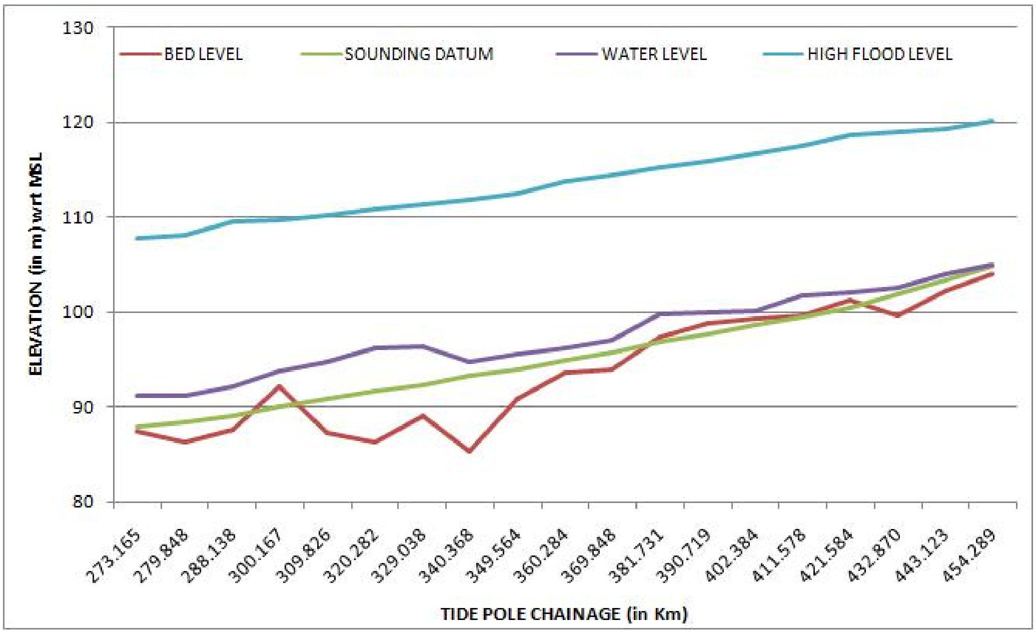


Fig. 10 Water Depth Variation in Stretch 2

From the above graph it seen that the water depth variation in stretch-2 (Betwa Mouth to Chambal Mouth) are to the tune of 0.2 m 4.5m.

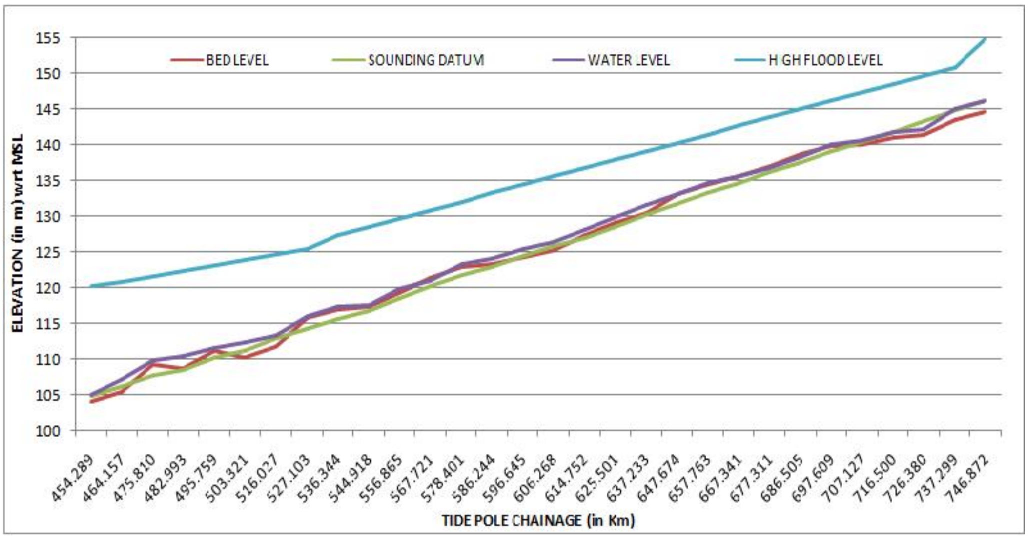


Fig. 11 Water Depth Variation in Stretch 3

From the above graph it clearly seen that the water depth variation in stretch-3 (Chambal Mouth to Agra) are to the tune of 0.08 m 2.21m.

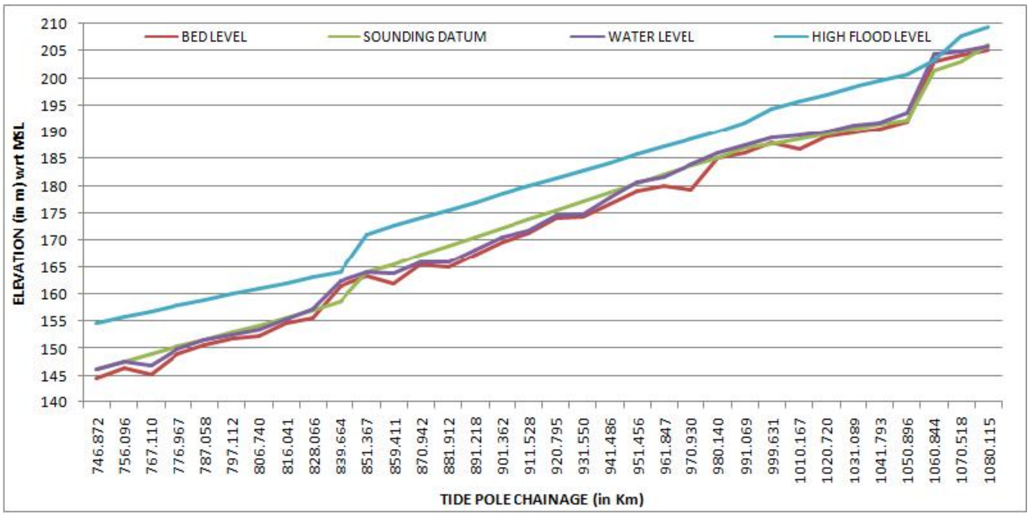


Fig. 12 Water Depth Variation in Stretch 3

From the above graph it clearly seen that the water depth variation in stretch-4 (Agra to Delhi) are in the tune of 0.07 m 3.85m.Also, Stretch and sub stretch wise summarized water depth available during survey period is given in below table:

The geotechnical investigations were carried out during January 2019 to March 2019 at proposed locations and consist of total 30 nos. of Boreholes up to 30m depth below river bed level/ground level. Laboratory test has been carried out of the sample collected during SPT. From the laboratory test results, the different strata of the soil are found and they are categories as Loose brownish grey silty fine sand(SM) up to approximately 2-5 m depth, Medium dense brownish grey silty medium sand with traces of mica(SM) from 5-15 m depth, Dense yellowish brown silty medium sand with traces of mica(SM) from 15-22m depth, Very dense yellowish blue silty coarse sand with traces of mica(SM-SP) from 22m to 30 m depth. Lowest & highest N value among all borehole is 6 & 67 respectively.

0.5 River Navigation Improvement Works

After analysis the Construction of level reaches through barrages, weirs and or similar structures / interventions has been proposed. It is proposed to construct barrages with Navigation locks across River Yamuna at approx. every 30 km (60 Km between first 2 barrages) beginning 1st barrage from Ch. 371 Km at Kalpi to Ch. 1022 at Greater NOIDA as shown below

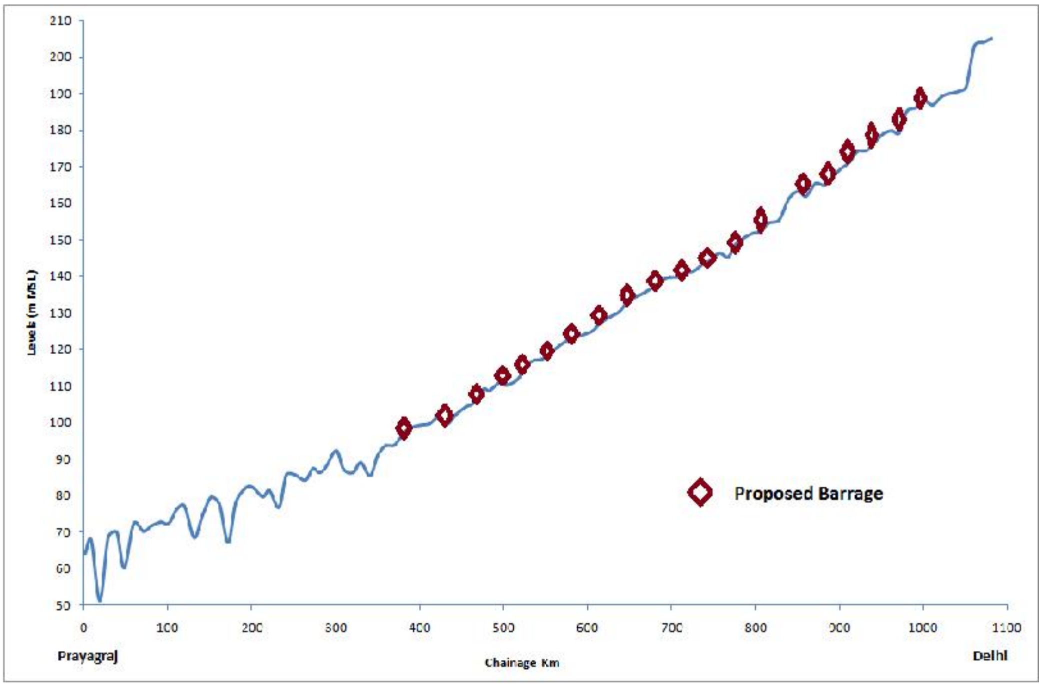


Fig. 13 Location Proposed Barrages

The barrage sitesare so located that the authorized water depth (2.5m) is maintained. The proposal consists of construction of barrages with navigation locks including vertical lift gates enabling a requite ponding level to maintain authorized water depth of 2.5m during lean season

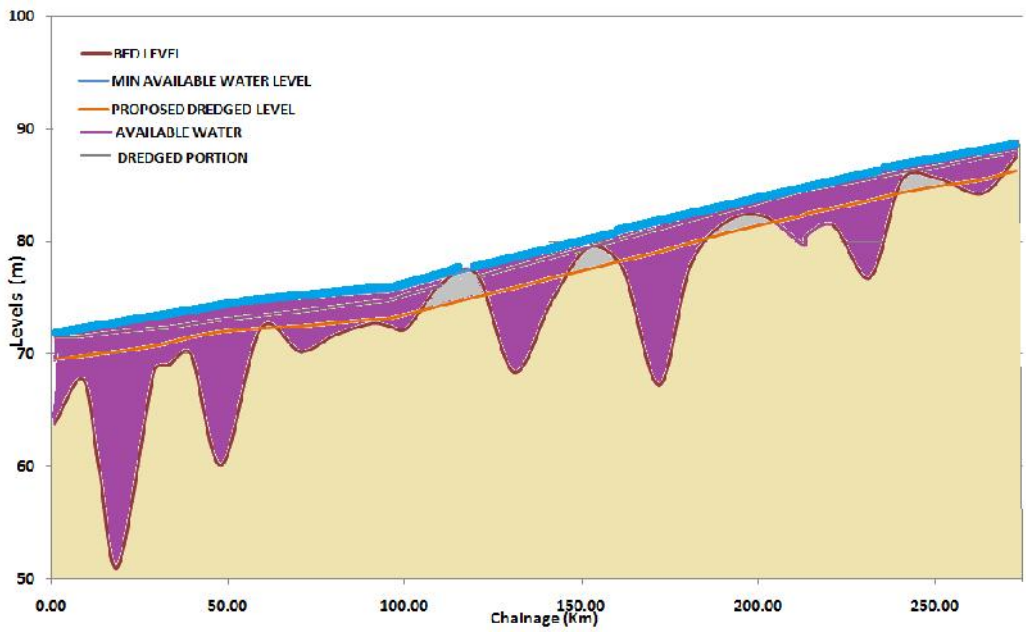


Fig. 14 No Barrage in Stretch-1 (Ch. 0km to Ch. 272 km)

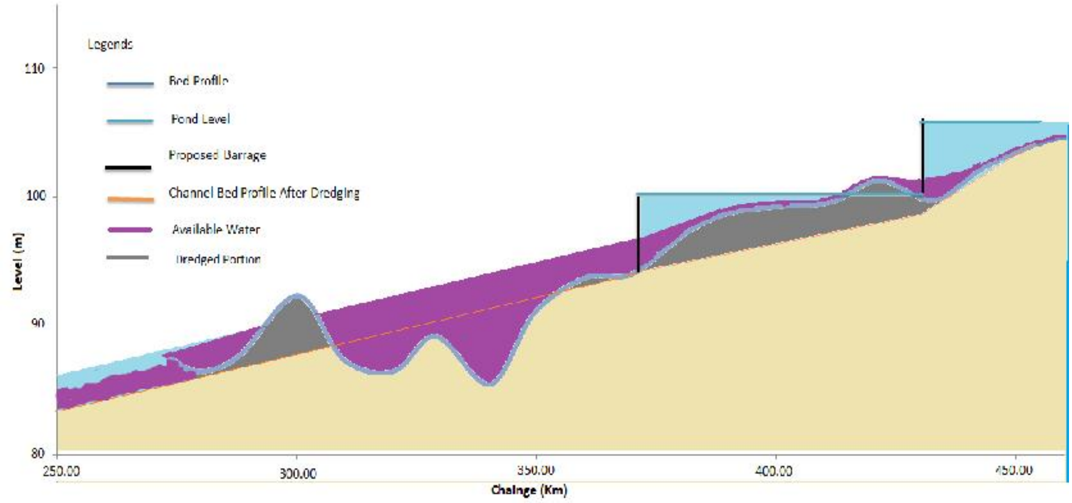


Fig. 15 Barrage Location for Stretch-2 (Ch. 272 km to Ch. 453 km)

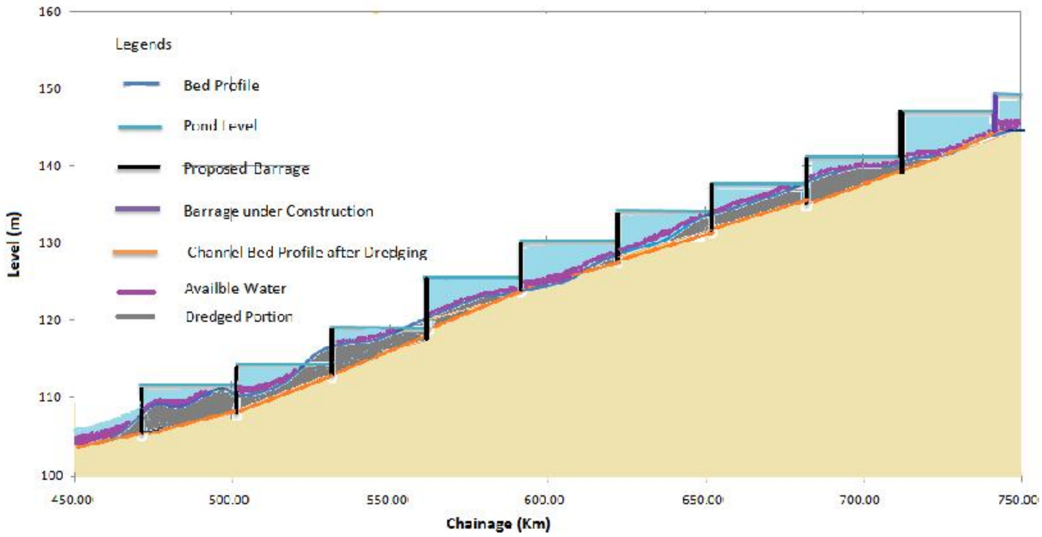


Fig. 16 Barrage Location for Stretch-3 (Ch. 453 km to Ch. 743 km)

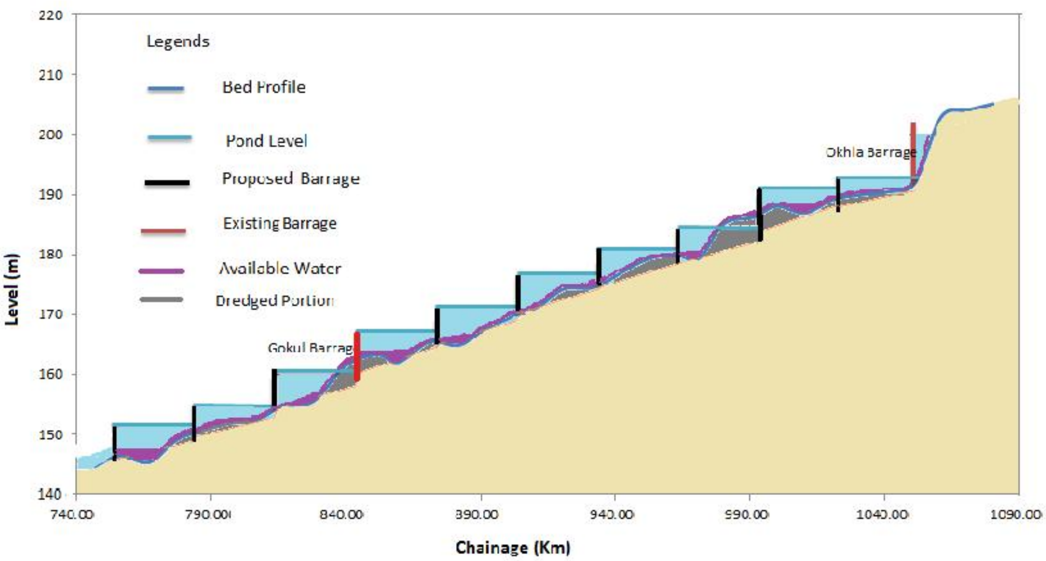


Fig. 17 Barrage Location for Stretch-4 (Ch. 743 km to Ch. 1081 km)

For that purpose it is proposed to store rain water at Barrages. The barrages are so located that the stipulated 2.5m depth is available round the year. The bed slope and hydrology of the river has been taken into consideration while locating the barrages. After data analysis it is found theoretically that 20 Nos. of barrages along with navigation locks would be required for the storage of water to maintain the 2.5m depth of water for navigation. The ponding levels are so designed that storage level of water would remain within the banks. This means that habitation/villages/agriculture fields would not be affected due to submergence. Storage can be made in the out falling rivers, if necessity arises, to avoid any submergence on the upstream side and without encroaching the rights of the beneficiaries. Two nos. Cross regulators one each on River Betwa and River Chambal have been proposed to store the water on the upstream side and to regulate the flow in river Yamuna whenever required. This will also avoid the flooding in the upstream area of River Betwa and Chambal. Proposing barrages along with dredging is more feasible in River Yamuna. Therefore, it is recommended to consider this option for development of navigation in the River Yamuna. Dredging quantity for each stretches for different class of waterways are presented in the following tables:

***Table 5 Dredging Quantity for Different class of waterways by considering dredging*along with Barrage**

Sr. No.	Stretch	Quantity for 2.5m depth	Quantity For Class IV	Quantity For Class III	Quantity For Class II	Quantity For Class I
1	Prayagraj to River Betwa Mouth (Ch. 0 to 272 km)	17.39	6.62	5.08	2.88	1.69
2	River Betwa Mouth to River Chambal Mouth (Ch.272 to 453 km)	17.96	7.71	6.31	3.84	2.43
3	River Chambal Mouth to Agra (Ch.453 to 743 km)	8.31	3.61	2.67	1.5	0.86
4	Agra to Delhi (Ch.743 to Ch.1081 km)	7.98	3.09	2.14	1.16	0.71
Total Dredging Quantity		**51.64**	**21.03**	**16.2**	**9.38**	**5.69**

0.6 Market Assessment

Delhi and Uttar Pradesh constitute predominant parts of primary hinterland for NW 110. A small area from west of NW 110 (less than 50 Km) of Madhya Pradesh, Rajasthan and Haryana falls under secondary or tertiary catchment area. The Hinterland map below depicts broad areas to be considered for this study, NW 1, NW 110 connectivity and nearby ports in East coast of India that are used for EXIM purpose by nearby landlocked region. Hinterland of NW 110 could participate in the EXIM trade, using a combination of NW 1 and NW 110. Apart from these, JNPT is also a major port that handles container traffic originated from northern region for export/import purpose.

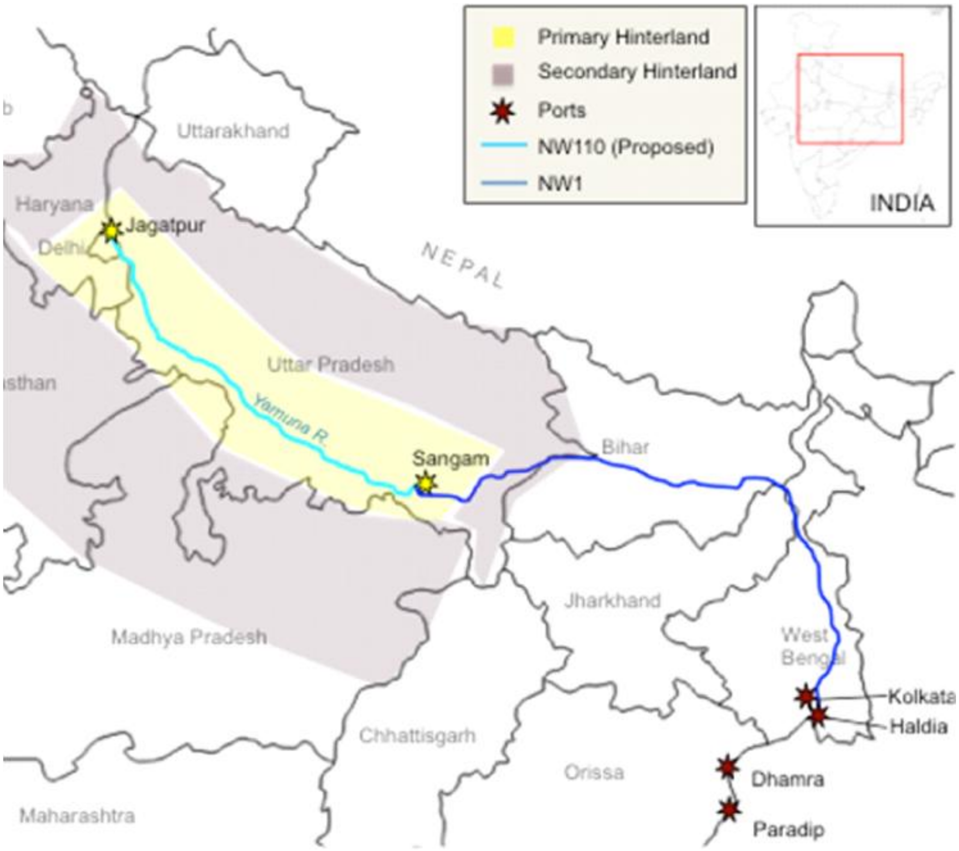


Fig. 18 Hinterland of NW 110

Prospects for transportation on Yamuna could broadly be divided into 2 categories namely, Cargo and Passenger. Two types of cargo are considered, finished products from existing industries and bulk material from mines and agriculture. Passenger segment could be divided into two categories, local residents and tourists. Local residents travel regularly for work related activities. Some local residents travel occasionally also for other purpose, like farming, visiting commercial centers etc. Tourists usually visit Taj Mahal, Sangam, some heritage sites in the region etc.

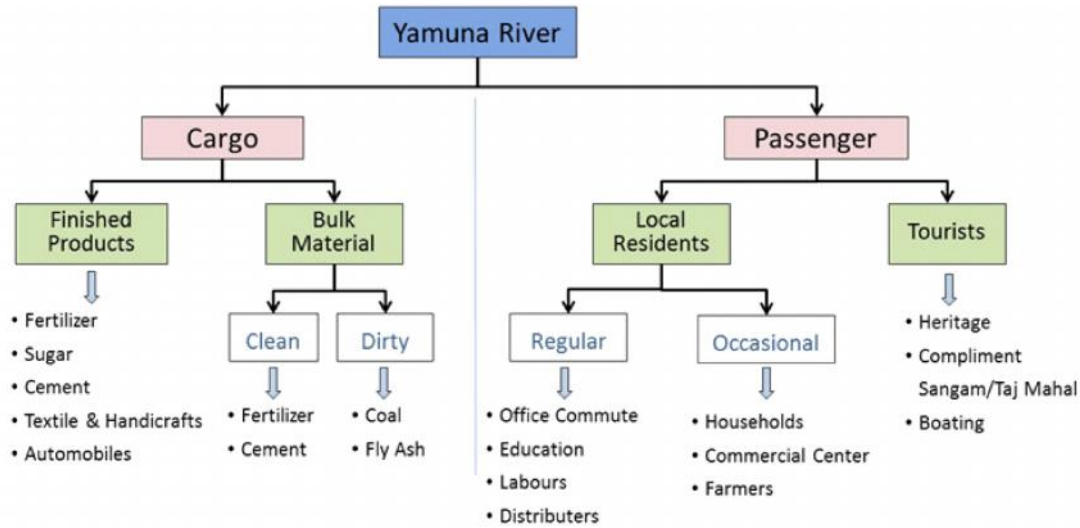


Fig. 19 Opportunity for Water Transportation in Yamuna (NW-110)

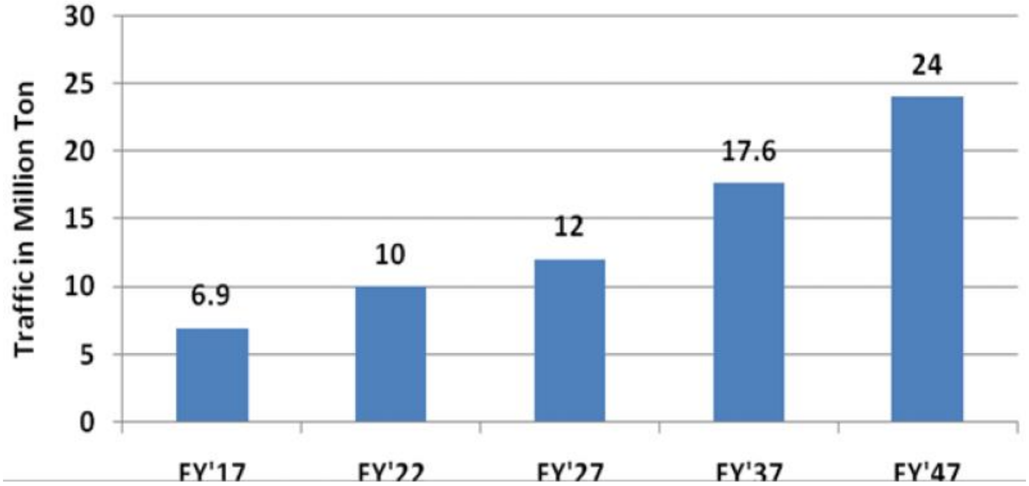


Fig. 20 Cumulative Cargo Traffic Projection

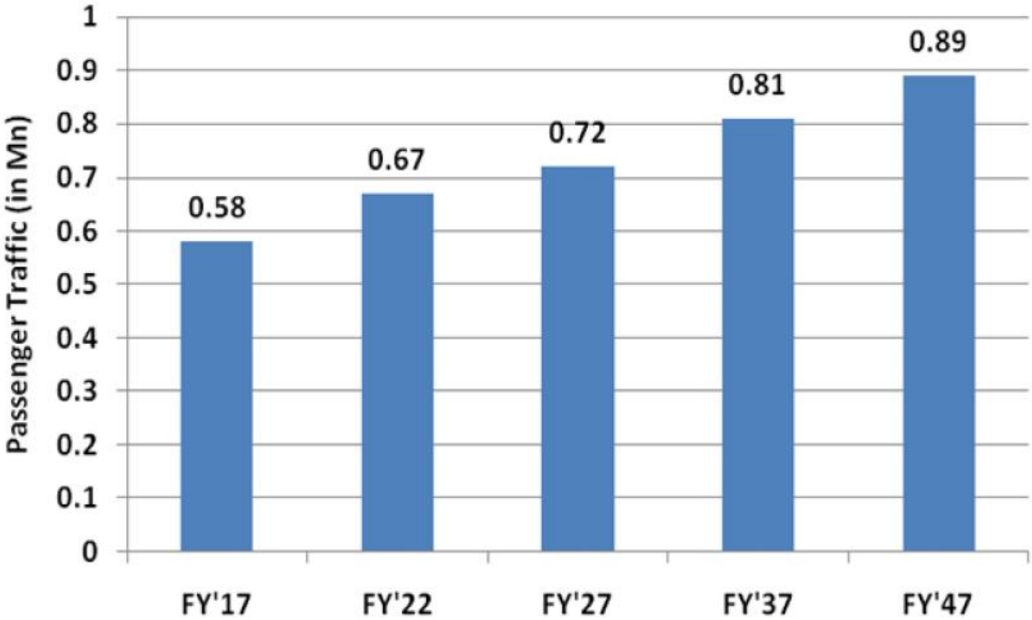


Fig. 21 Inter-District Passenger Traffic Projections

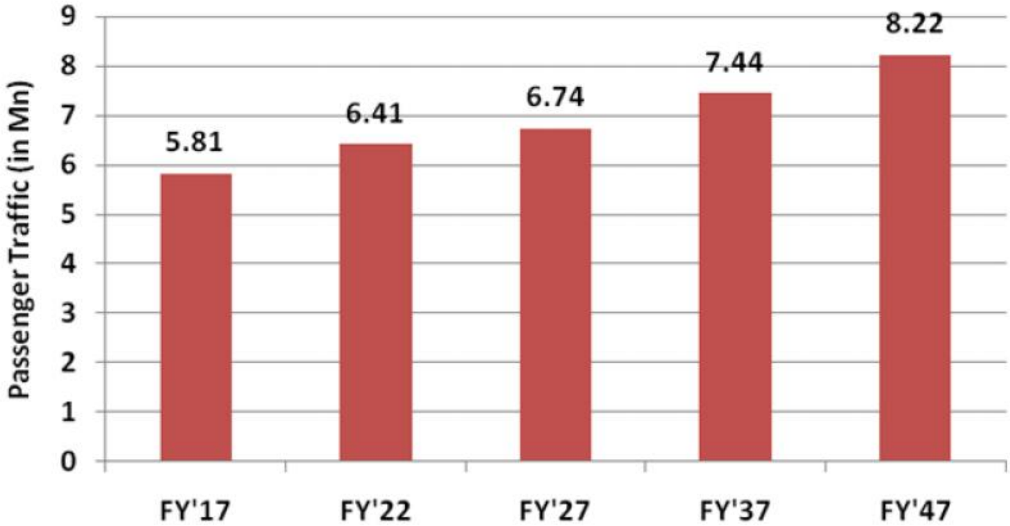


Fig. 22 Intra-District Passenger Traffic Projections

0.7 Waterway and Infrastructure Analysis

The location of the proposed terminals has been identified by considering the Availability of land for terminal, Availability of water depth at terminal site, Availability of cargo and industries nearby, Approach between terminal, nearby city and destination industry.Total 19 terminals are proposed at NW 110 for handling cargo and passengers. These terminals are located at various locations, on the bank of river Yamuna.

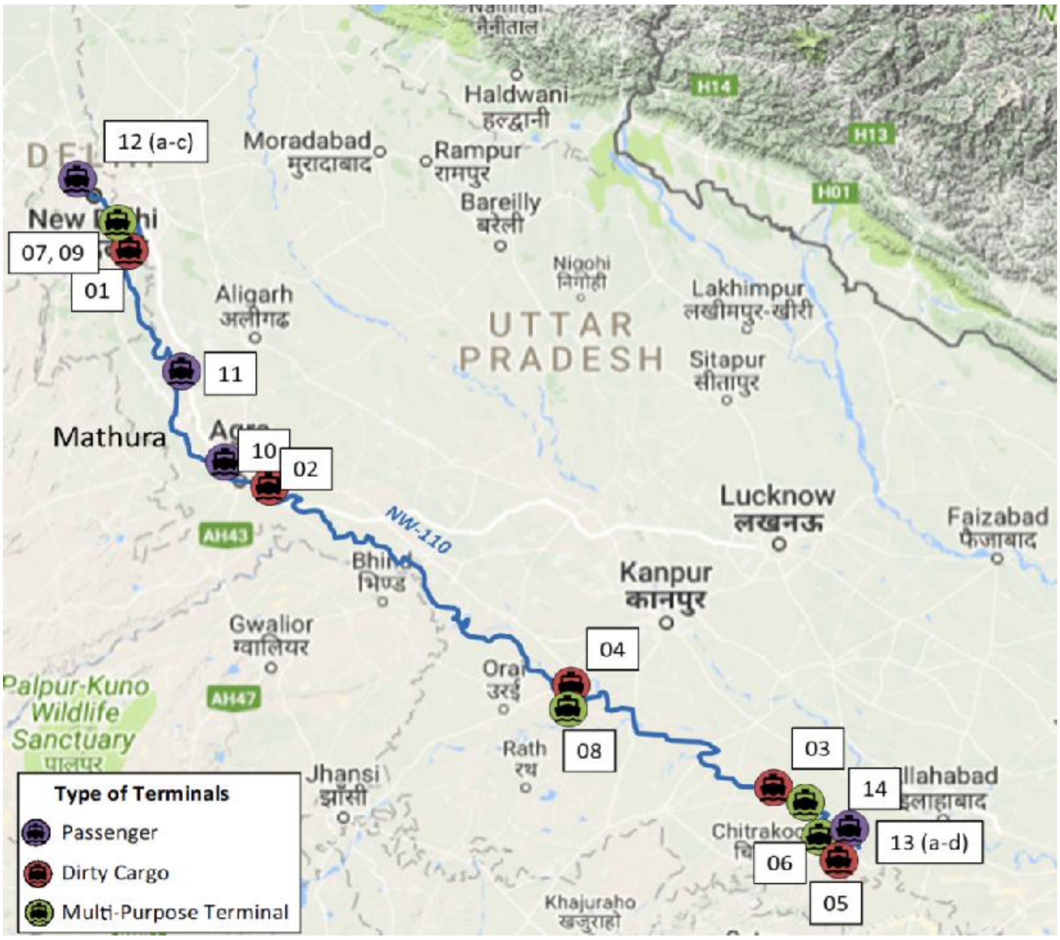


Fig. 23 Proposed Terminals on NW 110

Terminal No.	Terminal Location	Chainage (Km)	Cargo	Projected Traffic ('000 T)				
				Fy 17	Fy 22	Fy 27	Fy 37	Fy 47
T1	Madanpur Khadar, South Delhi	1047.8	Coal	1,083	1,592	2,032	2,866	3,851
T2	Samogar Mustkil, Agra	731.0	Coal	636	934	1,192	1,682	2,260
			Fly Ash	263	386	493	572	632
T3	Mahewa Khachhar, Kaushambhi	98.0	Coal	750	1,102	1,407	1,985	2,667
			Fly Ash	361	530	677	785	867
T4	Dilauliya Kachhar, Kanpur Dehat	349.2	Coal	682	1,002	1,279	1,803	2,424
			Fly Ash	586	861	1,099	1,275	1,408

Terminal No.	Terminal Location	Chainage (Km)	Cargo	Projected Traffic ('000 T)				
				Fy 17	Fy 22	Fy 27	Fy 37	Fy 47
T5	Near Naini Bridge, Prayagraj	3.0	Coal	1,407	2,068	2,639	3,723	5,003
			Fly Ash	571	839	1,071	1,242	1,372
T6	Near Jamuna Bridge, Prayagraj	4.2	Fertiliser, Food grains, Sugar	527	695	848	1,037	1,128
			Automobiles ('000 PCU)	32	41	52	70	93
T7	Madanpur Khadar, South Delhi	1049.0	Foodgrains, Sugar, Iron & Steel	805	1,077	1,329	1,703	1,986
			Automobiles ('000 PCU)	63	81	103	139	186
			Containers ('000 TEU)	250	351	470	657	840
T8	Daulatpur Kanpur, Dehat	349.8	Food grains, Sugar, Iron & Steel, Fertiliser	702	913	1,114	1,382	1,529
			Automobiles ('000 PCU)	32	41	52	70	93
T 14	Bakshi Moda, Prayagraj	8.5	Stone Chips / Silica Sand / Other Commodities ('000 Trucks)	12.7	12.7	14.9	17.1	19.1

As shown in the above table, coal handling terminals (Terminal 1-5) would cater to the coal (procured & imported) requirement of the numerous power plants in the hinterland. Terminal 6, 7 & 8 are proposed as multipurpose terminals for handling clean and multipurpose cargo, like iron & steel, automobile, food grains, sugar, containers etc. Terminal 7 & 8 would help in seamless movement of overseas trade as well as the domestic freight transportation.

It is proposed that three shipyards could be developed near the terminals one at Chainage 349 Km Kalpi, second at Chainage 731 Km near Agra and the third at Chainage 1049 km near Okhla. This location will ensure that for reaching a dry dock, upstream or downstream barges need to travel not exceeding 300-350 km distance as upper limit.

0.8 Model Studies

The CWPRS, Pune had conducted mathematical model study for routing the flood in river Yamuna and based the field survey data and Gauge-Discharge data available at CWC sites. The model was set up with inclusion of bridges, weir, barrages, etc. The mathematical model covering the reach starting from upstream boundary point of 6km upstream of Wazirabad Barrage at Delhi to downstream boundary at Sangam, Prayagraj, project was developed. Complete stretch of 1089km is divided in zone 43 and 44.

i. From Sangam at Prayagraj (CH 0km) to Agra (CH 755km) Zone 44
ii. From Agra (CH 755km) to Delhi (CH 1089km) Zone 43

and model is prepared for existing condition and by proposing the barrage the water level has been computed by modelling of River Yamuna.

For simulation of lean flows discharges ranging from 20 m^3/s to 200 m^3/s were run. For high flood simulation some observed high flows and 100 year return period discharges were used. The emphasis of study was onWater depths available along proposed navigation reach under existing conditions and measures for improvement of navigability.Analysis of model G-Q data, bathymetry data, and model results indicate following conclusions

i. Lean season minimum flows available from Delhi to Etawah are in the range of 5 to 20 m^3/s and average of 10 daily flows during lean season is in the range 20 to 40 m^3/s. As compared to this minimum lean season flows in downstream reach from Auraiya to Naini are 60 to 180 m^3/s and average ten daily flows are 120 to 400 m^3/s. The inflows from different tributariesviz. Chambal, Sind, Betwa and Ken improves flow in this lower reach.The baseline Understanding and presentation of baseline flow at different segments 50 km length each of the main river is presented in Fig. below

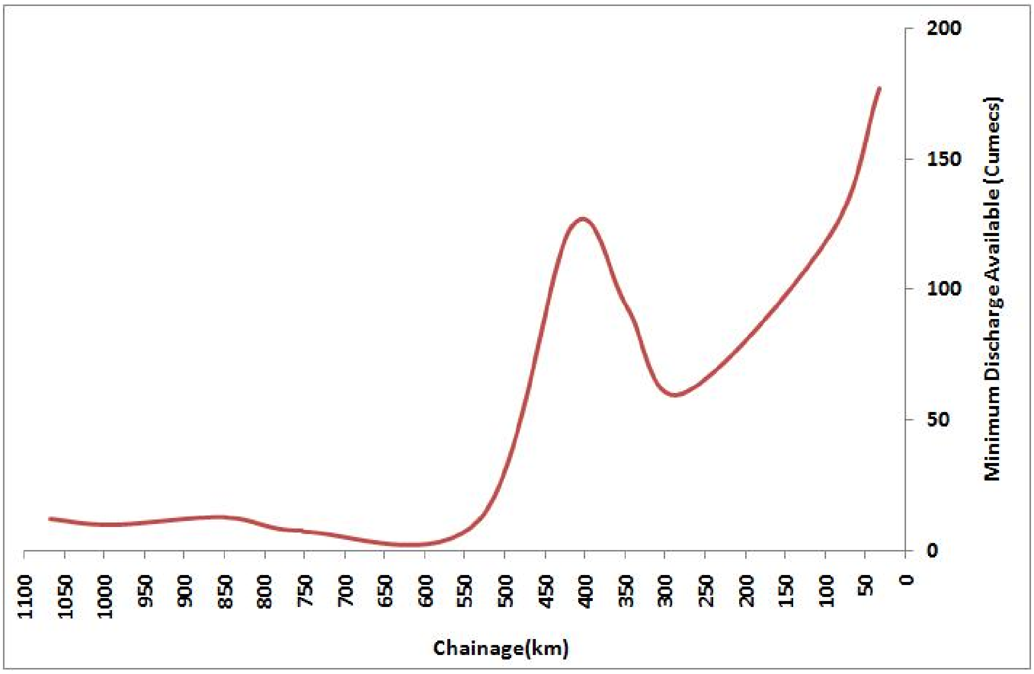


Fig. 24 Presentation of baseline flow at different segments

The needed flow for each 50 Km length has been computed to maintained 2.5 m draft for a waterway of 60m and 120m width and the available lean season flow are presented in the table given below:

Table 6 Needed flow and Available flow

Chainage (Km)	Targeted Depth (m)	Discharge Required (Cumec)		Available Lean Season flow (Cumec)
		60 m Channel Width	120 m Channel Width	
0 - 50	2.5	78.48	156.95	177.50
50 - 100	2.5	109.86	219.73	132.00
100 - 150	2.5	87.34	174.69	107.50
150 - 200	2.5	47.29	94.58	90.00
200 - 250	2.5	116.01	232.02	72.50
250 - 300	2.5	70.14	140.28	60.00
300 - 350	2.5	100.97	201.93	75.00
350 - 400	2.5	93.98	187.95	115.00
400 - 450	2.5	82.94	165.87	120.00
450 - 500	2.5	148.30	296.59	57.50
500 - 550	2.5	85.26	170.52	15.00
550 - 600	2.5	113.25	226.50	5.00
600 - 650	2.5	132.88	265.77	2.50
650 - 700	2.5	119.80	239.61	5.00
700 - 750	2.5	114.16	228.31	7.50
750 - 800	2.5	99.86	199.73	9.00
800 - 850	2.5	143.81	287.62	12.50
850 - 900	2.5	127.68	255.35	13.00
900 - 950	2.5	126.58	253.17	11.50
950 - 1000	2.5	128.74	257.48	10.00
1000 - 1050	2.5	130.01	260.02	10.00
1050 - 1081	2.5	406.65	813.29	12.50

The table above reveals that the available lean season flow is not enough with river bed and profile remaining as it is and is very low as compared to high requirement of discharge except in first 50 km of river stretch for 120m wide channel while the available lean season flow is enough to meet targeted draft of 2.5m up to chainage 370 Km for 60m wide channel. The remaining portion of the NW110 above Ch. 371 up to New Delhi at Ch. 1081 Km for 60m wide channel the available flow is not sufficient to meet targeted draft of 2.5m.

Yamuna river bed slope in reach from Okhla to Auraiya is about 1/5900 and is much steeper than the slope of lower reach from Auraiya to Naini (1/14250). The lower reach has undulating river bed with relatively mild average slope resulting in formation of many deep pools along the reach.

ii. The model results for the lower reach from 0 to 370 km with lean season flows mentioned above indicate that in most of the reach water depths will be above 2.5 m except for some intermittent reaches where bed levels are high. Even in these intermittent reaches water depths for minimum lean season flow of 50 m^3/s and 100 m^3/s will be in the range 0.6 m to 1.5 m and 0.8 m to 1.8 m respectively. Thus, the existing flow is enough with channelization of the riverincluding dredging of the order of 1.0 m to 1.9 m in these stretchesminimum water depths water depth of 2.5 m could be created in the entire stretch of 370 km. Considering minimum water level of 71.39 m at Naini (during period 1999- 2016)no dredging will be required in the reach 0 km to about 50 km. This reach of 370 km can provide navigable stretch with 2 m depth round the year after carrying out suggested dredging.

iii. Analysis of results for remaining reach from 370 to 1081 km up to Delhi/Palla for lean season minimum flows mentioned above indicate following

- Depths in this entire stretch will be in the range 0.5 m to 1.5 except for some deep pools and about 7 km reach on upstream of Okhla barrage where depth more than 2.5 m prevail.
- Reasons for low water depths are low lean season flows, steeper slope of reach and larger river bed width
- Even with increase in discharge to 50 and 100 m^3/s the rise in depth was very marginal due to steeper bed slope and wide river bed.
- Dredging river bed1.0 m to 2.0 m over such long reach will not be economical and it may not serve purpose due to inadequate flow in lean season.
- Provision of barrage at an interval of about 30 km with pond depth of 5 m to 6 m at each barrage is the only possible measure.

iv. Analysis of result for model runs with proposed 20 barrages in reach from 370 km to 1052 km (Okhla barrage) and maintaining design pond levels indicate following :

- With proposed 20 barrages in this 680 km reach and lean season flow of 20 to 30 m^3/s flow , water depths of 2 m and above will be created in about 560 km reach. In remaining 120 km reach depths will be less than 2 m.
- About 6 to 10 km reach on downstream of each barrage will have water depths 0.5 to 1.8 m.
- Major portion of 120 km reach identified with water depths less than 2 m will have depths in the range0.8 m to 1.5 m. Thus,dredging depths will be in the range 0.50 m to 1.2m.
- The dredging requirement in 120 km reach can be reduced further by raising design pond level by about 1 to 1.5 m after studying implications in case of each Barrage

With proposed barrages depths of 2.5 m will be available so that class IV waterway could be developed

0.9 Preliminary Engineering Designs

Design vessels of maximum length 110 m, beam 11.4 m, draught 2.5 m to 2.8m and air draught of 9m will ply in NW-1 waterway and the same vessels will travel to NW 110 also. However, the vessel size will vary in different stretched as per the available LAD and type and quantity of cargo to be transported. Vessels of size 1000-2000 DWT are expected to ply in the waterway NW 110.

It is planned to provide two-way cargo movements in the navigation channel and maintaining the width of channel between 60-120 m. However, at present it is planned to maintain the channel width of 50 m and side slopes of 1:5 from section Prayagraj to Delhi.

For maintaining 2.5 meter water depth in the channel from Delhi to Prayagraj 20 nos. of barrages has been proposed. The barrages have been designed for discharges ranging from 4200 m^3/s to 36000 m^3/s with guide bunds. The barrages have been founded well below the scour depths for design discharges. The length of barrages range from 219 m to 571m. Similarly, two regulators, one each at River Betwa Mouth and River Chambal Mouth have been proposed for watewr storage purposed. The regulators have been designed for discharges ranging from 20000 m^3/s to 33000 m^3/s with guide bunds. The regulators have been founded well below the scour depths for design discharges. The length of regulators range from 442 m to 602m. Navigational locks of dimensions 175m X 44m have been proposed at every barrage and regulator locations having two chambers separately for upstream and downstream vessels. The lock chamber dimensions of 125mx18mx3.5m has been proposed.

45 nos. existing bridges falling in the stretch of Yamuna River are not having requisite horizontal and vertical clearance as per IWAI guidelines and needs to be demolished and reconstructed.

Total 19 nos. of terminal have been identified including 8 Cargo terminals, 10 Passenger terminals and one Ro-Ro terminal. The proposed jetties at cargo terminals are required to handle Self-propelled barges, carrying capacity 1000 DWT, Size (70m X 12m), loaded draft 1.8m (Class-IV) or IWAI designed vessel of size (110m X 12m). The jetties are planned as a berthing structure proposed to be on piles, which provide least resistance to natural equilibrium and ease of extension/addition of facilities at a later date. The berthing structure is of length 125 m and width 25m. To cater to the berthing requirements at passenger terminals for easy embarkation/disembarkation to the taxi, a floating jetty of 50m x 20 m has been proposed. All the permanent structures including terminals will be protected with stone pitching weighing around 40 to 50 kg.

The Dry dock has been proposed with One Dry-Dock capable of repair and building of ships up to 110 m. The dimension of the Dry Dock would be 120 x 25 x 3 m. The facility would have an outfit jetty of 120 m. This would have the capacity to carryout outfitting on one ship at any given time.

0.10 Navigation & Communication System

DGPS, VTMS and Marine Lantern/Buoys have been proposed to be installed for safe navigation of vessels and to have complete control on traffic handled at terminal.

0.11 Socio Economic Environment Assessment

There exists an urgent need to involve NW 110 development agenda under major Government policies and objectives to increase socio economic benefits offered by NW 110. The major socio-economic benefits that will accrue with the development of inland waterway on NW 110 are as follows:

- Employment Generation
- Fuel savings due to Inland waterway transportation
- Carbon credit earned
- Reduction of congestion on existing modes
- Other benefits such as reduction in accidents, noise etc.
- Less cost of development
- Less land occupancy
- Property Uplift and Regeneration
- Transportation of goods and passengers
- Ecosystem Services

The employment generation to the tune of more than 50000 is estimated.

0.12 Capacities Building and Financing

IWAI should integrate administrative functions with operation, maintenance, and development function and run the enterprise on sound Business Management Principals. The set up should also have jurisdiction and control over all other Government, Public and Private Vessel Operators on the River Yamuna (NW-110). Other Government, Public and Private Parties can be allowed to carry on their present business as usual but under the administrative control on IWAI which frames rules and regulations for such operation. The conceptual set up of such organization envisages setting up of Inland Waterway Authority construction and maintenance division for River Yamuna with its headquarters at Prayagraj. Proposed Terminals for River Yamuna can be run under this setup.

Man power requirement for operation of waterway in River Yamuna includes for terminal operations, Navigational lock operation and departmental requirement. Departmental regional office will be set up at Prayagraj. Waterway maintenance division will be setup under the regional office for maintenance of navigable waterway. Every terminal will require institutional setup for proper functioning of terminal operations. Terminal manager will be the head at terminal responsible for overall terminal operations.

To facilitate unhindered private investment, IWAI can earmark some incentives, in the form of VGF/Subsidies, and attract more private parties in bid participation. The inland waterways project involves significant investment/operating cost, and such a backing from government could prove critical in presenting the project as a lucrative business opportunity to the private sector.

Navigation development by Government/Inland Waterways Authority of India would have to be made using Design and Build contract system. IWAI on behalf of Government would have the sole responsibility of operating and maintaining fairway.

Inland Waterway Authority could monitor and maintain river waterway system on its own. Alternatively, it could appoint a Project Management Unit, which would be working on a fixed fee to monitor and maintain round the year navigability on the waterway system. The professionals working at PMU would be acting on behalf of IWAI for implementation of fairway development project.

The Multipurpose terminals could be developed using Build, Own, Operate and Transfer (BOOT) model. The time duration for BOOT operator of this project could be 30 years or more. This could be developed following a principal used for development of terminals and freight villages on River Ganga (National Waterways NW-01). These terminals were found to be commercially viable on a standalone basis. Allowing Third Party Logistics Company or terminal operators develop this terminal following a Public-Private Partnership (PPP) model would help bring best practices in handling, storage, processing and evacuation of clean cargo.

0.13 Project Implementation Schedule

Phasing of the project has been considered on the basis of navigable depth, traffic potential and economic considerations. The project has been proposed to be developed in following three phases:

Table 7 Phasing of Project

Phase	Stretch	Construction period
Phase 1	Prayagraj (Ch. 0.0 Km) to River Chambal Mouth (Ch. 453 Km) and Upstream of Wazirabad Barrage, Delhi (Ch. 1074 Km) up to Jagatpur (Ch. 1081 Km)	Year 2021 to Year 2025
Phase 2	River Chambal Mouth (Ch. 453 Km) to Agra (Ch. 743 Km)	Year 2027 to Year 2031
Phase 3	Agra (Ch. 743 Km) to Okhla Barrage, Delhi to (Ch. 1052 Km)	Year 2032 to Year 2036

0.14 Project Costing

Project has been proposed to be developed in 3 phases. Total capital cost estimate for the phase-1, phase-2 and phase-3 worked out to **Rs. 7165.26 Crore Rs. 5078.01 Crore** and **Rs. 7386.60 Crore** respectively.

0.15 Economic and Financial Analysis

River Yamuna has been approached with the scope of handling both types of traffic i.e. Cargo and Passenger for along the river movement. Financial modeling for each terminal on River Yamuna has undertaken. It constitutes financial analysis for 9 Cargo terminals i.e. Terminal no. 1 to 8 & 14 and 10 Passenger Terminals i.e. Terminal no. 9, 10, 11, 12 (a,b,c) and 13 (a,b,c,d). Market-driven rates, benchmarks, and assumptions have been considered to develop financial models for each terminal.

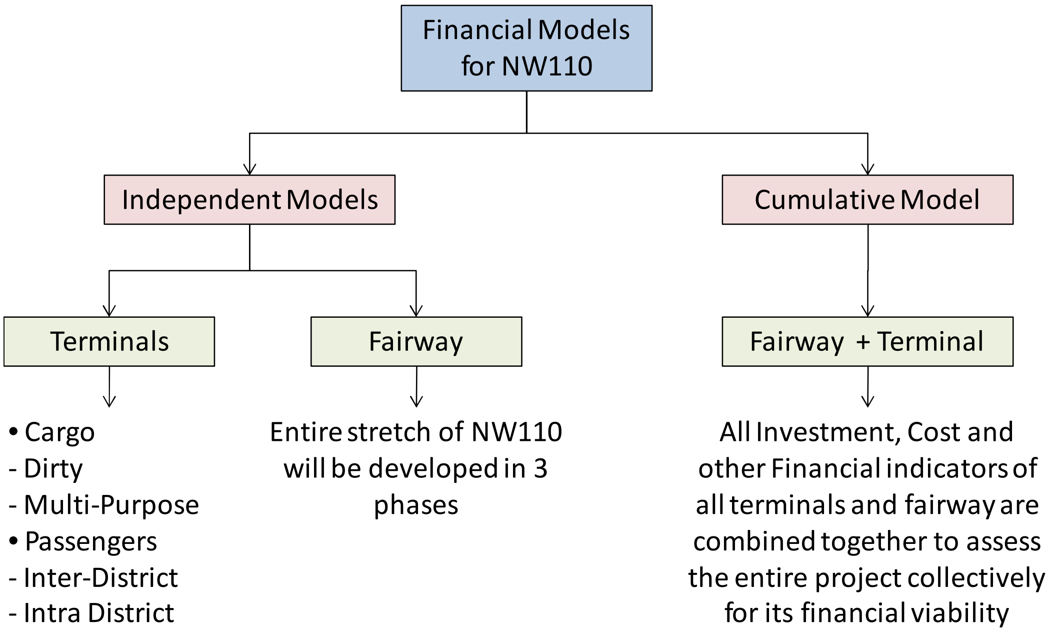


Fig. 25 Structuring of Financial Model

Table 8 Summary sheet of Financial and Economic Return

Type of Infrastructure	Capital Investment (INR Crore)	Financial Returns	Economic Returns	Project Period (Years)	Conclusion	Reasoning
Option 1						
Fairway + Terminal (0-1051 Km)	19,619	-9.0%	1.60%	45	Not Viable	Investment is very high
Option 2						
Fairway + Terminal (Phase 1)	7,199	Non-Existent	5.8%	45	Not Viable	Investment is very high
Fairway + Terminal (Phase 2)	5,065	Non-Existent	N.A	45	Not Viable	Investment is very high

Type of Infrastructure	Capital Investment (INR Crore)	Financial Returns	Economic Returns	Project Period (Years)	Conclusion	Reasoning
Fairway + Terminal (Phase 3)	7,355	Non-Existent	17.0%	45	Not Viable	Investment is very high
Total Cumulative	**19,619**					
Option 3						
Combination of Phase 1 & 2	12,264	Non-Existent	5.1%	45	Not Viable	Investment is very high
Option 4						
Fairway	**13,154**	Non-Existent		45	Not Viable	Investment is very high
Terminal 1	271	15.0%	77.9%	30	Viable on standalone basis	Coal Traffic is high.
Terminal 2	1,154	-2.8%	15.9%	30	Not Viable	Capital Investment is very high
Terminal 3	773	Non-Existent	10.1%	30	Not Viable	Capital Investment is very high
Terminal 4	422	Non-Existent	26.5%	30	Not Viable	Capital Investment is very high
Terminal 5	649	7.3%	19.0%	30	Viable on standalone basis	Coal Traffic is very high.
Terminal 6	459	Non-Existent	3.2%	30	Not Viable	Not fully operational till Phase 3 development of NW 110
Terminal 7	1,917	5.0%	31.7%	30	Viable on standalone basis	Multipurpose terminal with very high traffic
Terminal 8	454	1.3%	10.5%	30	Viable on standalone basis	Fertiliser /Iron & Steel traffic in Phase 1. Fully operational after development of Phase 3 NW 110
Terminal 9	18	0.1%	NA	30	Viable on standalone basis	Projected Traffic is very high due to Mathura & Agra
Terminal 10	76	N.A	NA	30	Not Viable	Traffic from Agra to Prayagraj very low. It will be viable after development of

Type of Infrastructure	Capital Investment (INR Crore)	Financial Returns	Economic Returns	Project Period (Years)	Conclusion	Reasoning
						Phase 3 for movement from Delhi to Agra
Terminal 11	16	6.0%	NA	30	Viable on standalone basis	Tourist Traffic is very high
Terminal 12 a	19	Non-Existent	NA	30	Not Viable	Very low Traffic due to availability of proper road transport
Terminal 12 b	18		NA	30		
Terminal 12 c	18		NA	30		
Terminal 13 a	75	Non-Existent	NA	30	Not Viable	Less traffic movement from Agra to Prayagraj.
Terminal 13 b	39	-3.4%	NA	30	Not Viable	Investment Cost is high.
Terminal 13 c	39	-0.3%	NA	30	Not Viable	
Terminal 13 d	40	-3.6%	NA	30	Not Viable	
Total	**19,619**					

0.16 Conclusions & Recommendations

The traffic projections likely to be transported using River Yamuna is based on the assumption that government will assist in matching the per ton transportation cost on River Yamuna at par with Railways. No cargo would shift from Railways to Waterways in the absence of the same. The project has been found to give no returns to very poor financial returns in all possible modes/structures of investments. Hence, the project has not been found to be financially viable on standalone basis.

This project will contribute in development of local / regional / national economy of the region. Also, the project will generate direct and indirect employment. Therefore, this project should be conceived for initiating the development of the region. In this sense, the project should not be confined to a merely profit-making concept rather the project should be financially self-sufficient. Hence, it is very much essential that the proposed developments be taken up.

The economic benefits like Employment Generation, Fuel savings due to Inland waterway transportation Carbon credit earned, Reduction of congestion on existing modes, reduction in accidents, noise etc., will accrue with the development of inland waterway on NW 110. River Yamuna NW 110 would generate various economic activities such as tourism, boating, water taxi, vessel/boat building & repairs, dredging services, hydrographical survey, safety management etc. Apart from industries, NW 110 would be attractive to both local residents and to visitors/Tourists. For both of these groups, planning and investment is required to maximize the level of engagement on River Yamuna.

Government needs to generate public interest, encouragement and involvement in the prospects and potential inherent in the inland waterways in river Yamuna. Government needs to be determined to provide an investment friendly climate and generate policy and incentives that will encourage new investors and investments in NW 110.

CHAPTER – 1

PROJECT DESCRIPTION

1.1 Introduction

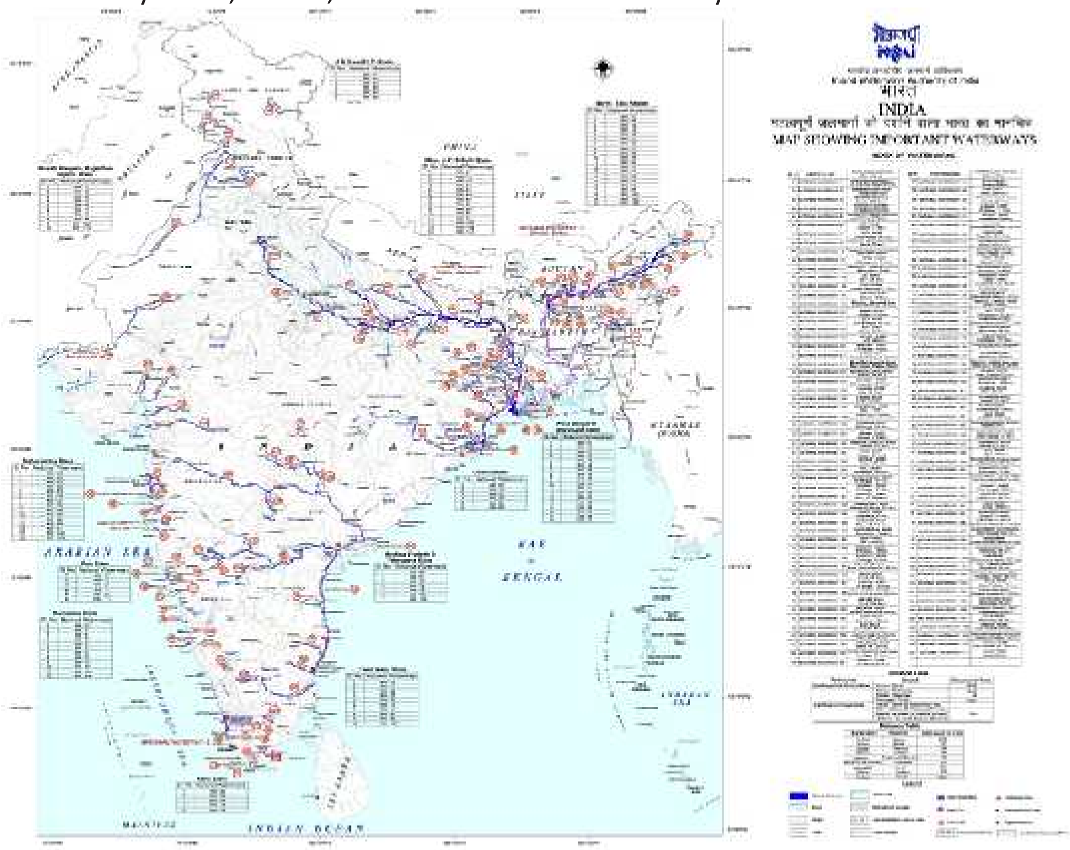
1.1.1 India has an extensive network of inland waterways in the form of rivers, canals, backwaters and creeks. Of the total navigable length of 20,236 km, 17,980 km of the river and 2,256 km of canals can be used by mechanized crafts. Freight transportation by waterways is highly under-utilized in the country as compared to countries and regions like the United States, China and the European Union. National waterways of India are well in line to become the lifeline of the country. Not only will these serve the transportation obligations of our nation, but also will serve as recreational centers.

1.1.2 Inland Water Transport (IWT) has the potential to form the most economic, reliable, safe and environment friendly mode of transport. When developed for use by modern inland waterway vessels, it can reduce investment needs in rail and road infrastructure, promote greater complementarities in the riparian states, enhance intra-regional trade and, through increased economies of scale, significantly reduce transport costs for the benefit of the entire economy and India's global trade competitiveness.

1.1.3 The Inland Waterways Authority of India Act, 1985, provides for "the constitution of an Authority for the regulation and development of inland waterways for purposes of shipping and navigation and for matters connected therewith or incidental thereto". This is the Inland Waterways Authority of India (IWAI) which "came into existence on 27th October 1986 for development and regulation of inland waterways for shipping and navigation. The Authority primarily undertakes projects for development and maintenance of IWT [Inland Water Transport] infrastructure on national waterways through grant received from Ministry of Shipping." This is the most important nodal body for the national waterways in the country.

1.1.4 Ministry of Shipping, Govt. of India had directed IWAI to identify the viable waterways in India for their phased development. Accordingly, 106 new waterways were identified by IWAI and intimated to MoS. In this regard, National Waterways Act, 2016 was published in the Gazette of India, Extraordinary, Part II, Section I dated 26th March, 2016 as an Act No. 17 of 2016. The National Waterways Act, 2016 came into force from 12 April 2017 as per the notification of the Government of India. This act has declared 111 rivers or river stretches, creeks, estuaries as National (inland) Waterways. The passage of this legislation enables the Central Government to regulate these waterways for development with regard to shipping, navigation and transport through mechanically propelled vessels. Prior to this Act there were five national waterways, each declared as such by their own separate legislation.

1.1.5 While navigation in rivers, lakes and other water bodies has been around since centuries, this has been more in the form of smaller vessels, connecting places not too far from each other. In some cases, especially near ports and coastal areas, this has evolved to more large-scale, commercial shipping. The national waterways project now intends to create such large scale, commercial shipping and navigation systems in these 111 waterways. These are intended to realise the potential of cargo and passenger traffic, including tourism and cruise. These waterways pass through 24 states and two union territories, with an approximate total length of 20274 km. These waterways will pass through nearly 138 river systems, creeks, estuaries and related canal systems of India



Source : IWAI **Fig. 1.1 National Waterways of India**

1.1.6 The transportation of goods in India, as of now, is primarily being carried out through rail and road with small share of coastal, pipeline and Waterways. Besides, the modal share of IWT in India stands at only 0.5 %, whereas that in China stands at 8.7%, in the US at 8.3% and Europe at 7%. Inland Water Transport (IWT) is a slower mode of transport when compared to rail and road. However, IWT is most reliable and best suited for transportation of bulk cargo such as grains, fertilizers, cement and fly ash. This is also the safest mode of transport, as it is the least susceptible to the vagaries a nature. This is nothing less than a tragedy, as IWT's fuel efficiency is no secret to the market - it is a well-known fact that about 1 litre of fuel can move 24 tonne km of freight by road, 85 tonne-km by rail and 105 tonne-km by inland water transport .

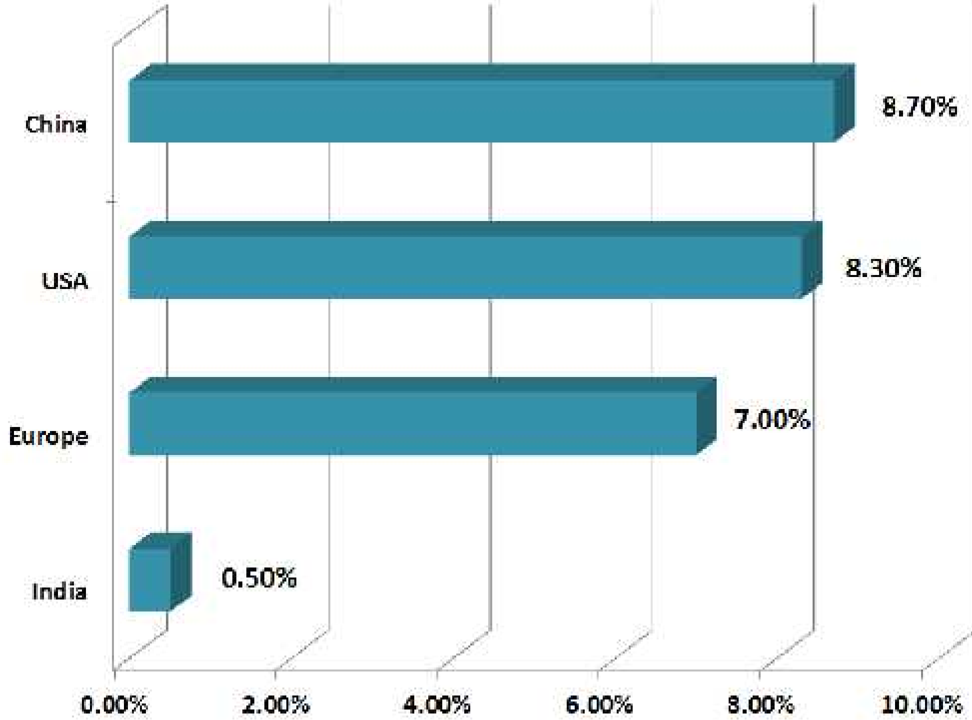


Fig. 1.2 Modal Share of IWT - Comparison

1.1.7 IWAI intends to explore transportation potential of National Waterway (NW) – 110. The proposed route is along the Yamuna River, stretching from Jagatpur (6 km upstream of Wazirabad Barrage) in Delhi to the confluence of Ganges and Yamuna rivers at Sangam, Prayagraj, in the state of Uttar Pradesh (UP). This Delhi-Prayagraj stretch is 1,089 km long, and passes through Delhi, Haryana and UP.

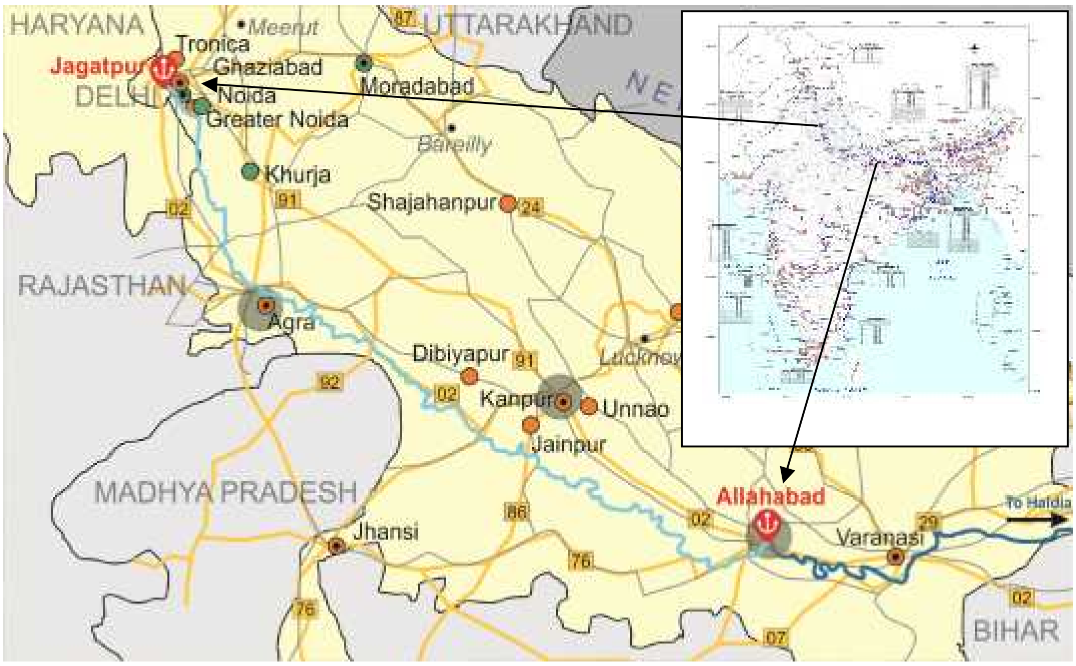


Fig.1.3 National Waterway-110 along with prominent locations

1.1.8 The inland water transport is the most efficient mode of transport from the point of energy consumption, cost of transport and environment friendliness. The some of the advantages of inland water transport are given below:

- It is operationally cheaper
- It is reliable and comparatively safer, being least prone to ‘in transit’ damage or pilferage
- The manpower requirement per unit of load is less as compared to road / railways
- The line cost per unit distance for creating usable fairway is much less than that of railways or roadways
- Assures adequate returns from efficient operations

1.1.9 With global economy and the WTO regime and greater movement of goods to and fro has created a heavy pressure on the already burdened road and rail transport systems. There is limit for expansion of rail and road capacity on account of constraints available land, high cost and environmental factors. In these conditions, IWT can play a supportive role for rail and road movement. There are some hazardous commodities and Over Dimensional Cargo (ODC) which cannot be allowed to be transported on road. In view of the above constraints, the development of IWT has been relevant in today’s context.

1.2 Need of the Project

1.2.1 Inland Waterways are economic multipliers, as they induce factors in development of an area, both through planned development policies and by the unplanned growth of related industries thus providing space for industrial clusters. They also nurture growth of other related industries like ship repairs and dredging activities. The clustering of related activities improves the competitive advantage of players by augmenting their productivity and reducing costs in movement and also paving the way for technological innovation. So, Inland Waterways create a kind of value chain of interrelated activities of the hinterland that are mutually supportive and continuously growing.

1.2.2 India embarked upon a large program of agricultural and industrial production which was resulted in substantial increase in the movement of cargo traffic. In addition to the above, rapid increase in industrialization during the past and present decades created huge impact on existing traffic movement by various modes. Due to the surge in road traffic, Govt. of India focused attention in widening and relaying of National Highways including construction of major time bound projects. In similar fashion, dedicated rail corridors for the movement of goods by rail are in the implementation stage by the Government. Hence, it is evident that all modes of transport need to be developed and the vital role which inland waterways can play in meeting the ever increasing transport needs for a faster economy could not be ignored.

1.2.3 Water based transport is effective as generally speaking, operating costs of fuel are low and environmental pollution is lower than for corresponding volumes of movement by road, rail or air. A major advantage is that the main infrastructure "the waterway" – is often naturally available, which then has to be trained, maintained and upgraded. Transport over waterways is especially effective when the source and/or destination are waterfront locations. IWT is being more energy efficient in comparison with other modes of transport which can help in reducing the transport cost and prices of commodities. IWT is the least energy consuming and energy efficient mode of transportation in addition to many other inherent advantages. IWT generates more employment per unit of investment in comparison with other forms of transportation. Investments in this sector have not equaled those in rail in early years and road in more recent times, there are proposals for investing in this sector. Keeping in mind the various advantages of inland waterways such as cost effectiveness, relative fuel efficiency and importance of mobility besides welfare and development of remote countries, a number of countries are now taking initiatives to make better use of the existing capacity and making investments in IWT. Several development projects aimed at enhancement of IWT infrastructure and operations are underway in Asia despite the recent declining trend in the usage of the region's inland waterways.

1.2.4 NW 110 is proposed to be developed as alternate mode of transportation for cargo and passenger movement. This development would help to decongest traffic of road and railway by shifting it to waterway. This landlocked northern region uses only roadway and railway as primary means of transportation for EXIM trade. Development of NW – 110 could open a new door of opportunity for industries as well as local commuters. Project study would determine all possibilities of decongesting and diverting present traffic to waterway backed with detailed logistics and financial analysis.

1.3 Purpose of the Project

1.3.1 Transport has been considered as a primary factor of economic development. Inland waterways transportation is one of the oldest economic and environmental sustainable modes of transportation for passengers and cargo. In some areas, it is the only means of mobility and access to basic services. The sector encompasses various types and sizes of vessels, operating on waterways in major rivers of India. Inland waterways play a vital role in economic development, especially in remote areas. The potential opportunities for IWT sector depends considerably on the specific regional context, such as geographical conditions, level of road development and socio-economic conditions. Developing and maintaining NW – 110 is an opportunity to improve sustainable development of this waterway and the hinterland.

1.3.2 Globalization and increase in population put pressure on existing transportation modes to meet increased demand. If towns and cities along the banks of Yamuna fails to keep up with the growing need of transportation and are prone to lack of infrastructural facilities, then it reduces the living standard of people. In such situation, development of NW – 110 for cargo, passenger and tourism movement would create a brand value to Yamuna's adjoining states. Development of river Yamuna for passenger and cargo movement opens a new door of transportation and would help to ease the burden of existing modes.

1.3.3 Through the ages, rivers have served as effective waterways, carrying people and goods over long distances. Even today, many countries depend heavily on inland water transport, especially for large and bulky cargo, as it is cheaper, more reliable and less polluting than transporting goods by road or rail. India has yet to develop this cheaper and greener mode of transportation. Goods still travel by congested road and rail networks, slowing the movement of cargo, adding to uncertainties, and increasing the costs of trade. So much so that logistics costs in India are estimated to account for the country's GDP.

1.3.4 The waterway has the potential to emerge as the leading logistics artery for northern India. The waterway's stretch between Kolkata and Delhi passes through one of India's most densely populated areas. A sizeable forty percent of all India's traded goods either originates from this resource-rich region or is destined for its teeming markets. While the region is estimated to generate about 370 million tonnes of freight annually, only a tiny fraction of this - about 5 million tonnes - currently travels by water.

1.3.5 Currently, cargo from the riparian states takes circuitous land routes to reach the sea ports of Mumbai in Maharashtra and Kandla in Gujarat, rather than going to the much-closer port at Kolkata via NW-1. The NW-110 meets NW-1 at Prayagraj. The development of NW-110 will help riparian states direct some of their freight to the Kolkata-Haldia complex, making the movement of freight more reliable and reducing logistics costs significantly. The Capacity Augmentation of NW-110 Project will help put in place the infrastructure and services needed to ensure that NW-110 emerges as an efficient transport artery in this important economic region. Once operational, the waterway will form part of the larger multi-modal transport network being planned along the river. It will link up with the Eastern Dedicated Rail Freight Corridor, as well as with the area's existing network of highways. This web of water, road and rail arteries will help the region's industries and manufacturing units switch seamlessly between different modes of transport as they send their goods to markets in India and abroad. Farmers in the agriculturally-rich plain will also benefit, as the waterway opens up markets further afield. NW-110 would generate huge employment opportunities. Employment generation during NW development is a one-time impact. However, once NW-110 gets operational, it would generate more employment for local people as well as other migrants. For example, every proposed terminal would require staffs for handling various tasks, like technical jobs, administration related jobs etc. Hence, NW-110 would benefit the region and community by providing employment opportunities.

1.3.6 The utilization of IWT in river Yamuna is the most important factor that determines the variation in the opportunities of inland waterways on socioeconomic development of the districts that fall in the hinterland of the river. Waterways develop economic activities, recreational activities, tourism industry, enhance the socio-economic life of local community and provide sustainable mobility. Inland waterways boost the economic productivity of the hinterland. The proposed waterway NW 110 in river Yamuna would not only offer an alternative mode of transportation for the community but would also generate more new economic activities, like tourism and homestay, boat building, sand mining and fishing industry.

1.3.7 There are considerable variations in the availability of navigation at different stretches and favourable depths as would be available time to time is taken advantage of stretch wise for cargo movement as would be optimal. IWAI has been monitoring the NW-1 in totality obtaining/recording stretch wise waterway behaviour mean liability, navigational channel stability, river water quality, riverine life, fishing aspects and on relevant such data. Agencies like Central Inland Water Transport Corporation (CIWTC), a Public Sector Undertaking, certain private cargo movers and IWAI themselves are moving cargo in the NW-1. River monitoring, navigational guidance / cautions, temporary restrictions, flood warnings / restrictions caused by other rivers joining the NW – 1 on the route etc. are recorded and given to user agencies.

1.4 Scope of the Study and Structure of the report

1.4.1 The brief scope of work envisaged by IWAI is listed hereunder:

❖ **Technical Analysis**
- Collection and Review the Available Data and Reports
- Study, map and analysis of existing structures on the river, Hydrological aspects, changes in river course, available survey, data gaps etc.
- Undertake physical condition surveys of existing locks / barrages, sedimentation and mathematical model studies
- Develop viable outline options for river navigation improvement works, SWOT analysis on all options

❖ **Market assessment**
- Market Analysis
- Market Survey
- Market Development
- Market Trends

❖ **Waterway & Infrastructure Analysis**
- Study and map Terminal locations
- Need and location for multimodal logistics hubs
- Terminal connectivity with road and rail

- Fleet Analysis Study
- Develop viable outline options for common user facilities

❖ **Preliminary Engineering works for providing and/or improving facilities**
- Preliminary design, cost estimates, layouts and basic drawings and specifications for the selected option
- Construction schedule
- Provision of navigational aids, Ro-Ro jetties, revetment / bank protection / slope protection, River training works / conservancy works for critical locations, dredging for critical locations

❖ **Financial Analysis**
- Financial Internal Rate of Return (FIRR)
- Economic Internal Rate of Return (EIRR)
- Revenue Model

❖ **Economic Analysis**
- Comparison of whole life costs and benefits of the proposed river improvement program

❖ **Capacity Building and Financing**
- Identify institutional, financial, regulatory, taxation, procedural bottlenecks including concerns (safety, security) that hinders growth of the IWT sector and propose solutions required for development of the sector as safe, secure, efficient and clean mode of transport
- Propose financing plan to promote IWT Sector
- Conducting stakeholder meeting along with IWAI

The detailed scope of work is given as **Annexure 1.1**

1.4.2 The present report deals with the various options, analysis and economics of suggested developmental works proposed in NW – 110. The results and analysis of field surveys and available data have been considered for planning and design purpose. The Final Detailed Project Report consists of following chapters:

Executive Summary
Chapter – 1 Project Description
Chapter – 2 Site conditions
Chapter – 3 Technical Analysis
Chapter – 4 Field Surveys and Investigations
Chapter – 5 River Navigation Improvement Works
Chapter – 6 Market Assessments
Chapter – 7 Waterway And Infrastructure Analysis
Chapter – 8 Model Study
Chapter – 9 Preliminary Engineering Designs
Chapter – 10 Navigation and Communication System

Chapter – 11 Socio Economic Environment Assessment
Chapter – 12 Capacity Building and Financing
Chapter – 13 Project Implementation Schedule
Chapter – 14 Project Costing
Chapter – 15 Economic and Financial Analysis
Chapter – 16 Conclusions and Recommendations

CHAPTER – 2

SITE CONDITION

2.1 General

2.1.1 The River Yamuna is the biggest tributary of the River Ganga. It is also considered as sacred river in India besides River Ganga. River Yamuna originates in the Tehri Garhwal district of Uttarakhand from the Yamunotri glacier (31° 00'N 78° 27'E) near Banderpoonch peaks at the elevation of about 6,320m above the sea level in the Mussoorie range of lower Himalayas. Arising from the source, the Yamuna river flows through a series of valleys for about 200 km in lower Himalayas and then emerges into Indo-Gangetic plains.

2.1.2 In the upper reaches, the gradient of the river is steep and the entire geomorphology of the valley has been carved by the erosive action of the river water. In the headwater reach of 200 km, the Yamuna draws water from several major streams. The combined stream flows through the Shivalik range of hills of Himachal Pradesh and Uttarakhand states and enters into the plains at Dak Pathar in Uttarakhand. From Dak Pathar, the Yamuna flows through the famous Sikh religious shrine of Poanta Sahib. Flowing through the Poanta Sahib, it emerges from the foothills of Kalesan, north of Hathnikund/Tajewala where the river water get diverted into Western Yamuna Canal and Eastern Yamuna Canal for irrigation.

2.1.3 River Yamuna enters Delhi near Palla village after traversing for about 224 km. Further downstream, Yamuna flows through the Agra city which is famous for Taj Mahal. Shortly afterwards, it passes through another historical city, Mathura. The total length of River Yamuna from its origin to Prayagraj (*Erstwhile Allahabad*) (confluence with Ganga) is 1,376 km and the drainage area is 3,66,223 Sq.km. River Yamuna is a mighty river in itself and has a number of tributaries. In its first 170 km stretch, the tributaries the Risiganga, Hanumanganga, Tons and Giri join the main river. Later big rivers, such as the Chambal, the Sind, the Betwa and the Ken join it prior to fusing with the Ganga at a holy place named as Triveni Sangam in Prayagraj after covering a span of 1,376 km.

2.1.4 The catchment of the Yamuna river system covers the parts of Uttar Pradesh, Uttarakhand, Himachal Pradesh, Haryana, Rajasthan, Madhya Pradesh and Delhi. River Yamuna also forms natural state boundaries between the states of Uttarakhand and Himachal Pradesh, and also amid the states of Uttar Pradesh and Haryana. Cities like Delhi, Baghpat, Mathura, Noida, Firozabad, Agra, Kalpi, Etawah, Hamirpur and Prayagraj, are situated on the riverbanks of the Yamuna

2.1.5 The portion of River Yamuna stretching from Jagatpur (6 km upstream of Wazirabad Barrage) in Delhi to the confluence of Ganges and Yamuna rivers at Sangam, Prayagraj, in the state of Uttar Pradesh (UP) covering a length of 1089 Km has been declared as National Waterway (NW) – 110 by National Waterways Act, 2016.

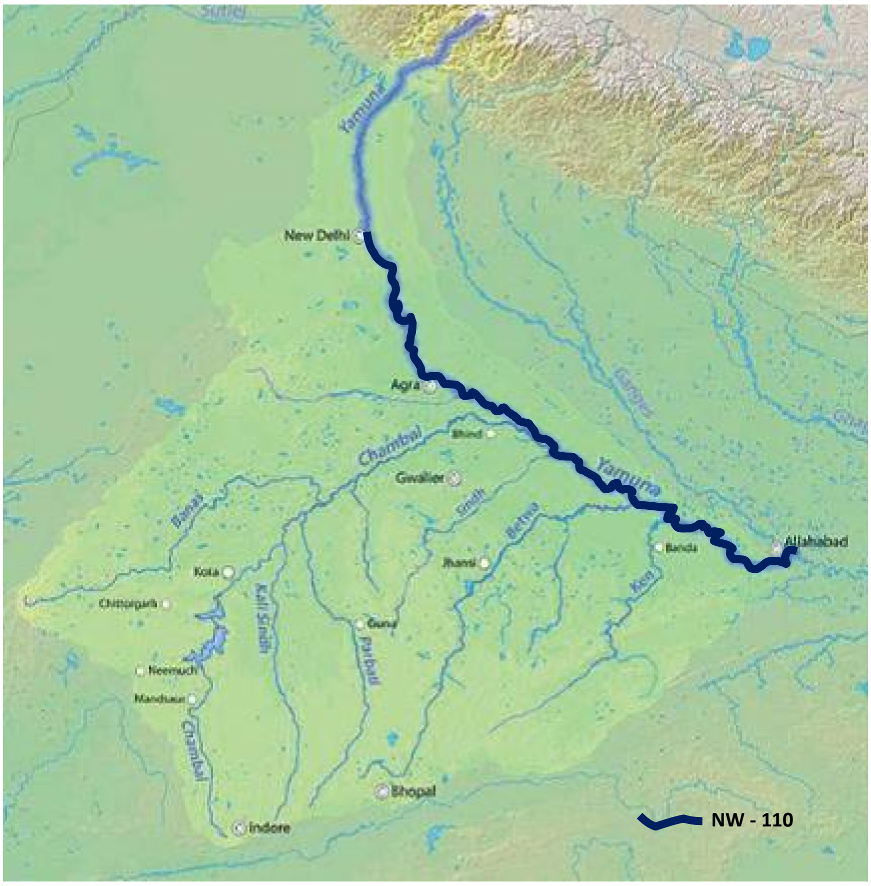


Fig. 2.1 Project Site

2.2 River Yamuna Basin

2.2.1 The River Yamuna is one of the important and sacred rivers of India. It is the largest tributary of the River Ganga. It originates from Yamunotri glacier in the Mussoorie range of the lower Himalayas, and after traversing 1,376 km joins the River Ganga at Prayagraj. The drainage area of the Yamuna basin is 366,220 sq km, which comprises part of seven states, viz. Uttarakhand, Himachal Pradesh, Uttar Pradesh, Haryana, Delhi, Rajasthan and Madhya Pradesh.

Table 2.1 River Yamuna Basin Area in Various States

State	Area in Yamuna Basin (km^2)	Area in Major Sub-Basin (km^2)					
		Hindon	Chambal	Sind	Betwa	Ken	Others
Uttarakhand	3771 **(1.1%)**	-	-	-	-	-	3771 (3.74%)
Himachal Pradesh (HP)	5799 **(1.7%)**	-	-	-	-	-	5799 (5.76%)
Uttar Pradesh (UP)	70437 **(20.4%)**	7083 (100%)	452 (0.32%)	748 (2.89%)	14438 (30.12%)	3336 (13.66%)	44380 (44.06%)
Haryana	21265 **(6.1%)**	-	-	-	-	-	21265 (21.11%)
Rajasthan	102883 **(29.7%)**	-	79495 (56.87%)	-	-	-	23388 (23.22%)
Madhya Pradesh (MP)	140208 **(40.6%)**	-	59838 (42.81%)	25131 (97.11%)	33502 (69.88%)	21090 (86.34%)	647 (0.64%)

Source: CWC

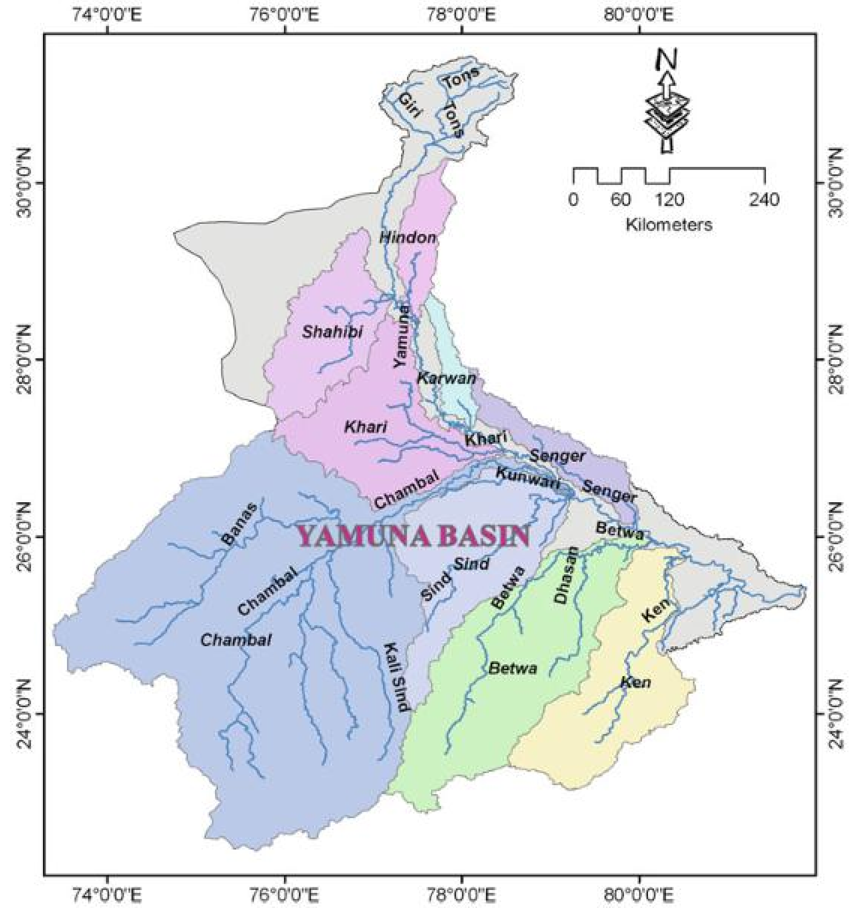


Fig. 2.2 River Yamuna Basin

Yamuna Lower: The geographical extent of the Yamuna Lower sub-basin lies between 77° 6' to 81° 55' east longitudes and 22° 51' to 28° 1' north latitudes of the country. The Sind, the Betwa, the Dhasan, the Ken rivers are the major tributaries in the Yamuna lower sub-basin. The Yamuna Lower sub-basin is the largest sub-basin of the Ganga basin with a total catchment area of 1,24,867 Sq.km. The sub-basin majorly covers the states of Uttar Pradesh and Madhya Pradesh.

Yamuna Middle: The geographical extent of the Yamuna Middle sub-basin lies between 75° 51' to 79° 19' east longitudes and 26° 15' to 28° 43' north latitudes of the country. The major river flowing in this sub-basin is the Yamuna itself. The Yamuna Middle sub-basin of Ganga basin has a total catchment area of 34,586 Sq.km. The sub-basin covers the states of Delhi, Haryana, Rajasthan and Uttar Pradesh. Some other major rivers flowing in this sub-basin are Utangan or Banganga, Bangan, Gambhir, Kasaundi, Karwan Nadi and Jhirha.

Yamuna Upper: The geographical extent of the Yamuna Upper sub-basin lies between 75° 45' to 78° 37' east longitudes and 27° 18' to 31° 25' north latitudes of the country. The physiographical and geological features of the Yamuna Upper sub-basin which lies in the Himalayan range accounts for most of the runoff in the river. This region on an average receives a good rainfall of about 1500 mm. The Yamuna Upper sub-basin of Ganga basin has a total catchment area of 35,798 Sq.km. The sub-basin covers the states of Uttarakhand, Himachal Pradesh, Delhi, Haryana, Rajasthan and Uttar Pradesh.

2.3 Major Tributaries of River Yamuna falling in NW 110 Stretch

2.3.1 The tributaries of Yamuna account for 70.9% of the catchment area; the balance of 29.1% area is directly drained by the Yamuna. Further the catchment area of Yamuna amounts to 40.2% of the area of the Ganga basin and 10.7% of the land in our country. The River Yamuna has four main tributaries in the Himalayan region viz. Rishi Ganga, Hanuman Ganga, Tons and Giri. In the plains, the main tributaries are the Hindon, Chambal, Sind, Betwa and Ken. The river water is generally used for irrigation, drinking and industries as well as for mass bathing, laundry, cattle bathing, and secretion of the cremation ash. The construction of diversion structures at regular intervals (Hathinikund, Wazirabad, Okhla, Gokul, etc.) for irrigation, domestic and industrial water supply, has largely modified the flow regime of the river.

2.3.2 The important tributaries falling in Yamuna River NW 110 are the Hindon, the Chambal, the Betwa, the Ken and the Sindh. A brief description of important tributaries of the Yamuna is given in the following sections:

i. **Hindon:** Hindon is an important tributary of Yamuna River, which is sandwiched between two major rivers: Ganga on the left and Yamuna on the right. Hindon originates from upper Shivalik (lower Himalayas). It is purely rain fed river with a catchment area of about 7,083 Sq.km and this river has a total run of about 400 km.

ii. **Chambal**: The most important tributary of the Yamuna is the Chambal River also known as Charmanvati in ancient times is the largest river flowing through Rajasthan state. It rises in the Vindhya range near Mhow in the Indore district of Madhya Pradesh at an elevation of 854 m and flows generally northerly direction up to the Madhya Pradesh-Rajasthan border. In this reach, the Chamla, the Siwana and the Retam join the river from the left and the Shipra and the Chhoti Kali Sindh from the right. It receives a major tributary from the right near the village of Laban, the Kali Sindh and another tributary the Kural from the left. The Banas the major left bank tributary of Chambal, joins the Chambal near the village of Rameshwar and other major right bank tributary, the Parbati joins the river near the village of Pali district. The river is mainly a rainfed river.

iii. **Betwa:** The Betwa river tributary of the Yamuna rises in the Bhopal district of Madhya Pradesh at an elevation of about 475 m above the mean sea level. After flowing in a generally north-eastern direction through Madhya Pradesh, it enters the Jhansi district of Uttar Pradesh. After traversing a distance of 590 km, the river joins the Yamuna near Hamirpur in Uttar Pradesh. One of the important tributaries of the Betwa river is the Dhasan river. The river has 14 principal tributaries out of which 11 are completely in Madhya Pradesh. The Halali and Dhasan rivers are the important tributaries of the Betwa river, the Halali being the largest tributary with a length of 180 km.

iv. **Ken:** The Ken, one of the tributary of Yamuna flows through the Madhya Pradesh and Uttar Pradesh states. The Ken river has its origin on the north-west slopes of the Kaimur hills in the Satna district of Madhya Pradesh. It generally flows in a north-easterly direction and joins the Yamuna near Chilla. The river has a total length of 357 km and forms a state boundary between Chhattarpur district of Madhya Pradesh and Banda district of Uttar Pradesh. The tributaries of Ken are the Sonar, the Bearma, the Kopra, the Bewas, the Urmil, the Mirhasan, the Kutni, the Kail, the Gurne, the Patan, the Siameri, the Chandrawal, the Banne etc. The longest tributary is Sonar which is 227km in length and wholly lies in Madhya Pradesh.

v. **Sindh:** The Sindh river is one of the longest rivers of the Central India to join the Yamuna river on its right bank. It rises in a tank 543m above the sea level near a village in Vidisha district of Madhya Pradesh. It generally flows in north-eastern direction joins Yamuna in Uttar Pradesh, slightly downstream of the confluence of the Chambal with the Yamuna. The river receives number of tributaries; the more important of them are the Parbati and the Kunwari on its left bank and the Pahuj on its right.

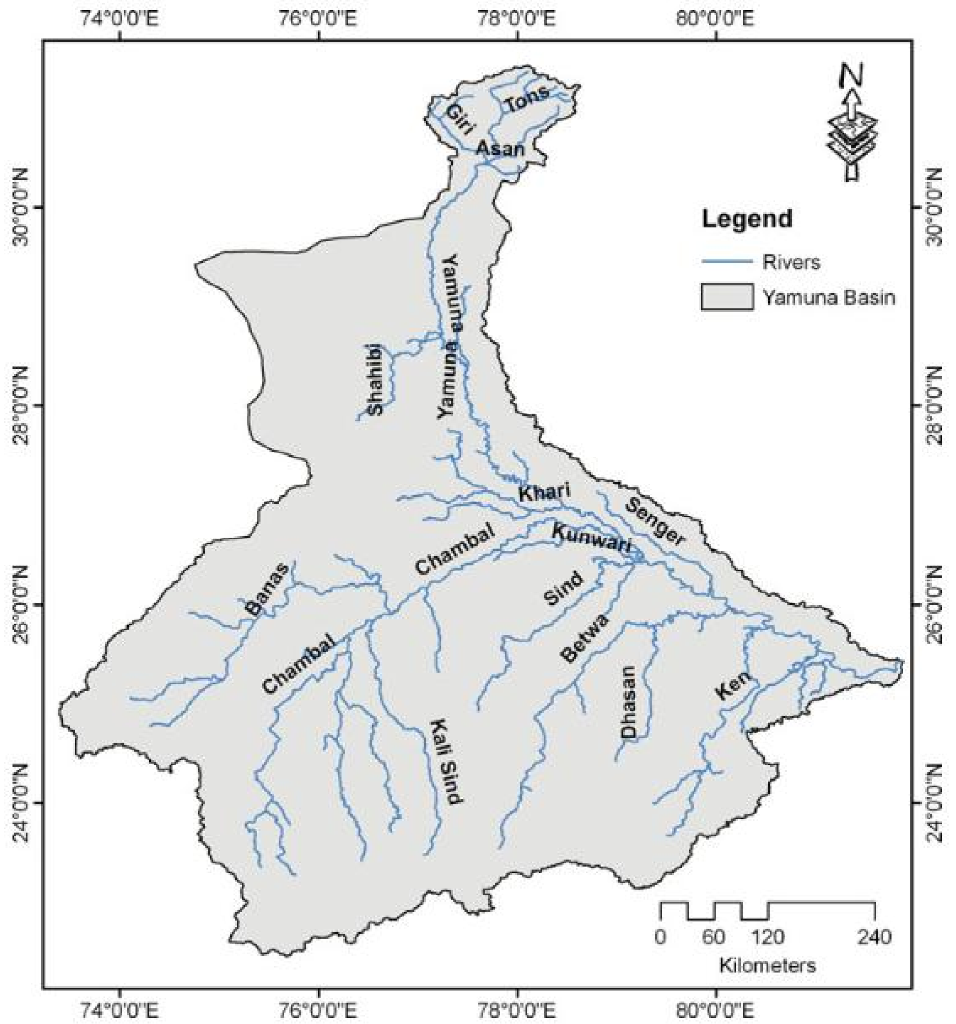


Fig. 2.3 Major Tributaries of River Yamuna

Table 2.2 Length of major river tributaries

River	Length (km)	Origin
Hindon	256	Southern slopes of Shiwaliks in the Saharanpur district of Uttar Pradesh
Chambal	960	Vindhya range near Mhow in the Indore district of Madhya Pradesh
Betwa	789	Bhopal district of Madhya Pradesh
Ken	357	North-west slopes of Kaimur hills in Satna district of Madhya Pradesh
Sindh	415	Near a village in the Vidisha district of Madhya Pradesh

2.4 Sharing of River Yamuna Waters

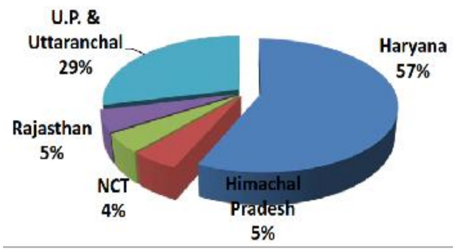
2.4.1 The historic agreement on the sharing of Yamuna waters considering their irrigation consumptive drinking water requirements between the basin states of Haryana, Uttar Pradesh, Himachal Pradesh, Rajasthan & Delhi took place on May 12, 1994. The Interstate Agreement also envisages that a minimum flow of 10 cumec shall be maintained in Yamuna downstream of Tajewala and Okhla head works throughout the year for ecological considerations. It is also assessed that a quantum of 680 MCM is not utilizable due to flood spills. The allocations of the utilizable water resources of river Yamuna assessed on mean year availability are given here under in BCM (Billion cubic metre):

Table 2.3 State wise Water Allocation of River Yamuna

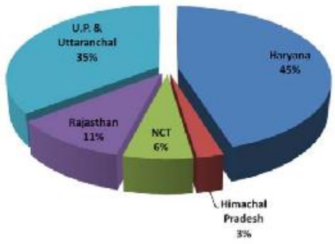
Sl. No.	States	Allocations (Billion cubic metre)				Allocation (%)
		Jul – Oct	Nov -Feb	Mar - Jun	Total	
1.	Haryana	4.107	0.686	0.937	**5.730**	**48%**
2.	Uttar Pradesh	3.216	0.343	0.473	**4.032**	**34%**
3.	Himachal Pradesh	0.190	0.108	0.080	**0.378**	**3%**
4.	Rajasthan	0.963	0.070	0.086	**1.119**	**9%**
5.	Delhi	0.580	0.068	0.076	**0.724**	**6%**
	Total	**9.056**	**1.275**	**1.652**	**11.983**	**100%**

Source: CWC, Irrigation and Water Resources Dept. Govt. of Haryana at Panchkula

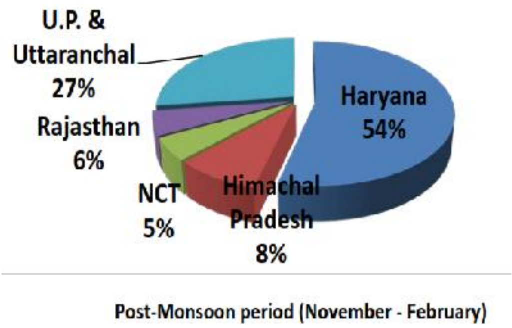
2.4.2 At present allocation to UP is now divided in two parts after the formation of the state Uttarakhand i.e. in the ratio of UP 28.64% and Uttarakhand 5.01%.Wazirabad Barrage located in Delhi which is storage reservoir from where the water is being lifted for the drinking purposes of Delhi state. The storage level at Wazirabad Barrage is maintained at EL 205.60 m. At about 22 km downstream of Wazirabad there is Okhla Barrage on River Yamuna from where two canals off takes i.e. Agra canal (63.5 cumecs) for irrigation purposes in U.P and Gurgaon Canal (14.15 cumecs) for Haryana and draw their share as per Agreement. At about 150 km downstream of Okhla barrage there is Gokul Barrage near city Mathura in U.P.



Pre-Monsoon period (March - June)



Monsoon period (July to October)



Source: Central Pollution Control Board

Fig. 2.4 Latest season wise sharing of River Yamuna Water

2.5 Usage of Yamuna River Water

The river water is abstracted at different locations for varied uses. At two places i.e. Hathnikund / Tajewala and Okhla, the water abstraction is significant. The points of abstraction and addition in water of Yamuna River are shown in **Fig. 2.5**.

Domestic Water Supplies

Significant use of Yamuna water for domestic water supply is found in urban agglomerations like Delhi, Mathura, Agra and Prayagraj.

The annual abstraction at various locations is given in **Table 2.4** and percent use of abstracted water for various purposes is shown in **Fig. 2.6**.

Table 2.4 Water Abstraction from River Yamuna

Sl. No.	Location	River water abstraction (MLD)	Abstraction use
1.	Hathnikund	20000	Irrigation, Drinking water supply and others
2.	Wazirabad	1100	Drinking water supply
3.	Wazirabad to Okhla Stretch	5000	Irrigation and others
4.	Okhla to Etawah Stretch	400	Irrigation, Drinking water supply and others
5.	Etawah to Prayagraj Stretch	475	Irrigation, Drinking water supply and others

Source: Central Pollution Control Board

Irrigation

Irrigation is an important use of Yamuna river water. It has been estimated that about 92% of River Yamuna water is used for irrigation. In the entire Yamuna basin the irrigated land is about 12.3 million hectares and approximately half of it (about 49%) is irrigated exclusively from surface water. At present there are four irrigation canals transporting the Yamuna river water to the command areas as shown at **Table 2.5**.

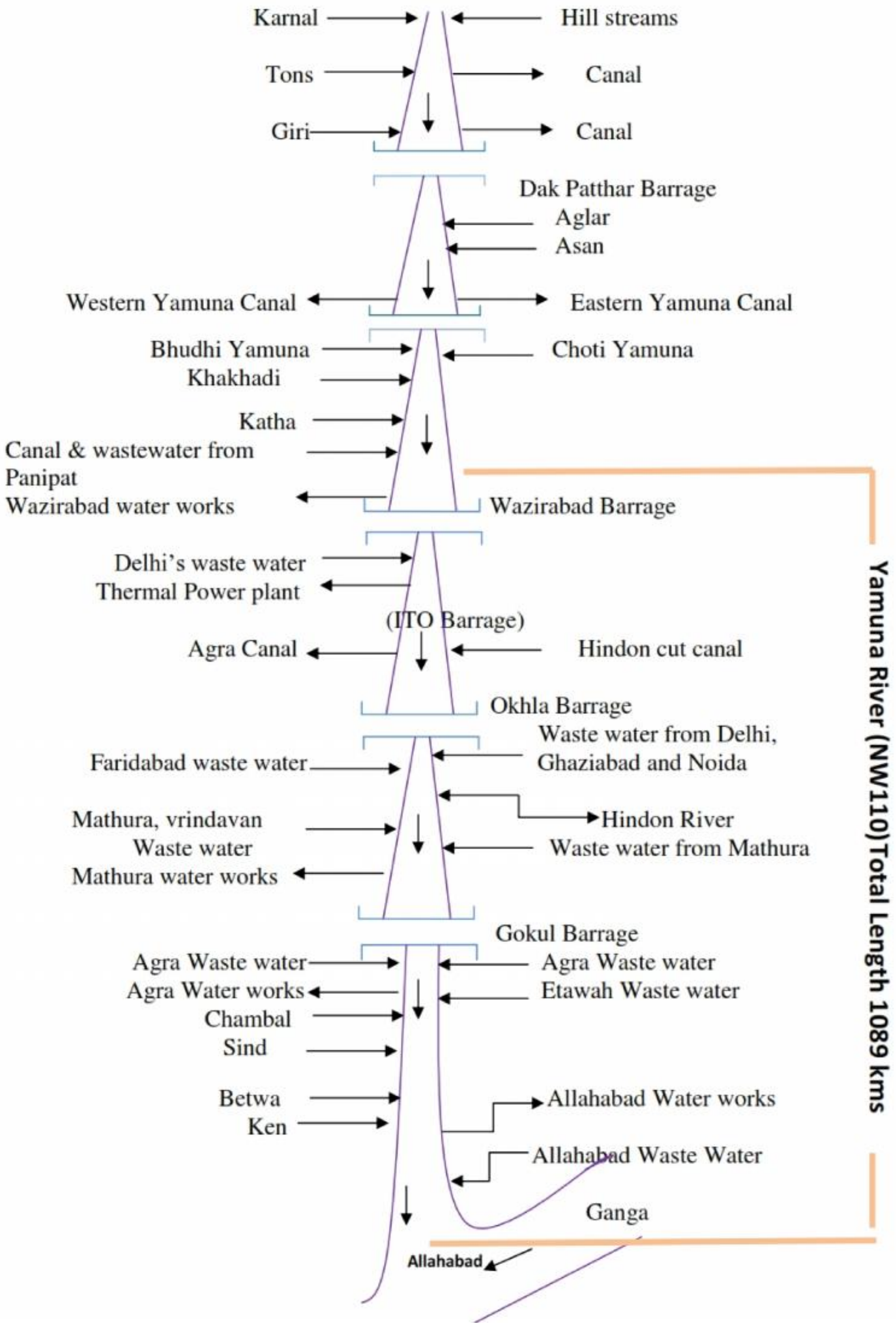


Fig. 2.5 Schematic Line Diagram of sources of water and Extraction for River Yamuna

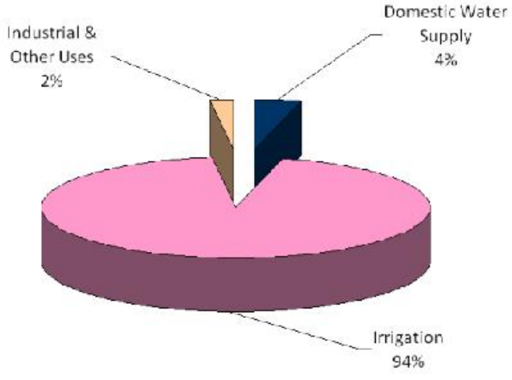


Fig. 2.6 Percentage of water abstracted from River Yamuna for various uses

Table 2.5 Canals in River Yamuna

Sl. No.	Canal	Origin	Capacity (m^3/sec)	Area (hectares)	State
1.	Western Yamuna Canal (WJC)	Right bank of Yamuna River at Hathnikund / Tajewala barrage	163.00	486,000	Haryana
2.	Eastern Yamuna Canal (EJC)	left bank of the River Yamuna at Hathnikund / Tajewala barrage	85.00	191,000	Uttar Pradesh
3.	Agra Canal	Right bank of Yamuna River at Okhla barrage	63.50	138,000	Two districts of Mathura and Agra in Uttar Pradesh
4.	Gurgaon Canal	Takes off from Agra canal at a distance of around 8 km from its off take at Okhla barrage	14.15	40,000	Interstate project between Rajasthan & Haryana and

Source: Irrigation and Water Resources Department Govt. of Haryana at Panchkula

2.6 Project Site

2.6.1 Meteorological Conditions

Meteorologically River Yamuna basin is a heterogeneous basin having great spatial variation of rainfall pattern ranging from 200 to 2350 mm. However, the average annual rainfall varies between 400 to 1500 mm. The entire basin comes under the influence of the south-west monsoon and a major part of the rainfall is received between June and September. Winter rainfall is scanty. In the basin, rainfall distribution is increasing from North-West to the South-East direction. Mean maximum temperature of 24 to 42.5 °C and mean minimum temperature of 3.0 to 11.0 °C.

Rainfall

In the Yamuna river basin, in upper Himalayan part of the basin, it receives water from the glacier melt runoff. During the non-monsoon period, water availability in the river is due to glacier melt and base flow. Excluding the upper Himalayan segment, Yamuna river basin is rain fed and perennial behaviour of the river is due to upstream storages and base flow. The weather in the River Yamuna NW 110 is characterized by a distinct wet season during the period of southwest monsoon (June to September). By the end of June the monsoon reaches the New Delhi. In the majority of the stretch of NW 110, the rainy season spreads over three months (July, August and September) and usually 70 to 80 percent of the total annual rainfall occurs during this period. The average annual rainfall varies between 400 to 1100 mm.

Temperature

Mean maximum and mean minimum temperature in the basin spatially varied between 24.25° to 42.46°C and -1.05° to 10.81°C, respectively. The mean maximum daily temperature even in the coldest month (January) does not fall below 21°C whereas the air temperature starts rapidly rising all over River Yamuna NW 110 stretch from March onwards, beginning a hot season that prevails from April to June. Usually, May is the hottest month in most part of the stretch. The air temperature starts falling with the onset of the monsoon from June onwards, making the weather more humid and equable. Mean maximum and mean Minimum temperature varies between 42°C and 7°C respectively.

Wind

The mean wind speed prevailing in the area is varying around 1.2 m/s in upper reaches to 1.5 m/s in lower reaches

Relative Humidity

The average relative humidity varies 53% to 55% in the project area.

2.6.2 Topography

Topography of the River Yamuna basin varies between steep topography in the Himalayan segment to almost flat in the middle and lower segments. The elevation in the Yamuna River basin varies from about 6,300 m above mean sea level (msl) near Yamunotri Glacier to around 70 m (above msl)

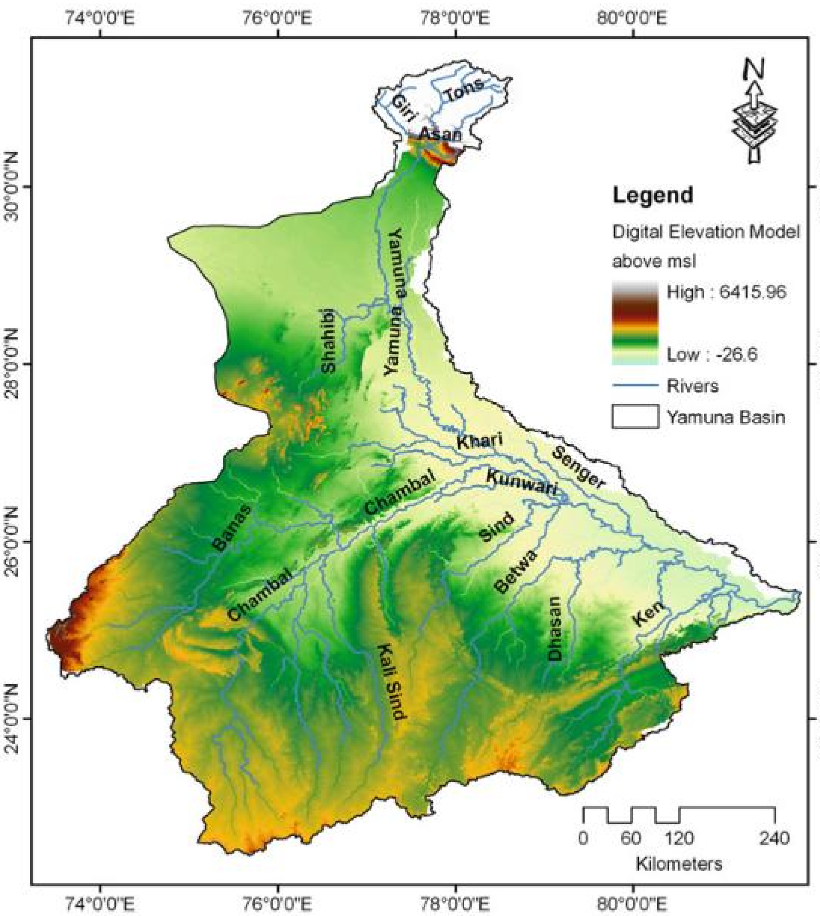


Fig. 2.7 Digital Elevation Model of River Yamuna Basin

near the confluence of Yamuna River with River Ganges at Prayagraj. The general topography of the River Yamuna NW 110 is plain with levels varying from 70–200m above msl. In River Yamuna stretch NW 110 the river flattened gradually with an average slope varying from 0.04% to 0.011%. The average rate of fall is 0.11 m/km.

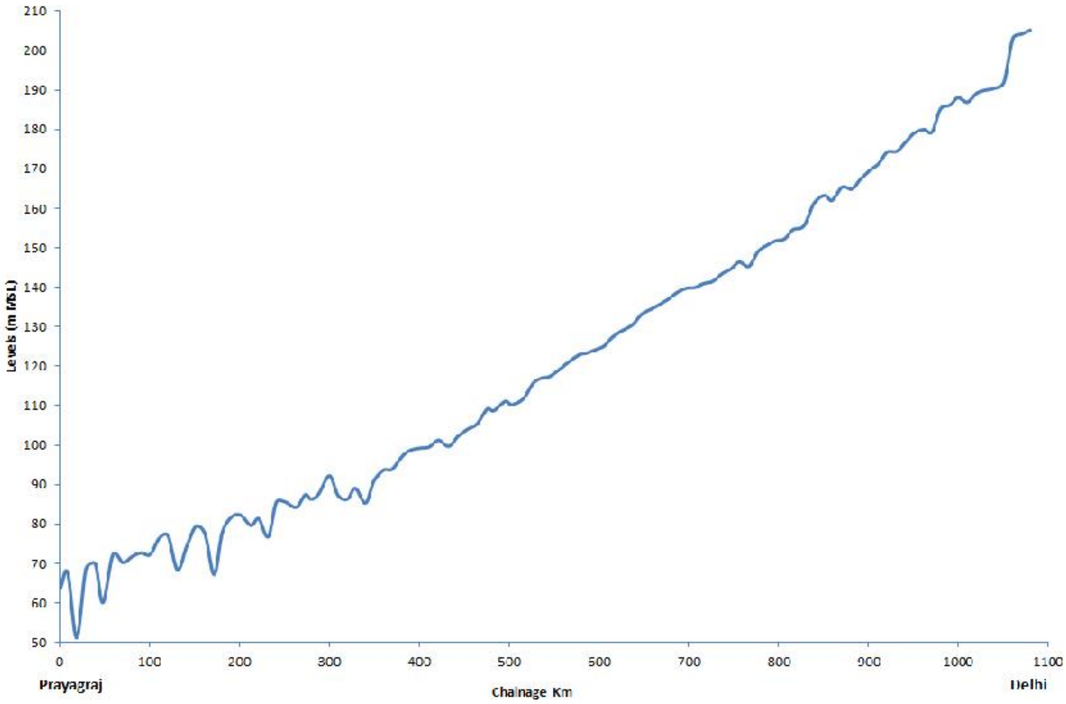


Fig. 2.8 Longitudinal profile of River Slope NW 110

2.6.3 Geology

The geological formation of the Yamuna basin has five major classes, viz., Proterozoic, Paleozoic, Mesozoic, Cenozoic and Deccan Volcanics/Sediments. Major area of River Yamuna NW 110 stretch comes under Cenozoic category. This plain has a deeply incised river with 15–30 m of cliff sections along the river banks. Repeated degradation and aggradations events separated by the stratigraphic discontinuities are recognized in the alluvial sequence, which represents relatively slow rates of accumulation. Alluvium deposits are found in patches near and along the River Yamuna.

2.6.4 Soil

The Yamuna basin under project area consists of mainly alluvial, medium black, and mix red black, and red sandy variety of soils. The majority of soil type is alluvial and covers about 42% of the basin area. Soil texture is loamy fine sand or coarser without podegenic horizons that have retained original structure of parent materials.

2.6.5 Seismicity

According to IS 1893 (Part 1): 2002, India has been divided into four seismic zones i.e., Zone II, Zone III, Zone IV, and Zone V. Major portion of River Yamuna NW 110 stretch falls in Zone III i.e. moderate intensity seismic zone where the basic co-efficient may be considered around 0.16. No major earthquake has been reported in the project area in recent years or recent past. As a result, jetty, berth, land buildings and land based structures for this project would be designed to withstand maximum lateral load due to gravity load.

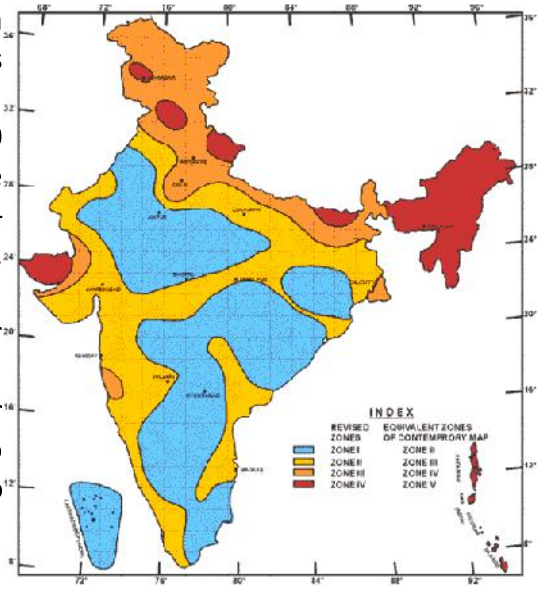


Fig. 2.9 Seismic Index Map of India

2.6.5 River Morphology & Mobility

River Yamuna NW 110 is significantly mobile and changes flowing pattern in one season to another. The river is meandering or sinuous throughout its length with minor secondary branches and several chutes. At Prayagraj, the Yamuna carries 64×10^6t sediment loads to the Ganges River.

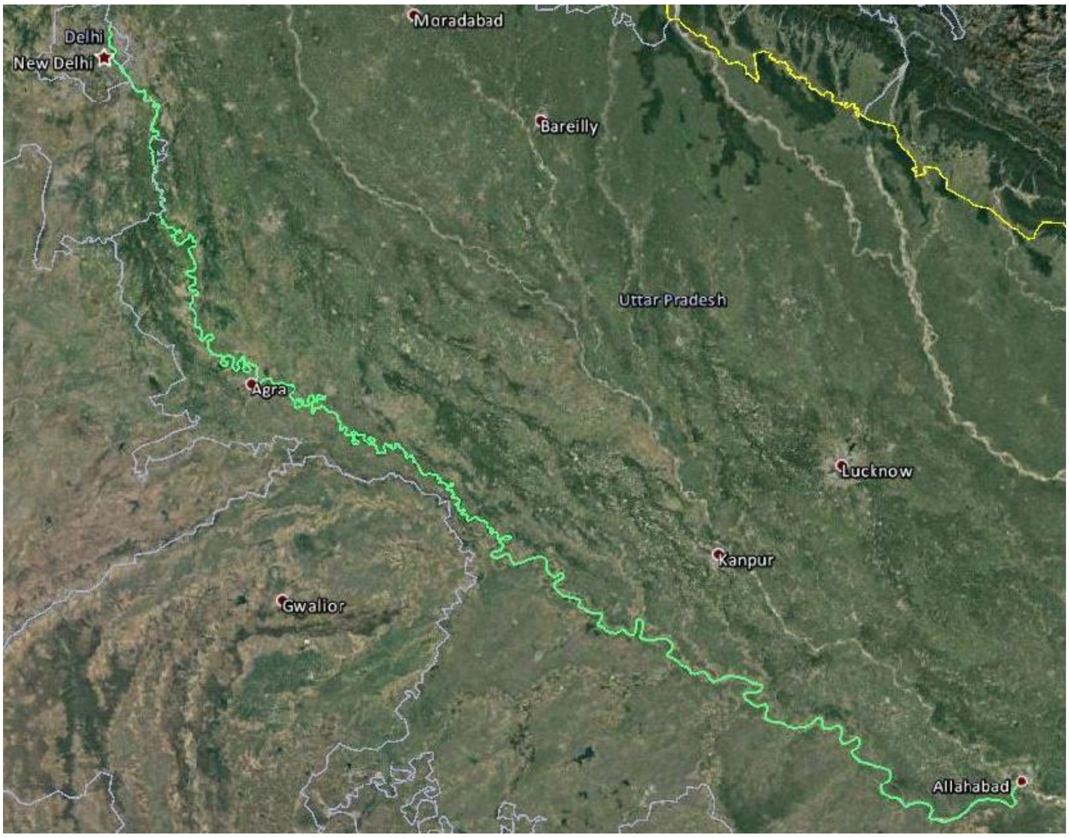


Fig. 2.10 Meandering River Yamuna NW 110

2.6.6 Environmental Flow

The environmental flow, in general, include the water required for the assimilation of pollutants, evaporation, groundwater conservation, and aquatic-habitat conservation. Due to large abstractions at the Hathinikund barrage, the downstream part of the river is almost dry, though the 4.5 m^3/s water is allocated for the downstream release during December to June. However, after traversing a few kilometers, this water disappears and the river becomes dry up to the Palla. After the Wazirabad barrage near Delhi, there is no release during the dry period (i.e., December to June). The water available in the Wazirabad barrage to the Okhla barrage stretch is due to wastewater outfalls of more than 30 m^3/s with recorded BOD of more than 30 mg/l. After the Okhla barrage, a similar situation persists and the river has little water all the way up to Etawah where the Chambal River joins. However, due to base flow, the river does not get dry. After Etawah, the river quality gets improved and up to the confluence with Ganga River, it becomes environmentally good. The environmental flow releases from various regulation points in River Yamuna to support flora and fauna is given in the table below:

Table 2.6 Environmental flow requirements in various reaches of River Yamuna NW 110

Month	Release from Wazirabad (Wazirabad to Okhla (m^3/s)	Release from Okhla (Okhla to Agra (m^3/s)	From Agra (Agra to Etawah) (m^3/s)	From Etawah (Etawah to Prayagraj) (m^3/s)
January	14.5	42.4	63.8	91.6
February	14.7	45.5	67.8	98.8
March	12.3	36.7	54.9	86.3
April	17.6	48.4	69.7	89.2
May	11.0	33.8	51.1	60.7
June	15.99	45.5	66.6	89.2
July	83.3	117.3	196.8	606.7
August	189.0	221.1	435.4	1,707.3
September	162.4	209.5	409.0	1,507.5
October	36.4	115.3	182.4	301.4
November	22.4	69.3	107.4	137.7
December	15.0	47.0	72.9	116.7

Source: CWC

2.7 Central Water Commission Gauge Stations on River Yamuna NW 110

The locations of the existing Gauge Stations (gauge-discharge) on River Yamuna NW 110 maintained by Central Water Commission (CWC) are shown in **Fig. 2.11**, and their salient features are given in Table 2.7.

Table 2.7 Details of CWC Gauging Station on River Yamuna NW 110

Site Name	Location	State	Zero of the Gauge (m) w.r.t. MSL	Type of Site
Palla	28° 49' 46"N, 77° 13' 27" E	Delhi	206	GDQ
Delhi Rly Bridge	28°39'45"N, 77°14'48"E	Delhi	197	GDSQ
Mohana	28°13'27"N, 77°27'25"E	Haryana	185	GDSQ
Mathura (Pyagghat)	27°29'54"N, 77°41'47"E	Uttar Pradesh	160	GQ
Gokul Barrage	27°26'30"N, 77°42'54"E	Uttar Pradesh	160(US) 157.65(DS)	G
Agra (P.G)	27° 15' 22"N, 78° 01' 25"E	Uttar Pradesh	146	GDSQ
Agra (J.B)	27°12'18"N, 78° 02'07"E	Uttar Pradesh	145	G
Etawah	26° 45' 00"N, 78° 59' 00" E	Uttar Pradesh	114	GDSQ
Auraiya	26°25'38"N, 79°25'05"E	Uttar Pradesh	99	GDSQ
Kalpi	26°11'60"N, 79°42'00"E	Uttar Pradesh	90	GD
Chillaghat	25°56'60"N, 80° 09'00"E	Uttar Pradesh	79	G
Hamirpur	25°57'34"N, 80° 09'13"E	Uttar Pradesh	88	GDQ
Rajapur	25°23'23"N, 81°09'15"E	Uttar Pradesh	65	GD
Pratappur	25° 22' 00"N, 81° 40' 00" E	Uttar Pradesh	70	GDSQ
Naini	25°21'56"N, 81°48'00"E	Uttar Pradesh	70	G

Source : CWC, Govt. of India

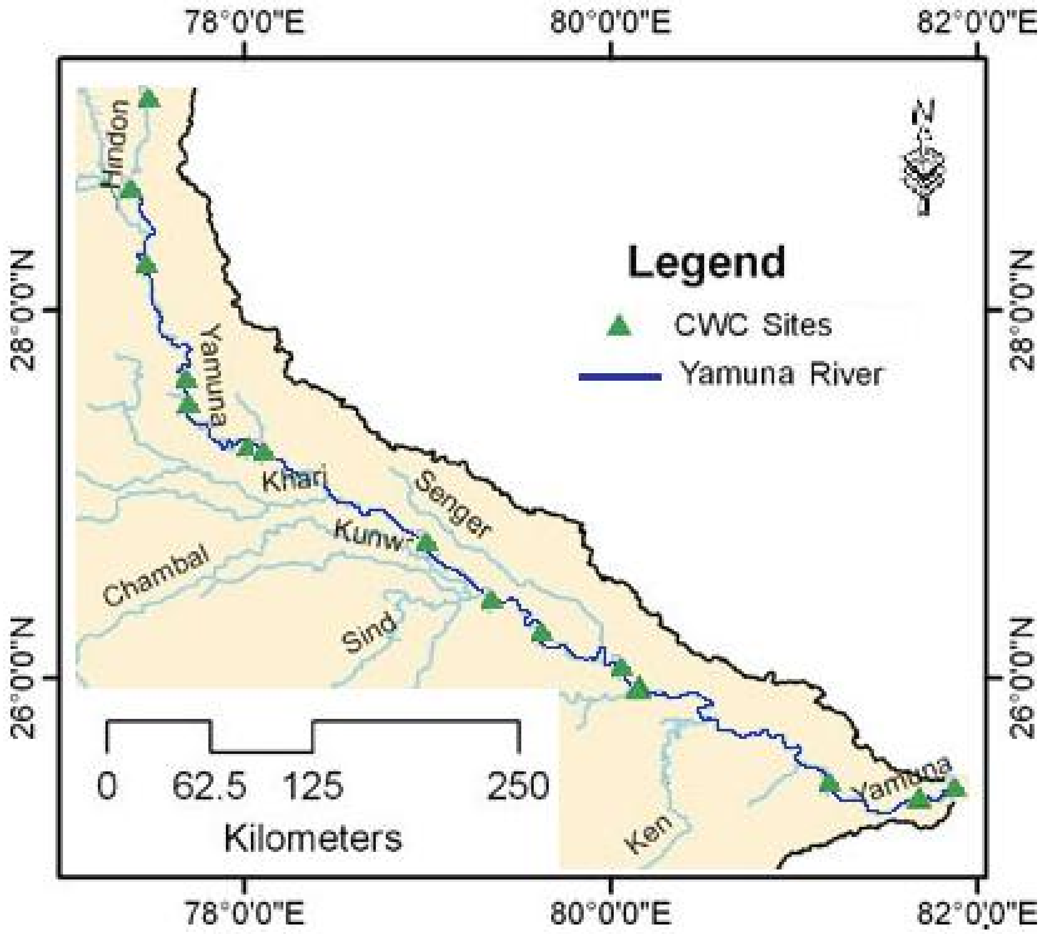


Fig. 2.11 Locations River Yamuna NW 110

2.8 CWC Flood forecasting and level monitoring Stations on River Yamuna NW 110

Overall there are 9 nos. flood forecasting stations and 4 nos. level monitoring stations on River Yamuna NW 110. The list of flood forecasting stations and level monitoring stations is given below

Table 2.8 List of CWC Flood Forecasting sites

S. No.	Site	District / State	Warning Level (m)	Danger Level (m)	Highest Flood Level (m)	HFL Date
1.	Delhi R. B.	North, Delhi	204.00	204.83	207.49	06.09.1978
2.	Mathura P.G.	Mathura, UP	165.20	166.00	169.73	08.09.1978
3.	Agra (J.B.)	Agra, UP	151.40	152.40	154.76	09.09.1978
4.	Etawah	Etawah, UP	120.92	121.92	126.13	11.09.1978
5.	Auraiya	Auraiya, UP	112.00	113.00	118.19	25.08.1996
6.	Kalpi	Jalaun, UP	107.00	108.00	112.98	25.08.1996
7.	Hamirpur	Hamirpur, UP	102.63	103.63	108.59	12.09.1983
8.	Chillaghat	Banda, UP	99.00	100.00	105.16	06.09.1978
9.	Naini	Prayagraj, UP	83.74	84.73	87.99	08.09.1978

Table 2.9 List of CWC Level Monitoring Sites

S. No.	Site	District	State	HFL(M)	HFL Date
1.	Mohana	Faridabad	Haryana	193.13	06.09.1978
2.	Mathura (Gokul Barrage)	Mathura	UP	166.30	26.09.2010
3.	Rajapur	Chitrakoot	UP	96.37	07.09.1978
4.	Pratappur	Prayagraj	UP	90.10	08.09.1978

2.9 Existing Cross structures on River Yamuna NW 110

2.9.1 Bridges

There are total 78 nos. of bridges on River Yamuna NW 110. The nos. of bridges are summarized here under:

Nos. of Existing Road Bridges	-	49
Nos. of Under Construction Road Bridges	-	15
Nos. of Existing Rail Bridges	-	12
Nos. of Under Construction Rail Bridges	-	2
Total Bridges on River Yamuna NW 110	**-**	**78**

The locations of road bridges and rail bridges are shown in **Fig. 2.12** and **Fig. 2.13** respectively.

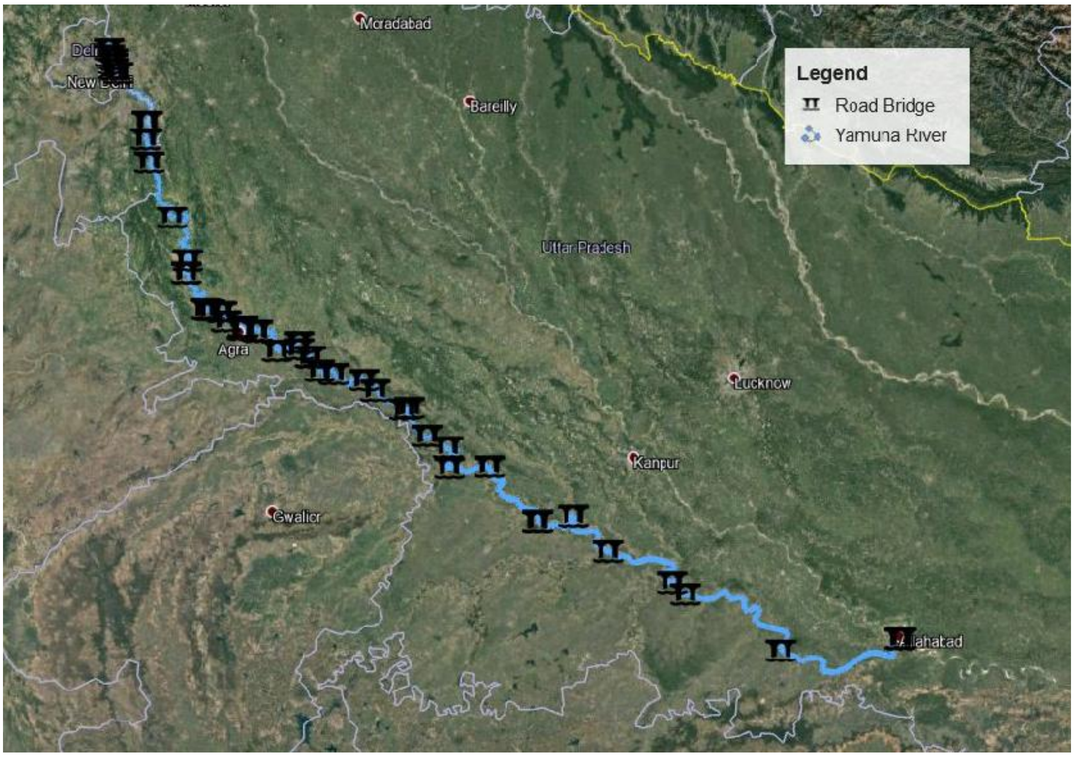


Fig. 2.12 Locations of Existing Road Bridges on River Yamuna NW 110

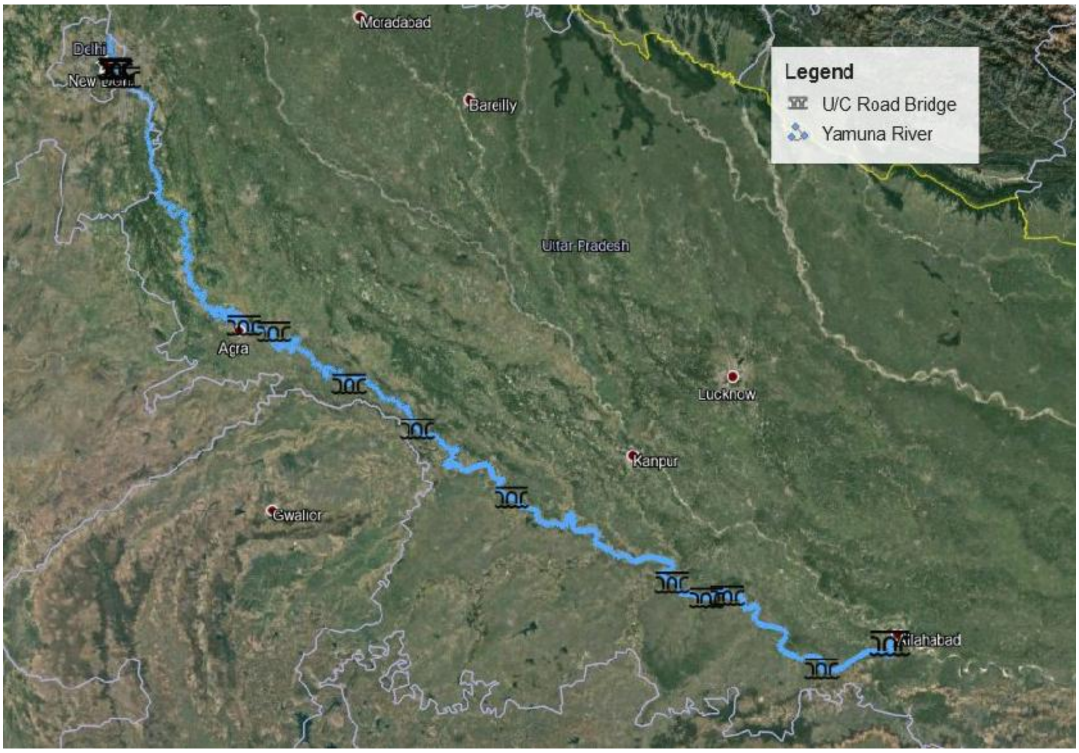


Fig. 2.13 Locations of Under Construction Road Bridges on River Yamuna NW 110

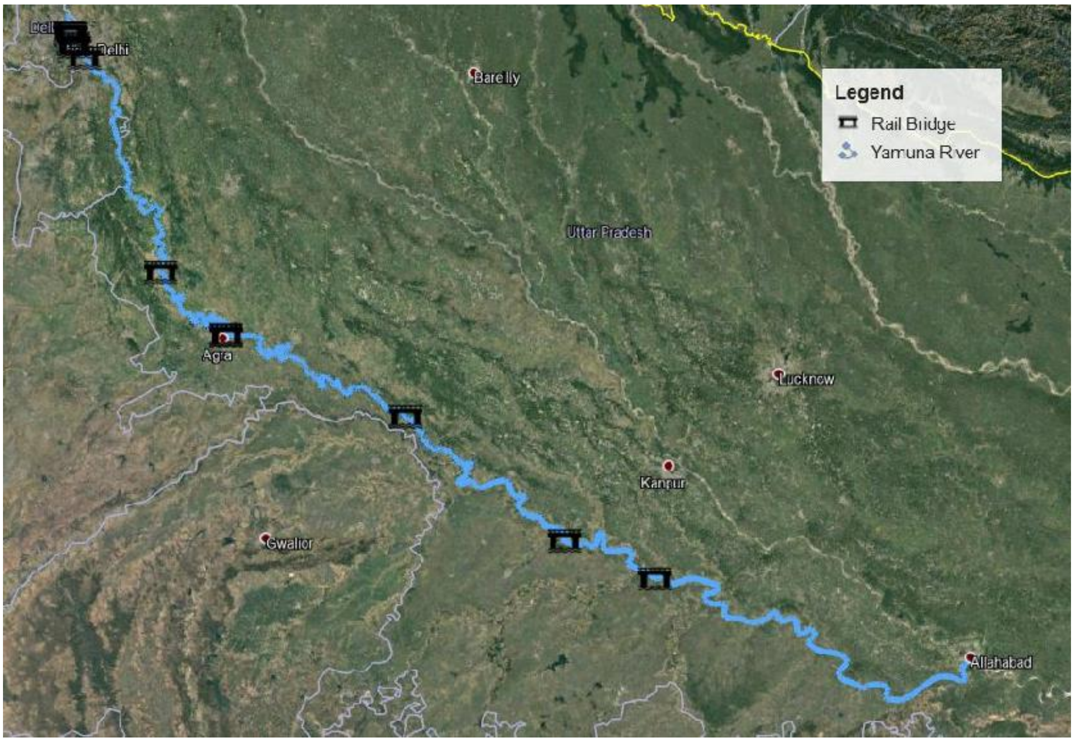


Fig. 2.14 Locations of Existing Rail Bridges on River Yamuna NW 110

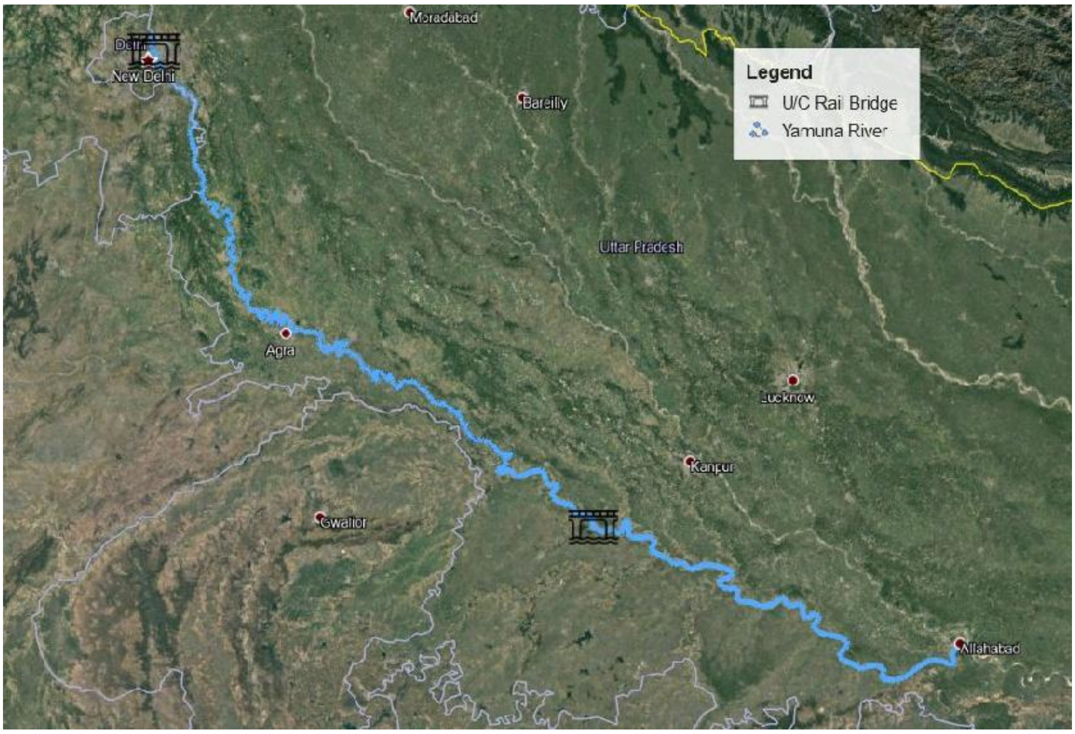


Fig. 2.15 Locations of Under Construction Rail Bridges on River Yamuna NW 110

2.9.2 High Tension (HT) Lines

There are total 44 nos. of HT lines crossing over River Yamuna NW 110. The locations of HT lines are shown in **Fig. 2.16**.

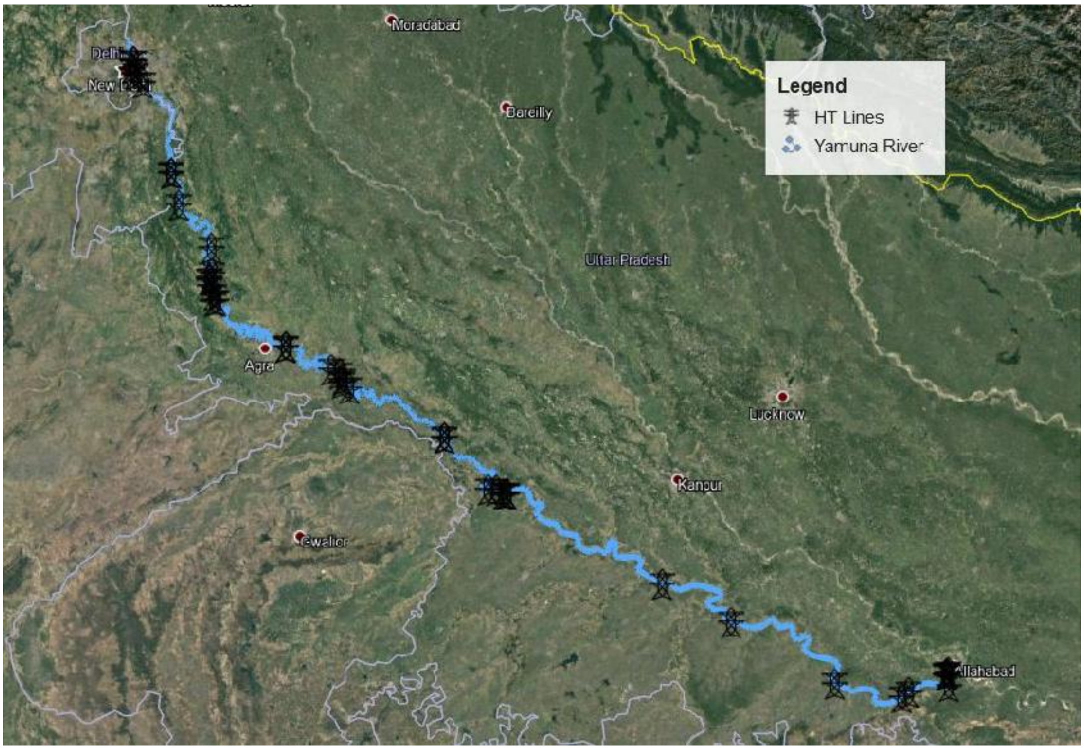


Fig. 2.16 Locations of HT Lines on River Yamuna NW 110

2.9.3 Pontoons

Total 7 nos. of pontoons are installed on River Yamuna NW 110. The locations of pontoon bridges are shown in **Fig. 2.17**.

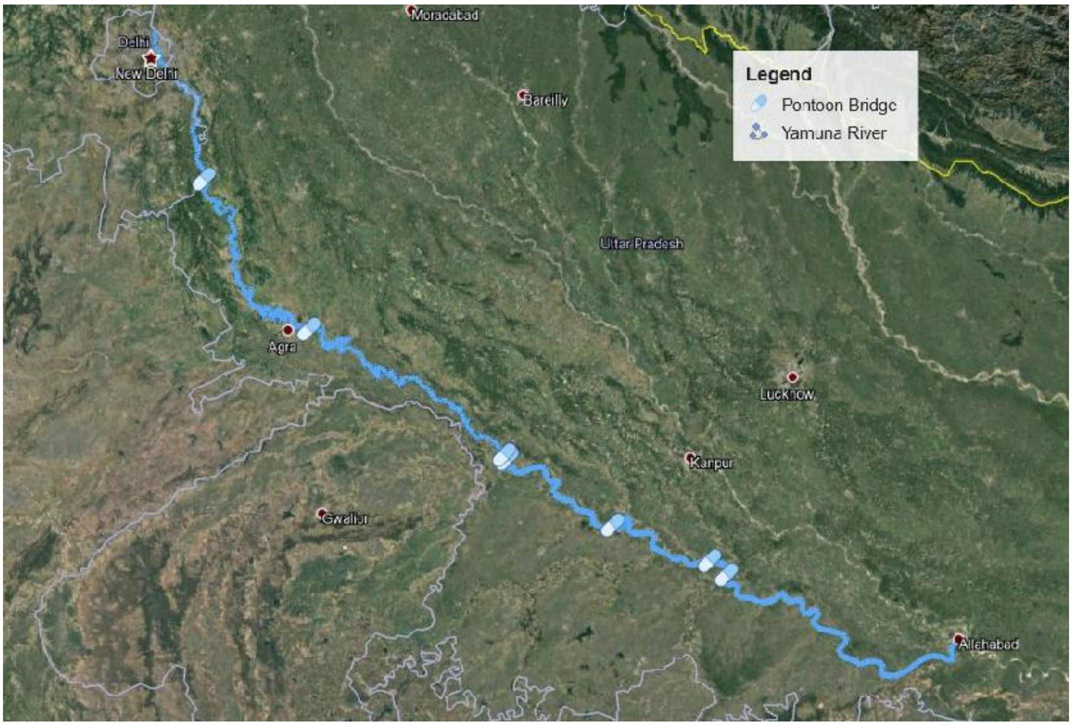


Fig. 2.17 Locations of Pontoons on River Yamuna NW 110

2.9.4 Barrages

There is no Dam, Weir, Anicut, Aqueducts and Navigational Locks in project study stretch except Barrages. There are total 4 nos. of barrage **over River Yamuna NW 110** as shown in the table given below.

Table 2.10 Barrages on River Yamuna

Sl. No.	Structure	Location	Chainage (Km)
1.	Wazirabad barrage	Delhi	1074.101
2.	ITO Barrage	Delhi	1063.136
3.	Okhla Barrage	Delhi	1052.007
4.	Gokul Barrage	Mathura (in Uttar Pradesh)	842.292

The locations of barrages are shown in **Fig. 2.18**.

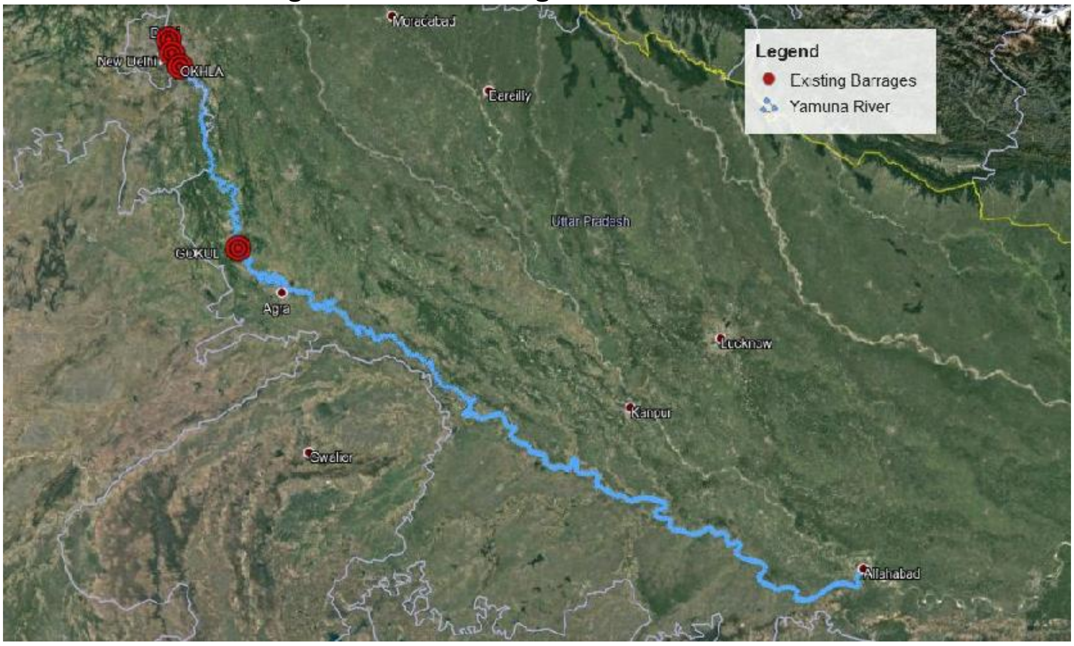


Fig. 2.18 Locations of Barrages on River Yamuna NW 110

Physical condition of Existing Barrages

WAPCOS undertook the physical condition survey of existing barrages on river Yamuna and associated works on 10th July 2018. Details of structures were collected and photographs were taken of existing condition of structures.

Wazirabad Barrage

Wazirabad Barrage located in Delhi and was constructed in the year 1959, for the drinking purposes of Delhi state. It is a storage reservoir from where the water is being lifted for Haidarpur Water treatment plant and Chandrawal Water treatment plant. At present Delhi state has constructed more water treatment plant like at Dwarka and Nangloi.

The storage level at Wazirabad barrage is maintained at EL 205.60 m. Water is being supplied by Haryana through Munak Canal and Drain No. 8 to maintain the storage level of EL 205.60m as per agreement between Haryana and Delhi. It is a 454m long barrage with 17 Nos. spillway bays of 17.5 m and 12 Nos. under-sluices of 8m each on the right side. Top of crest of spillway bays is 1.2m higher than the under-sluices. The existing piers and abutments are in good conditions. The Gates provided at Barrage site are also of good conditions but needs painting to prevent rusting. Weed growth on the upstream and downstream sides have been noticed and needs to be removed for smooth flow.

The condition of existing earthen bunds on left and right side are not in good shape and needs to be smoothened. The roadway provided on the barrage is in bad shape and the top layer needs to be relayed with bituminous concrete. The walkway along the road is in damaged condition and needs to be repaired completely. As the pedestrian also feels inconvenient while moving on the walkway.

Being a storage reservoir no navigational lock has been provided at site of barrage. Also there is no need to provide navigational lock in the Wazirabad barrage as there is no vessel movement. The existing conditions as explained can be viewed from the photographs given below:

Fig. 2.19 Present view on the upstream of Wazirabad Barrage at CH 1074.1 KM

Fig. 2.20 Present view on the downstream of Wazirabad Barrage

Fig. 2.21 Present view showing flow of Yamuna River on the upstream of Wazirabad Barrage

Fig. 2.22 Present view showing flow of Yamuna River on the downstream of Wazirabad Barrage

Fig. 2.23 Left Bank view on the upstream of Wazirabad Barrage

Fig. 2.24 Right Bank view on the upstream of Wazirabad Barrage

Fig. 2.25 Sangam Pump house on the left bank of Yamuna river u/s of Wazirabad Barrage

Fig. 2.26 View of Water works on the right bank of Yamuna river u/s of Wazirabad Barrage

ITO Barrage

The ITO barrage was constructed in the year 1965-66. The barrage, also called Yamuna barrage is 552 meter long. Barrage is located on Yamuna River near ITO(Delhi), which connects Paharganj-Gaziabad Vikas marg in Delhi. There are 22 nos. spillway bays of 18.3m each and 10 nos. under sluices bays of 8.38 meter each.

The Yamuna water from ITO Barrage is meant for the cooling of two units of Indraprastha Power Generation, Thermal Rajghat Power Station located on the downstream of Barrage. 16 Nos. drains falls on the upstream of this barrage between Wazirabad and ITO Bridge. The quality of water is very poor not even to smell. The colour of the water is blackish. The Jalas (made of grass & bushesh) are apparently seen on the u/s side of the barrage and needs to be removed. The existing piers and abutments are in good conditions. The Gates and regulating platform provided at Barrage site are also in good conditions and found rusting. Painting is required on the gates and regulating platform to prevent further rusting. The roadway provided on the barrage is in well maintained.

No navigational lock has been provided at site of barrage. The existing conditions as explained can be viewed from the photographs given below:

Fig. 2.27 Present view on the upstream of Yamuna Barrage at ITO at CH 1063.1 KM

Fig. 2.28 Present view on the downstream of Yamuna Barrage at ITO

Fig. 2.29 Present view showing flow of Yamuna River on the upstream of Yamuna Barrage at ITO

Fig. 2.30 Present view showing flow of Yamuna River on the downstream of Yamuna Barrage at ITO

Fig. 2.31 Salient features of Yamuna Barrage at ITO, Delhi

Fig. 2.32 Existing Condition of Gates at Yamuna Barrage ITO, Delhi

Okhla Barrage

Okhla Barrage was constructed in the year 1982 across Yamuna River in Delhi. The regulation of OKhla Barrage is with the Irrigation Department of Uttar Pradesh. The length of Okhla barrage is 552.09 meter with clear waterway of 494.1 meter. There are 22 nos. spillway bays and 5 nos. under sluices bays of 18.3 meter each. Agra canal is off taking on the right side of the barrage meant for irrigating the fields of Uttar Pradesh. Gurgaon Canal also offtakes from the barrage meant for irrigating the fields of Haryana State. The barrage is facilitating the Delhi-Noida carriageway of Mahamaya-Kalindi Kunj road.

The Pond level at Okhla barrage is at EL 201.35 m. The existing piers and abutments are in good conditions. The Gates and regulating platform provided at Barrage site are also of good conditions well painted. Dense weed growth (Jalkhumbi) have been noticed on the upstream side of the barrage which needs to be removed for smooth flow.

The roadway provided on the barrage is in good shape. No navigational lock has been provided at site of barrage. Also there is no need to provide navigational lock in this barrage as there is no vessel movement upstream of the barrage. The existing conditions as explained can be viewed from the photographs given below:

Fig. 2.33 Present view on the upstream of Okhla Barrage at CH 1052 KM

Fig. 2.34 Present view on the downstream of Okhla Barrage

Fig. 2.35 Present view on the downstream of off taking Agra Canal at Okhla Barrage

Fig. 2.36 Present view of Agra Canal Head works at Okhla barrage

Fig. 2.37 Present condition of regulating platform and gates at Okhla barrage

Fig. 2.38 Present view showing flow of Yamuna River on the upstream of Okhla Barrage

Fig. 2.39 Present view showing flow of Yamuna River on the downstream of Okhla Barrage

Fig. 2.40 Salient features of Okhla Barrage

Gokul Barrage

Gokul barrage was constructed in the year 2001 and located across Yamuna River near Mathura City in Uttar Pradesh. The barrage is 435 meters long. There are 17 nos. spillway bays and 4 nos. under sluices bays of 18.3 meter each and one under sluice of 2.0 meter wide. The Yamuna water from Gokul Barrage is meant only for drinking supply to cities Mathura, Vrindavan and Agra.

The pond level at Gokul barrage is at EL 165.00 m. The existing piers and abutments are in good condition. The Gates provided at Barrage site are also of good conditions but needs painting to prevent rusting.

The condition of existing guide bunds on left and right side are in good shape and well maintained. The bridge provided on the barrage is also in good condition. Heavy traffic has been noticed at site. There is no navigational lock at site of barrage. The existing conditions as explained can be viewed from the photographs given below:

Fig. 2.41 Present View of Gates and piers from upstream of Gokul Barrage at CH 842 KM

Fig. 2.42 Present View of Gates and piers from downstream of Gokul Barrage at CH 842 KM

Fig. 2.43 Present view showing flow of Yamuna River on the upstream of Gokul Barrage

Fig. 2.44 Present view showing flow of Yamuna River on the downstream of Gokul Barrage

CHAPTER – 3

TECHNICAL ANALYSIS

3.1 Data Collection

All relating data of bathymetric and topographic survey carried out by the IWAI for Yamuna River from Delhi to Prayagraj stretch for an average width of 400m for cross sectional surveys at 200 m interval has been collected. Ten year hydrological data was collected from IWAI, Central Water Commission (CWC) and State Irrigation Department/Flood Control Departments concerned. All related data of system tributaries, distributaries and other rivers, waters connected with NW-110 from CWC has been collected. The satellite imageries of the project area were collected from National Remote Sensing Agency (NRSA). The toposheets related to the project area has been collected from Survey of India. The data related to similar studies on other major rivers in India and the recommendations of previous Master Plan studies was collected from WAPCOS reports and IWAI.

3.2 Hydrological data analysis

Hydrological data give most vital information on water availability in river reach and sediment concentration in river water. Gauge- discharge, sediment and river cross section data (at gauging site) falling in study stretch collected from CWC for 14 gauging stations on River Yamuna NW 110 from the year 2000 to year 2015 and analyzed. The hydrological data has been analyzed in the following head:

- Observed Maximum and Minimum Water Level and Discharge
- Monthly Average Maximum and Average Minimum Water Level
- Average Ten daily flow data analysis
- Gauge-Discharge Curve
- Sediment Data Analysis

3.2.1 Observed Maximum and Minimum Water Level and Discharge

The minimum and maximum water level and discharge observed at each gauging station from the year 2000 to year 2015 is given in table below:

Table 3.1 Observed Min and Max Water Level and Discharge at each Gauge Station

S. No.	Station Name	Ch. (Km)	Zero of the Gauge (m)	Chart Datum (m)	Minimum		Maximum	
					Min WL (m)	Min Q (m^3/s)	Max WL (m)	Max Q (m^3/s)
1.	Delhi R. B.	1068.00	197.00	201.85	199.35	8.99	207.13	3466.00
2.	Mohana	991.00	185.00	187.04	186.78	2.25	192.26	7981.00
3.	Mathura (Prayaghat)	848.27	160.00	163.57	161.02	9.78	167.34	1776.00

S. No.	Station Name	Ch. (Km)	Zero of the Gauge (m)	Chart Datum (m)	Minimum		Maximum	
					Min WL (m)	Min Q (m^3/s)	Max WL (m)	Max Q (m^3/s)
4.	Gokul Barrage (U/S)	842.29	160.00	163.21	162.90	NA	166.17	NA
	Gokul Barrage (D/S)		157.65	158.92	156.80	NA	166.07	NA
5.	Agra (Poiyaghat)	752.00	146.00	147.21	146.79	3.15	152.52	6063.00
6.	Agra (JB)	746.45	145.00	146.18	145.01	NA	152.08	NA
7.	Etawah	531.84	114.00	114.91	114.16	5.97	122.40	3999.00
8.	Auraiya	417.51	99.00	99.98	99.75	56.49	114.35	21004.0
9.	Kalpi	349.60	90.00	94.01	91.96	75.63	109.55	25749.0
10.	Hamirpur	280.53	88.00	88.40	88.24	3.09	106.38	30019.0
11.	Chillaghat	213.78	75.00	84.60	84	NA	103.32	NA
12.	Rajapur	95.51	65.00	74.83	73.37	44.94	93.01	37603.0
13.	Pratappur	33.13	70.00	72.43	71.81	66.94	89.25	30000.0
14.	Naini	13.34	70.00	71.82	71.39	NA	86.60	NA

Source : CWC

It has been analysed that the overall water level variation to the tune of 3m to 9m in upper reaches and 15m to 20min lower reaches has been observed. Similarly, the overall discharge variation to the tune of 1765 m^3/s to 6000 m^3/s in upper reaches and 21000 m^3/s to 37600 m^3/sin lower reaches has been observed.

Further, analysis has been carried out to find out the annual variation of the minimum water level and maximum water level as well as minimum & maximum Discharge each year over a data period at each gauge station.

Table 3.2 Annual Variation in Min & Max Water Level as well as Min & Max Discharge

Gauge Station	Ch. (Km)	Minimum Water level wrt MSL (m)	Maximum Water level wrt MSL (m)	Minimum Discharge (m^3/s)	Maximum Discharge (m^3/s)
Delhi Rly Bridge	1068.000	199.35 to 202.20	202.50 to 207.13	8.99 to 20.84	81.70 to 3466.00
Mohana	991.000	186.81 to 187.02	187.94 to 192.26	2.25 to 15.78	133.10 to 7981.00

Gauge Station	Ch. (Km)	Minimum Water level wrt MSL (m)	Maximum Water level wrt MSL (m)	Minimum Discharge (m^3/s)	Maximum Discharge (m^3/s)
Mathura	848.270	161.02 to 162.37	164.24 to 167.34	9.78 to 20.79	32.10 to 1776.00
Gokul Barrage	842.292	162.90 to 163.35	163.75 to 166.17	**NA**	**NA**
Agra (P.G)	752.000	146.79 to 147.12	148.05 to 152.50	3.15 to 16.02	133.71 to 6063.00
Agra (J.B)	746.447	145.01 to 146.35	147.06 to 152.08	**NA**	**NA**
Etawah	531.842	114.16 to 115.01	115.98 to 122.40	5.97 to 25.68	113.6 to 3999.00
Auraiya	417.514	99.75 to 100.22	101.09 to 114.35	56.49 to 285.8	370.40 to 21004.00
Kalpi	349.602	91.96 to 95.03	95.48 to 109.55	75.63 to 208.50	358.80 to 25749.00
Hamirpur	280.532	88.24 to 89.35	89.35 to 106.38	30.87 to 105.7	235.90 to 30019.00
Chillaghat	213.781	84.00 to 85.52	85.55 to 103.32	**NA**	**NA**
Rajapur	95.505	73.37 to 75.79	76.69 to 93.01	44.94 to 288.30	432.00 to 37603.00
Pratappur	33.129	71.81 to 74.03	73.72 to 89.25	29.57 to 446.7	520.00 to 30000.00
Naini	13.342	71.39 to 73.06	73.05 to 86.60	**NA**	**NA**

Source : CWC

It is analsyed from the above table that the annual variation of minimum water level itself is in the range of 0.2 m to 3.1 m and maximum water level is in the range of 2.4 m to 17.8 m. Similarly, the variation of minimum discharge is in the range of 12m^3/s to 417m^3/s and maximum discharge in the range of 1744m^3/s to 3717m^3/s.

River Yamuna NW 110 experiences high water level variations, i.e. of order of 18m during high season. The variability of water levels during the dry season is lower than during the high season, with variations of the order of 2-3m. The period of the year in which the minimum water level can occur varies with location along the river. In the upstream reaches from Delhi to Etawah the minimum water levels occur from October to July. Downstream of Etawah two major tributaries, Chambal and Betwa that join the river, the minimum water levels occur between February and June.

Keeping in view, the annual variation in the minimum& maximum water level, the average of the annual minimum water level and annual maximum water level at each gauge station has been worked out. The same is presented in the table and in graph given below:

Table 3.3 Average Minimum water level and Maximum water level

wrt MSL

Gauge Station	Chainage (Km)	Avg. Min. WL (m)	Avg. Max. WL (m)	HFL (m)	LWL (m)
Delhi Rly Bridge	1068.00	202.20	203.03	207.13	199.35
Mohana	991.00	187.30	188.28	192.26	186.78
Mathura	848.27	163.09	163.87	167.34	161.02
Gokul Barrage	842.29	163.38	163.77	166.17	162.90
Agra (P.G)	752.00	147.37	148.29	152.52	146.79
Agra (J.B)	746.45	146.57	147.49	152.08	145.01
Etawah	531.84	115.26	116.37	122.40	114.16
Auraiya	417.51	100.70	102.29	114.35	99.75
Kalpi	349.60	95.00	96.89	109.55	91.96
Hamirpur	280.53	89.41	91.40	106.38	88.24
Chillaghat	213.78	85.73	87.76	103.32	84.00
Rajapur	95.51	76.36	78.50	93.01	73.37
Pratappur	33.13	73.98	75.91	89.25	71.81
Naini	13.34	73.12	74.95	86.60	71.39

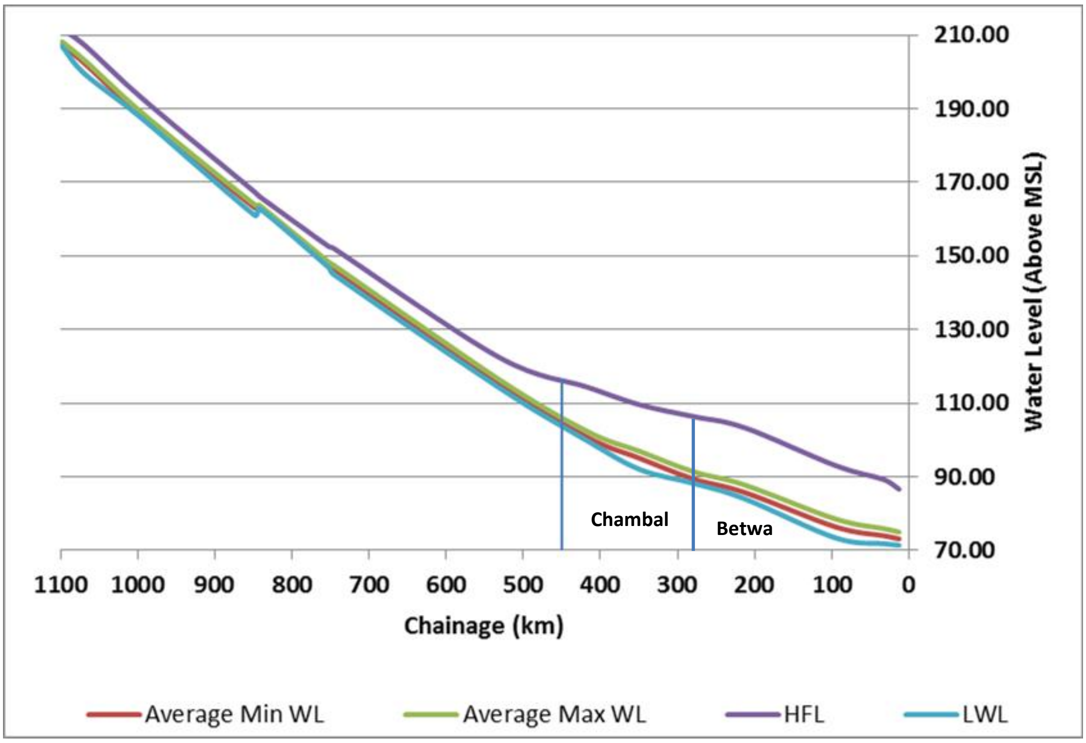


Fig. 3.1 Average Water Level Variation

From the above, it has been analysed that the average water level variation to the tune of 0.4 m to 1.1 m in upper reaches and 1.6 m to 2.1 min lower reaches has been observed which is due to confluence of Chambal River (at Ch. 453 km) and Betwa River (at Ch.272km) with River Yamuna NW 110.

3.2.2 Monthly Average Maximum and Average Minimum Water Level

NW-110 experiences high water level variations, i.e. of order 3m to 18m during flood season (July to September) along the stretch.Monthly Maximum and minimum water level data for various CWC gauge stations has been analyzed and presented in Annexure 3.1.These data helps us to get some insight into the minimum and maximum depth available with respect to chart datum during different months of the year. Monthly Maximum and minimum water level data for various CWC gauge stations has been further analyzed to compute monthly average minimum and monthly average maximum water level. These data depict minimum and maximum depth available with respect to chart datum during different months of the year. A typical graph of monthly water level variation is given below:

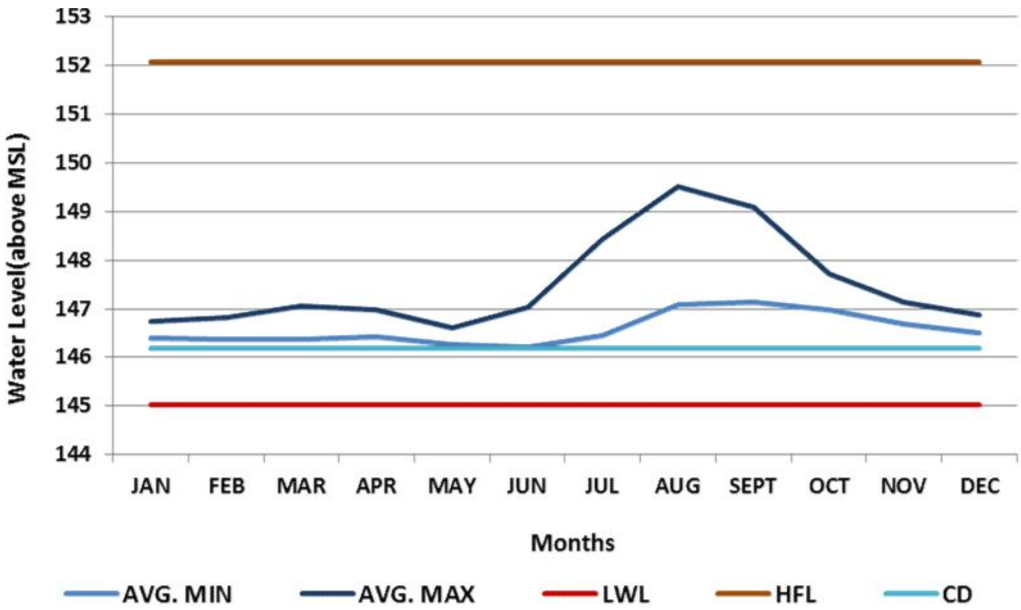


Fig.3.2 Monthly water level variation at Agra (JB) (Typical)

It is quite evident from the above graph that the water levels, in general are at their highest in August-September and sharply decrease in October-November. In general, they continue to decrease during the whole low flow season, from December to May, and start to rise again in June-July. Similar graphs for all the gauge stations (14 nos. of stations) in the reach under consideration have been plotted and are given in Annexure3.2.

3.2.3 Average Ten daily flow data analysis

The daily gauge discharge data for five major stations namely Agra (P.G.), Etawah, Auraiya, Hamirpur and Pratappur has been analysed for computation of ten daily average flows. Details of the analysis is shown in the Annexure 3.3.This analysis indicates rise in ten daily flows from the month June to September then reduction from October to January and from January onwards further reduction in flow till June. Gauge station wise analysis and result are summarized as below:

Agra (PG)

The results of analysis for the station indicate range of average 10 daily discharges in different period of year as following

- June - Begins at 22 m^3/s and increases to 82 m^3/s
- July to September - Begins at 85 m^3/s and increases to 670 m^3/s
- October to January - Begins at 280 m^3/s and decreases to 43 m^3/s
- February to May - Begins at 38 m^3/s and decreases to 21m^3/s

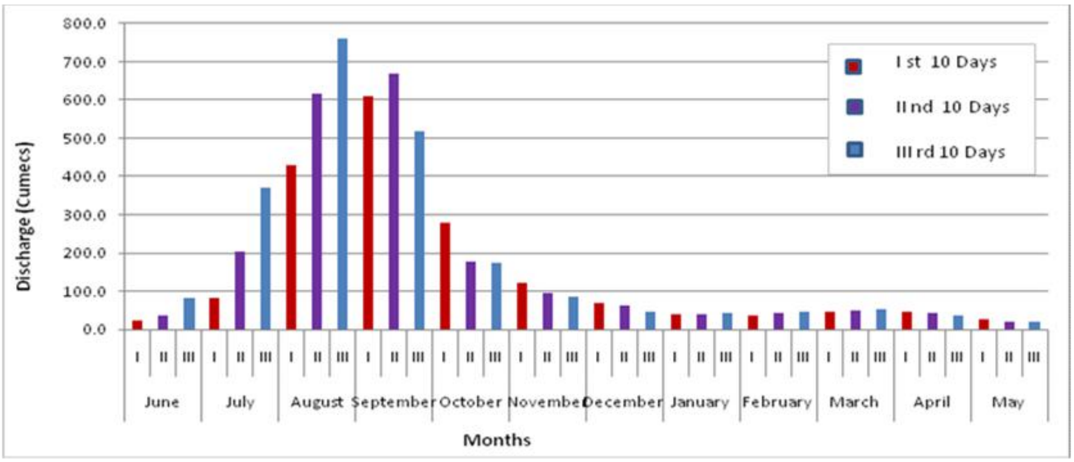


Fig. 3.3 Average 10 daily discharges at Agra (PG) gauging site on River Yamuna NW110

Etawah

The results of analysis for the station indicate range of average 10 daily discharges in different period of year as following

- June - Begins at 17 m^3/s and increases to 83 m^3/s
- July to September - Begins at 92 m^3/s and increases to 487 m^3/s
- October to January - Begins at 290 m^3/s and decreases to 45 m^3/s
- February to May - Begins at 40 m^3/s and decreases to 18 m^3/s

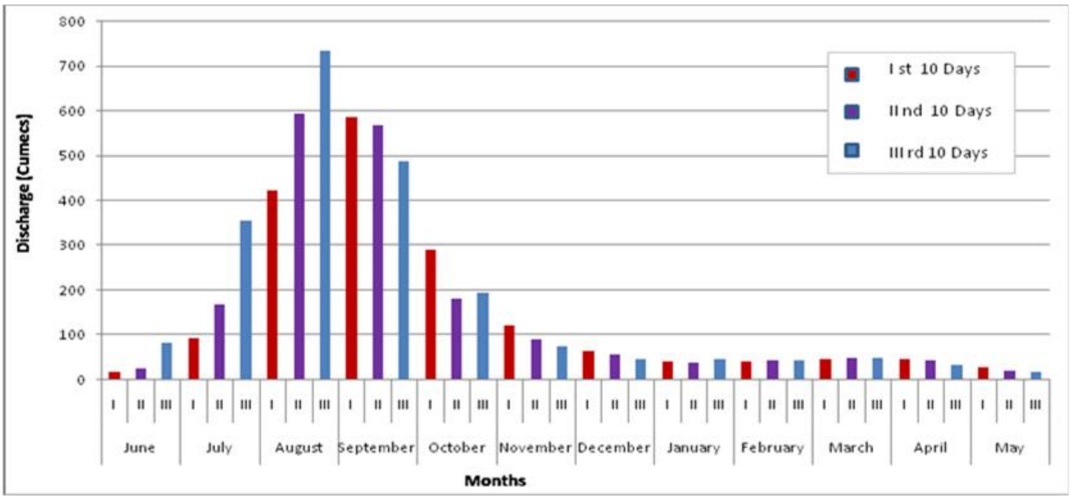


Fig. 3.4 Average 10 daily discharges at Etawah gauging site on River Yamuna NW 110

Auraiya

The results of analysis for the station indicate range of average 10 daily discharges in different period of year as following

- June - Begins at 133m^3/s and increases to 213 m^3/s
- July to August - Begins at 1100m^3/s and increases to 3366m^3/s
- September - Begins at 2490 m^3/s and decreases to1005 m^3/s
- October to January - Begins at 787m^3/s and decreases to 223 m^3/s
- February to May - Begins at 211m^3/s and decreases to 134m^3/s

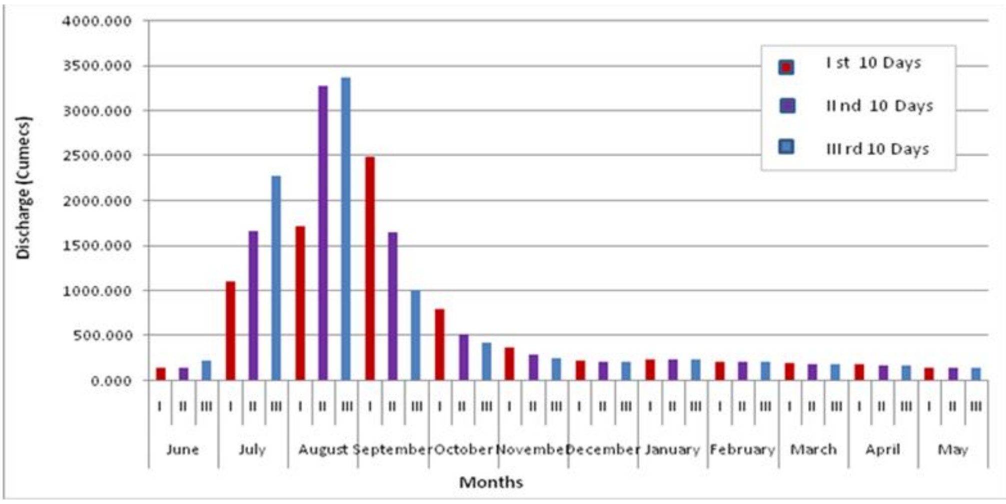


Fig. 3.5 Average 10 daily discharges at Auraiya gauging site on River Yamuna NW 100

Hamirpur

The results of analysis for the station indicate range of average 10 daily discharges in different period of year as following

- June - Begins at 90 m^3/s and increases to 540 m^3/s
- July to September - Begins at 1375 m^3/s and increases to 1735 m^3/s
- October to January - Begins at 1097 m^3/s and decreases to 170 m^3/s
- February to May - Begins at 173 m^3/s and decreases to 84 m^3/s

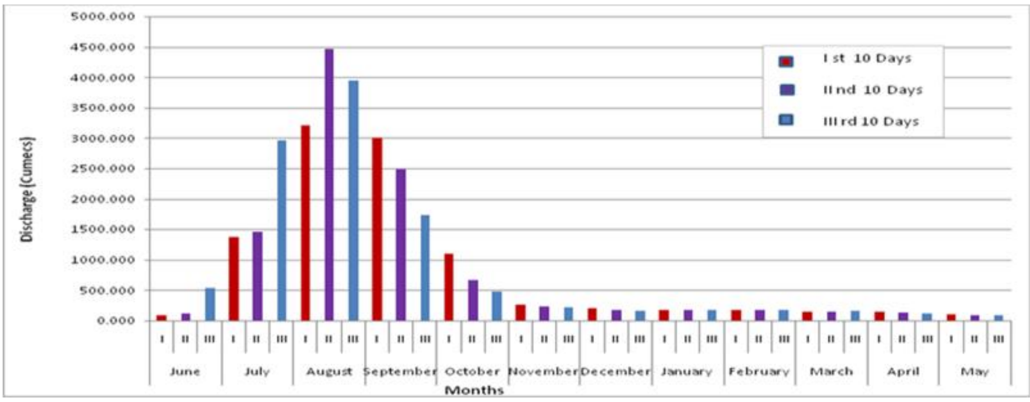


Fig. 3.6 Average 10 daily discharges at Hamirpur gauging site on River Yamuna NW 110

Pratappur

The results of analysis for the station indicate range of average 10 daily discharges in different period of year as following

- June - Begins at 310 m^3/s and increases to 675 m^3/s
- July to September - Begins at 2596 m^3/s and increases to 5280 m^3/s
- October to January - Begins at 2080 m^3/s and decreases to 417 m^3/s
- February to May - Begins at 408 m^3/s and decreases to 300 m^3/s

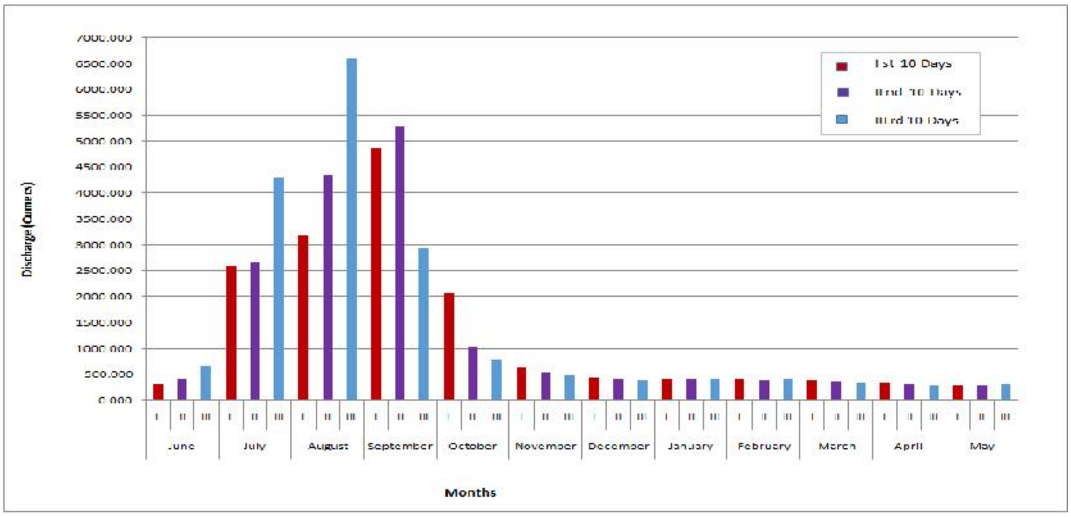


Fig. 3.7 Average 10 daily discharges at Pratappur gauging site on River YamunaNW 110

Table 3.4 Summary of Ten Daily Discharge

Gauge Station	June	July to September	October to January	February to May
Agra (PG)	Begins at 22 and increases to 82 m^3/s	Begins at 85 m^3/s and increases to 670 m^3/s	Begins at 280 m^3/s and decreases to 43 m^3/s	Begins at 38 m^3/s and decreases to 21 m^3/s
Etawah	Begins at 17 m^3/s and increases to 83 m^3/s	Begins at 92 m^3/s and increases to 487 m^3/s	Begins at 290 m^3/s and decreases to 45 m^3/s	Begins at 40 m^3/s and decreases to 18 m^3/s
Auraiya	Begins at 133 m^3/s and increases to 213 m^3/s	Begins at 1100 m^3/s and increases to 3366 m^3/s then decreases to 1005 m^3/s	Begins at 787 m^3/s and decreases to 223 m^3/s	Begins at 211 m^3/s and decreases to 134 m^3/s
Hamirpur	Begins at 90 m^3/s and increases to 540 m^3/s	Begins at 1375 m^3/s and increases to 1735 m^3/s	Begins at 1097 m^3/s and decreases to 170 m^3/s	Begins at 173 m^3/s and decreases to 84 m^3/s
Pratappur	Begins at 310 m^3/s and increases to 675 m^3/s	Begins at 2596 m^3/s and increases to 5280 m^3/s	Begins at 2080 m^3/s and decreases to 417 m^3/s	Begins at 408 m^3/s and decreases to 300 m^3/s

3.2.4 Gauge-Discharge Data Analysis

The daily gauge discharge data for five major stations namely Agra (P.G.), Etawah, Auraiya, Hamirpur and Pratappur has been analysed.

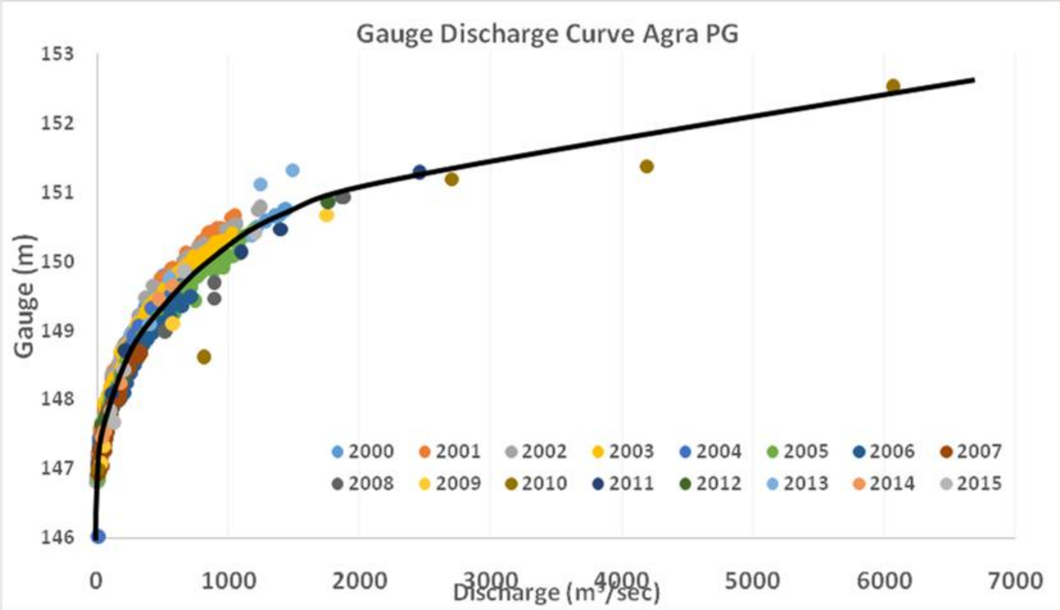


Fig. 3.8 Gauge Discharge Curve at Agra (PG)

These gauge discharge relationship will be useful for estimation of flood discharge for different water levels. Graphs will be useful for estimation of discharge required to maintain 2.5 m flow depth under the existing conditions of river channels.

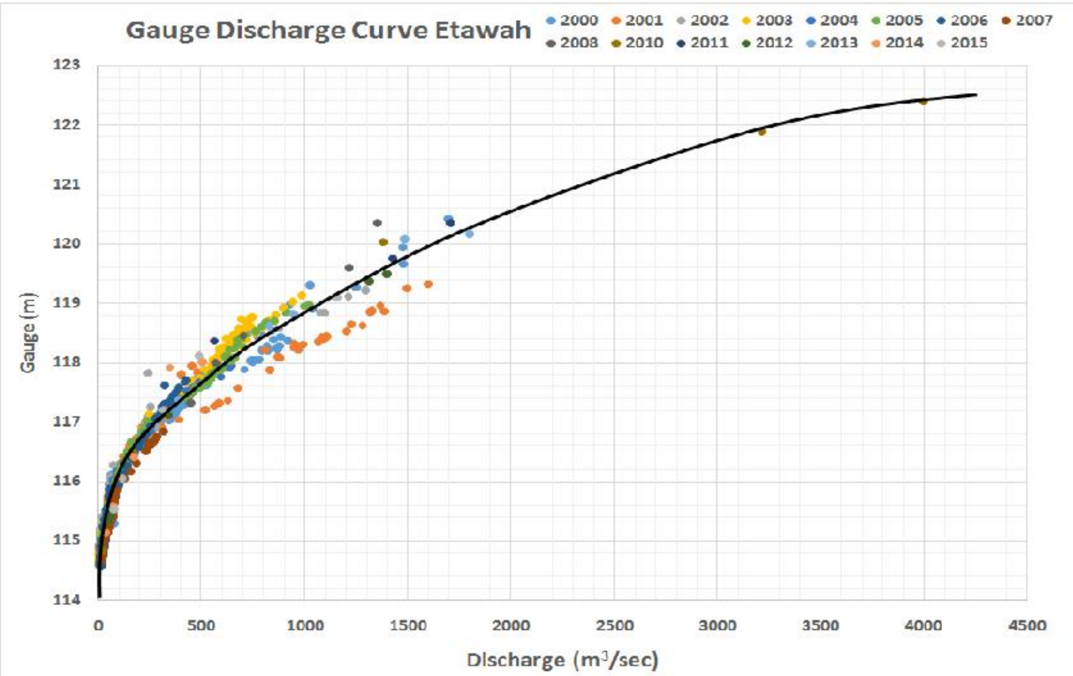


Fig. 3.9 Gauge Discharge Curve at Etawah

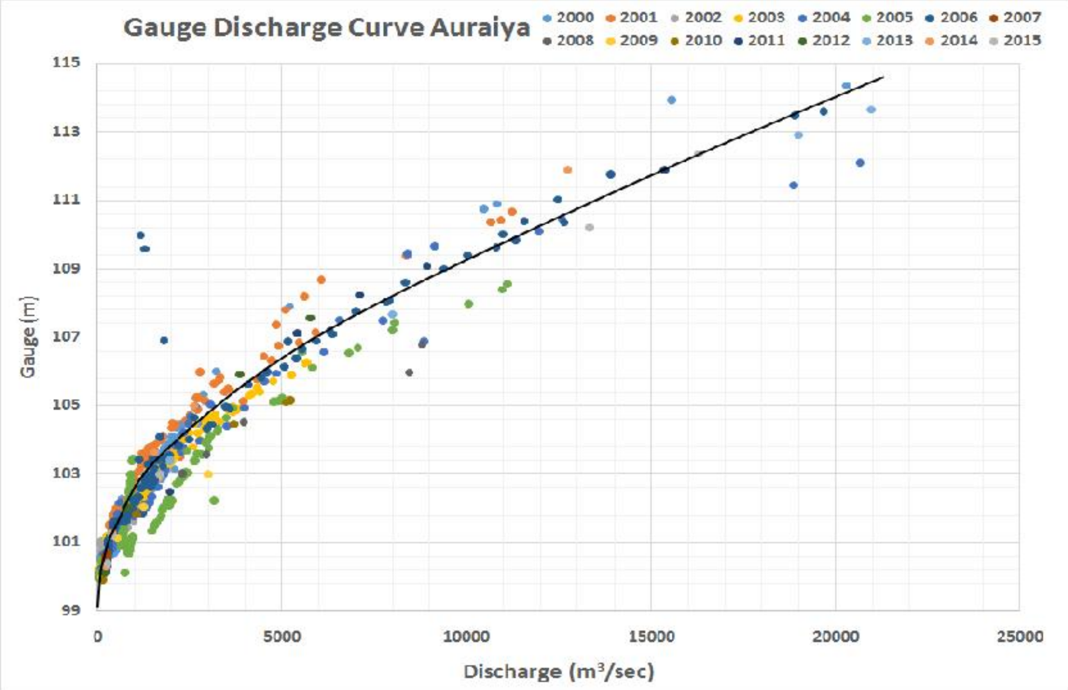


Fig. 3.10 Gauge Discharge Curve at Auraiya

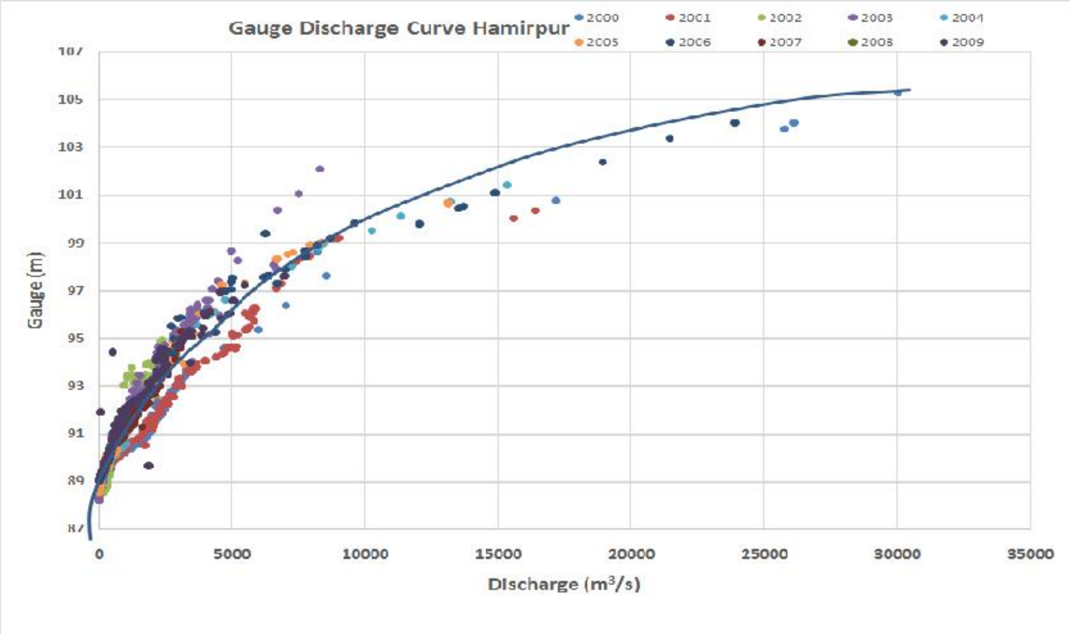


Fig. 3.11 Gauge Discharge Curve at Hamirpur

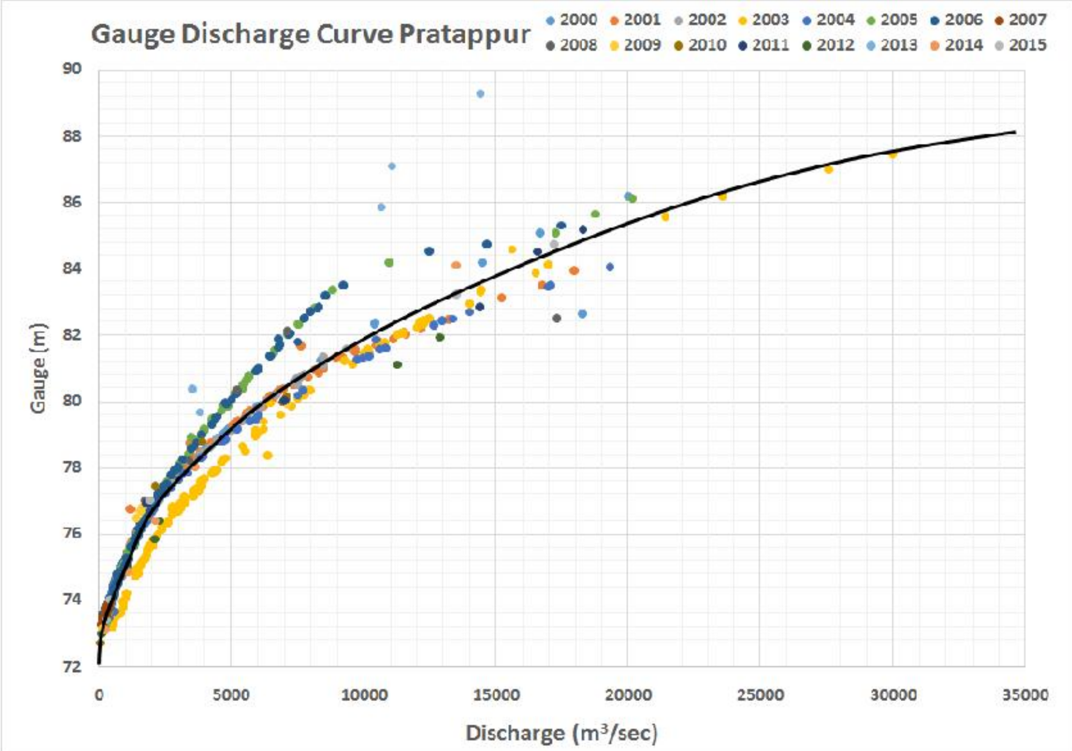


Fig. 3.12 Gauge Discharge Curve at Pratappur

3.2.5 Sediment Data Analysis

The suspended sediment data for five major stations namely Agra (P.G.), Etawah, Auraiya, Hamirpur and Pratappur was analysed to establish relationship between discharge and suspended sediments. These results are presented in the following figures.

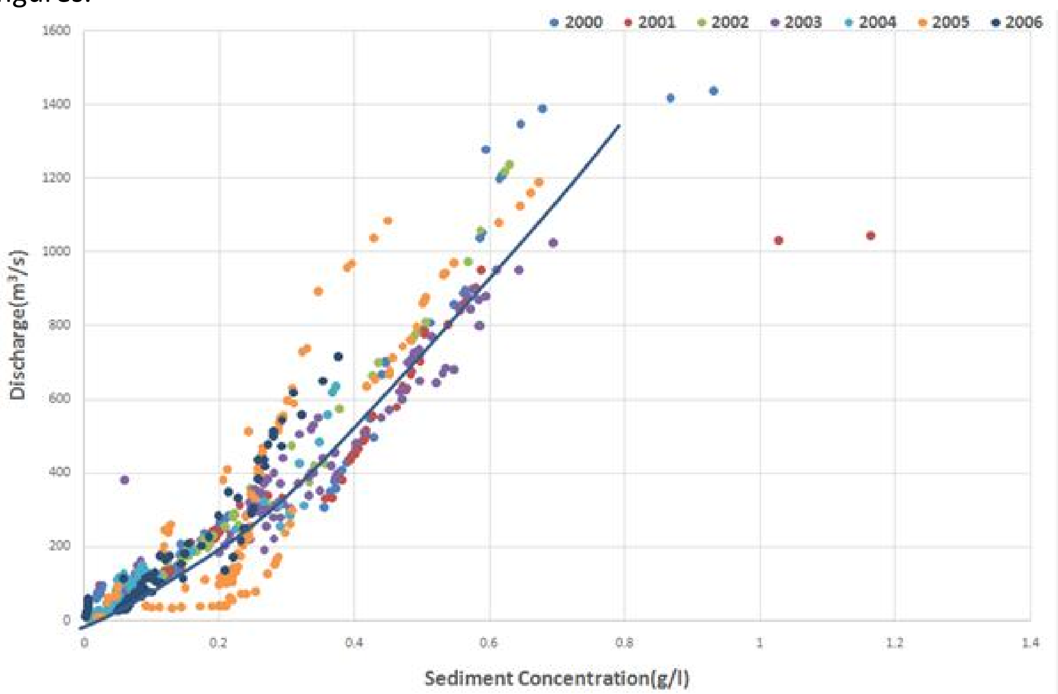


Fig. 3.13 Discharge Sediment Concentration Graph at Agra (PG)

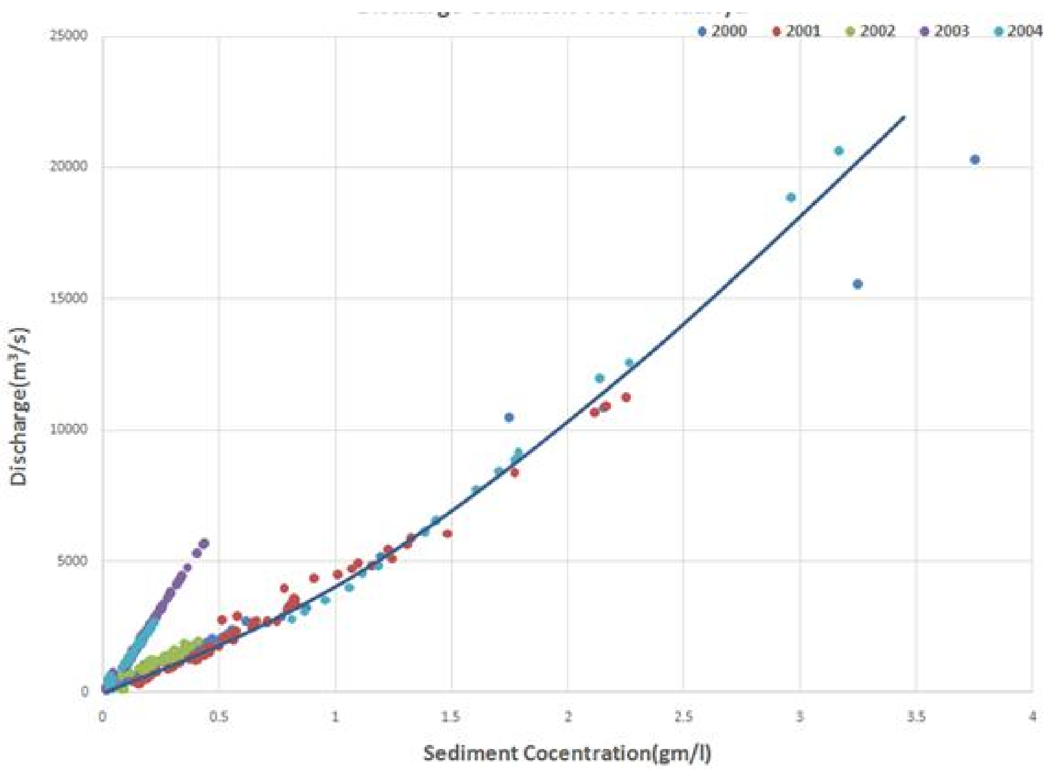


Fig. 3.14 Discharge Sediment Concentration Graph at Auraiya

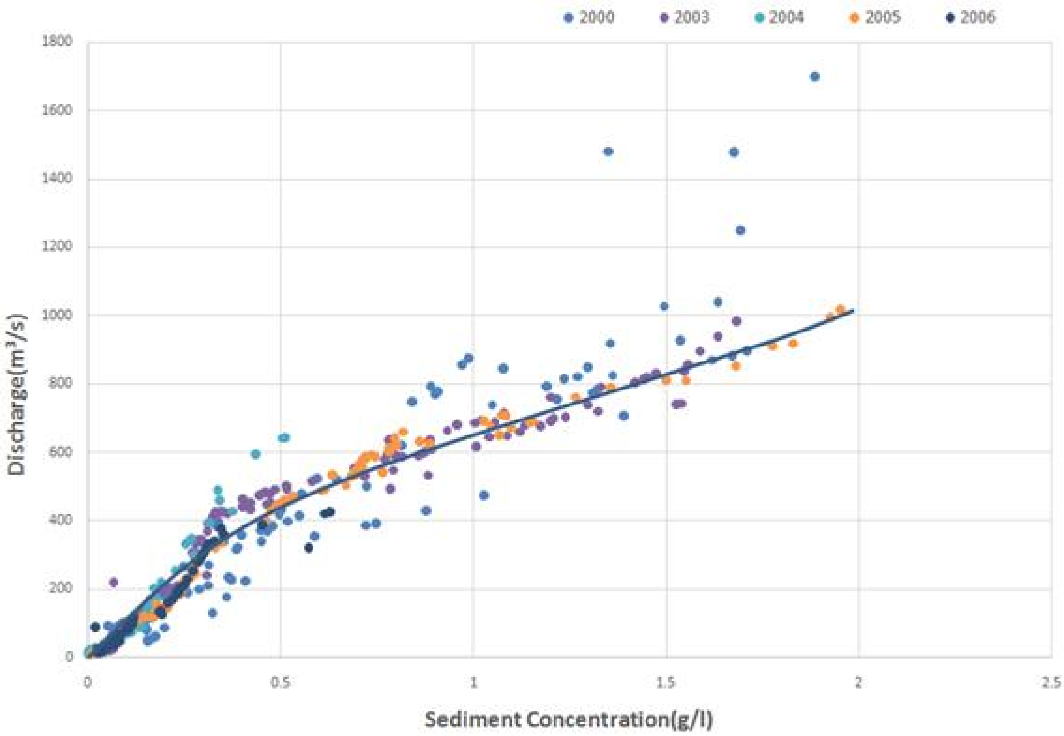


Fig. 3.15 Discharge Sediment Concentration Graph at Etawah

From the discharge sediment concentration graphs it is depicted that during non-monsoon period almost entire sediment was fine sand & silt/clay and during monsoon 80 to 90 % sediment is fine sand.

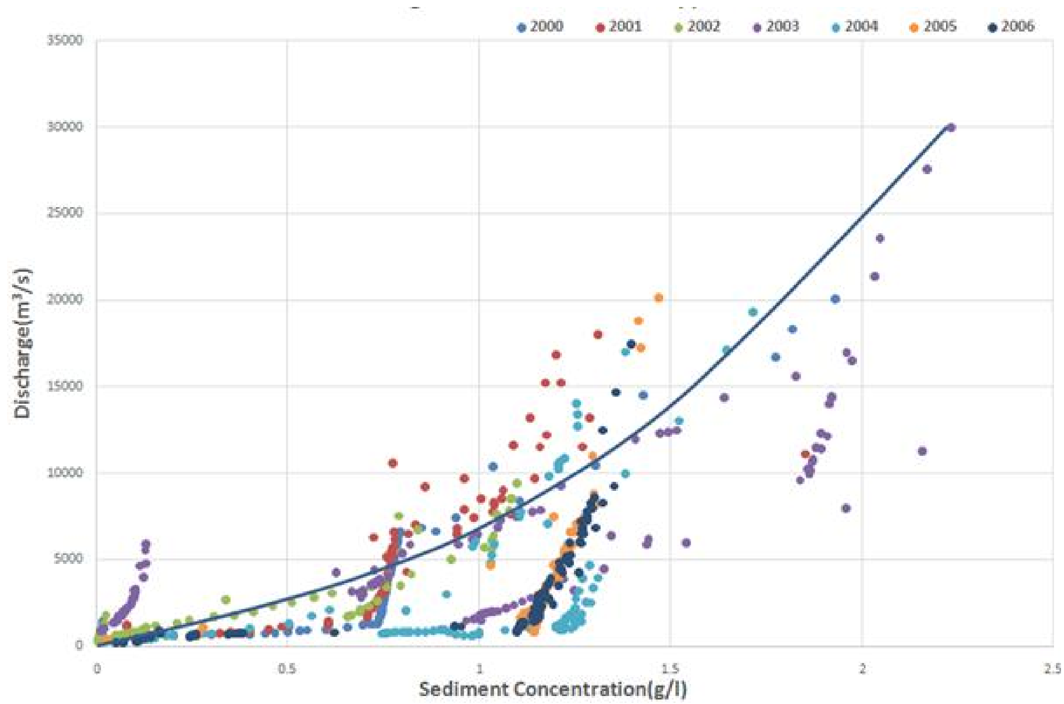


Fig. 3.16 Discharge Sediment Concentration Graph at Pratappur

3.3 Assessment of Water availability/Flow Depth

Statistical analysis has been carried out by computing average monthly water level value from the available hydrological data over the period of years from 2000 to 2015 of the gauge stations to assess the water availability round the year in the River Yamuna NW 110. The duration curves of cumulative monthly elevation has been plotted to find out the duration of availability of 2.5m water depth throughout the year. Also, the minimum water depth available for 330 days has been shown:

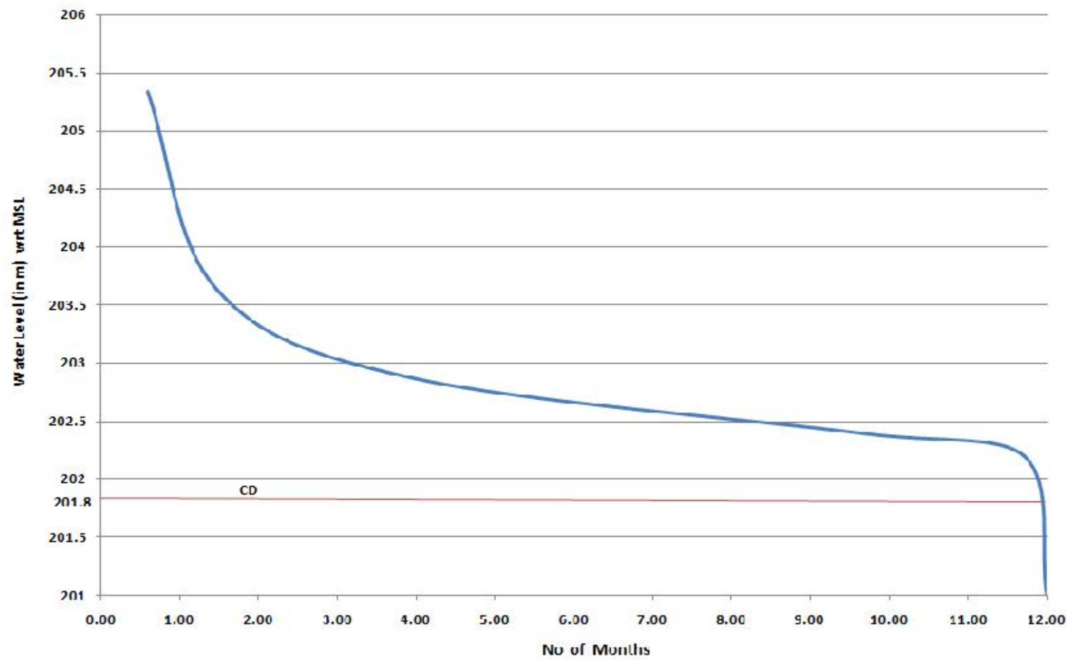


Fig. 3.17 Duration Curve of Monthly Elevation at Delhi Railway Bridge

It is quite clear from the above graph that the 2.5 m water depth at Delhi Railway Bridge is Available merely for approximately 30 days and for 330 days min water depth (wrt CD) available is just is 0.7m.

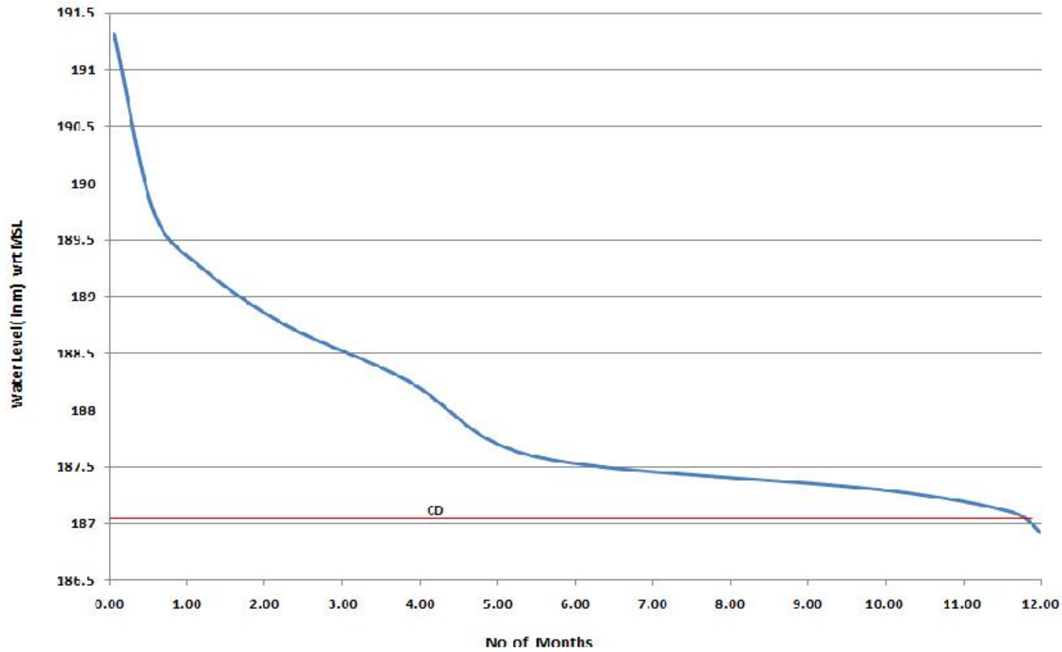


Fig. 3.18 Duration Curve of Monthly Elevation at Mohana

It is quite clear from the above graph that the 2.5 m water depth at Mohana is available merely for approximately 30 days and for 330 days min water depth (wrt CD) available is just 0.3m.

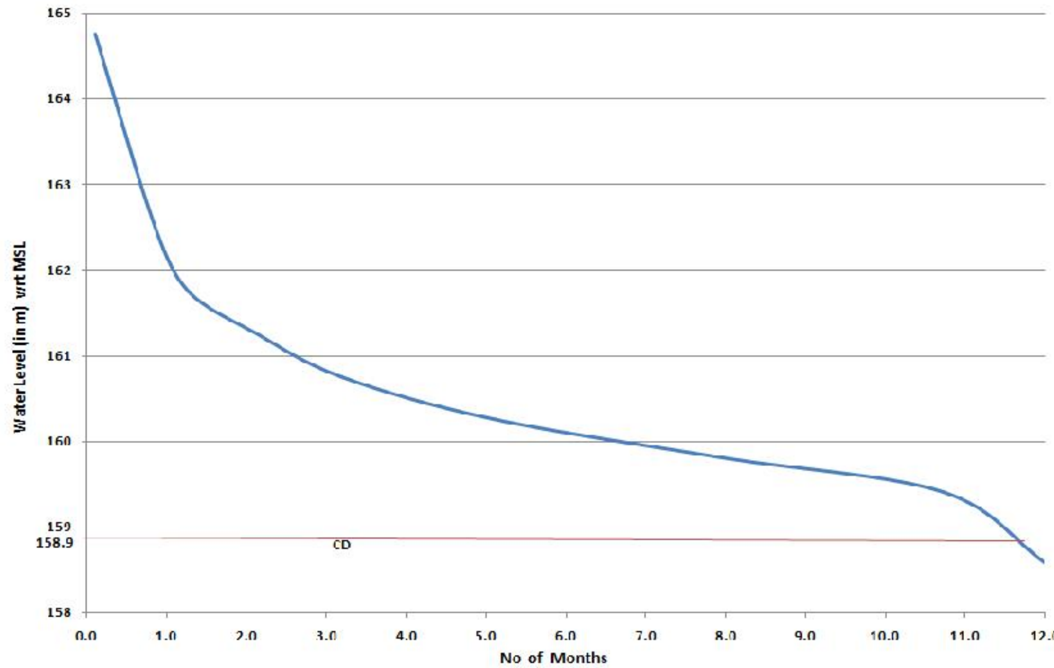


Fig. 3.19 Duration Curve of Monthly Elevation at Gokul Barrage

It is quite clear from the above graph that the 2.5 m water depth at Gokul Barrage is Available merely for approximately 45 days and for 330 days min water depth (wrt CD) available is just 0.6m.

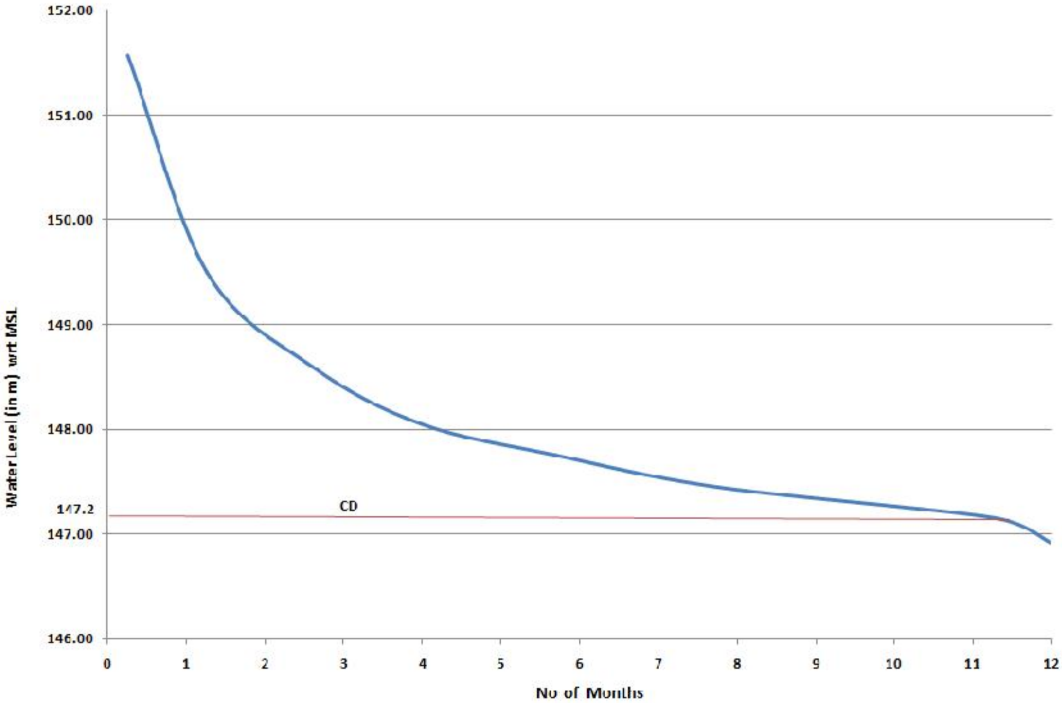


Fig. 3.20 Duration Curve of Monthly Elevation at Agra (PG)

It is quite clear from the above graph that the 2.5 m water depth at Agra (PG) is Available merely for approximately 40 days and for 330 days min water depth (wrt CD) available is approximately 0.2m.

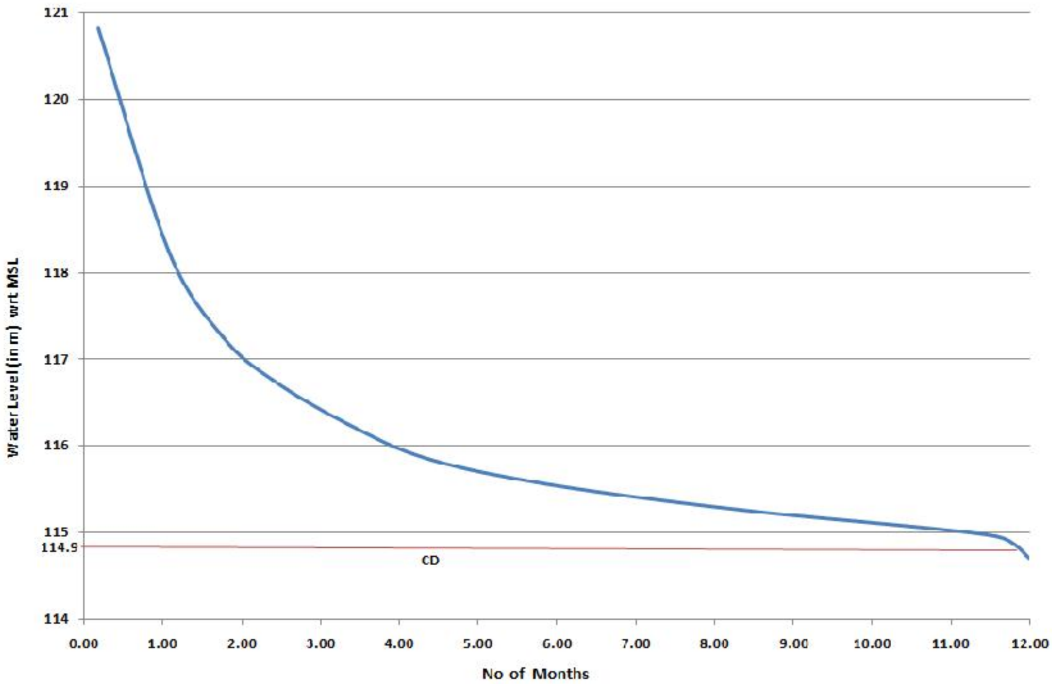


Fig. 3.21 Duration Curve of Monthly Elevation at Etawah

It is quite clear from the above graph that the 2.5 m water depth at Etawah is Available merely for approximately 50 days and for 330 days min water depth (wrt CD) available is approximately 0.3m.

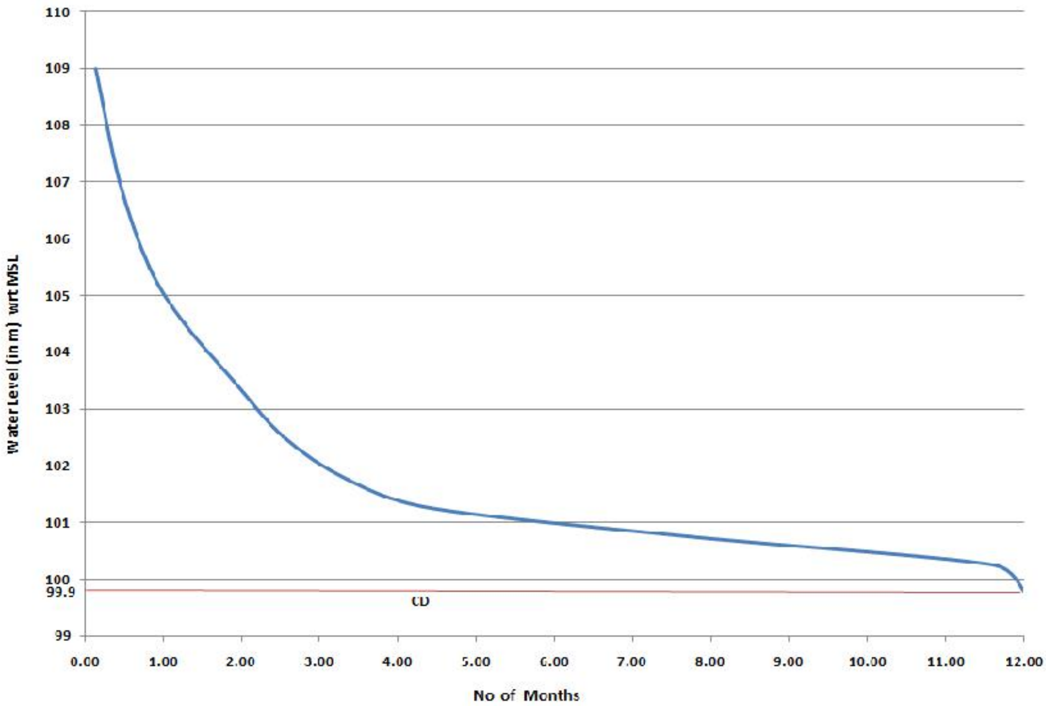


Fig. 3.22 Duration Curve of Monthly Elevation at Auraiya

It is quite clear from the above graph that the 2.5 m water depth at Auraiya is Available merely for approximately 80 days and for 330 days min water depth (wrt CD) available is approximately 0.5m.

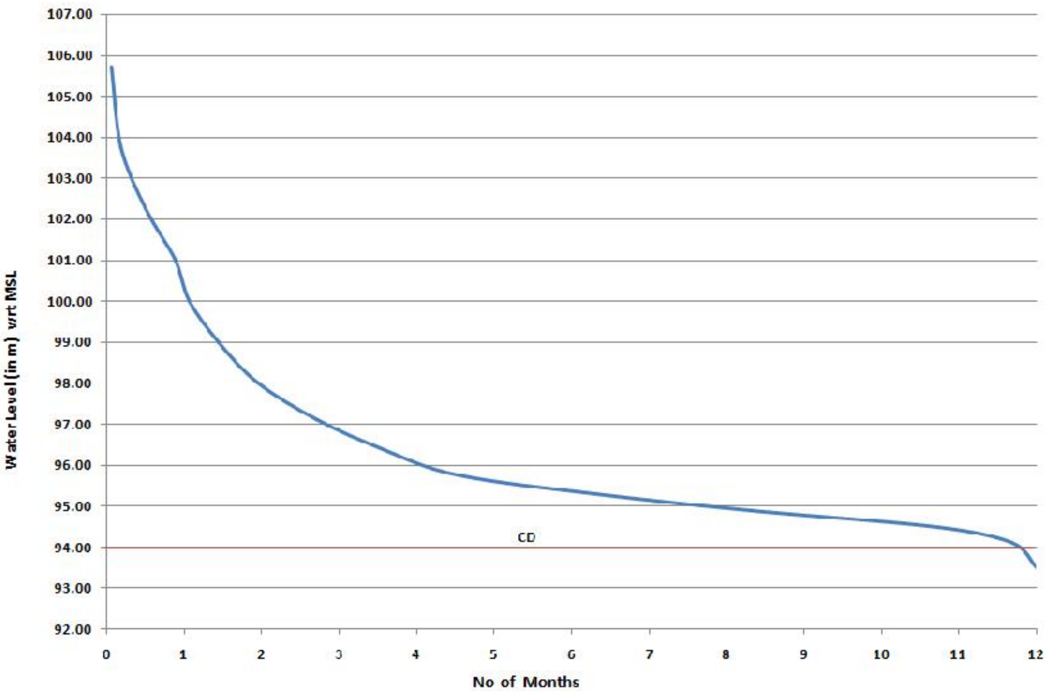


Fig. 3.23 Duration Curve of Monthly Elevation at Kalpi

It is quite clear from the above graph that the 2.5 m water depth at Kalpi is Available merely for approximately 100 days and for 330 days min water depth (wrt CD) available is approximately 0.5m.

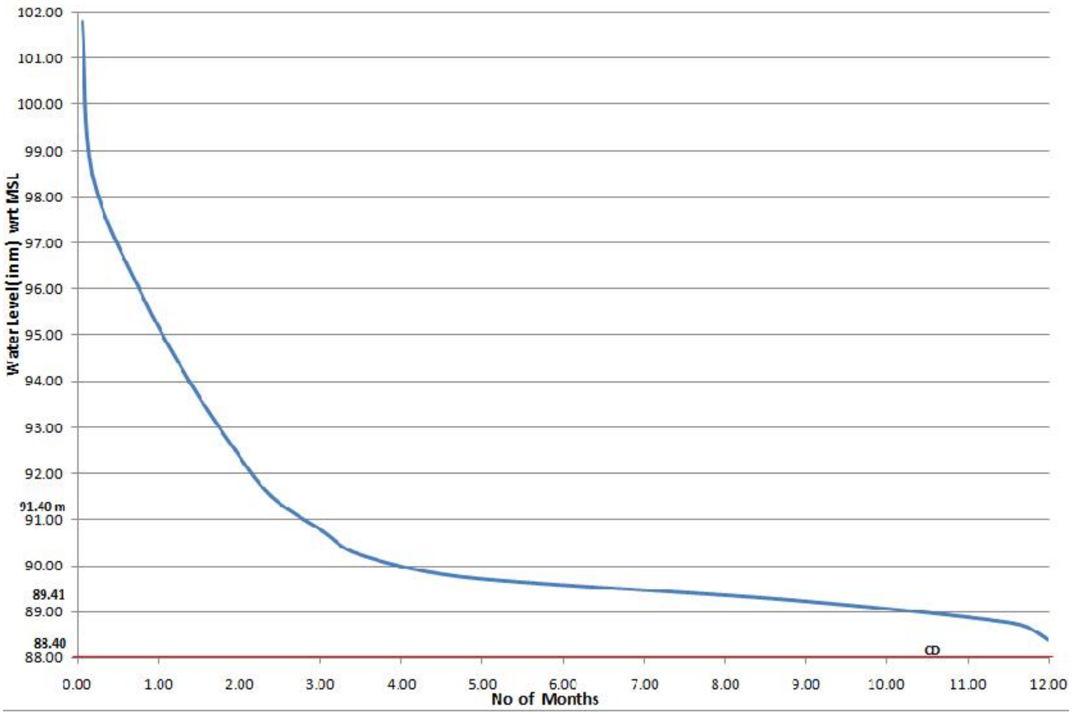


Fig. 3.24 Duration Curve of Monthly Elevation at Hamirpur

It is quite clear from the above graph that the 2.5 m water depth at Hamirpur is Available merely for approximately 90 days and for 330 days min water depth (wrt CD) available is approximately 0.7m.

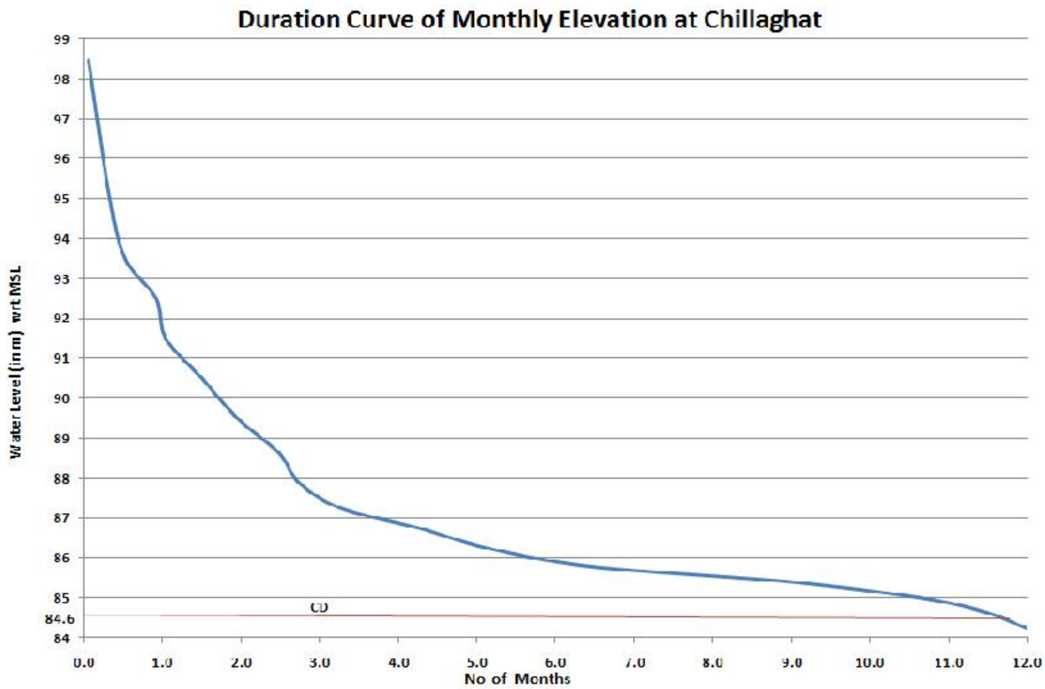


Fig. 3.25 Duration Curve of Monthly Elevation at Chillaghat

It is quite clear from the above graph that the 2.5 m water depth at Chillaghat is Available merely for approximately 110 days and for 330 days min water depth (wrt CD) available is approximately 0.6m.

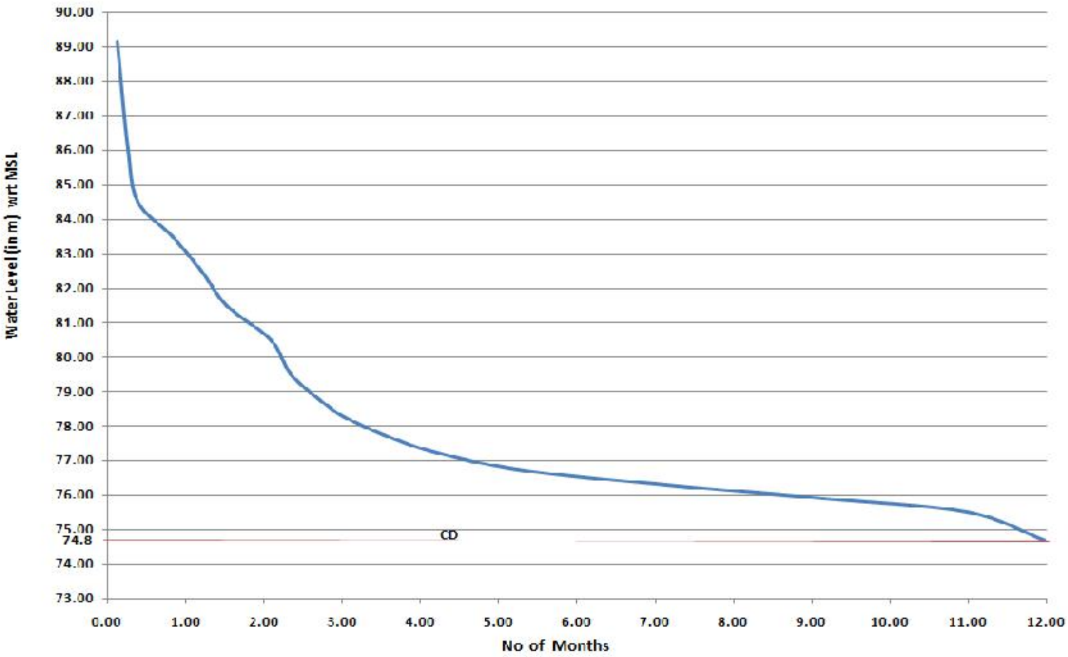


Fig. 3.26 Duration Curve of Monthly Elevation at Rajapur

It is quite clear from the above graph that the 2.5 m water depth at Rajapur is Available merely for approximately 120 days and for 330 days min water depth (wrt CD) available is approximately 1.1m.

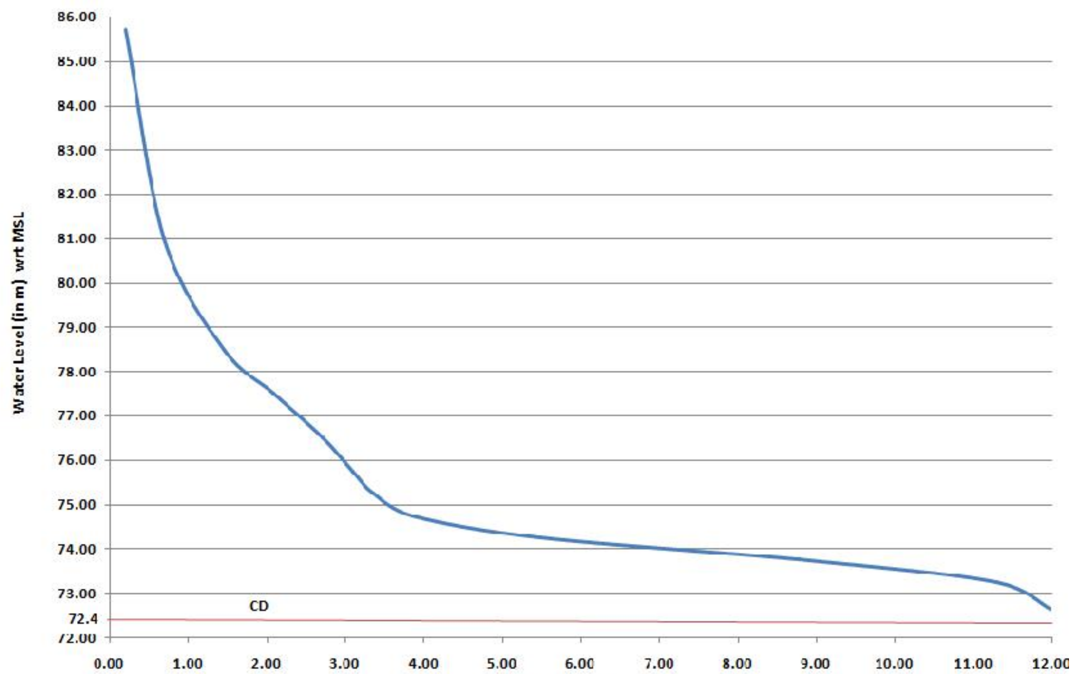


Fig. 3.27 Duration Curve of Monthly Elevation at Pratappur

It is quite clear from the above graph that the 2.5 m water depth at Pratappur is Available merely for approximately 110 days and for 330 days min water depth (wrt CD) available is approximately 1.0m.

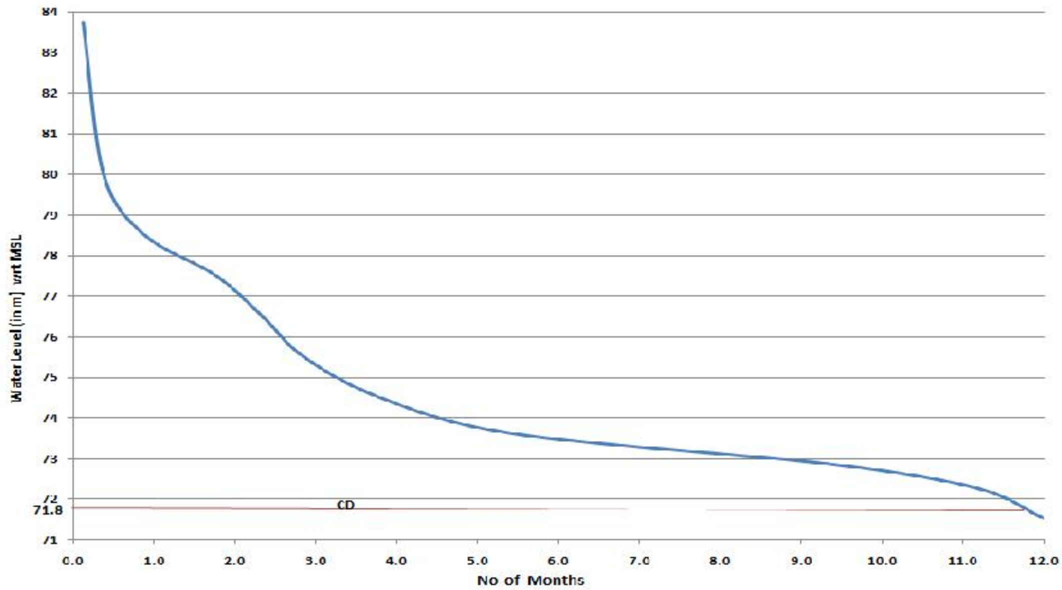


Fig. 3.28 Duration Curve of Monthly Elevation at Naini

It is quite clear from the above graph that the 2.5 m water depth at Naini is Available merely for approximately 130 days and for 330 days min water depth (wrt CD) available is approximately 0.9m.

Table 3.5 Summary of Water Availability

Gauge Station/Chainage	Approx. No. of days for which minimum 2.5 m water depth available (Days)	Minimum Water depth available for 330 days (m)
Delhi Railway Bridge (Ch.1068km)	30	0.7
Mohana (Ch.991km)	30	0.3
Gokul Barrage (Ch.842.29km)	45	0.6
Agra (Poiyaghat) (Ch.752km)	40	0.2
Etawah (Ch.531.84km)	50	0.3
Auraiya (Ch.417.51km)	80	0.5
Kalpi (Ch.349.60km)	100	0.5
Hamirpur (Ch.28.53km)	90	0.7
Chillaghat (Ch.213.78km)	110	0.6
Rajapur (Ch.95.51km)	120	1.1
Pratappur (Ch.33.13km)	110	1.0
Naini (Ch.13.34km)	130	0.9

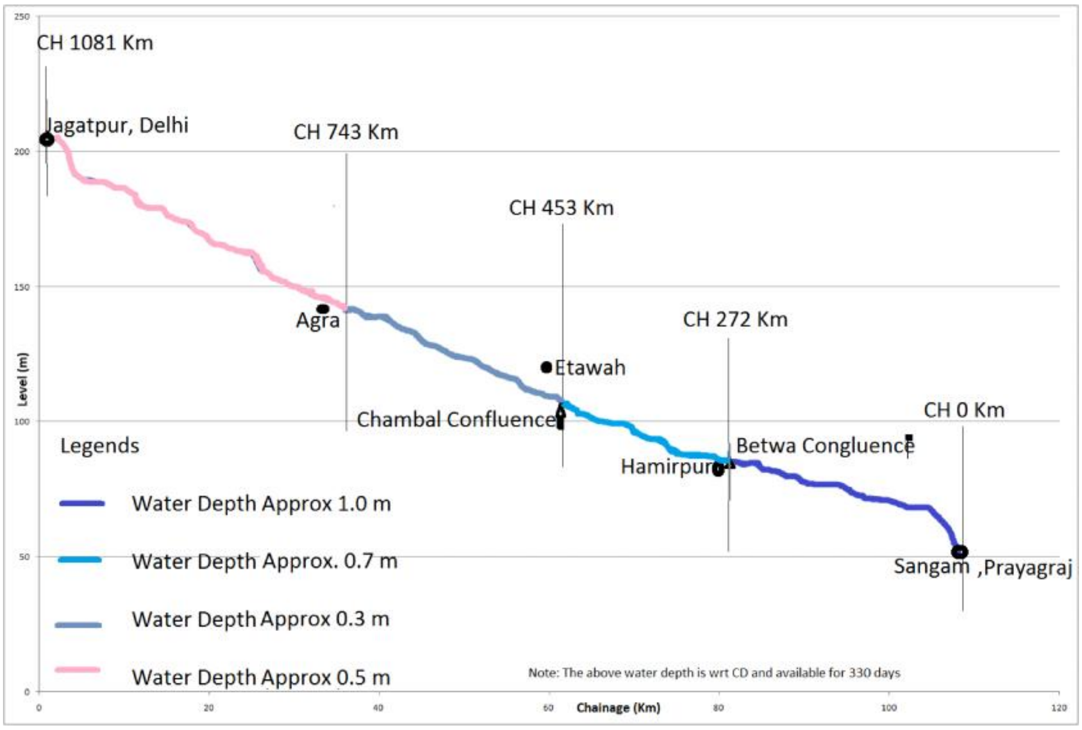


Fig.3.29 Stretches wise water availability for 330 days

Minimum & Maximum surface water levels at 12 gauging stations between Delhi and Prayagraj for 3 annual probability of occurrence is given in Table 3.6 & Table 3.7 & Fig. 3.30 & Fig. 3.31 below

Table 3.6 Minimum Water Levels for Range of Annual Probabilities

Gauge Station	Minimum Water Level (m) (wrt MSL)		
	50%	10%	1%
Delhi Railway Bridge (Ch.1068km)	202.25	202.36	203.49
Mohana (Ch.991km)	187.20	187.85	188.86
Gokul Barrage (Ch.842.29km)	163.11	163.75	164.38
Agra (Poiyaghat) (Ch.752km)	147.23	147.92	154.12
Etawah (Ch.531.84km)	115.08	116.19	117.48
Auraiya (Ch.417.51km)	100.48	101.76	104.75
Kalpi (Ch.349.60km)	94.73	96.62	99.60
Hamirpur (Ch.28.53km)	89.10	90.81	94.50
Chillaghat (Ch.213.78km)	85.34	87.78	91.41
Rajapur (Ch.95.51km)	75.97	78.78	82.88
Pratappur (Ch.33.13km)	73.61	75.81	79.60
Naini (Ch.13.34km)	72.65	75.22	78.41

The annual probability analysis depicts that the water level variation of 0.2m to 0.8m occurs for 50% annual probability.

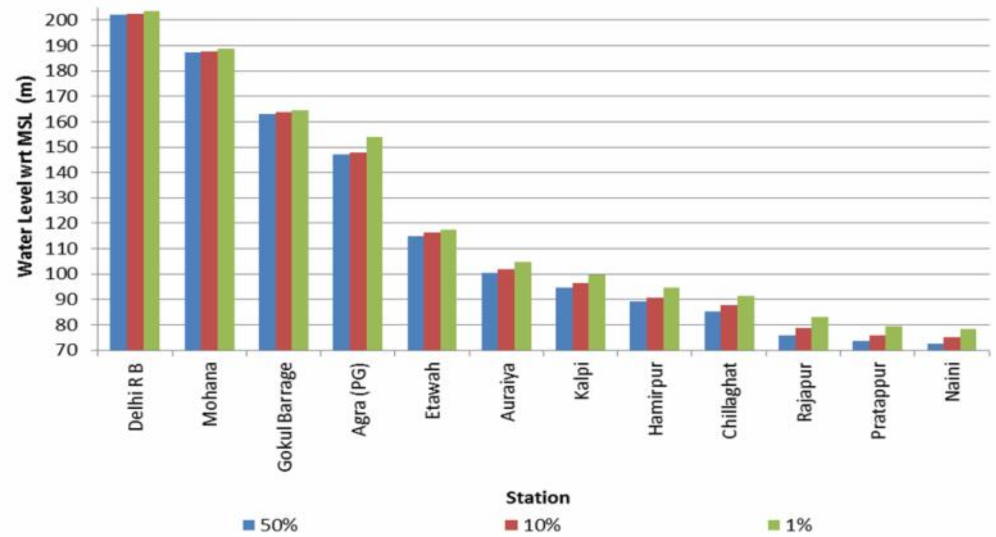


Fig. 3.30 Minimum Water Levels for Range of Annual Probabilities

Table 3.7 Maximum Water Levels for Range of Annual Probabilities

Gauge Station	Maximum Water Level (m) (wrt MSL)		
	50%	10%	1%
Delhi Railway Bridge (Ch.1068km)	202.49	204.66	207.09
Mohana (Ch.991km)	187.69	190.49	191.63
Gokul Barrage (Ch.842.29km)	163.92	164.88	166.95
Agra (Poiyaghat) (Ch.752km)	147.81	150.39	151.38
Etawah (Ch.531.84km)	115.76	118.92	121.88
Auraiya (Ch.417.51km)	100.97	106.75	113.65
Kalpi (Ch.349.60km)	95.41	101.78	109.36
Hamirpur (Ch.28.53km)	89.60	97.60	105.29
Chillaghat (Ch.213.78km)	86.04	93.85	100.99
Rajapur (Ch.95.51km)	76.52	85.79	91.13
Pratappur (Ch.33.13km)	74.06	82.38	87.44
Naini (Ch.13.34km)	73.26	80.75	85.63

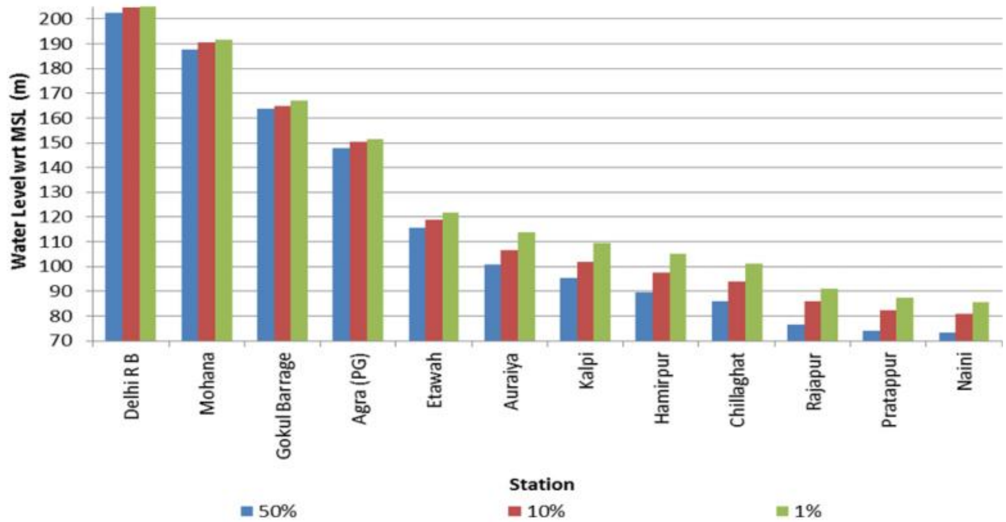
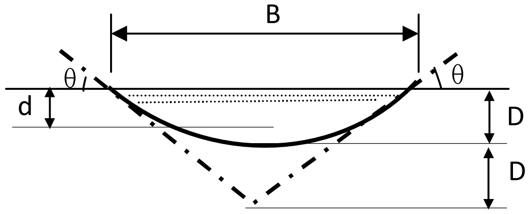


Fig. 3.31 Maximum Water Levels for Range of Annual Probabilities

3.4 Flow Requirement for Navigation

For development of an authorized depth in a river it is essential that a minimum required discharge is available. In order to calculate the min discharge required to maintain required depth CBIP formula is used and it is given as under:

$$d = \left\{ \frac{Q^{4/11}}{204\ m\ (S)^{1/2}} \right\}$$



Where d = Depth available (m)

S = Energy / Water slope

θ = Natural angle of repose of a shore or a stabilized bank

m = cot θ = B/6d

d = 2/3 D

Q = Discharge (m^3/s)

Considering energy/water slope and width of river as per the field survey the discharge required for the targeted authorized depth of 2.5m works out as under:

Table 3.8 Discharge requirement for Development of LAD

Chainage (Km)	Width of river during lean season B (m)	Target LAD d (m)	Water / Energy Slope S	m = B/6d	$(S)^{1/2}$	$(d)^{11/4}$	Discharge (m^3/s) Q
0 - 50	650	2.5	0.0000599	43.33	0.00773951	12.42611	850.16
50 - 100	630	2.5	0.0001174	42.00	0.01083513	12.42611	1153.58
100 - 150	550	2.5	0.0000742	36.67	0.00861394	12.42611	800.64
150 - 200	520	2.5	0.00002175	34.67	0.00466369	12.42611	409.83
200 - 250	750	2.5	0.0001309	50.00	0.01144115	12.42611	1450.12
250 - 300	450	2.5	0.00004785	30.00	0.00691737	12.42611	526.05
300 - 350	650	2.5	0.00009915	43.33	0.00995741	12.42611	1093.79
350 - 400	400	2.5	0.0000859	26.67	0.00926823	12.42611	626.51
400 - 450	540	2.5	0.0000669	36.00	0.00817924	12.42611	746.42
450 - 500	250	2.5	0.0002139	16.67	0.01462532	12.42611	617.90
500 - 550	250	2.5	0.0000707	16.67	0.00840833	12.42611	355.24
550 - 600	300	2.5	0.00012475	20.00	0.01116915	12.42611	566.26
600 - 650	280	2.5	0.00017175	18.67	0.01310534	12.42611	620.13
650 - 700	240	2.5	0.0001396	16.00	0.01181524	12.42611	479.21
700 - 750	275	2.5	0.00012675	18.33	0.01125833	12.42611	523.22
750 - 800	200	2.5	0.000097	13.33	0.00984886	12.42611	332.88
800 - 850	300	2.5	0.00020115	20.00	0.01418274	12.42611	719.04
850 - 900	250	2.5	0.00015855	16.67	0.01259166	12.42611	531.98
900 - 950	300	2.5	0.00015585	20.00	0.01248399	12.42611	632.92
950 - 1000	250	2.5	0.0001612	16.67	0.01269646	12.42611	536.41
1000 - 1050	280	2.5	0.0001644	18.67	0.01282186	12.42611	606.71
1050 - 1081	300	2.5	0.00016084	20.00	0.01268207	12.42611	642.96

Above calculations are based on single channel i.e. the river without braiding. However braiding is one of the essential characteristics of the alluvial rivers. If the relationship between d and Q mentioned above is extrapolated for braided channel reveals that only 0.8d is developed at 2 channel braiding location and only 0.67d at 3 channel braiding location. The discharge requirement indicated above are based on the assumption that shape of the channel is parabolic and is free from undulation. However in actual the bed comprises an undulating bed with multiple pools. These pools act as dead storages for the water and the discharge through this recession may not contribute in developing the navigation channel of particular LAD. The dead storages account for 10% to 40% discharge available at a cross-section. Hence to develop an authorized depth discharge required is about 1.1. to 1.4 times the discharge calculated from CBIP formula.

3.3.2 Discharge Duration Analysis

Statistical analysis has been carried out by computing average monthly discharge from the available hydrological data over data period. Discharge duration curve is plotted to find out the minimum base flow available for 330 days. The discharge duration curve is given below:

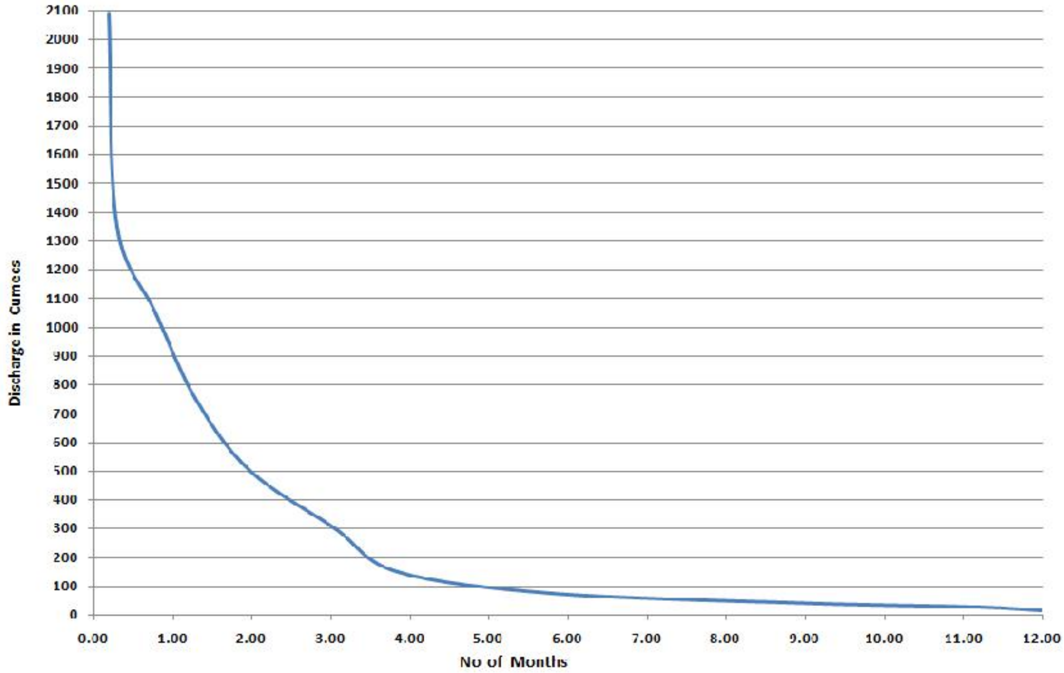


Fig. 3.32 Discharge Duration Curve at Delhi Railway Bridge

From the above graph it can be seen that minimum base flow of approximately 40 m^3/s is available for 330 days at Delhi Railway Bridge.

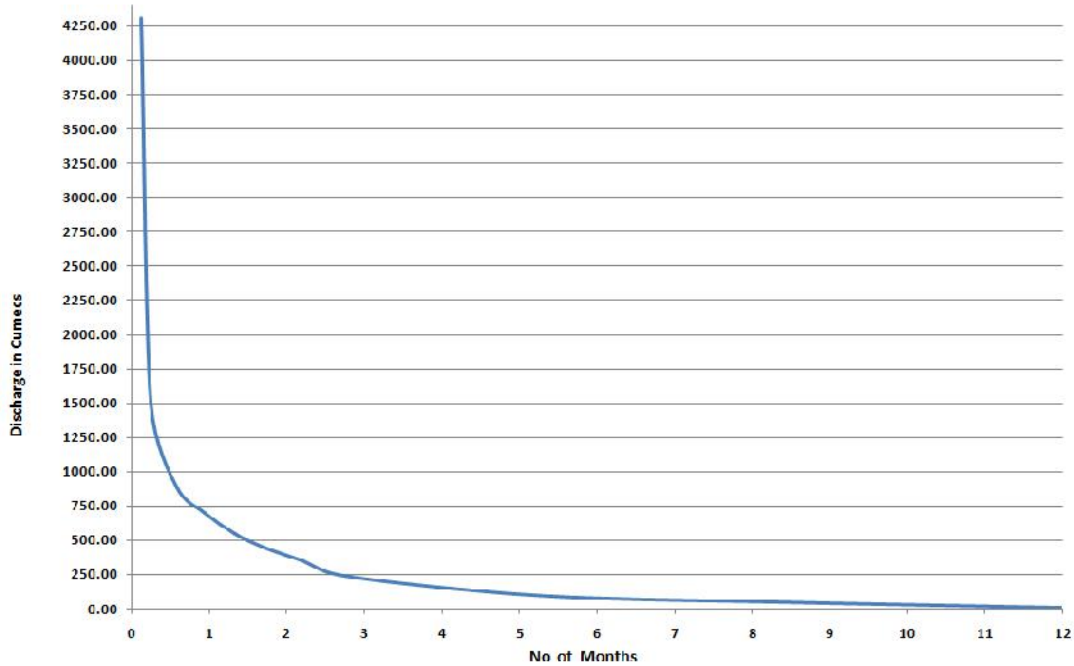


Fig. 3.33 Discharge Duration Curve at Agra (PG)

From the above graph it can be seen that minimum base flow of approximately 20 m^3/s is available for 330 days at Agra (PG)

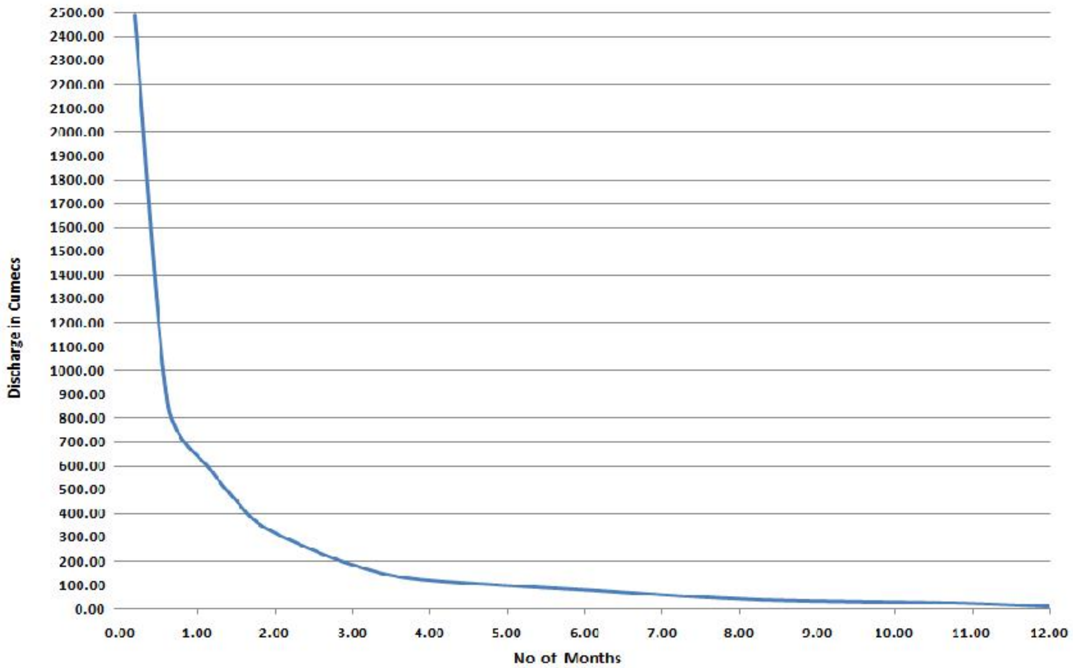


Fig. 3.34 Discharge Duration Curve at Etawah

From the above graph it can be seen that minimum base flow of approximately 20 m^3/s is available for 330 days at Etawah.

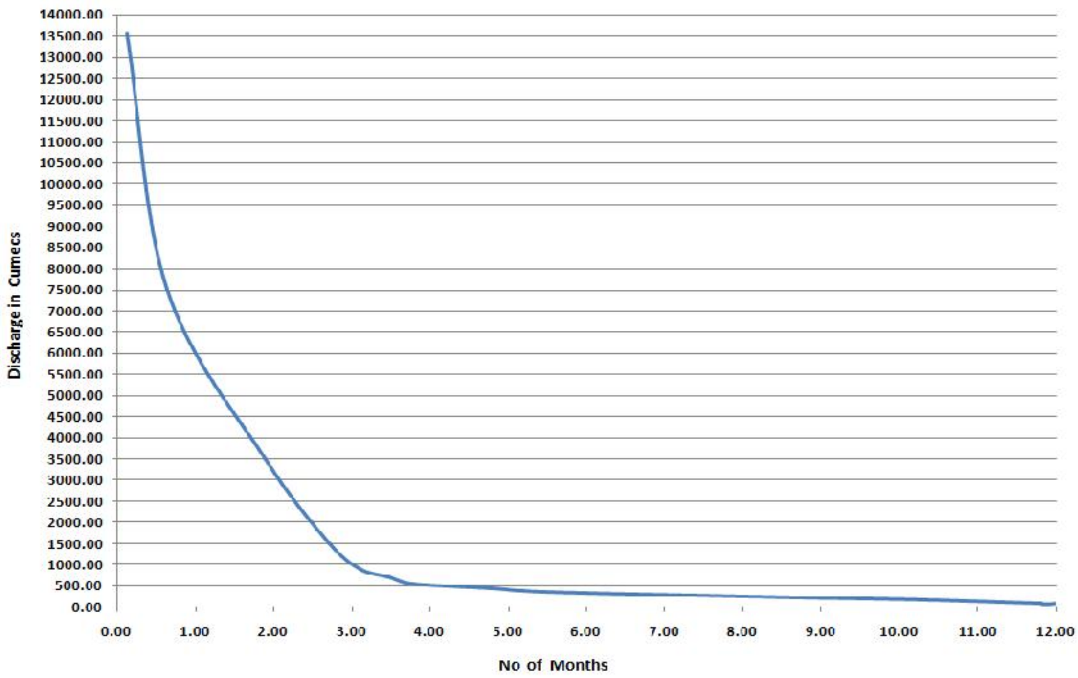


Fig. 3.35 Discharge Duration Curve at Auraiya

From the above graph it can be seen that minimum base flow of approximately 150 m^3/s is available for 330 days at Auraiya.

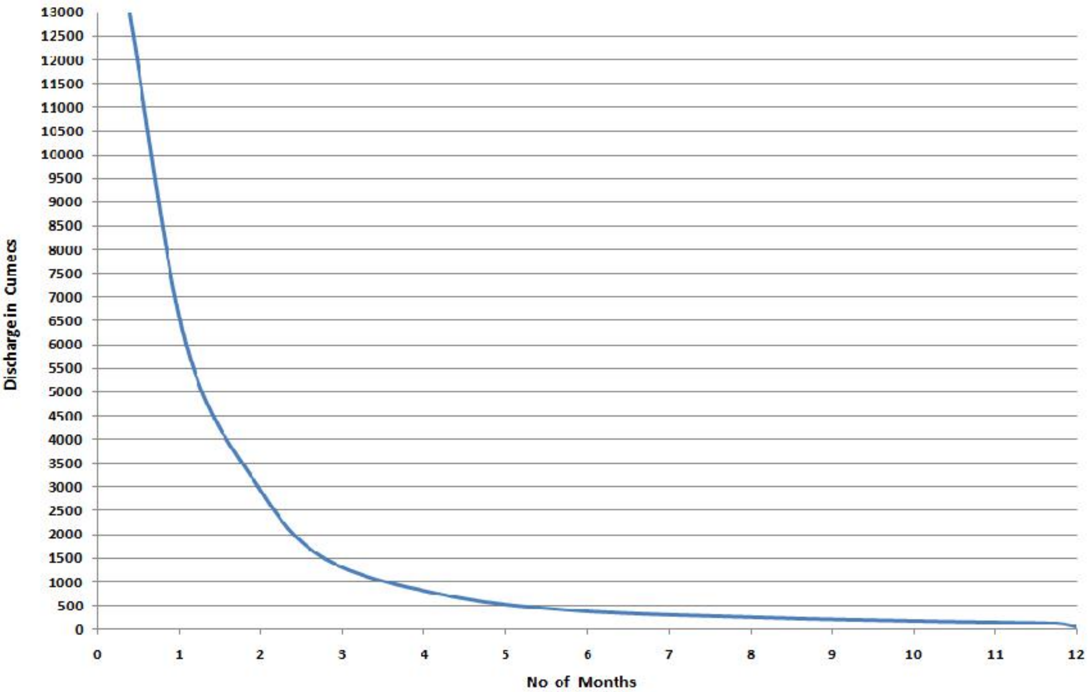


Fig. 3.36 Discharge Duration Curve at Kalpi

From the above graph it can be seen that minimum base flow of approximately 140 m^3/s is available for 330 days at Kalpi.

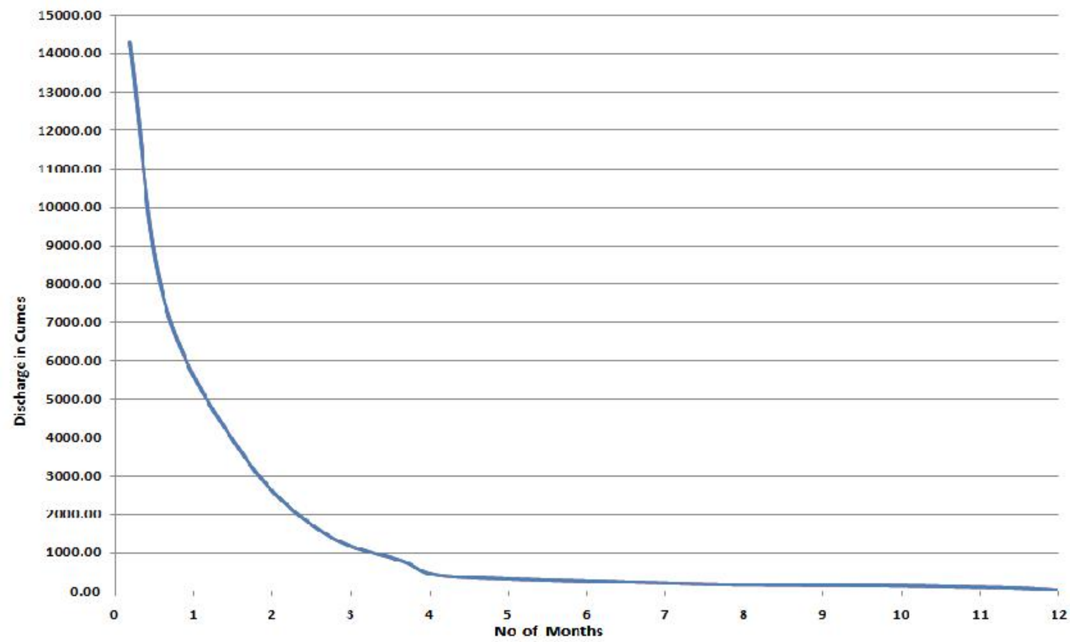


Fig. 3.37 Discharge Duration Curve at Hamirpur

From the above graph it can be seen that minimum base flow of approximately 100 m^3/s is available for 330 days at Hamirpur.

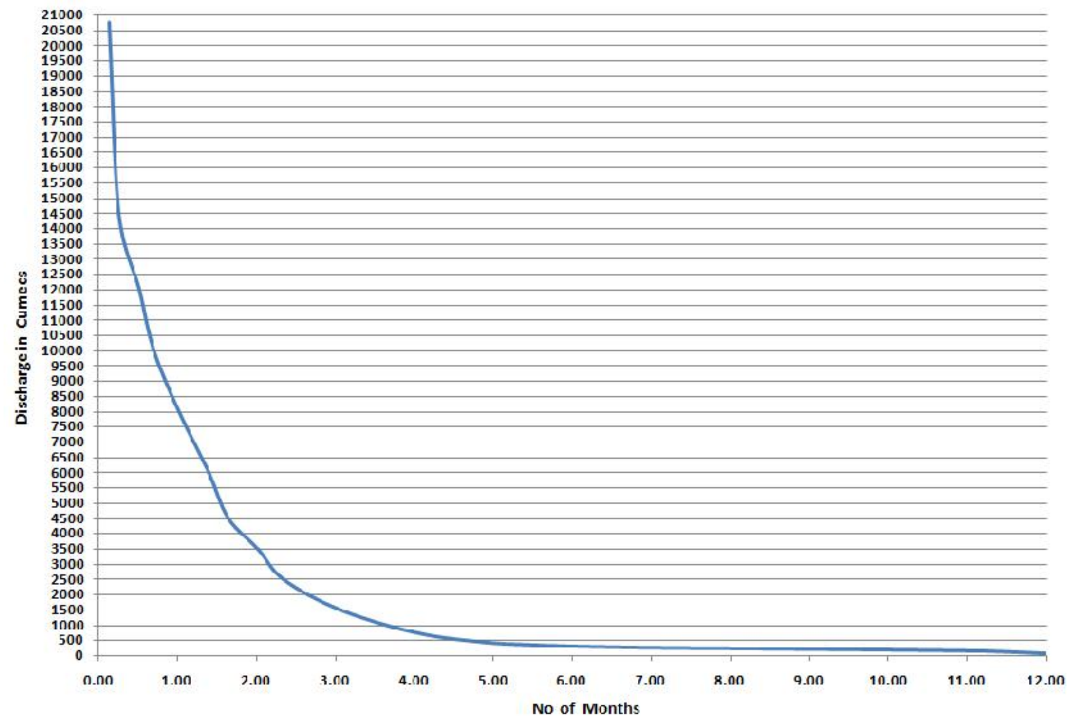


Fig. 3.38 Discharge Duration Curve at Rajapur

From the above graph it can be seen that minimum base flow of approximately 225m^3/s is available for 330 days at Rajapur.

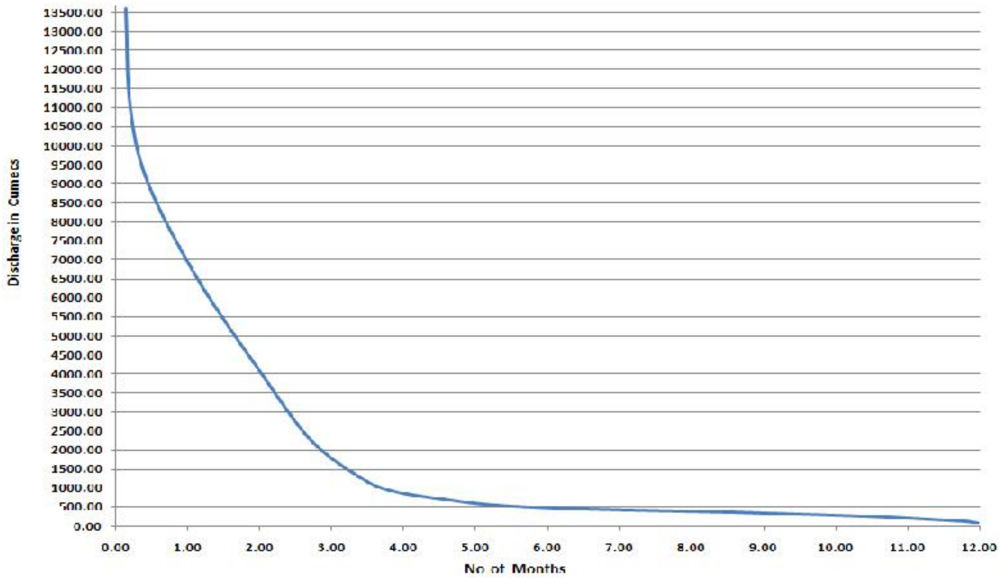


Fig. 3.39 Discharge Duration Curve at Pratappur

From the above graph it can be seen that minimum base flow of approximately 210 m^3/s is available for 330 days at Pratappur.

3.5 Flow Frequency Analysis

The flow frequency curves have been plotted followed by estimation of 50%, 75% and 90% dependable flow. This may also be referred to as a cumulative discharge frequency curve and it is usually applied to daily mean discharges. The slope of the flow duration curve indicates the response characteristics of a river. A steeply sloped curve results from very variable discharge usually for small catchments with little storage; those with a flat slope indicate little variation in flow regime. The following discharge duration curve at each gauge stations give the understanding about the base flow.

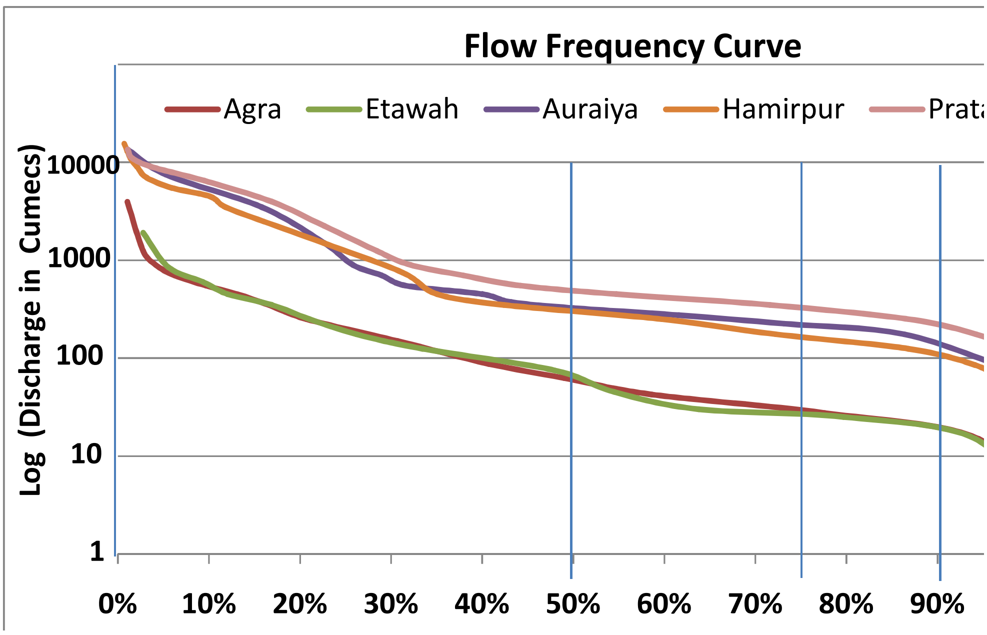


Fig. 3.40 Flow Frequency Curve

Table 3.9 Discharge availability at different location in the River Yamuna

Gauge Station	Dependable Flow (m^3/s)		
	50 %	75 %	90 %
Agra(Ch.752 km)	60	30	20
Etawah(Ch.531.84 km)	70	30	20
Auraiya(Ch.417.51 km)	325	200	120
Hamirpur(Ch.280.53 km)	290	160	100
Pratappur(Ch.33.13 km)	500	320	210

On comparing the water availability and discharge required (as calculated and presented in the above sections) it is found that from Prayagraj Sangam at Ch. 0 Km upto u/s Kalpi at Ch. 371 km minimum targeted depth for navigation can be maintained with dredging only. The remaining portion of the NW110 above Ch. 371 upto New Delhi at Ch. 1081 Km Barrages with Navigation Locks would be required to store the water and to maintain the required depth for navigation due to non-availability of requisite discharge throughout the year.

3.6 Yield Assessment and Water Requirement

For the storage of water in the channel Yield in the River Yamuna at various gauge stations falling in the stretch has been analyzed. The summary of the yield having 90 percent dependability is given below:

Table 3.10 90 Percent Dependable Yield

Gauge station	Yield (MCM)		
	Monsoon Period	Non- monsoon Period	Round the Year
Agra (PG) (Ch.752 km)	1142.7	496.79	1773.56
Etawah (Ch.531.84 km)	793.17	484.54	1572.19
Auraiya (Ch.417.51 km)	5564.03	3597.54	9161.57

The volume of water required for maintaining 2.5m water depth for navigation has been worked out considering storage of water in the river by constructing barrages at 20 locations. No water storage has been proposed from Ch. 0 Km to 371 Km.

Table 3.11 Annual Water Requirements for Navigation

Chainage km	Total Volume of Water Required (in MCM) (V)	Chainage km	Total Volume of Water Required (in MCM) (V)
371-431	89.10	741-751	9.73
431-471	52.05	751-781	25.65
471-501	27.23	781-811	30.15
501-531	27.23	811-842	34.65
531-561	29.19	842-872	30.15
561-591	31.16	872-902	30.15
591-621	30.38	902-932	34.65
621-651	28.01	932-962	32.40
651-681	26.44	962-992	30.15
681-711	28.01	992-1022	31.50
711-741	29.19	1022-1051	33.50

The total water requirement for navigation comes out 720.66 MCM from Ch. 371 Km to Ch. 1051 Km

3.7 Calculation of Design flood Discharge

3.7.1 Defining the design flood

The Design Flood for a hydraulic structure may also be defined in a number of ways, like:

- The maximum flood that any structure can safely pass.
- The flood considered for the design of a structure corresponding to a maximum tolerable risk.
- The flood which a project (involving a hydraulic structure) can sustain without any substantial damage, either to the objects which it protects or to its own structures.
- The largest flood that may be selected for design as safety evaluation of a structure.

3.7.2 Design flood for barrages and weirs

Weirs and barrages, which are diversion structures, have usually small storage capacities, and the risk of loss of life and property would rarely be enhanced by failure of the structure. Apart from damage/loss of structure the failure would cause disruption of irrigation and communications that are dependent on the barrage. According to the bureau of Indian Standard guidelines IS: 6966(Part-I) -1989, "Hydraulic design of barrages and weirs-guidelines for alluvial reaches", the following are recommended:

- SPF or 500 year return period flood for designing free board
- 50 year return period flood for designing of items other than free board.

Standard Project Flood (SPF)

This is the flood resulting from the most sever combination of meteorological and hydrological conditions considered reasonably characteristic of the region. The SPF is computed from the Standard Project Storm (SPS) over the watershed considered and may be taken as the largest storm observed in the region of the watershed. It is not maximized for the most critical atmospheric conditions but it may be transposed from an adjacent region to the watershed under consideration.

3.7.3 Gumbel's Equations used for Calculation of Design Discharge

Equation $X_T = X_{av} + K*\sigma$

Where ,

T Recurrence Interval

X_{av} is mean of the sample value

σ Standard Deviation of the sample $\sigma=(\sum(X-X_{av})^2/(N-1))$^0.5

K is frequency factor expressed as $K = (Y_T-Y_n)/S_n$

in which

Y_T Reduced variate, a function of T and given by

$Y_T = 0.834 + 2.303loglog(T/T-1)$

Y_n Reduced mean, a function of sample size n

S_n Reduced standard deviation, a function of sample size n

Available Hydrological data over the period of years from 2000 to 2015 of the gauge stations for calculation of design discharge has been analyzed and result are summarized in the following table:

Table 3.12 Design Discharge at Different Return Period

Gauge Stations	Return Period Discharge (Cumecs)		
	50 Yr	100 Yr	500 Yr
Delhi Railway Bridge(1068km)	4846	5439	11449
Mohana(Ch992km)	7534	8717	11449
Agra(Ch.752 km)	3435	3840	4777
Etawah(Ch.531.84 km)	4287	4820	6050
Auraiya(Ch.417.51 km)	33119	37408	47320
Kalpi(Ch.349.60 km)	34236	38802	49355
Hamirpur (Ch.280.53 km)	44666	50535	64097

3.8 Topographic and Satellite Imageries Data Analysis

Toposheets are useful to obtain information such as topography of the area, width of river and deep channel, nature of river, channel bends, and locations of various structures across and along river course and tendency of shifting of deep channel. Total 37 toposheets of 1: 50000 scales were procured from SOI and analyzed to study various aspects mentioned below:

- Radius of curvature at bends
- Changes in alignment of deep channel and overall river course – This was done by comparison of toposheets and satellite imageries of different periods
- Identification of various structures across (Dams/weirs/barrages/bridges/HT & LT lines) and along river(roads, flood embankments, bank protection

works, ghats, temples and other historic monuments, flood plains and general land use.

Also, Satellite Imageries were collected from National Remote Sensing Centre Hyderabad for the past 10 years.Landsat05, Landsat07 and Landsat08 imageries of 30m spatial resolution provide very good details of entire course of Yamuna River. Route of Yamuna River from Delhi to Prayagraj has been analyzed using Landsat satellite imagery for a period of 10 years from 2008 to 2017. Satellite imagery of two seasons July to September and October to December has been analyzed for each of the years. The basic idea of route analysis is to find the significant change of rivers course. The detail of Landsat imagery used for river course analysis for a period of 10 years is given in Annexure 3.4

Course Change Analysis:

Spatial analysis of river's course within a year in two different seasons.

Table 3.13 Observations on satellite imagery collected

Year	Observations
2008- July to September 2008- October to December	No Change in course of the river observed. From July to September width of river increased at a few places.
2009- July to September 2009- October to December	No Change in course of the river observed.
2010- July to September 2010- October to December	No Change in course of the river observed. From July to September width of river increased at a few places because of flood.
2011- July to September 2011- October to December	No Change in course of the river observed.
2012- July to September 2012- October to December	No Change in course of the river observed.
2013- July to September 2013- October to December	No Change in course of the river observed.
2014- July to September 2014- October to December	No Change in course of the river observed.
2015- July to September 2015- October to December	No Change in course of the river observed.
2016- July to September 2016- October to December	No Change in course of the river observed.
2017- July to September 2017- October to December	No Change in course of the river observed.

Spatial analysis of river's course in two different years:

Table 3.14 Observations on satellite imagery collected

Year	Observations
2008- 2009	No Change in course of the river observed.
2009- 2010	Width of River increased at a few places because of

Year	Observations
	flood in the year 2010. At (189115.564, 3021766.401) the river changes its course also.
2010- 2011	Width of River increased at a few places because of flood in the year 2010. At (77.859, 27.284) the river changes its course also.
2011- 2012	No significant change in course of river observed.
2012- 2013	No significant change in course of river observed.
2013- 2014	No Change in course of the river observed.
2014- 2015	No Change in course of the river observed.
2015- 2016	No Change in course of the river observed.
2016- 2017	No Change in course of the river observed.

It has been analyzed that the course of the river didn't change in two consecutive years. The above analysis indicate that the deep channel keeps on meandering within the high banks which is a normal process in the alluvial river channel, however these changes does not happen on every year. For each river there is typical cycle based on the hydrological cycles the meanders keep on shifting gradually over the years. Though the analysis shows some changes or shift in deep channel course these movements of deep channel are either within Khadir or within high banks during flood time that is within the normal flood plain where there is no habitation but seasonal agricultural land. This could be seen from recent Google images in which old course is marked. Such locations are between Okhla barrage and Gokul Barrage. In rest of the reach after confluence with Chambal River, the deep channel meanders within Khadir. The comparison of general river course with old toposheets of year 1991-92 also shows that there are no significant river course changes in the reach under consideration; the morphological change on the river bed is restricted to the deep channel alignment within the river banks.

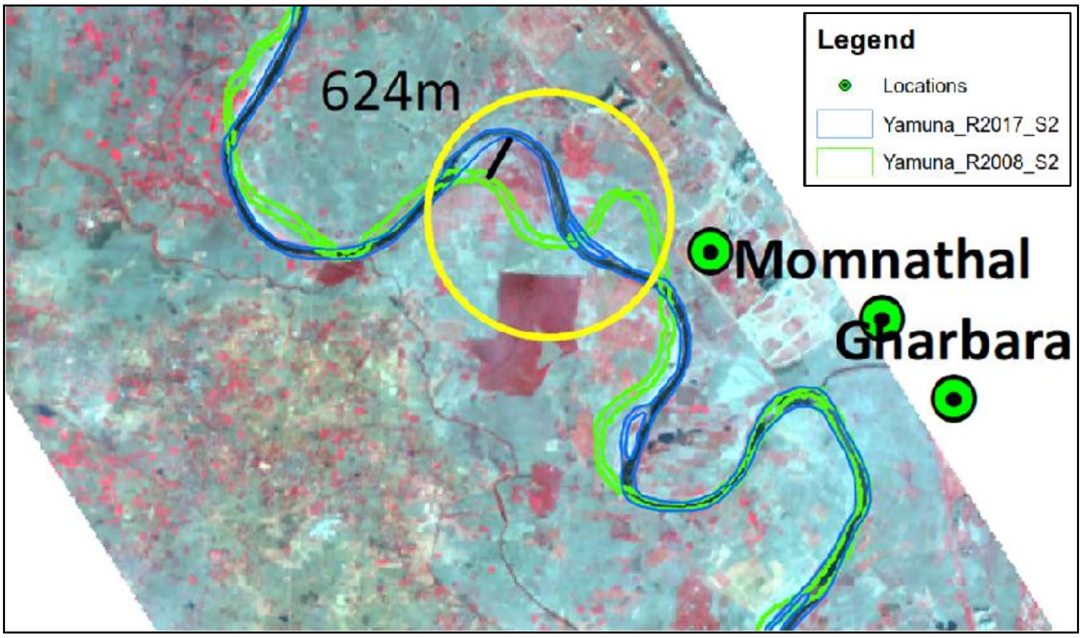


Fig. 3.41 Satellite Image for the river stretch at CH 1020 km to CH 1038 km

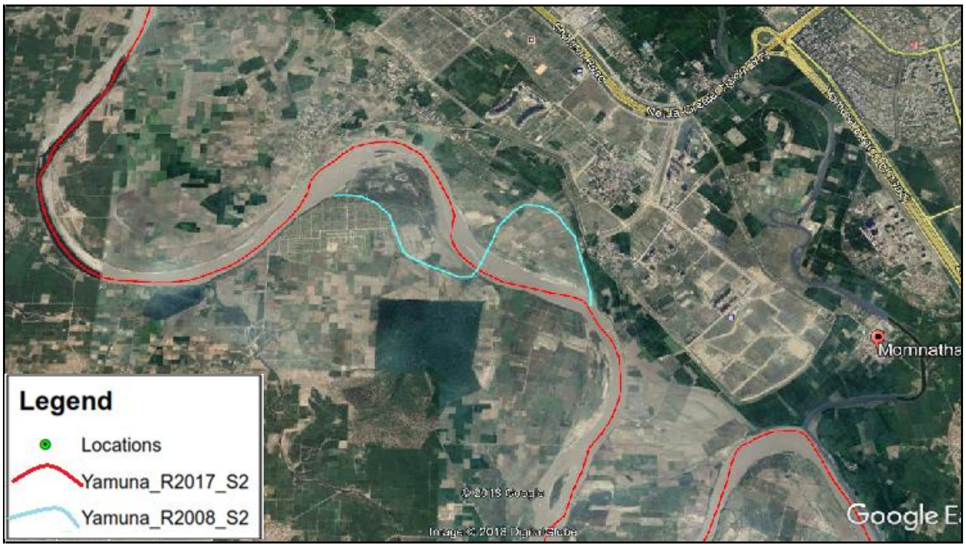


Fig. 3.42 Current Google Earth Satellite Image for the river stretch at CH 1020km to CH 1038 km

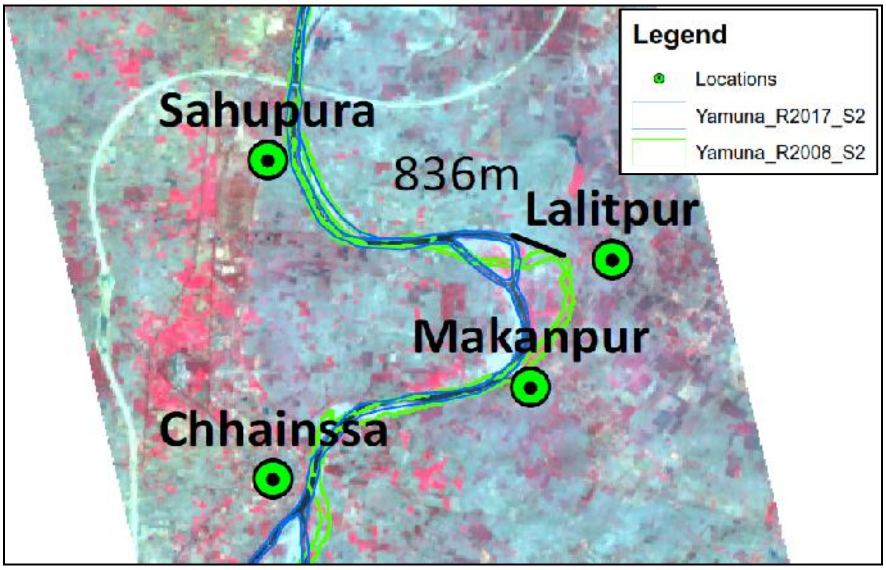


Fig. 3.43 Satellite Image for the river stretch at CH 995km to CH 1005km

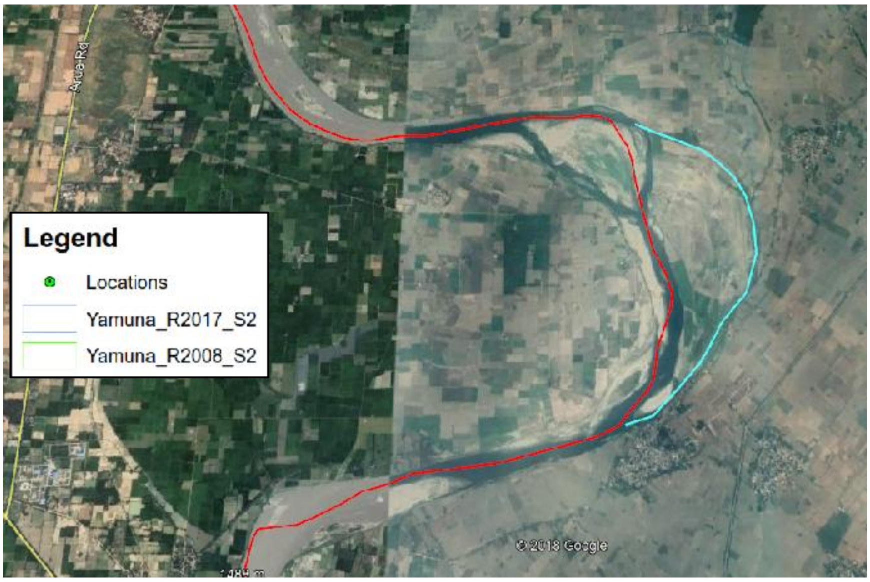


Fig. 3.44 Current Google Earth Satellite Image for the river stretch at CH 995km to Ch 1005 km

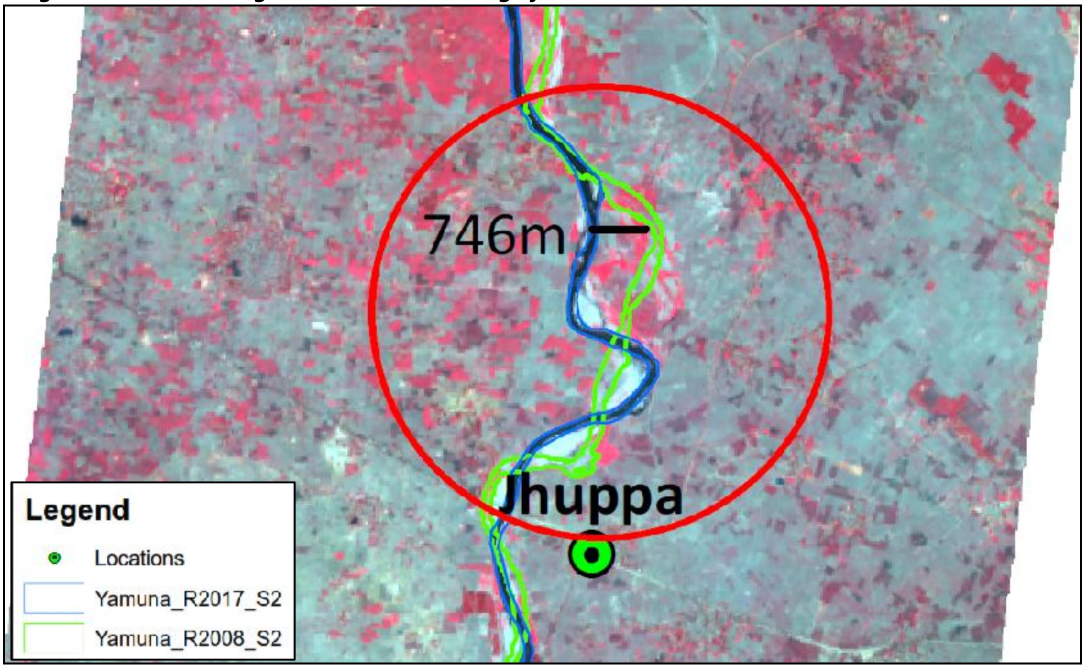


Fig. 3.45 Satellite Image for the river stretch at CH 975km to CH 982km

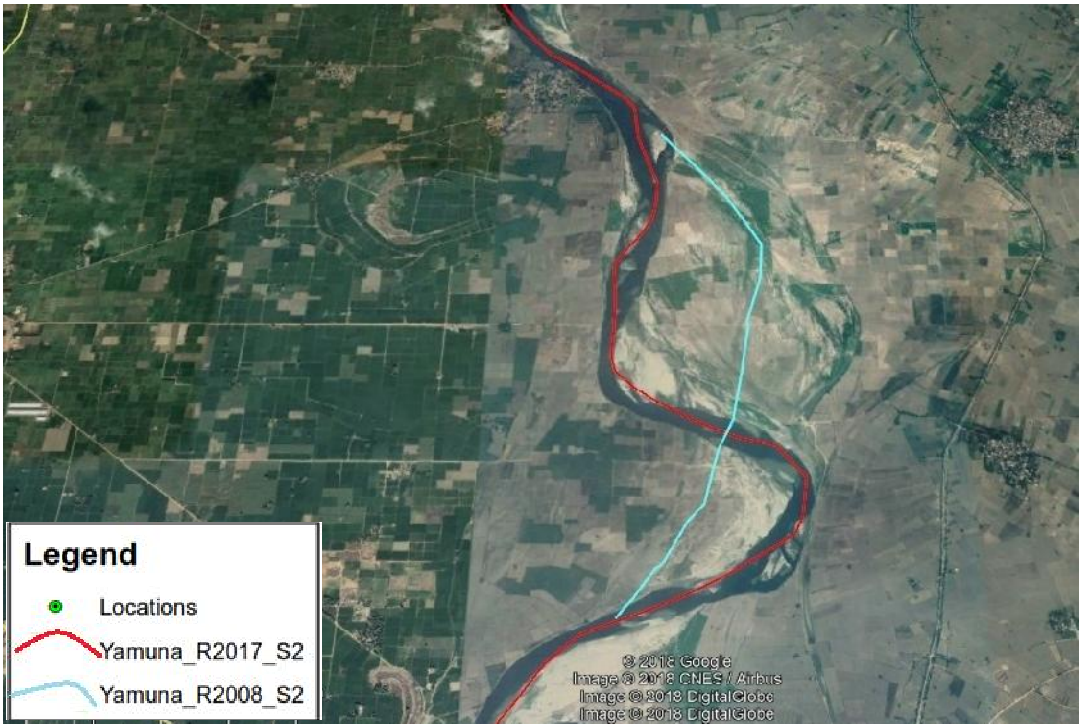


Fig. 3.46 Current Google Earth Satellite Image for the river stretch at CH 975 km to CH 982 km

3.9 Geomorphic study of River Yamuna NW 110

Geomorphic changes in the river course and the catchment is a long term process influenced by the geology and hydrology of the catchment. Disintegration, transportation of sediment by surface runoff, erosion and deposition on catchment, river bed and banks/flood plains are complex processes responsible for long term geomorphic changes. For assessment and analysis/interpretation of these geomorphic changes, extensive topographical and bathymetry data over the catchment and along the river course is required along with hydrological data of catchment and hydraulic data along river course for relevant period.

For assessment and analysis/interpretation of these geomorphic changes, extensive topographical and bathymetry data over the catchment and along the river course is required along with hydrological data of catchment and hydraulic data along river course for relevant period. Thus, geomorphic study involves extensive data collection and analysis. Availability of such extensive data is major hurdle in many cases. In present case of Yamuna river reach of about 1081 km (Delhi to Prayagraj) attempt was made to assess geomorphic changes along river courses by studying available data. These changes included ***morphological changes in plan form of river course and changes in river cross sections (indicating changes in river bed and banks)*** along the course. For this purpose following data was utilized

- Satellite imageries of past 10 years
- Survey of India Topo-sheets
- River cross sections at CWC gauging stations

- ➢ Discharge, water level and sediment concentration data at CWC gauging stations
- ➢ Grain size distribution analysis of Yamuna river bed and bank material samples – Over the reach of 1081 km under consideration samples of bed and bank material were collected at an interval of 20 km as below

    - river bed samples in deep channels and on shoals
    - Three samples on each on left bank and right bank (at top of bank, at mid depth on bank slope and at toe/ bottom of bank)
    - Total 8 to 10 samples at each location/chainage

3.9.1 Analysis of Data

Analysis of toposheets and satellite imageries

Total 37 toposheets of 1: 50000 scale and satellite imageries (pre and post monsoon) for 10 year period (2008- 2017) were analyzed to study

- ➢ Nature of river bed and banks along the navigation route
- ➢ Changes in alignment of deep channel and overall river course – This was done by comparison of toposheets and satellite imageries for period 2008 - 2017

Satellite Imageries were collected from National Remote Sensing Centre Hyderabad for the past 10 years. Landsat05, Landsat07 and Landsat08 imageries were of 30m spatial resolution which provided good details of entire course of Yamuna River. The details of Landsat imagery used for river course analysis are given in Annexure 3.4. The basic purpose of analysis was to find the significant seasonal and long term morphological changes of river course during data period.

Conclusions of analysis

- Comparison of toposheets with satellite imageries of period 2008-2017 do not indicate any major planform changes in river course
- Comparison of satellite imageries of different years for past 10 years also do not indicate any major planform changes in in Yamuna river course
- Satellite imagery analysis for past 10 years indicate increase in river channel width at few locations viz. from Ch. 975 km to Ch 982 km, from Ch. 995 km to Ch 1005 km and from Ch. 1020 km to Ch 1038 km post 2010 flood due to bank erosion.
- Except for year 2010 and that too at few locations pre and post monsoon imageries do not indicate any morphological changes for remaining years.
- Though the analysis shows some changes or shift in plan form of deep channel course, these movements of deep channel are either within Khadir or within high banks that is within the normal flood plain where there is no habitation but seasonal agricultural land. Such locations are between Okhla barrage and Gokul Barrage as indicated above. In rest of the reach after

confluence with Chambal River, the deep channel meanders within Khadir. The comparison of general river course with toposheets also shows that there are no significant river course changes in the reach under consideration.

Analysis of river cross sections at CWC gauging sites

Analysis of river cross section data for different years can give information of river bed level changes – aggradation /degradation- in different reaches of river course. Such data of cross sections for different years in entire reach was analysed for three major CWC gauging stations namely at Agra (PG), Etawah and Hamirpur. The cross sections of different years at a given site were superimposed to study changes in bed and bank profiles over the period of data. Attempt was also made to link noticeable major changes in bed and bank profiles to the flood discharges. Location wise analysis of cross sections is summarised below

Findings from comparative study of Yamuna River cross sections at Etawah

- In general, there are no major changes in river morphology at Etawah gauging station and sections appear to be more or less stable.
- During 1991 to April 2010 the river bed profile shape was same but extent of bed level variation was of about 0 to 2 m and the deep channel was hugging right bank. Some progressive bank erosion along the right bank is also seen from the figure given below.
- Dec 2010 profile however showed different shape of bed profile indicating shift of deep channel from right bank towards centre of river bottom width. Also severe erosion is seen on right bank. The reason of these changes was the flood of July 2010 which was highest flood during data period.

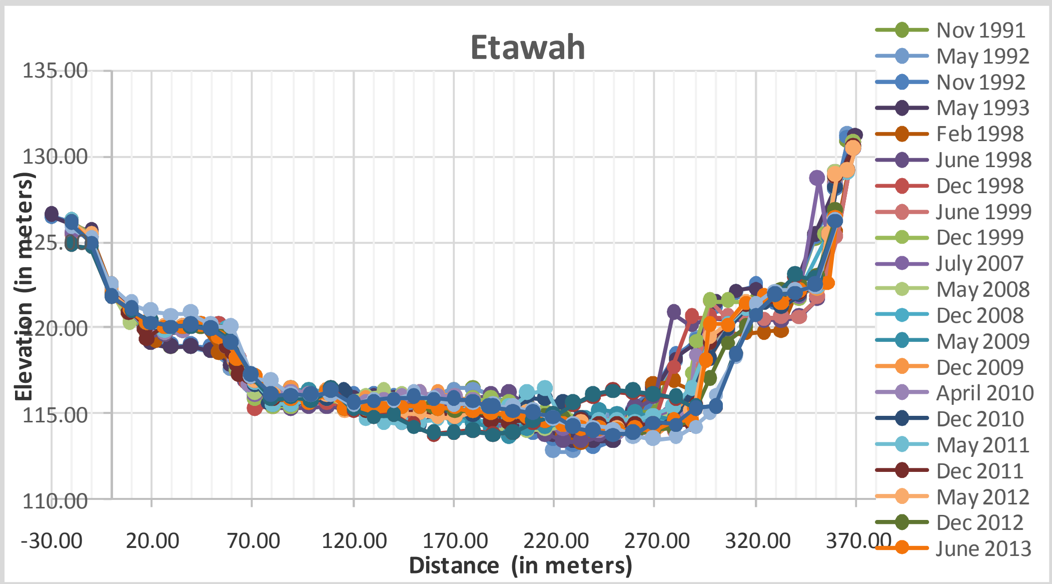


Fig. 3.47 Variation in River Cross section at Etawah

Findings from comparative study of Yamuna River cross sections at Agra (PG)

➢ No major changes in river morphology except river bed level changes of order of 1.5 to 2 meter as shown below

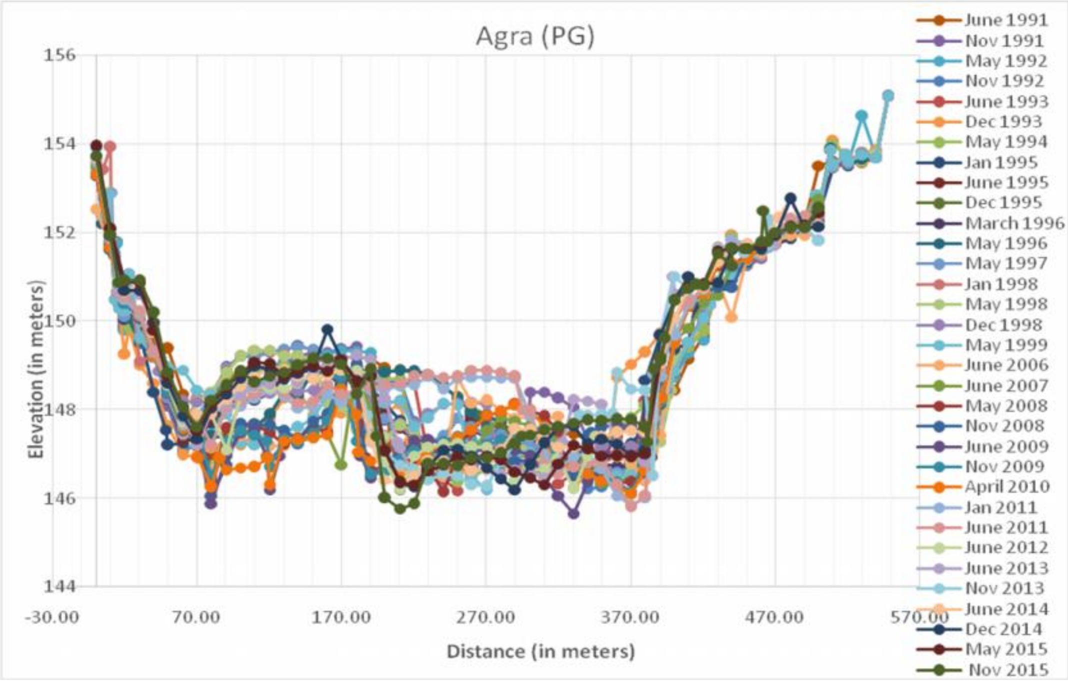


Fig. 3.48 Variation in River Cross section at Agra (PG)

➢ From 1991 to April 2010 a shoal is seen on river bed with a deep channel near both banks. From 2010 onwards formation of a deep channel in central portion started. This was due to high flood of July 2010. The central channel depth progressively increased while depth of right bank channel decreased during 2012 to 2015. Thus, the morphological changes such as shifts in deep channel position and bed level changes were restricted within the river banks.
➢ The deep channel near right bank is comparatively much wider and deeper than that of left bank.
➢ The river banks indicate some erosion from river bed level RL148 m to RL 152m after July 2010 flood.
➢ As the deep channels are present at both the banks due to presence of central shoal, both banks indicate steep slopes from river bed level of about RL147 m to RL 152 m.

Findings from comparative study of Yamuna River cross sections at Hamirpur

➢ The river cross sections are mostly stable and there are no major morphological changes on river bed except variation of 1 to 2 meters on river bed as indicated in figure given below
➢ The deep channel was hugging right bank during this period and position of deep channel remained unchanged.
➢ Except for some erosion on left bank no major bank erosion indicated during the period in spite of highest flood of 30000 m^3/s during July 2000.
➢ Right bank slope is much steeper as compared to left bank during entire period of data.

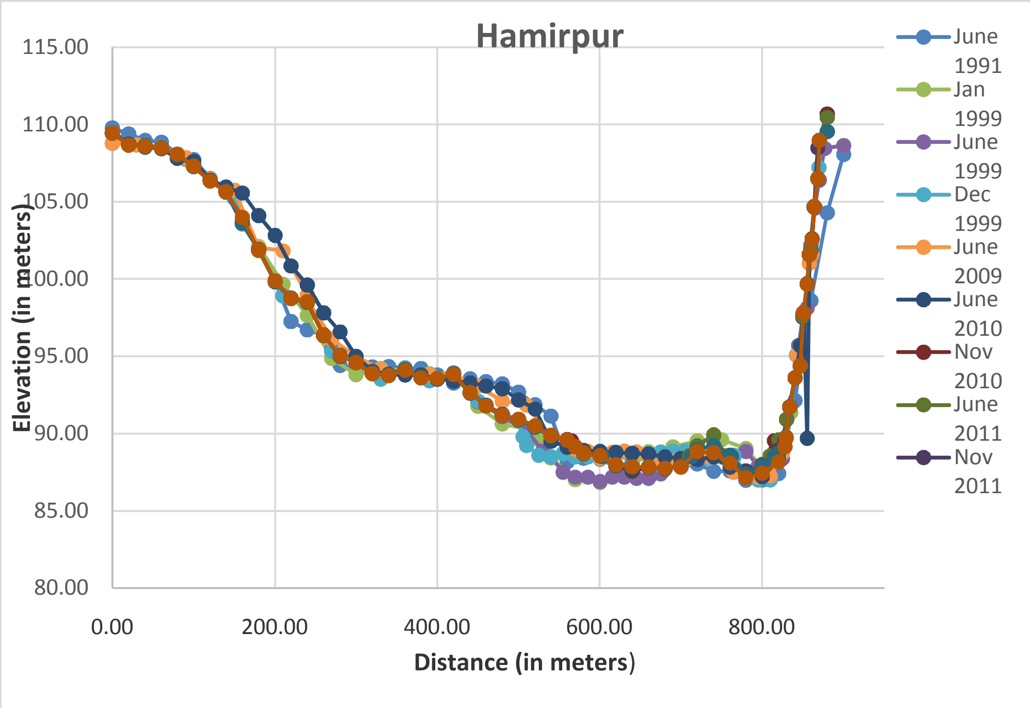


Fig. 3.49 Variation in River Cross section at Hamirpur

Analysis of 25 year data of Yamuna river cross sections at 3 locations – Agra (PG), Etawah and Hamirpur in general indicate that over the period of data there were bed level changes of deep channel in the rage 1 to 2m which include erosion as well as deposition. Major changes in bed profile were in year of high floods. Except for some bank erosion in some years, minor shift in deep channel position and bed level changes to the tune of 1 to 2 m the river sections were nearly stable.

3.9.2 Discharge and sediment concentration data at CWC gauging stations

Discharge and sediment concentration data for Agra (PG), Etawah, Auraiya and Pratappur gauging stations was available for period 1992- 2014 for monsoon and non-monsoon period. Discharge and sediment concentration relationship in the form of plot is presented in chapter 3 for these gauging stations using most of data during flood period. These data clearly indicate large scatter.

Attempt has been made to draw a curve showing relationship between discharge and sediment concentration. Analysis of these data for four gauging stations indicates following conclusions.

- Range of sediment concentration (grams/litre) for different discharges observed during monsoon period was as Tabulated below.

Table 3.15 Sediment concentration at various discharges

Station	Discharge (m^3/s)	Sedimentation Concentration range	Station	Discharge (m^3/s)	Sedimentation Concentration range

		(gms/lit)			(gms/lit)
Agra (PG)	200	0.1 - 0.25	Etawah	200	0.20-0.40
	400	0.3 - 0.40		400	0.30-0.60
	600	0.45-0.55		600	0.75-1.00
	800	0.60-0.80		800	1.00-1.10
	1000	0.85-1.00		1000	1.10-1.20
	1500	1.10-1.50		1500	-
	2000	1.60-1.80		2000	1.50-1.80
	3000	2.00-2.10			
	4000	2.20-2.30			
Auraiya	1000	0.15-0.30	Pratappur	1000	0.10-0.20
	2000	0.45-0.55		2000	0.25-0.70
	5000	1.10-1.25		5000	0.75-1.00
	10000	2.00		10000	1.10-1.40
	15000	2.65		15000	1.40-1.70
	20000	3.20		20000	1.70-2.00
				30000	2.25

- During non-monsoon period (November to June) Sediment concentration was in the range 0.01 to 0.15 gms/l normally. Whenever there was increase in flow due to rainfall in June concentration increased to 0.30 to 0.40 gms/l.
- During non-monsoon period almost entire sediment was fine sand & silt/clay
- During monsoon 80 to 90 % sediment was fine sand.

CHAPTER – 4

FIELD SURVEYS AND INVESTIGATIONS

4.1 General

4.1.1 The basic planning of the navigation development must provide the necessary comfort to vessels, both for smooth navigation and for loading / unloading operations at the terminals. These operations are contingent upon Topographic and Hydrographic survey which have to be available to the planner for arriving at the optimum layout, which would maximize the throughput at the most economic cost.

4.1.2 For planning of navigational channel and terminal facilities, it is necessary to carry out surveys such as topographic survey and hydrographic survey. The available charts only give the macro level information about the bathymetry and topography of the area. Therefore, for planning of navigational channel and terminal facilities, it is necessary to undertake fresh field surveys and Investigations.

4.1.3 WAPCOS undertook cross section surveys up to +2m above High Flood Level at every 200m interval (excluding Bathymetric survey, the data for the same has been provided by IWAI) and additional survey necessary to fill data gaps and record details after physical verification, wherever necessary.

4.2 Topographic and Hydrographic Survey

4.2.1 Survey Methodology

The survey was carried out on WGS 84 Datum. The projection used was Transverse Mercator and the grid used was Universe Transverse Mercator Grid (Zone 44). Differential signal corrections for the DGPS system were automatically obtained from the nearest DGLL Beacon and it was throughout the survey area. HYPACK Ver. 6.2b Hydrographic Survey Software developed by Coastal Oceanographical INC., USA was used for the data logging during the survey and for data processing thereafter. The area intended to be surveyed has been completely sounded and there are no portions within the assigned survey area that would require further sounding. The data logging during the survey was achieved by interfacing both Echo sounder and DGPS Receiver to the HYPACK software on a laptop/PC carried on board sounding boat. The entire system was supported by battery power and backed by an on board small Honda generator. The position and depth data were logged in continuously during the survey, once every 500 millisecond. All digitally logged data were automatically stored in the assigned files. No significant difficulties were experienced in the operation of the digital surveying system during the survey.

In order to present survey data and results in detail the whole River Yamuna NW 110 Course has been divided in following 4 stretches with considering Chaiange 0.0 Km at Prayagraj increasing towards Delhi and Ch. 1089 Km at Delhi

(i) Prayagraj to River Betwa Mouth (Ch. 0 to Ch.272)
(ii) River Betwa Mouth to River Chambal Mouth (Ch.272 to Ch.453)
(iii) River Chambal Mouth to Agra (Ch.453 to Ch.743)
(iv) Agra to Delhi (Ch.743 to Ch.1089)

Fig. 4.1 Location of Stretches

4.2.2 Survey Geodesy

The survey was conducted in WGS84 datum; Universal Transverse Mercator (UTM) projection (Zone 44). The geodetic parameters used during the survey are as follows:

Table 4.1 Geodetic and Projection Parameters used for the Survey

Global Positioning System Geodetic Parameters	
Spheroid	WGS-84
Datum Transformation	None
Semi-major axis (a)	6378137.0000 m
Semi-minor axis (b)	6356752.3142 m
Eccentricity	***0.0818 191909 28906***
Inverse flattening (1/f)	298.257223563
Projection Parameters	
Grid Projection	Universal Transverse Mercator
Central Meridian (CM)	81 ^{o} East (Zone 44)

Origin Latitude (False Lat)	0.0°
Hemisphere	North
False Easting (FE)	500000.0 m
False Northing (FN)	0.0 m
Scale Factor on CM	0.999600
Units	International Metres

4.2.3 Establishment of Bench Mark

The Bench Marks of the survey area for survey is based on the datum level erected on gauge of Yamuna River. The Bench mark of CWC (R46) was recovered at Yamuna River Bank at Hamirpur and was used to transfer of datum (MSL) to the BMs. The BM position for YR 81 near the confluence of Yamuna and Betwa River thus derived is:

Table 4.2 Bench Mark Details

Latitude:	25°55' 08.7892"N
Longitude:	80°12' 33.5304" E
RL Ht.	96.868m

TBM was connected from (R-46) CWC Bench Mark at Yamuna River Bank Hamirpur

Table 4.3 Temporary Bench Mark Details

Latitude:	25°57' 32.9327"N
Longitude:	80°09' 11.6881"E
RL Hgt.	109.153m

BM YR-81

CWC BM AT HAMIRPUR

4.2.4 Horizontal Control

The survey boat used for the survey operations throughout the project was positioned by the Differential Global Positioning System (DGPS). Differential signal corrections for the DGPS system were automatically obtained by establishing high

precision DGPS.
The Trimble DGPS Receiver was used for positioning of the depths. The position correction details were received from the high precision DGPS and position data were found to be in differential mode, and in order.

For survey horizontal control was carried out from Bench Mark situated at Yamuna River Bank Hamirpur. The Trimble base station was set up at same station and 24 hours observation was carried out. Raw data was collected and converted to Trimble RTX format for on line processing system. The BM position of YR 81, at confluence and value thus derived is 96.868m. TBM was connected from the CWC Bench Mark at Yamuna River Bank Hamirpur value is 109.153 w.r.t. MSL.

4.2.5 Vertical Control

Vertical control was started from CWC Bench Mark at Yamuna River Bank Hamirpur value is 109.153m w.r.t. MSL. Graduated Tide Poles were installed at 10 Kilometre interval along the River. Water levels were measured at 60-minute interval during entire survey period. At site, reference marks were also made and checked regularly during the survey period to ensure that the tide pole was not disturbed / dis-levelled.

IWAI had provided Sounding datum at gauges on river stretch. The gauge value was used for calculation of sounding datum at every tide pole. The distance and slope between the two gauges was used to interpolate the datum at tide pole. If the tide pole is close to the gauge then the value of gauge is used as sounding datum. The Data provided by IWAI was used to arrive at the sounding datum values at BM Pillars and at tide pole.

Table 4.4 Sounding Datum wrt MSL

Sl. No.	Place	Ch. (Km)	Sounding datum w.r.t M.S.L (provided by IWAI)
1.	CWC Naini	13.342	71.822
2.	CWC Pratappur	33.129	72.443
3.	CWC Rajapur	95.505	74.833
4.	CWC Chilla Ghat	213.958	84.602
5.	CWC Hamirpur	280.532	88.400
6.	CWC Kalpi	349.602	94.005
7.	CWC Auraiya	417.514	99.982
8.	CWC Etawah	531.842	114.908
9.	CWC Agra (J.B.)	746.447	146.183

4.2.6 Instrument used

Positioning System

1 No. Trimble DGPS system

Trimble DGPS

Navigation & Data Logging System

To provide on-line route guidance, log navigation data, provide QC of navigation data, etc. The system comprises the following equipment:

1 No. HP Laptop
1 No. Hypack Max version 6.2b Navigation & Data Logging Software
1 No. Positioning & sensor interfaces Sufficient Paper Rolls

Bathy Echo Sounder

Single Beam Echo Sounder System

1 No. Bathy 500 dual frequency Echo Sounder
1 No. Dual frequency transducer 33 kHz & 210 kHz + mounting bracket & base plate

Current Meter

1 No. 2D Falmouth current meter

Falmouth current meter

Water Sampler & Bottom Sampler

1 No. Water Sampler
1 No. Van veen Grab

Van veen Grab

Water Sampler

Topographic Survey

3 Nos. Trimble PPK Controllers.
1 No, Trimble PPK base.
1 No. Nikon Auto level with tacky staff
2 Nos. Tide station

Methodology of Trimble *R3*

Auto Level

The Trimble® R3 GPS system is a complete L1 GPS post processed solution from the industry leader in GPS surveying technology. Combining an L1 GPS receiver and antenna, rugged handheld controller, and easy-to-use field and office software, the Trimble R3 system brings precise sub centimeter control to our site, establishes new localized control, and collects topographic data

Trimble R3

The base station is located at the known point which transmits the signals for handheld controllers. The controller observes the points for default 1 Hour time Period which is manually operated and stores that points.

Survey Vessel

A small Gemini boat made of inflatable rubber with draught 0.4 meter was used for collecting bathymetry data.

4.2.7 Existing Hydrological/Topographical Reference levels

The temporary Benchmarks are constructed at every 10 Km intervals along the entire stretch of survey and have been linked with Survey of India (SOI) benchmarks using DGPS survey. Total 108 nos. benchmarks are constructed and serially numbered as YE01 at Delhi and YR108 at Prayagraj (Allahabad). Detailed description of Benchmark, position and value are given in Annexure 4.1

4.2.8 Chart Datum / Sounding Datum

- There are 108 Tide Poles constructed as a reference sounding datum to observe the water depth with reference to that tide pole and it is reduced by Chart Datum of each CWC gauge stations. The constructed Tide pole is serially numbered as TP01 at Delhi and TP108 at Prayagraj (Allahabad). The details of the Sounding Datum are given in the Annexure 4.2 and the Details of collected Water level of different gauge stations w.r.t. MSL are given in the Annexure 4.3

4.3 Existing Cross Structures/Bridges

The summary of the number of cross structure crossing the River Yamuna from Prayagraj (Allahabad) to Delhi is given in the following table:

Table 4.5 Existing Bridges

Sl. No.	Stretch	Rail Bridges	Road Bridges	Pontoon Bridges	Under Construction Bridges		Total
					Rail	Road	

Sl. No.	Stretch	Rail Bridges	Road Bridges	Pontoon Bridges	Under Construction Bridges		Total
					Rail	Road	
1.	Prayagraj to River Betwa Mouth (Ch. 0 Km to Ch. 272 Km)	1	5	2	0	5	13
2.	River Betwa Mouth to River Chambal Mouth (Ch. 272 Km to Ch. 453 Km)	1	6	2	1	1	11
3.	Chambal Mouth to Agra (Ch. 453 Km to Ch. 743 Km)	1	15	2	0	3	21
4.	Agra to Delhi (Ch. 743 to Ch. 1081 Km)	9	23	1	1	6	40
Total Number of Bridges		**12**	**49**	**7**	**2**	**15**	**85**

The Details of the existing structures / bridges are given in Annexure 4.4

4.4 High Tension Lines

Total 43 nos. of High tension lines are crossing River Yamuna (NW110). Stretch-wise nos. of High Tension lines are given as below:

- Stretch 1 - There are 10 High Tension Lines in this stretch.
- Stretch 2 - There are 5 High Tension Lines in this stretch.
- Stretch 3 - There are 9 High Tension Lines in this stretch.
- Stretch 4 - There are 19 High Tension Lines in this stretch.

The details of the High tension lines are given in the Annexure 4.5

4.5 Pipe Lines / Cables

- Stretch 1 - There are no Pipe Lines / Cables in this stretch.
- Stretch 2 - There are no Pipe Lines / Cables in this stretch.
- Stretch 3 - There are no Pipe Lines / Cables in this stretch.
- Stretch 4 - There are no Pipe Lines / Cables in this stretch.

4.6 Dams / Barrages / Locks / Weirs / Anicuts / Aqueducts

- Stretch 1/2/3 – No Such Structures.
- Stretch 4– There are 4 barrages in this stretch

The Details of the Barrages are given in the Annexure 4.6

4.7 Bends

There are several sinusoidal bends in the River Yamuna (NW110). The critical locations of bends are given as below:

Table 4.6 Radius of Curvature

Ch. (Km)	Bend Radius (m)	Ch. (Km)	Bend Radius (m)	Ch. (Km)	Bend Radius (m)	Ch. (Km)	Bend Radius (m)
55.5	**370**	526.5	**560**	667.5	**600**	902.3	**375**
133.0	**650**	527.5	**450**	677.0	**620**	903.5	**560**
143.0	**500**	528.4	**420**	680.5	**470**	908.0	**350**
149.4	**600**	530.6	**700**	687.0	**430**	908.6	**260**
289.0	**410**	536.2	**420**	689.0	**380**	909.4	**310**
337.4	**500**	539.0	**300**	702.6	**430**	921.0	**380**
351.4	**540**	541.0	**320**	705.8	**700**	922.6	**205**
369.2	**350**	561.5	**400**	710.0	**400**	926.5	**465**
401.0	**465**	564.5	**380**	717.0	**680**	934.9	**480**
433.5	**700**	566.3	**300**	722.0	**600**	937.0	**360**
453.5	**330**	567.3	**520**	723.6	**740**	938.5	**355**
460.0	**340**	573.7	**445**	733.0	**440**	940.8	**455**
467.0	**280**	580.0	**320**	757.6	**330**	941.6	**290**
470.5	**520**	581.4	**420**	761.4	**370**	942.3	**400**
473.3	**405**	588.5	**310**	773.0	**320**	949.0	**340**
474.5	**670**	589.8	**455**	778.0	**560**	954.0	**700**
475.9	**270**	600.0	**380**	785.5	**490**	957.7	**460**
480.2	**420**	603.0	**590**	789.0	**320**	959.6	**320**
481.7	**270**	607.5	**750**	797.1	**680**	963.0	**380**
493.6	**430**	611.7	**505**	798.0	**250**	966.0	**420**
499.0	**420**	613.5	**500**	808.0	**710**	976.5	**350**
501.3	**270**	619.7	**600**	823.3	**680**	992.0	**590**
502.2	**340**	621.0	**560**	830.0	**680**	996.0	**330**
504.3	**270**	625.0	**450**	840.5	**480**	1001.0	**450**
508.0	**600**	626.8	**700**	860.0	**300**	1018.0	**320**
510.7	**600**	635.0	**750**	861.5	**400**	1021.3	**380**

4.8 Velocity and Discharge Details

Table 4.7 Velocity & Discharge Details over the Stretch

Stretch	Sub-Stretch No.	Ch. (km)	Position				Observed Depth (m) (D)	Velocity (m /se c.) 0.5 D	Average Velocity (m/sec.)	Sectional area (sq. m.)	Discharge (Cumec)
			Latitude (N)	Longitude (E)	Easting (m)	Northing (m)					
Stretch 1	1	0.815	25°25'32.8442"	81°52'53.3104"	588642.63	2812389.00	8.4	0.128	0.099	3065.07	303.442
	1	8.726	25°24'10.0453"	81°48'35.9825"	581469.62	2809796.40	6.2	0.155	0.109	3256.11	354.915
	1	18.82	25°19'30.4897"	81°47'54.7836"	580369.86	2801190.00	7.6	0.116	0.099	5152.1	510.058
	1	29.00	25°21'22.4426"	81°42'23.9915"	571103.46	2804581.80	4.8	0.191	0.143	1155.42	165.225
	2	39.27	25°20'17.6321"	81°36'25.9692"	561105.68	2802539.00	3.0	0.284	0.231	463.67	107.108
	2	47.91	25°17'14.6268"	81°32'28.4029"	554487.45	2796881.30	4.0	0.324	0.303	1599.26	484.575
	2	59.31	25°15'54.1994"	81°25'57.8580"	543573.62	2794367.70	3.2	0.093	0.081	1073.12	86.922
	3	70.41	25°19'40.9297"	81°23'50.5353"	539991.67	2801330.80	5.4	0.088	0.065	1366.55	88.825
	3	78.91	25°20'35.6053"	81°18'59.3727'	531847.97	2802991.00	4.4	0.069	0.057	1088.66	62.053
	4	90.31	25°21'40.3491'	81°13'36.1938"	522811.00	2804964.10	1.3	0.329	0.301	409.66	123.308
	4	100.60	25°24'34.7639"	81°08'48.0221"	514751.27	2810317.80	6.0	0.097	0.071	1961.34	139.255
	4	110.40	25°28'46.2277"	81°11'21.1690”	519018.76	2818058.20	3.0	0.140	0.105	444.36	46.657
	5	120.40	25°30'58.1065"	81°06'17.1369"	510526.74	2822105.40	3.0	0.199	0.156	797.50	124.409

Stretch	Sub-Stretch No.	Ch. (km)	Position				Observed Depth (m) (D)	Velocity (m /se c.) 0.5 D	Average Velocity (m/sec.)	Sectional area (sq. m.)	Discharge (Cumec)
			Latitude (N)	Longitude (E)	Easting (m)	Northing (m)					
	5	131.00	25°33'21.8315"	81°00'45.3095"	501264.27	2826522.30	6.6	0.103	0.089	3325.40	295.960
	5	141.30	25°37'40.0711"	81°02'00.4434"	503358.73	2834466.30	6.0	0.064	0.052	2843.91	147.883
	6	151.80	25°37'28.4758"	80°56'38.8688"	494391.03	2834110.30	3.1	0.127	0.112	741.31	83.026
	6	161.60	25°41'16.1095"	80°55'05.1067"	491780.61	2841113.90	3.9	0.123	0.102	2291.04	233.685
	6	171.90	25°43'01.2066"	80°50'58.1007"	484899.63	2844352.80	10.0	0.123	0.102	2740.76	279.557
	7	180.70	25°41'25.4618"	80°46'43.5184"	477800.58	2841417.60	6.0	0.159	0.132	1616.79	213.416
	7	191.10	25°41'39.2079"	80°40'43.4650"	467766.21	2841861.00	2.8	0.137	0.111	988.90	109.767
	7	201.30	25°42'56.7634"	80°34'51.4260"	457962.00	2844274.20	2.5	0.094	0.068	1484.70	100.959
	8	212.80	25°46'39.9870"	80°32'26.5650"	453949.16	2851154.40	6.8	0.152	0.143	2413.76	345.168
	8	221.50	25°48'42.0291"	80°28'13.4250"	446913.77	2854935.10	4.8	0.118	0.098	1171.48	114.804
	8	231.90	25°50'42.3052"	80°32'41.6400"	454394.80	2858607.10	7.3	0.087	0.075	1803.35	135.251
	9	241.00	25°53'14.4063"	80°29'45.2180"	449501.81	2863304.00	2.4	0.141	0.100	587.712	58.771
	9	250.90	25°54'48.5178"	80°24'10.9750"	440214.14	2866238.20	3.6	0.142	0.101	1444.56	145.900
	9	263.30	25°54'17.2223"	80°17'33.8110"	429159.52	2865330.40	6.0	0.210	0.167	2207.31	368.620
Stretch 2	10	273.17	25°55'16.8961"	80°12'37.6230"	420929.68	2867213.20	2.6	0.308	0.285	1099.61	313.388
	10	279.88	25°57'29.2708"	80°09'37.6040"	415947.72	2871316.70	3.4	0.181	0.149	1410.56	210.173
	10	288.12	25°59'45.3321"	80°05'24.9870"	408951.26	2875549.50	6.0	0.222	0.178	1451.36	258.341
	11	300.39	26°04'04.9833"	80°04'17.6030"	407134.64	2883550.70	3.0	0.325	0.303	723.53	219.229
	11	309.85	26°04'06.0629"	79°58'41.9970"	397809.81	2883653.70	6.4	0.188	0.151	2095.85	316.473
	11	314.71	26°06'28.7052"	79°57'50.9590"	396464.64	2892837.50	2.5	0.166	0.145	2255.40	327.032
	11	329.10	26°06'28.7052"	79°55'38.0771"	392735.51	2888083.30	5.0	0.134	0.112	2032.05	227.589
	12	340.29	26°06'13.4989"	79°50'28.6055"	384135.11	2887689.10	2.4	0.275	0.189	1277.69	241.484
	12	349.57	26°07'42.7183"	79°45'32.8836"	375946.53	2890509.80	2.6	0.348	0.299	934.03	279.274
	13	360.21	26°11'05.7567"	79°43'50.3136"	373158.86	2896784.30	2.6	0.317	0.275	521.66	143.457
	13	370.34	26°12'54.4525"	79°38'44.0401"	364691.57	2900214.60	1.6	0.329	0.298	334.39	99.647
	13	381.67	26°15'35.5972"	79°33'51.7140"	356633.41	2905260.10	2.4	0.172	0.131	167.53	21.947
	14	390.74	26°19'29.3832"	79°32'12.0217"	353949.01	2912484.60	2.2	0.150	0.121	287.04	34.731
	14	402.24	26°21'12.3272"	79°30'56.3273"	351886.57	2915676.10	3.9	0.174	0.131	386.33	50.608
	14	411.46	26°25'36.0335"	79°28'51.4531"	348520.52	2923830.70	5.6	0.167	0.153	1230.18	188.216
	15	421.43	26°24'58.8357"	79°23'04.7261"	338900.27	2922803.10	2.0	0.372	0.301	290.11	87.324
	15	432.67	26°26'16.2747"	79°18'07.0707"	330684.37	2925292.20	2.8	0.144	0.132	467.68	61.733
	15	442.96	26°26'31.9553"	79°12'52.7461"	321983.25	2925892.60	3.6	0.387	0.311	635.40	197.610
Stretch 3	16	454.30	26°29'59.2174"	79°15'12.4736"	325940.73	2932217.50	0.9	0.620	0.523	49.30	25.784
	16	464.20	26°31'12.8845"	79°16'17.0567"	327759.47	2934460.20	1.4	0.817	0.741	85.09	60.832
	16	475.50	26°32'47.9949"	79°13'04.5252"	322470.18	2937460.00	1.6	0.564	0.454	63.88	29.002
	17	483.00	26°35'03.8120"	79°10'48.5170"	318765.18	2941692.60	1.8	0.449	0.356	71.69	25.523
	17	495.40	26°36'36.7381"	79°05'28.9564"	309965.86	2944681.10	2.2	0.326	0.282	90.00	25.380
	17	503.30	26°38'00.9651"	79°03'33.2784"	306805.15	2947321.40	2.0	0.370	0.295	200.82	59.241
	18	516.20	26°41'49.4611"	79°01'02.9804"	302757.40	2954417.50	1.6	0.350	0.287	60.70	17.420
	18	526.80	26°44'57.1260"	79°01'12.4053"	303107.72	2960189.00	2.0	0.354	0.290	69.60	20.184
	18	536.80	26°45'42.2373"	78°56'41.2760"	295638.60	2961696.20	1.8	0.460	0.321	58.10	18.650
	19	544.90	26°47'18.4211"	78°54'57.1483"	292810.25	2964703.40	1.6	0.697	0.456	49.00	22.344
	19	556.60	26°50'23.9043"	78°50'03.1957"	284787.93	2970548.10	1.6	0.571	0.388	76.99	29.871
	19	567.30	26°52'55.2781"	78°46'37.7338"	279196.69	2975305.50	2.0	0.408	0.311	87.72	27.281
	20	579.00	26°54'37.7975"	78°42'38.1425"	272640.75	2978578.90	2.2	0.444	0.322	67.14	21.621
	20	586.20	26°53'46.2182"	78°40'20.3562"	268809.36	2977060.60	0.6	0.776	0.578	11.50	6.647
	20	596.70	26°54'47.8872"	78°37'12.8601"	263670.38	2979055.10	1.6	0.741	0.537	41.40	22.232
	21	606.30	26°55'26.1711"	78°36'31.3646"	262547.59	2980255.10	0.8	0.874	0.659	21.87	14.416
	21	614.70	26°57'47.5793"	78°33'55.9544"	258343.23	2984689.90	1.2	0.905	0.734	33.15	24.332
	21	625.60	26°56'14.2259"	78°31'55.4961"	254964.48	2981880.70	0.6	0.834	0.648	80.29	52.028
	22	637.40	26°57'39.1344"	78°29'22.2828"	250789.11	2984577.70	1.4	0.883	0.668	91.43	61.074
	22	647.70	27°00'30.4135"	78°27'11.9005"	247298.99	2989922.40	0.8	0.815	0.655	127.27	83.363
	22	657.80	27°03'49.3185"	78°23'01.2782"	240515.36	2996187.30	0.8	0.946	0.752	187.57	141.053
	23	667.30	27°03'08.6314"	78°18'57.7166"	233775.69	2995076.10	0.8	0.788	0.594	94.50	56.133
	23	677.30	27°06'49.8972"	78°20'54.7431"	237145.12	3001819.70	0.8	0.765	0.574	90.48	51.936
	23	686.60	27°06'32.7460"	78°19'21.3396"	234560.64	3001346.20	0.8	0.741	0.551	63.75	35.126
	24	697.60	27°05'23.6975"	78°16'09.6861"	229234.17	2999334.00	0.8	0.741	0.567	68.85	44.339
	24	706.80	27°04'43.5429"	78°15'13.0053"	227645.25	2998131.80	0.8	0.823	0.644	76.80	2.918
	24	716.50	27°07'30.3507"	78°11'50.6199"	222182.14	3003390.60	0.8	0.069	0.038	81.12	3.083
	25	726.30	27°10'26.2022"	78°10'40.4682"	220371.33	3008848.20	1.6	0.855	0.684	130.38	89.181
	25	737.20	27°12'04.3485"	78°04'52.6954"	210864.94	3012089.50	1.4	0.712	0.534	107.43	57.366
tc	26	755.90	27°16'01.4173"	77°59'25.1874"	796060.59	3019556.81	1.4	0.213	0.106	147.90	15.670

Stretch	Sub-Stretch No.	Ch. (km)	Position				Observed Depth (m) (D)	Velocity (m /se c.) 0.5 D	Average Velocity (m/sec.)	Sectional area (sq. m.)	Discharge (Cumec)
			Latitude (N)	Longitude (E)	Easting (m)	Northing (m)					
	26	766.90	27°14'48.6841"	77°57'32.4344"	793011.10	3017243.38	0.7	0.289	0.143	71.38	10.207
	27	776.80	27°16'17.0164"	77°56'06.5151"	790582.67	3019907.51	0.7	0.271	0.120	126.50	15.180
	26	778.80	27°12'27.8666"	78°02'10.3680"	206412.90	3012918.60	1.5	0.590	0.447	273.32	122.174
	27	786.90	27°15'53.1495"	77°54'34.8409"	788077.44	3019113.62	0.8	0.275	0.139	64.78	9.004
	28	796.90	27°16'15.3678"	77°52'08.3489"	784030.95	3019704.53	1.0	0.310	0.209	73.08	15.273
	28	806.60	27°17'12.5643"	77°51'15.1415"	782526.79	3021432.08	1.4	0.321	0.247	66.30	16.376
	28	815.90	27°19'40.8555"	77°47'03.7596"	775509.67	3025841.69	2.0	0.415	0.398	86.86	34.570
	29	827.00	27°22'31.6670"	77°46'15.2947"	774060.03	3031071.11	1.7	0.100	0.176	81.00	14.256
	29	839.50	27°25'20.2158"	77°43'02.6028"	768650.36	3036143.71	1.5	0.212	0.156	115.20	17.971
	30	851.30	27°30'41.3242"	77°40'54.6442"	764921.26	3045953.65	1.2	0.098	0.119	318.50	37.901
	30	859.30	27°34'01.2194"	77°42'57.1397"	768148.97	3052181.40	1.3	0.222	0.188	168.00	31.584
	31	870.90	27°36'39.8916"	77°42'10.0949"	766751.35	3057038.45	1.5	0.467	0.355	56.16	19.936
	31	881.90	27°40'13.3868"	77°40'40.0911"	764140.22	3063557.89	1.4	0.525	0.457	44.00	20.108
	31	890.50	27°43'19.0381"	77°41'34.6111"	765509.75	3069306.45	3.1	0.723	0.676	29.25	19.773
	32	901.00	27°47'32.6322"	77°42'23.5059"	766677.51	3077143.84	2.4	0.456	0.383	76.30	29.222
	32	911.20	27°48'48.9559"	77°39'35.6502"	762030.52	3079393.33	1.2	0.512	0.455	22.00	10.010
	33	920.70	27°49'18.2454"	77°35'42.6955"	755634.31	3080158.54	2.6	0.545	0.422	47.40	20.002
	33	931.40	27°50'53.9470"	77°36'27.4077"	756795.54	3083130.97	2.2	0.832	0.754	25.30	19.076
	33	941.40	27°53'16.3153"	77°32'17.4121"	749863.44	3087370.52	1.9	0.910	0.851	85.50	72.760
	34	951.30	27°57'14.1104"	77°32'09.1772"	749486.34	3094686.98	2.2	0.954	0.813	603.20	490.401
	34	961.50	28°00'47.2734"	77°31'42.0074"	748607.58	3101234.38	3.1	0.845	0.741	501.60	371.680
	34	970.80	28°04'07.9430"	77°28'53.9523"	743889.90	3107318.10	2.3	0.658	0.503	447.85	225.268
	35	980.00	28°08'08.0193"	77°29'11.4938"	744217.75	3114719.24	2.8	0.256	0.188	69.00	12.972
	35	990.70	28°13'27.9548"	77°27'23.3053"	741065.54	3124509.14	1.3	0.378	0.208	100.10	20.820
	36	999.50	28°16'50.1351"	77°30'00.1204"	745213.11	3130821.46	2.5	0.365	0.208	12.00	2.496
	36	1010	28°20'55.4977"	77°28'51.3696"	743184.06	3138337.13	1.7	0.276	0.188	25.20	4.737
	36	1021	28°23'53.4767"	77°28'35.1108"	742628.59	3143807.72	2.8	0.216	0.188	107.80	20.266
	37	1031	28°25'40.6463"	77°25'18.0333"	737196.86	3146998.11	3.2	0.201	0.169	130.00	21.970
	37	1042	28°28'26.5490"	77°22'18.8104"	732218.29	3152008.63	1.9	0.212	0.169	56.00	9.464
	38	1051	28°32'24.8726"	77°19'18.5800"	727173.34	3159250.09	2.9	0.255	0.208	70.68	14.701
	38	1061	28°36'29.2006"	77°15'26.1449"	720712.48	3166651.39	2.3	0.215	0.198	357.00	70.680
	38	1070	28°40'44.3630"	77°13'58.8435"	718193.81	3174462.42	1.6	0.278	0.208	110.60	23.004
	39	1081	28° 45′46.3478″	77°14′7.6250″	718257.83	3183764.04	1.5	0.759	0.688	144.00	99.072

4.9 Waterway description for Stretch-1 (Prayagraj to Betwa Mouth)

4.9.1 Sub Stretch 01 – Prayagraj to Manpur (Ch. 0.0 km - 30.0 km)

Fig. 4.2 Google map showing Ch. 0.00 Km Prayagraj to Ch. 30.00 Km Manpur

Table 4.8 Water Depth Stretches at Sub Stretch 01 – Ch. 0.0 km Prayagraj to Ch.30.0 km Manpur

Stretch	Stretch with water depths less than 1.2m (Km)	Stretch with water depths b/w 1.2m to 1.4m (Km)	Stretch with water depths b/w 1.5m to 1.7m (Km)	Stretch with water depths b/w 1.8m to 2.0m (Km)	Stretch with water depths more than 2.0m (Km)
Prayagraj to Manpur	0.60	1.80	0.00	0.20	27.40

First stretch of River Yamuna begins from Prayagraj Sangam. The Minimum and Maximum width in this stretch is 328m and 902m. The minimum & maximum water depth is -1.1m and 23.1m. BM Pillar YR 108 is established on North Bank of River at Ch. 0.80km. Boating club is at Ch. 1.00km Akabar fort at Ch. 1.40km. A Road connecting near Boat Club Naini Bridge is at Ch. 2.80km connecting from Prayagraj to Jahangirabad Road. Yamuna Railway Bridge is at Ch 4.00km with Horizontal and vertical clearance 25.00m & 2.276m. Parallel Road is running from Ch. 0.00km on South Bank of River. Prayagraj city is situated at Ch. 6.00km. A Pump House is under construction at Ch. 6.90km. Agricultural land found between Ch. 8.00km & 9.00km

BM Pillar YR 107 is established at Ch. 8.70km on North West Bank near Samya Devi Temple. High Tension lines are crossing at Ch. 8.95km, 9.30km, 9.90km and 10.30km. A Pump House is under construction at Ch. 9.30km on SE Bank. Baksi Moda Village is on NW Bank of River. A Parallel Road is running from Ch. 11.00km to Ch. 7.00km. Gandoka Village at Ch. 8.7km on NW Bank. A Sand chur formed from Ch. 11.40km to 12.20km. Baswan Village is at Ch. 13.10km on NE Bank. Amiliya Village is at Ch. 14.90km, Palpur at Ch. 15.30km. A road is connecting near Ch. 15.40km. A Parallel Road is running from Ch. 12.00km to Ch. 28.00km. A High Tension Line is crossing at Ch. 17.20km near Irodaganj Village. A road is connected to river near the High Tension line on NE Bank. A Temple is at Ch. 18.10km on South Bank. BM Pillar YR 106 is established at Ch. 18.70km on NW Bank. Road is connecting at Ch. 19.00km in South Bank. A Temple is at Ch. 19.70km on South Bank. Roads are connecting at Ch. 20.50km, 21.10km, 23.10km & 24.30km Adampur Madaripur village is at Ch. 21.80km, Bisauna is at Ch. 23.80km on North Bank. A road is connecting at South Bank at Ch 21.00km near Khanjasa Uparhar Village. A Parallel Road is running from Ch. 21.00km to Ch. 30.00km on South Bank. There are villages Birwal, Jagadishpur, Manpur at Ch. 24.00km, 25.60km and at Ch.29.00km respectively. BM Pillar YR -105 is situated at Ch. 29.01km. Mainapur Village is at Ch. 29.40km on North Bank and Manpur village on South Bank. Except few places water depth of more than 2m is available. Current is very less. Fishing activities seen throughout the stretch except near Prayagraj. Both the Bank are unprotected Road connectivity is good *throughout the stretch. Sand mining seen near Mainapur Village. This is known as* Mainapur Khadan.

Table 4.9 Water Depth Stretches at Sub Stretch 01 – Ch. 0.0 km Prayagraj to Ch.30.0 km Manpur

Ch. (km)	Observed (m)	Reduced (m)	Ch. (km)	Observed (m)	Reduced (m)
1.00	12.3	9.9	16.00	10.4	9.6
2.00	9.7	6.9	17.00	11.3	10.0
3.00	7.6	5.3	18.00	17.6	16.1
4.00	13.6	11.2	19.00	18.1	16.1
5.00	8.6	6.6	20.00	3.3	1.5
6.00	16.0	14.0	21.00	3.4	1.6
7.00	8.6	6.8	22.00	3.9	2.1
8.00	5.6	3.7	23.00	5.5	3.7
9.00	9.2	7.1	24.00	5.5	4.0
10.00	16.5	14.4	25.00	5.5	4.1
11.00	15.2	13.7	26.00	6.1	4.8
12.00	4.9	3.4	27.00	7.4	5.9
13.00	3.0	1.7	28.00	2.5	1.1
14.00	10.8	9.3	29.00	5.5	4.1
15.00	17.0	15.3	30.00	5.4	3.7

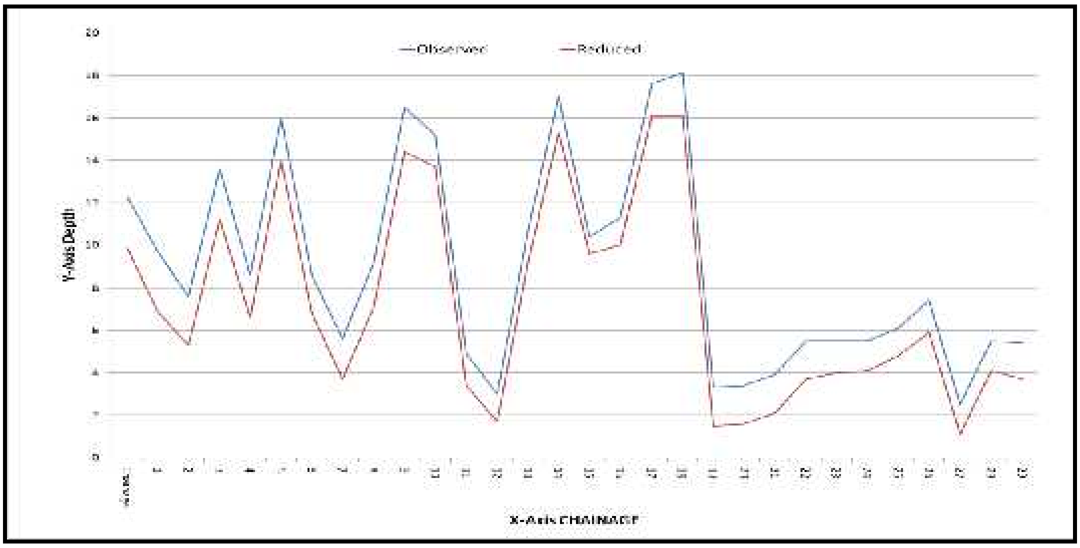


Fig. 4.3 Water Depths Ch. 0.00 Km Prayagraj to Ch. 30.00 Km Manpur

4.9.2 Sub Stretch 02 – Manpur to Dhana Uparhar (Ch. 30.0 km - 60.0 km)

Table 4.10 Water Depth Stretches at Sub Stretch 02 – Ch. 30.0 km Manpur to Ch. 60.0 km Dhana Uparhar

Stretch	Stretch with water depths less than 1.2m (Km)	Stretch with water depths between 1.2m to 1.4m (Km)	Stretch with water depths between 1.5m to 1.7m (Km)	Stretch with water depths between 1.8m to 2.0m (Km)	Stretch with water depths more than 2.0m (Km)
Manpur to Dhana Uparhar	7.20	1.00	2.00	1.00	18.80

Fig. 4.4 Google map showing Ch. 30.00 Km Manpur to Ch. 60.00 Km Dhana Uparhar

Minimum and Maximum width in this stretches 172.0m and 741.0m. Min and max depth found in this stretch are -1.1mtr and 15.6mtr. Shairgarh Village is at Ch. 30.6km on North Bank. Road is connected at Ch. 31.0km, 31.2km and 31.9km. NasirpurTalukaIbrohimpur and NoorpurHazipur Villages at Ch. 32.0km and 32.6km in North Bank. Road is connected near Ch. 33.8km on North Bank. Majhihari Amad Choil village is at Ch. 34.0km on South Bank. A sanchur formed from Ch. 35.2km to 39.400m. Rasoolpur village is at Ch. 36.00km on North Bank of River. Audhan village is at Ch. 37.5km on North Bank of River

BM Pillar YR – 104 is established at Ch. 39.4km on North Bank. A Road is connecting near the Pillar via Durgapur Village. A High Tension line crossing at 43.4 km. Pump House is at Ch. 44.8km on South Bank of River and High Tension line crossing at 47.4km.

BM Pillare YR -103 is established at Ch. 48.0km. Shyampur Uri Malhaipur, Kataleya, Diya Uparhar, Chhekawa Uparhar and Aingawa Uparhar villages are at Ch. 49.8km, 51.0km, 56.8km, 58.0km and 59.4km on North Bank.

BM Pillar YR -102 established at Ch. 59.0km on North Bank. Pratapur Village is at Ch. 46.4km on South Bank of River. A Road is running parallel from Pratapur and near the Ch. 50.6km on South Bank. Purab Palai Mustakil village is on South Bank at Ch. 57.7km. Water is available more than 2mtr in this stretch except 30.0km to 31.2km, 34.8km to 38.3km, 39.7km to 41.7km, 42.8km to 44.00km and 51.4km to 56.00km. Current is very less. Fishing activity seen in full stretch. Fishing is under govt. Supervision. Water quality is good. No hindrance found in this stretch. Both the Bank are Unprotected. Water way can be started after dredging some places.

Table 4.11 Water Depth Stretches at Sub Stretch 02 – Ch. 30.0 km Manpur to 60.0 km Dhana Uparhar

Ch.(km)	Observed(m)	Reduced(m)	Ch.(km)	Observed(m)	Reduced(m)
31	4.4	3.2	46	3.7	2.4
32	5.5	3.9	47	4.0	2.4
33	8.4	6.8	48	5.4	3.7
34	6.9	4.2	49	6.9	5.3
35	4.1	2.7	50	5.3	3.5
36	2.6	1.2	51	4.3	2.6
37	3.7	2.3	52	2.6	0.9
38	3.1	2.0	53	2.9	1.2
39	3.9	2.5	54	3.0	1.3
40	2.6	1.2	55	2.2	-0.2
41	3.1	1.6	56	3.7	2.0
42	4.0	2.9	57	8.2	6.2
43	4.4	3.1	58	6.2	4.8
44	4.3	2.8	59	3.9	1.9
45	4.3	2.8	60	3.4	1.1

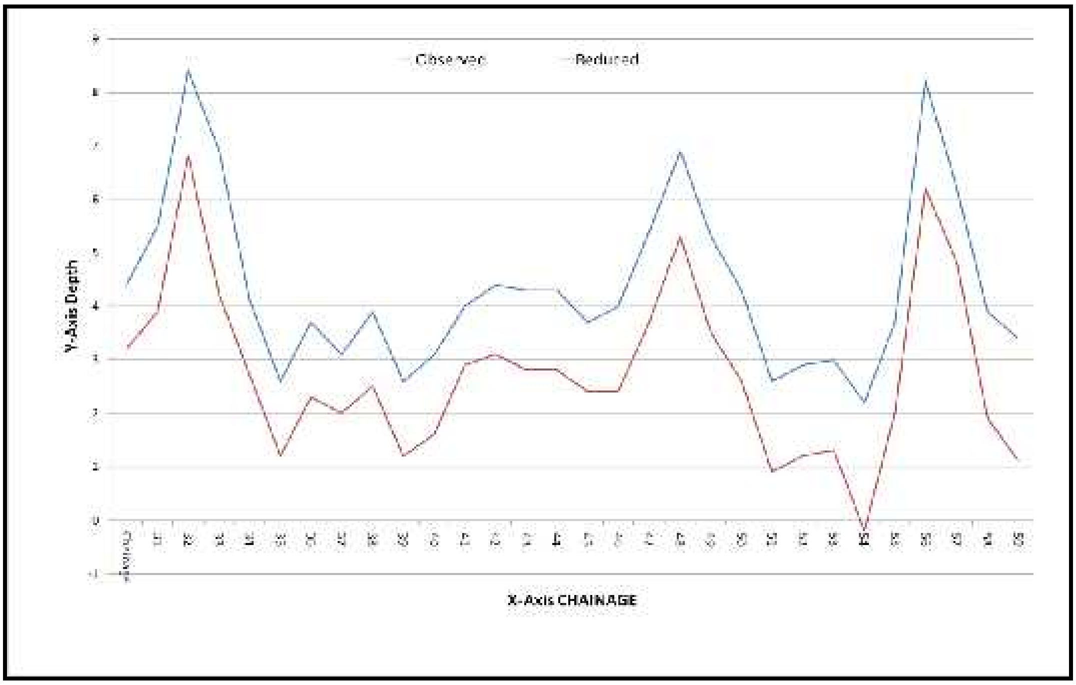


Fig. 4.5 Water Depths Ch. 30.0 Km Manpur to Ch. 60.00 Km Dhana Uparhar

4.9.3 SubStretch – 03 Dhana Uparhar to Ranipur (Ch. 60.0 km - 90.0 km)

Minimum and Maximum width in this stretch is 278mtr and 896mtr. Minimum and Maximum depth observed in this stretch is -2.1mtr and 14.1mr.

Villages Dhana Uparhar, Mahila Uparhar, are at Ch. 60.2km and 62.2km on North Bank and Mankunwar Ahatmali, Tipauli Mustakil are at Ch.60.8km & 62.2km on South Bank. Pump House is at Ch. 61.8km on South Bank. A Temple is at Ch. 64.00km. Mau Bridge is under construction at Ch. 64.2km. Berocha Uparhar

Village is at Ch. 67.8km on East Bank. Villages Mall Mustakil, Mawai Kalan Mustakil and Barwal Mustakil are at Ch. 64.2km, 66.4km and 69.0km on West Bank.

Fig. 4.6 Google map showing Ch. 60 km Dhana Uparhar to Ch. 90 km Ranipur

Table 4.12 Water Depth Stretches at Sub Stretch 03 – Ch. 60.0 km Dhana Uparhar to Ch. 90.0 km Ranipur

Stretch	**Stretch with water depths less than 1.2m (Km)**	**Stretch with water depths between 1.2m to 1.4m (Km)**	**Stretch with water depths between 1.5m to 1.7m (Km)**	**Stretch with water depths between 1.8m to 2.0m (Km)**	**Stretch with water depths more than 2.0m (Km)**
Dhana Uparhar to Ranipur	12.40	1.00	0.40	0.20	16.00

BM Pillar YR -101 is established at Ch. 70.4km on NE Bank. Gopasahasa and Kosam Khiraj Villages are at Ch. 70.4km and 71.0km. Road is connecting to River near Both Villages. A Temple is at Ch. 71.4km on NE Bank. Village Tadi Mustakil and BiyawalMustakil on at Ch. 71.8km & 74.8km on South Bank. Kosam, Inam, Uparhar, Pali, Uparhar and Singhwal Villages at are at Ch. 73.4km, 74.0km and 75.8km on North Bank.

Pabhosa Village is at Ch. 78.4km on North Bank of River.BM Pillar YR 100 is established at Ch. 79.10km on North Bank. Road is connecting near Pabhosa village Bodahari Uparhar Village is at Ch. 80.0km on north Bank. Chakaur

Mustakil Village is at Ch. 79.0 on South Bank. A Sanchur is formed from Ch. 80.6km to 82.6km. Fishing net was found between Ch.81.00 km to 82.6km. Village Badahari Uparhar, Dedhawaluparhar & Katari are at Ch. 80.0km & 82.6km on North Bank. A Pump House is at Ch. 83.8km on South Bank. Sirwal Mafi Mustakil Village is at Ch. 84.8km on SW Bank. Road is Connecting near the Katari village on NE Bank. Water is available less than 2mtr except between Ch., 64.8km to 75.6km, 83.5km to 87.8km fishing activities found in the whole stretch. No mining seen in this stretch. Water quality is good. No hindrance found in this stretch. Current is very less. Both the Banks are unprotected. No Polluted water is discharged in the River. No ferry Service found in the stretch. Water way can be started after dredging

Table 4.13 Water Depth Stretches at Sub Stretch 03 -
Ch. 60.0 km Dhana Uparhar to 90.0 km Ranipur

Ch. (km)	Observed (m)	Reduced(m)	Ch. (km)	Observed (m)	Reduced (m)
61	1.3	-0.3	76	3.5	0.5
62	1.4	-0.3	77	2.8	-0.1
63	0.0	-0.3	78	4.2	1.1
64	4.2	1.9	79	4.7	1.6
65	8.4	6.0	80	4.1	1.1
66	7.5	5.4	81	2.6	-0.3
67	8.1	5.9	82	8.0	4.9
68	12.3	10.0	83	9.9	7.9
69	9.4	7.2	84	10.7	6.1
70	9.8	7.7	85	8.0	4.8
71	4.8	2.4	86	11.2	8.2
72	5.2	2.8	87	6.3	2.7
73	5.6	3.2	88	0.0	-0.3
74	6.0	3.7	89	2.0	-0.3
75	5.2	2.8	90	3.2	0.1

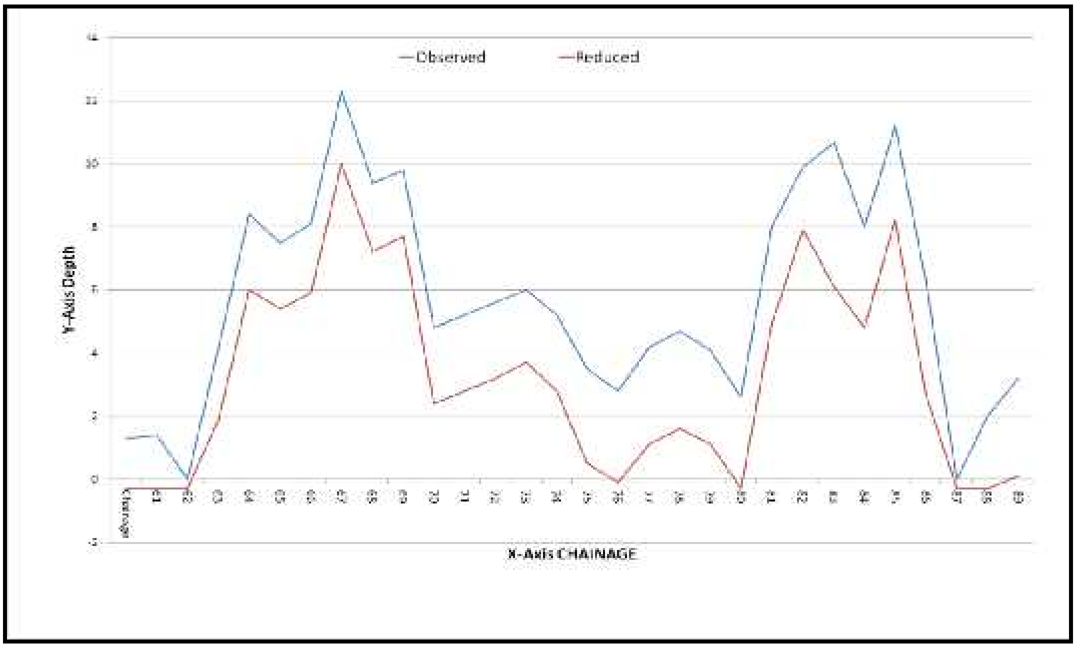


Fig. 4.7 Water Depth Ch. 60 km Dhana Uparhar to Ch. 90 km Ranipur

4.9.4 Sub Stretch – 04 Ranipur to Kot (Ch. 90.0 km - 120.0 km)

Fig. 4.8 Google map showing Ch. 90 km Ranipur to Ch. 120 km Kot

Table 4.14 Water Depth Stretches at Sub Stretch 04 - Ch. 90.0 km Ranipur to Ch. 120.0 km Kot

Stretch	Stretch with water depths less than 1.2m (Km)	Stretch with water depths between 1.2m to	Stretch with water depths between 1.5m to	Stretch with water depths between 1.8m to	Stretch with water depths more than

		1.4m (Km)	1.7m (Km)	2.0m (Km)	2.0m (Km)
Ranipur to Kot	18.20	0.60	0.00	0.40	10.80

Minimum and Maximum width in this stretch is 199mtr and 706mtr. Minimum and maximum depth observed during the survey -2.4mtr and 9.9mtr. BM Pillar YR – 99 is established at Ch. 90.5km near Hatawa Abbaspur Uparhar village in North Bank of River. Villages Ragauli Ahatmali and Bhambhet Ahatmali are at Ch. 93.7km and 95.4km on South Bank and Shahpur Uparhar, Mubarakpu Uparhar at Ch. 94.7km and 95.0km on North Bank. High Tension Line crossing at 96.3km. A Temples is found at Ch. 96.5km and 98.2km on South West Bank. Rajapur is at Ch. 98.2km. Rajapur Bridge is at Ch. 98.7km with Horizontal and Vertical clearance 27.00mtr and 1.87mtr. This Bridge is Connecting Prayagraj to Rajapur. Mahewa Uparhar Village is at Ch. 98.8km on NE Bank of River. A Pump House is at Ch. 99.2km on west Bank. BM Pillar YR - 98 is established at Ch. 100.8km on East Bank. Villages Konkota Bangar at Ch. 101km on West Bank and Jamunapur Uparhar is at Ch. 101.7km on East Bank. A Temple is at Ch. 103km on SE Bank. Mawai village is on SE Bank of River and Connected via Mud Road to River Dheraha Village is at Ch. 106.5km on SE Bank. A temple is at Ch. 107.40km on East Bank of River. A Pump House is at Ch. 107.8km on East Bank. Village SurwalBangar is on West Bank and a Mud Road is connecting to river. A Bench Mark Pillar YR-97 is established at Ch. 110.4km on East Bank of River near Arieuli Village. There are two Temple at Ch. 114.6km and 115.3km. Villages Said Pursalampur and Parvejpur at Ch. 114.6km, 115.5km and 116.6km North Bank of River. Water is very lees from Ch. 90.00km to 94km, 101.5km to 104.0km, 108.0km to 120km. It means this stretch is Maximum dry area. More quantity to be dredged required for water way. Water quality is good as there is no polluted water discharged in the river. Both the Bank is unprotected. Current is very lees. Fishing activities are found where ever water is available. Rajapur Bridge is only good connectivity to River. Rajapur town/city found near this stretch Maximum use of land is for agriculture. No ferry service /Jetty/ghat is in this stretch. Water way can be started after dredging.

Table 4.15 Water Depth Stretches at Sub Stretch 04 –
Ch. 90.0 km Ranipur to Ch. 120.0 km Kot

CH. (km)	OBSERVED(m)	REDUCED(m)	CH.(km)	OBSERVED(m)	REDUCED (m)
90	2.2	-0.3	106	8.8	6.6
91	3.0	1.3	107	8.5	5.5
92	1.3	0.0	108	9.3	7.7
93	2.1	-0.3	109	4.3	2.4
94	3.9	1.2	110	7.0	1.5
95	4.5	2.2	111	0.0	-0.3
96	10.1	8.6	112	2.7	-0.3
97	9.6	7.3	113	1.3	-0.1
98	9.7	6.6	114	3.5	1.3
99	9.5	6.6	115	3.7	1.1
100	9.8	7.4	116	3.0	0.6
101	7.0	7.0	117	2.7	0.1

CH. (km)	OBSERVED(m)	REDUCED(m)	CH.(km)	OBSERVED(m)	REDUCED (m)
102	7.1	5.0	118	3.0	0.9
103	4.1	4.1	119	2.3	0.1
104	5.7	3.9	120	2.3	-0.3

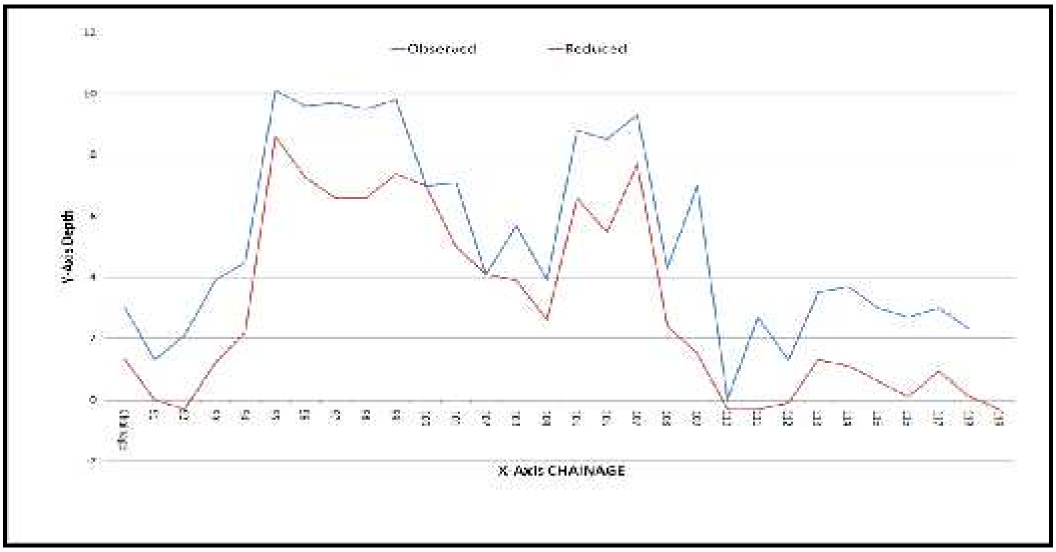


Fig. 4.9 Water Depth Ch. 90.0 km Ranipur to Ch. 120.0 km Kot

4.9.5 Sub Stretch – 05 Kot to Gurwal (Ch. 120.0 km - 150.0 km)

Fig. 4.10 Google map showing Ch. 120 km Kot to Ch.150 km Gurwal

Table 4.16 Water Depth Stretches at Sub Stretch 05 - Ch. 120 km Kot to Ch.150 km Gurwal

Stretch	Stretch with water depths less than 1.2m (Km)	Stretch with water depths between 1.2m to	Stretch with water depths between	Stretch with water depths between	Stretch with water depths more

		1.4m (Km)	1.5m to 1.7m (Km)	1.8m to 2.0m (Km)	than 2.0m (Km)
Kot to Gurwal	9.40	1.20	0.00	1.20	18.20

Minimum and Maximum width in this stretch is 287.0mtr and 449.4 mtr. Minimum and maximum depth observed -2.6mtr and 19.2mtr. BM pillar YR- 96 is established at ch.120.350km on North Bank of River. Kot Village is at Ch. 120.8km on north Bank of River. A road is connected to the River near the Village. Kot is a mining area. In off season people of local area are taking the sand from here. A temple is at Ch. 122.8km and Village Kharkhar is at 122.6km on North Bank. A Temple found at Ch. 124.9km. Telephone Tower seen at Ch. 125.3km on North Bank Chilli mal bangar Village is at Ch.125.0km. Pump House is at Ch. 126.3km on South Bank of River. A Temple is at Ch. 129.4 km Joraunpur village is at Ch. 129.8km on SW Bank of River. A BaghainRivar is connecting to Yamuna River at Ch. 129.6km on SW Bank. BM Pillar YR-95 is established at Ch. 131.0km on NE Bank. Lakhanpur village is at Ch. 131.2km on SW Bank. A Road is connecting near the Village. A Temple is at Ch. 133.100km on West Bank. Amethee village is at Ch. 137.2km on NW Bank. A Garha Village is at Ch. 137.8km and shamshan Ghat is at same Ch. near the Bank. Temple found at Ch. 139.6km on west Bank at Ch. 140.6km at 141.0 Ch. at Ch. 141.3km and at Ch. 141.6km on East Bank. A BM Pillar YR. - 94 Established at Ch. 141.3km on East Bank. Ekdala village is at Ch. 141.4km on East Bank. A Road is connecting near the Pillar. Kishanpur village is at Ch. 142.6km, Jagdishpur at 146.0km Bikauna at 148.4km and Gunwale is at Ch. 149.4km on North Bank. A small Village Called knead is at Ch. 150.0km on SW Bank. Water Quality Found good as there is no polluted nala is connecting in this stretch. Both the Banks are Unprotected. Fishing activities found in some places where ever water is available. Mining found in some area. Depth found below 2.0m from Ch. 120.0km to 123.6km, 127.1km to 129.8km, 141.8km to 145.2km and from 149.6km to 150km. Rest all area is more than 02.0mtr depth found. No hindrance found in this stretch. Current is lees. Water way can be developed after dredging in some area.

Table 4.17 Water Depth Stretches at Sub Stretch 05 – Ch. 120 km Kot to Ch.150 km Gurwal

CH. (km)	OBSERVED(m)	REDUCED(m)	CH. (km)	OBSERVED(m)	REDUCED(m)
121	2.5	-0.3	136	10.4	7.6
122	2.0	-0.2	137	12.9	9.7
123	2.0	-0.3	138	6.8	3.6
124	3.5	1.3	139	6.0	3.6
125	6.6	3.9	140	6.6	4.2
126	5.8	3.3	141	9.0	6.7
127	5.3	2.3	142	17.6	15.3
128	6.4	4.1	143	12.7	10.2
129	3.9	2.2	144	4.2	1.5
130	2.9	0.7	145	3.4	1.3
131	6.0	0.2	146	3.4	0.7
132	12.2	10.8	147	4.5	2.0

CH. (km)	OBSERVED(m)	REDUCED(m)	CH. (km)	OBSERVED(m)	REDUCED(m)
133	15.3	13.2	148	6.5	3.9
134	18.3	16.0	149	11.6	9.0
135	14.2	12.0	150	8.7	6.0

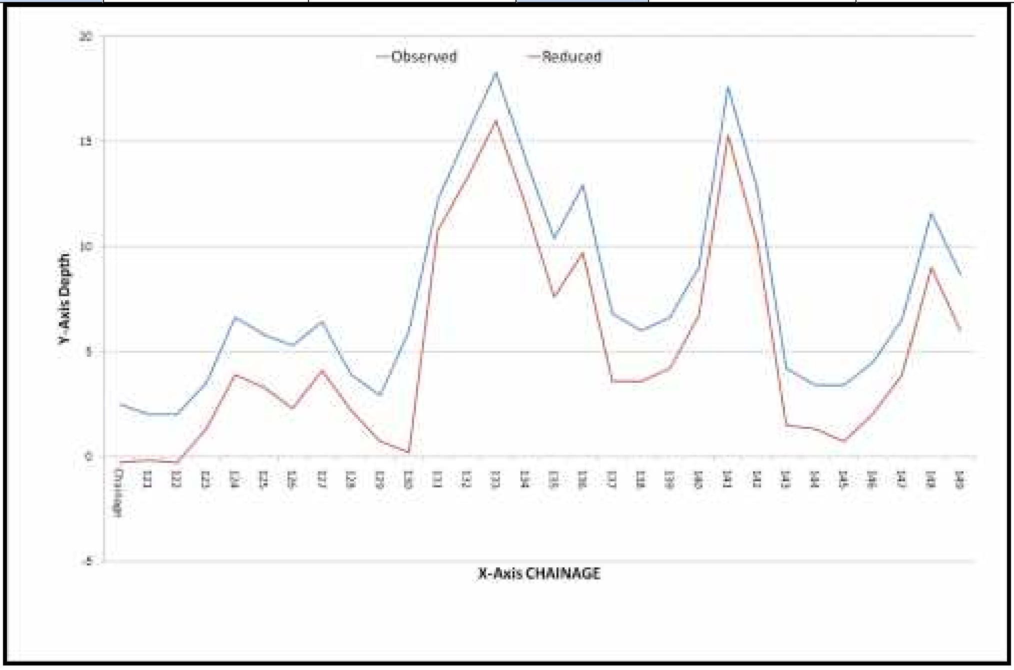


Fig. 4.11 Water Depth Ch. 120 Kot to Ch.150 km Gurwal

4.9.6 Sub Stretch – 06 Gurwal to Samgara (Ch. 150.0 km - 180.0 km)

Fig. 4.12 Google map showing Ch. 150 km Gurwal to Ch. 180 km Samgara

Table 4.18 Water Depth Stretches at Sub Stretch 06 –
Ch. 150 km Gurwal to Ch. 180 km Samgara

Stretch	Stretch with water	Stretch with water	Stretch with water	Stretch with water	Stretch with water

	depths less than 1.2m (Km)	depths between 1.2m to 1.4m (Km)	depths between 1.5m to 1.7m (Km)	depths between 1.8m to 2.0m (Km)	depths more than 2.0m (Km)
Gurwal to Samgara	7.60	1.60	1.60	0.80	18.40

Minimum and maximum width in this stretch is 393.0mtr and737.2mtr. Minimum and maximum depths observed in this stretch are -2.0mtr and 23.7mtr. A BM Pillar YR 93 established at Ch. 151.9km on East Bank. Villages Mudvara at Ch. 152.8km and matehana at 154.3km on west Bank, Gadhiva Majhgawan, Madauli and Raiapur Bhasrauli at Ch. 153.2, 155.8km and 158.0km on East Bank. A Road is connected near the village. Sarkandi Village is at Ch. 160.3km on North Bank.

A BM Pillar YR–92 is established at Ch. 161.6km on North Bank .Charaka village is at Ch. 162.4km and road is connected near the Village. Two villages Laxmanpur and Saibansi are at Ch. 162.8km and 163.0km on North Bank. Marka Village is at Ch. 167.7km on SW Bank. A Bridge is under construction at Ch. 168.8km named as marka Bridge. A Ramnagar village is at Ch. 169.3km on East Bank. A kachha Rasta is connecting near Ch. 170.0km.
A BM pillar YR-91 is established at Ch. 171.8km on East Bank Near Jarauli village. Jarauli village is at Ch. 172.0km on East Bank. Dharampur and deaimau are at Ch. 172.6km and 172.8km on NE Bank. Sarwal village is at Ch. 176.8km and sevramau is at 179.8km on NW Bank. Water quality is good as there is no any dirty water coming to river. Both the banks are unprotected. Current is very less. Fishing activities are seen throughout the stretch where ever water is available. Maximum land use is for agriculture. Dry area found between Ch. 150.0km to 154.8km, 158.8km to 161.6km, 163.0km to 163.8km, 175.4km to 175.8km, rest area water is available. No hindrance found in this stretch. Water way can be started after dredging some area.

Table 4.19 Water Depth Stretches at Sub Stretch 06 – Ch. 150 km Gurwal to Ch. 180 km Samgara

CH. (km)	OBSERVED(m)	REDUCED(m)	CH.(km)	OBSERVED(m)	REDUCED(m)
151	9.8	6.7	166	5.4	1.6
152	3.4	0.6	167	8.5	2.4
153	2.6	0.1	168	19.9	17.4
154	2.5	0.1	169	8.9	6.5
155	2.7	-0.1	170	9.2	6.4
156	2.5	-0.2	171	4.5	2.3
157	5.3	2.3	172	8.8	5.9
158	9.8	6.5	173	9.9	7.4
159	10.5	7.8	174	15.8	13.8
160	9.6	6.9	175	6.5	4.1
161	4.9	2.1	176	6.1	4.3

CH. (km)	OBSERVED(m)	REDUCED(m)	CH.(km)	OBSERVED(m)	REDUCED(m)
162	3.7	1.3	177	6.6	3.8
163	3.6	0.8	178	3.9	2.3
164	7.9	4.9	179	6.4	3.8
165	4.7	1.6	180	3.7	1.9

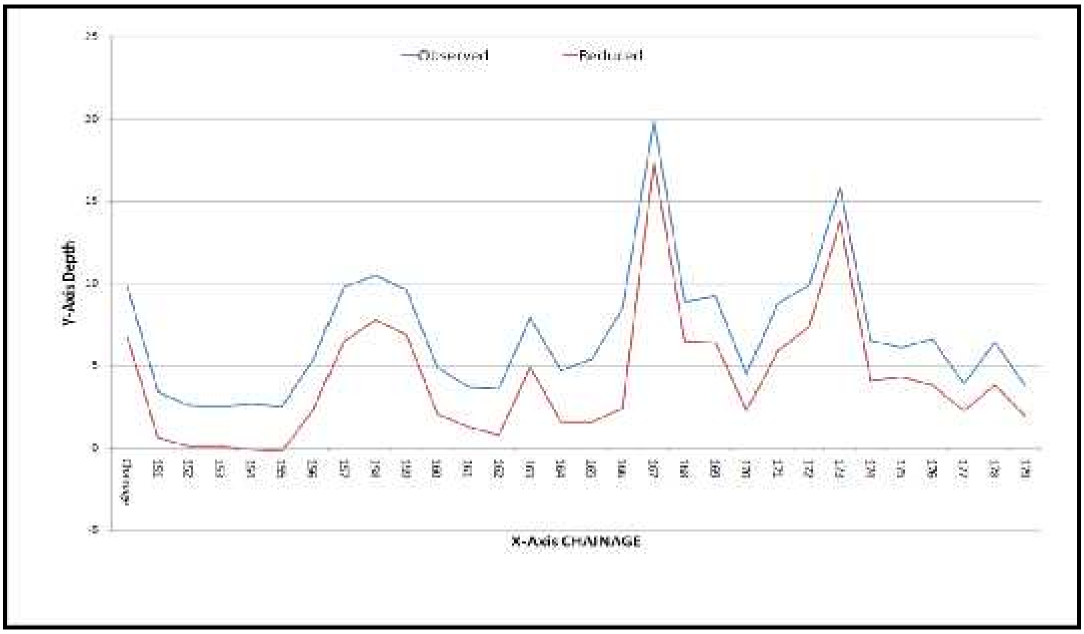


Fig. 4.13 Water Depth Ch. 150 km Gurwal to Ch. 180 km Samgara

4.9.7 Sub Stretch – 07 Samgara to Korra-Kanak (Ch. 180.0 km - 210.0 km)

Fig. 4.14 Google map showing Ch. 180 km Samgara to Ch. 210 km Korra-Kanak

Table 4.20 Water Depth Stretches at Sub Stretch 07–
Ch. 180 km Samgara to Ch. 210 km Korra-Kanak

Stretch	Stretch with	Stretch with	Stretch with	Stretch with	Stretch with

	water depths less than 1.2m (Km)	water depths between 1.2m to 1.4m (Km)	water depths between 1.5m to 1.7m (Km)	water depths between 1.8m to 2.0m (Km)	water depths more than 2.0m (Km)
Samgara to Korra-Kanak	4.20	4.60	0.80	0.60	19.80

Minimum and maximum width in this stretch is 376.0mtr and 840.0m. Minimum and maximum observed depths are -1.0mtr and 14.6mtr.

BM Pillar YR – 90 is established at Ch. 180.9km. Village Samgara is at Ch. 181.0km on south Bank and a road is connecting near the Village. A bridge is under construction named as Augasi Bridge. Augasi Village is at Ch. 185.6km on south Bank. Due to bridge under construction people are crossing the river by boat. This ferry service is available only in off season. Lamheta Village is at Ch. 189.8km on North Bank and a road is connecting near the village at Ch. 190.0km. BM Pillar YR-89 is established at Ch. 190.8km on North Bank. Amlikaur village is at Ch. 192.6km on SW Bank and Gadhi Village is at 193.2km. Dattauli Bridge is at Ch. 198.8km with horizontal and vertical clearance 30.00mtr and 2.024mtr. High Tension line is crossing at Ch. 199.6km with 4.0mtr vertical clearance.

BM Pillar YR – 88 is established at Ch. 201.4km on North Bank. Jawaharpur village is at Ch. 201.3km on South Bank. Korakanale village is at Ch. 209.4km on NE Bank. Water quality is good. Current is very less. Fishing activity seen throughout the stretch. Both the Banks are unprotected. No hindrance found in this stretch. Depths observed very less from Ch. 182.00km to 184.00km, 188.00km to 193.2km, 194.2km to 198.1km, 200.9km to 202.6km rest all area is having sufficient water. Water way can be started after dredging in some area.

Table 4.21 Water Depth Stretches at Sub Stretch 07 - Ch. 180 km Samgara to Ch. 210 km Korra-Kanak

CH.(km)	OBSERVED(m)	REDUCED(m)	CH.(km)	OBSERVED(m)	REDUCED(m)
181	4.8	1.8	196	3.3	2.5
182	5.4	2.9	197	3.0	2.3
183	5.5	3.5	198	2.5	1.4
184	5.0	3.7	199	3.2	1.3
185	4.7	3.1	200	4.8	2.4
186	5.7	2.8	201	6.6	4.1
187	7.3	4.8	202	2.4	0.9
188	6.8	3.8	203	3.2	1.5
189	4.6	3.5	204	3.9	1.3
190	2.2	0.1	205	4.8	2.1
191	1.4	0.9	206	7.5	5.7
192	2.8	0.4	207	10.5	8.6

CH.(km)	OBSERVED(m)	REDUCED(m)	CH.(km)	OBSERVED(m)	REDUCED(m)
193	4.0	2.1	208	8.6	6.4
194	4.3	1.0	209	9.4	6.9
195	4.1	2.3	210	6.2	4.6

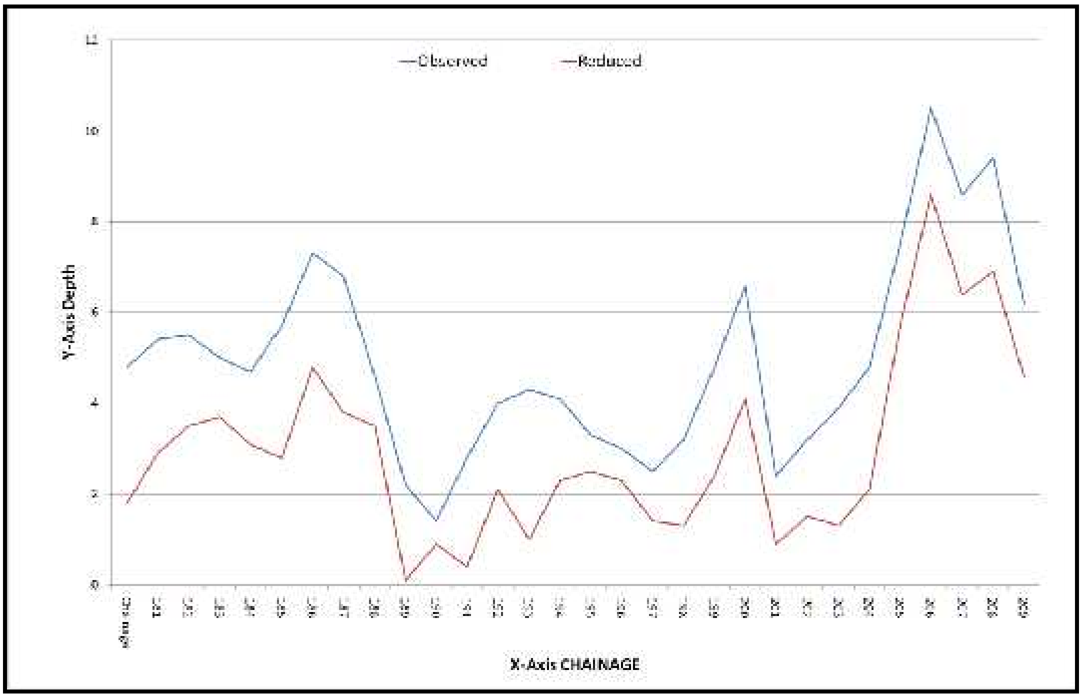


Fig. 4.15 Water Depth Ch. 180 km Samgara to Ch. 210 km Korra-Kanak

4.9.8 Sub Stretch – 08 Korra-Kanak to Ichhawar (Ch. 210.0 km - 240.0 km)

Fig. 4.16 Google map showing Ch. 210 km KorraKanak to 240 km Ichhawar

Table 4.22 Water Depth Stretches at Sub Stretch 08 - Ch. 210 km KorraKanak to 240 km Ichhawar

Stretch	Stretch	Stretch	Stretch	Stretch	Stretch

	with water depths less than 1.2m (Km)	with water depths between 1.2m to 1.4m (Km)	with water depths between 1.5m to 1.7m (Km)	with water depths between 1.8m to 2.0m (Km)	with water depths more than 2.0m (Km)
Korra-Kanak to Ichhawar	4.60	0.40	0.80	0.60	23.60

Minimum and maximum width in this stretch is 159.0mtr and 585 mtr. Minimum and maximum depths observed are 0.0mtr and 11.5mtr. BM Pillar YR 87 established at Ch. 212.8km on North Bank of river. A new chilla Bridge is under construction at Ch. 213.8km and old chilla Bridge is at Ch. 213.830km with horizontal and vertical clearance 27.00mtr and 1.60mtr. Madanpur and Chilla villages are at Ch. 213.6km and214.20km on south Bank. Ken River confluence is at Ch. 214.285 on South West side. Lasada Village is at Ch. 217.2km on SW Bank and Dasaull is at 217.6km Ch. on NE Bank. Urauli Village is at Ch. 219.4km on NW Bank and Adani is at 220.5km on SW Bank. BM Pillar YR 86 is established at Ch. 221.5km on NW Bank. Piparodor village is at Ch. 223.8km West Bank, Baragaon at Ch. 225.2km and madaulikalan is at 228.4km on North Bank. Adawal Village is at Ch. 229.200km on South Bank and Mahabara Village at Ch. 230.8km on North Bank. BM Pillar YR- 85 is established at Ch.232.100km on SE Bank near kodor village. A kachha Rasta is connecting near the village. A Rey village is at Ch. 234.2km on East Bank and road is connecting near the village. Dariyabad village at Ch. 235.4km on NE Bank. A rind nadi is connecting to Yamuna at Ch. 235.8km on NW Bank sabada village is at Ch. 237.8km on South Bank. Ichhawar Village is at Ch. 239.8km on South Bank and Road is connecting up to river near the Village. Water quality is good as there is no dirty water nala is connecting to river. Fishing activates seen in the full stretch current is less. Both the Banks are unprotected. No hindrance found during the survey. Depths observed below 2.0mtr from Ch. 224.8km to 227.km and from 235.6km to 238.0km rest all area insufficient depth available water way can be started after dredging in some area.

Table 4.23 Water Depth Stretches at Sub Stretch 08 – Ch. 210 km KorraKanak to 240 km Ichhawar

CH.(km)	OBSERVED(m)	REDUCED(m)	CH.(km)	OBSERVED(m)	REDUCED(m)
211	4.5	2.8	226	1.0	0.1
212	5.0	3.9	227	2.6	0.7
213	7.0	4.9	228	6.3	4.5
214	5.9	4.2	229	5.8	4.1
215	6.3	6.2	230	8.1	6.8
216	4.9	3.7	231	7.8	6.5
217	3.3	2.1	232	7.2	5.5
218	7.0	5.1	233	7.4	5.4
219	6.2	4.1	234	8.6	7.4

CH.(km)	OBSERVED(m)	REDUCED(m)	CH.(km)	OBSERVED(m)	REDUCED(m)
220	4.3	2.6	235	5.3	4.1
221	4.4	3.2	236	2.0	0.9
222	4.4	3.2	237	2.2	1.1
223	4.8	2.9	238	2.1	1
224	3.7	3.1	239	5.1	4.3
225	2.1	0.9	240	2.8	1.1

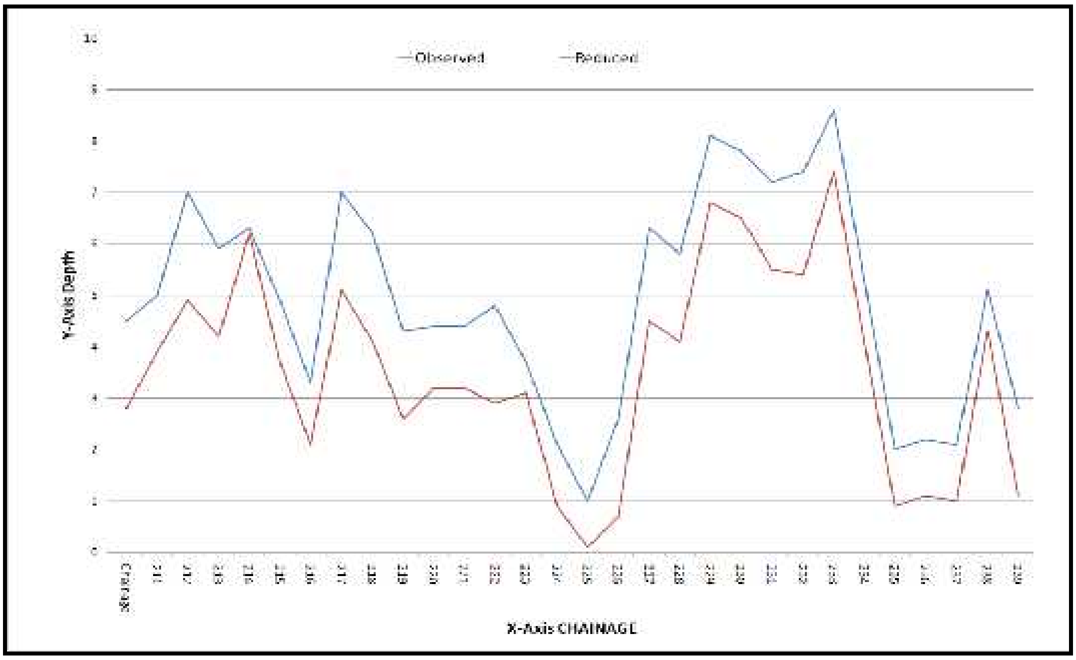


Fig. 4.17 Water Depth Ch. 210 km KorraKanak to 240 km Ichhawar

4.9.9 Sub Stretch – 09 Ichhawar to BadaGaon (Ch. 240.0 km - 272.0 km)

Fig. 4.18 Google map showing Ch. 240 km Ichhawar to Ch. 272 km BadaGaon

Table 4.24 Water Depth Stretches at Sub Stretch 09 –

Ch. 240 km Ichhawar to Ch. 272 km BadaGaon

Stretch	Stretch with water depths less than 1.2m (Km)	Stretch with water depths between 1.2m to 1.4m (Km)	Stretch with water depths between 1.5m to 1.7m (Km)	Stretch with water depths between 1.8m to 2.0m (Km)	Stretch with water depths more than 2.0m (Km)
Ichhawar to BadaGaon	13.40	1.40	1.40	1.00	14.80

Minimum and Maximum width in this stretch is 156.0mtr and 613.0m minimum and maximum depth observed in this stretch are -2.3mtr and 11.2mtr. Satidham ashram is at Ch. 240.70km on NE Bank. BM Pillar YR – 84 is established at Ch. 241.10km on NE Bank. A road is connected to the Pillar YR 84. Villages Bindour, Jafarganj, Gagaipur Dhaurahara, Bara and Kakora are at Chs. 241.50km, 242.3km, 245.0km, 246.7km, 248.7km and 251.0km on North Bank. Temples are at Ch. 244.5km and 246.3km on North Bank. A road is connecting to River near the temple at Ch. 246.3km. Villages on south Bank are Chandwara, Galauli and Gajipur, at Ch.s 245.0km, 248.8km and 250.5km. Bara village is at Ch. 248.7km on North Bank. Ferry service available at Ch. 248.7km to cross the river for villagers. BM Pillar YR – 83 is established at Ch. 250.9km on North Bank near Kakora Village. Villages at south bank are Khaptihakhurd, Narayrh, Bharuadanda and Narairaaira at Chs. 251.7km, 255.8km, 257.4km and 259.6km. Road is connecting at Ch. 257.7km. Rithiya village is at Ch. 257.0km on North Bank. A temple is at Ch. 260.2km on North Bank. Temples on South Bank are at Ch. 258.4km, 259.6km, 260.8km and 261.6km. Suraulibuzurg Danda village is at Ch. 261.5km on South West Bank. BM Pillar YR 82 is established at Ch. 263.3km on NE Bank. Village Mawai is at Ch. 264.3km and a temple at Ch. 264.3km on NE Bank. A pump House is at Ch. 267.100km on North Bank. Bapsaura village is at Ch. 267.8km. A temple is at Ch. 268.0km on South Bank. A temple is at Ch. 270.8km and Pump House at Ch. 271.7km on South Bank. Hamirpur Railway Bridge is at 272.0km with Horizontal and vertical clearance 70.0mtr and 1.798mtr. Water quality is good. Fishing activities seen throughout the stretch. Current is very less. No hindrance found during the survey. Both the Banks are unprotected. Connectivity is good in this stretch. A depth below 2.0mtr is from Ch. 250.0km to 257.4km, 261.2km to 263.1km and 267.0km to 269.7km. Water way can be started after dredging in some area.

Table 4.25 Water Depth Stretches at Sub Stretch 09 –
Ch. 240 km Ichhawar to Ch. 272 km BadaGaon

CH.(km)	OBSERVED(m)	REDUCED(m)	CH.(km)	OBSERVED(m)	REDUCED(m)
241	2.6	1.4	257	3.4	2.6
242	2.4	1.2	258	8.9	6.9
243	2.5	1.2	259	9.4	7.9
244	3.0	1.9	260	6.7	5.5
245	4.4	2.8	261	4.5	3.2
246	4.4	2.6	262	3.4	2.3

CH.(km)	OBSERVED(m)	REDUCED(m)	CH.(km)	OBSERVED(m)	REDUCED(m)
247	4.8	2.8	263	4.9	2.5
248	6.3	5.2	264	9.7	7.9
249	4.7	2.6	265	9.3	7.6
250	4.7	2.6	266	8.5	7.1
251	4.2	3.1	267	7.1	6.0
252	3.0	2.1	268	2.5	1.0
253	4.9	2.0	269	2.8	1.0
254	1.3	0.3	270	7.1	6.1
255	0.8	-0.2	271	7.3	5.6
256	2.2	1.1	272	5.7	4.2

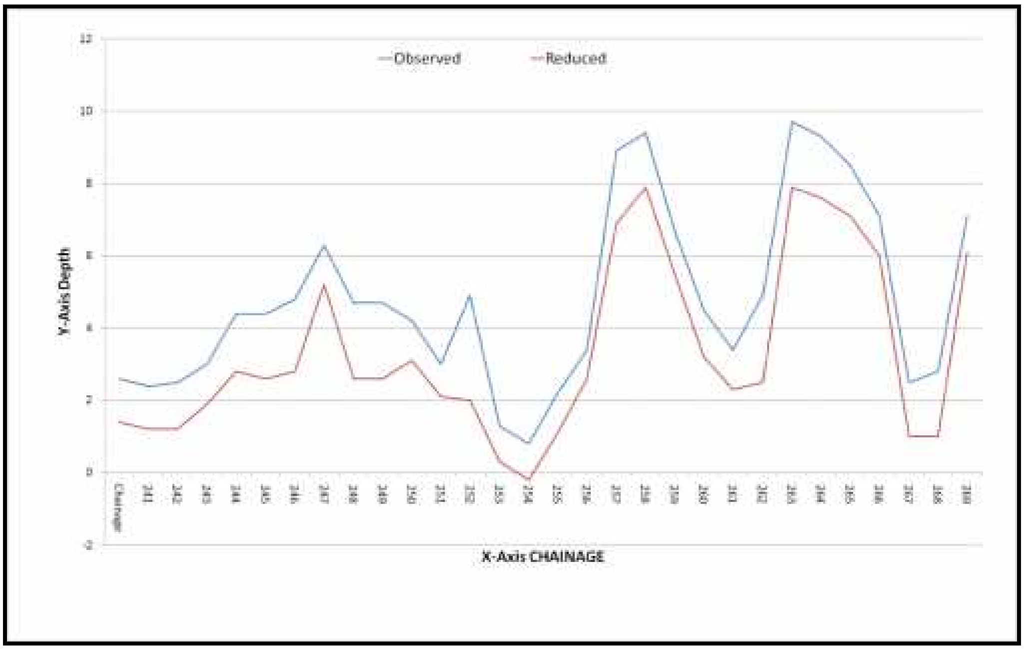


Fig. 4.19 Water Depth Ch. 240 km Ichhawar to Ch. 272 km BadaGaon

4.10 Waterway description for Stretch-2 (Betwa Mouth to Chambal Mouth)

4.10.1 Sub Stretch – 10 Badagaon to Kotupur (Ch. 272km - 300 km)

Fig. 4.20 Google map showing Ch. 272 km BadaGaon to Ch. 300 km Kotupur

***Table 4.26 Water Depth Stretches at Sub Stretch 10 –
Ch. 272 km BadaGaon to Ch. 300 km Kotupur***

Stretch	Stretch with water depths less than 1.2m (Km)	Stretch with water depths between 1.2m to 1.4m (Km)	Stretch with water depths between 1.5m to 1.7m (Km)	Stretch with water depths between 1.8m to 2.0m (Km)	Stretch with water depths more than 2.0m (Km)
Badagaon to Kotupur	15.60	0.80	1.00	1.40	9.20

Minimum and maximum width in this stretch is 297.0mtr and 1000mtr. Minimum and maximum depths observed are -2.9mtr and 19.0mtr. BM Pillar YR 81 is established at Ch. 273.2km on SW Bank near the Betwa Mouth samuhi village is at Ch. 275.9km and a Temple at Ch. 275.95km on NE Bank. Manghoopur Daria village is at 276.8km on SW Bank. A Temple is at Ch. 277.8km. A Pump House is at Ch. 277.9km on SW Bank. A Hamirpur Bridge at Ch.279.9km connecting Kanpur and Sagar with Horizontal and vertical clearance 45.75mtr and 1.960mtr.

BM Pillar YR 80 is established at Ch. 279.91 on NE Bank. Hamirpur city is from Ch. 279.0km to 284km on SE Bank. Monto Village is at Ch. 283.100km on NE Bank. Dahilar Avval village at Ch. 285.10km and shamshan Ghat at same Ch. on NE Bank. Chandupur Danda is on SW Bank at Ch. 287.9km.

BM Pillar YR-79 is established at Ch. 288.1km. Sikrohi Danda village is at Ch. 289.8km on West Bank. A Temple is at Ch. 292.1km and a village Handauli at Ch. 292.2km on SE Bank. Bhatpura Danda village at Ch. 293.0km on west Bank. Maunakhat Village at Ch. 294.1km, Jamvehiteer Danda Village is at Ch. 297.8km on South Bank. A Pump House is at Ch. 300 on South Bank. Water quality is good. Current is very less. Fishing activities seen in full stretch. Both the banks are unprotected except from Ch. 279.9km to 28.9km on SW Bank. No hindrance in this stretch. Dry area observed from Ch. 273.3km to 274.4km, 275km to 277.6km, 279.9km to 286.1km, 291.7km to 292.6km, 294km to 294.4km and 295.2km to 300.0km water way can be started after dredging same area.

Table 4.27 Water Depth Stretches at Sub Stretch 10 –
Ch. 272 km BadaGaon to Ch. 300 km Kotupur

CH. (km)	OBSERVED(m)	REDUCED(m)	CH. (km)	OBSERVED(m)	REDUCED(m)
273	2.9	1.5	287	5.6	0.6
274	2.4	1.0	288	5.2	2.7
275	7.7	5.9	289	12.1	10.7
276	4.4	2.6	290	6.6	5.1
277	3.0	1.0	291	4.9	2.6
278	5.1	3.9	292	4.3	2.1
279	5.9	4.5	293	7.0	5.0
280	4.7	2.8	294	5.2	3.4
281	3.5	2.5	295	8.6	6.0
282	3.1	2.4	296	4.1	3.0
283	3.5	3.3	297	4.0	2.0
284	5.6	4.2	298	1.8	1.0
285	3.1	1.9	299	2.5	1.0
286	4.9	2.3	300	1.6	0.8

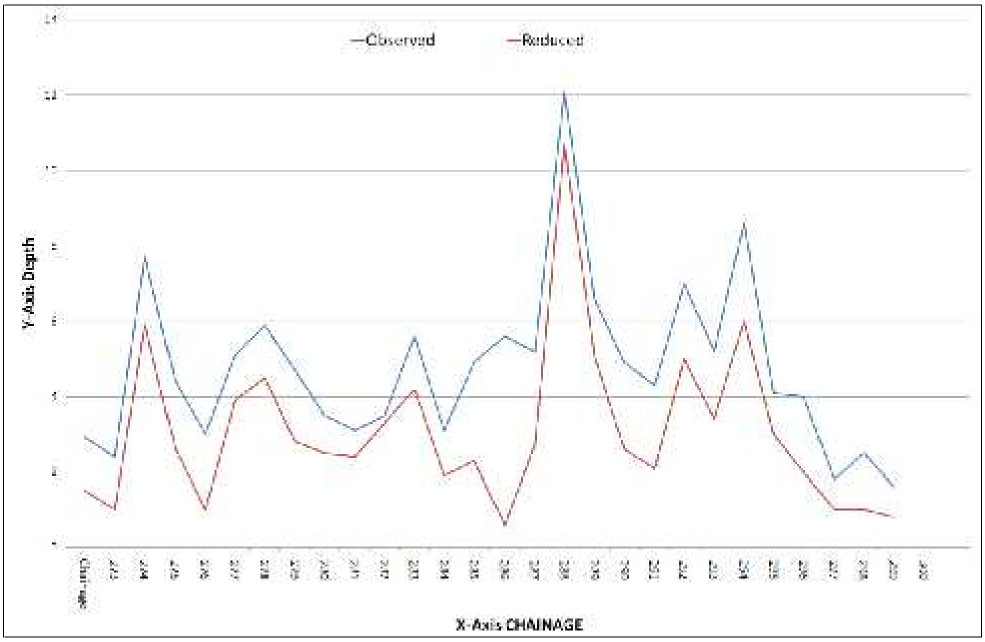


Fig. 4.21 Water Depth Ch. 272 km BadaGaon to Ch. 300 km Kotupur

4.10.2 Sub Stretch – 11 Kotupur to Aharauli (Ch. 300 km - 330 km)

Fig. 4.22 Google map showing Ch. 300 km Kotupur to Ch. 330 km Aharauli

Table 4.28 Water Depth Stretches at Sub Stretch 11 –
Ch. 300 km Kotupur to Ch. 330 km Aharauli

Stretch	Stretch with water depths less than 1.2m (Km)	Stretch with water depths between 1.2m to 1.4m (Km)	Stretch with water depths between 1.5m to 1.7m (Km)	Stretch with water depths between 1.8m to 2.0m (Km)	Stretch with water depths more than 2.0m (Km)
Kotupur to Aharauli	19.80	0.80	0.40	0.80	8.20

Minimum and maximum width in this stretch 234.0mtr.and 635.0. Minimum and maximum depths observed are -3.7mtr and 10.3mtr. BM Pillar YR – 78 is established at Ch. 300.2km on North Bank. Patia small village is at Ch. 300.7km on South Bank. Villages Kotupur and Bachhrauli are at Ch. 301.7km and 305.3km on south Bank. Garatha Amiratepur and katari are at Ch. s 304.6km, 306.5km and 309.6km on North Bank. BM Pillar YR–77 is established at Ch. 309.9km on North Bank of River Near Katari Village. Road is Connecting near this pillar. Villages Nirni, Misripur at Ch. 311.10km, 312.4km on SE and Umrahat is at 315.6km on NW Bank. A temple is at Ch. 316.6km on West Bank and Kator village is at Ch. 316.9km on East Bank. Manki Kalan Village is at Ch. 318.0km on West Bank. A Manki Bridge is at Ch. 320.3km and Connecting from Moosanagar to Jalaun with horizontal and vertical clearance 27.00mtr and 2.054mtr.

BM Pillar YR – 76 is established at Ch. 320.2km on NE Bank. Moosanagr Bangar and Hatiya Bangar are at Ch. 321.3km and 321.9km. A temple is at Ch. 321.5km on NE Bank. A Samshan Ghat is at Ch. 322.1km on South Bank. River Takes U turn from Ch. 320.0km. Village Nagina Bangar, Bamhrauli Ghat Barge and Aharauli Ghat Bangar are at Ch. 325.0km, 328.4km and 329.0km on West Bank. BM Pillar YR – 75 is established at Ch. 329.2km on west bank .Water quality is good. Both the Bank are unprotected fishing activities are seen in full stretch where ever water is available. No hindrance found in this stretch. Current is very less. Dry area is from Ch. 300km to 306.9km, 311.3km to 318.2km and 322.7km to 328km. A sanchur is formed from Ch. 326.3 to 326.6km. Water way can be started after dredging in some area.

Table 4.29 Water Depth Stretches at Sub Stretch 11 – Ch. 300 km Kotupur to Ch. 330 km Aharauli

CH. (km)	OBSERVED(m)	REDUCED(m)	CH. (km)	OBSERVED(m)	REDUCED(m)
301	2.7	0.4	316	1.8	0.5
302	4.0	2.3	317	3.2	2.1
303	3.8	2.0	318	6.1	5.2
304	3.6	2.0	319	8.2	7.1
305	3.0	2.0	320	9.8	8.0
306	2.4	0.9	321	12.2	10.5
307	5.5	4.1	322	11.4	10
308	6.6	5.2	323	4.0	1.9
309	7.2	6.5	324	1.9	0.3
310	8.4	6.7	325	3.7	2.5
311	8.6	7.1	326	5.5	4.0
312	3.7	2.9	327	5.2	4.0
313	3.9	3.4	328	5.2	4.0
314	3.3	2.7	329	7.5	6.0
315	2.1	1.0	330	12.1	10.0

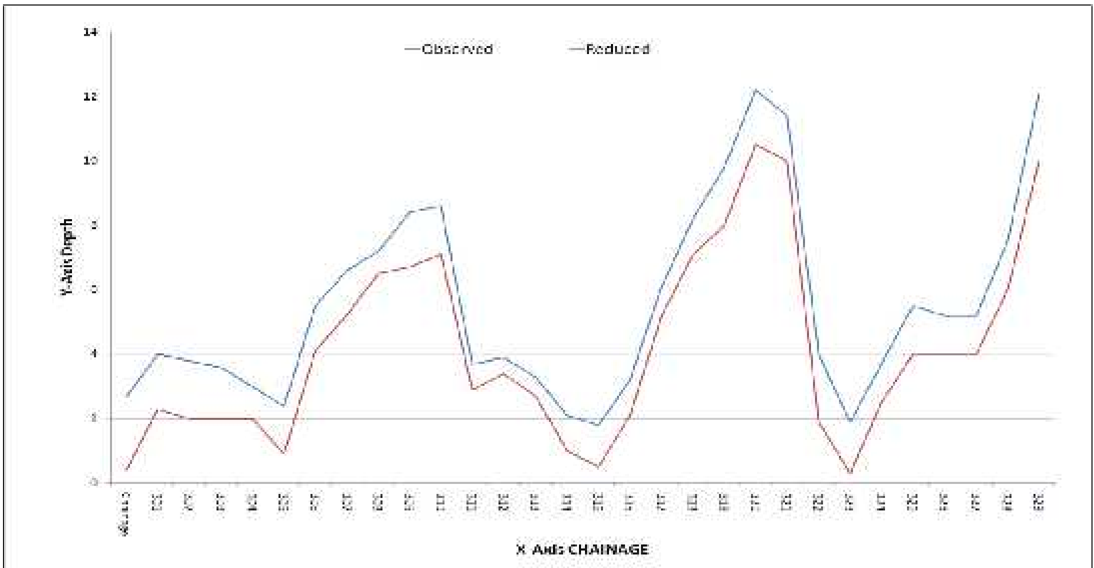


Fig. 4.23 Water Depth Ch. 300 km Kotupur to Ch. 330 km Aharauli

4.10.3 Sub Stretch – 12 Aharauli to Mustakil Gurakhas (Ch. 330 km - 360 km)

Fig. 4.24 Google map showing Ch. 330 km Aharauli to Ch. 360 km Mustakil Gurakhas

Table 4.30 Water Depth Stretches at Sub Stretch 12 –
Ch. 330 km Aharauli to Ch. 360 km Mus. Gurakhas

Stretch	Stretch with water depths less than 1.2m (Km)	Stretch with water depths between 1.2m to 1.4m (Km)	Stretch with water depths between 1.5m to 1.7m (Km)	Stretch with water depths between 1.8m to 2.0m (Km)	Stretch with water depths more than 2.0m (Km)
Aharauli to Mustakil Gurakhas	18.20	1.20	0.00	0.60	10.00

Minimum and maximum width in this stretch 116.00mtr and 441.0mtr.minimum and maximum depth are -1.9mtr and 16.0mtr. Ekona village is at Ch. 331.7km on South Bank and Pali is at Ch. 335.4km on south west Bank. A road is connecting at Ch. 338.6km on South Bank. Abhirva and Madraladpur Villages are at Ch. 339.8km and 340.5km on South Bank. BM Pillar YR–74 is established at Ch. 340.3km on North Bank. Villages Selhupur, Nagawa Bangar and Rasulpur Bhalar are at Ch. 342.0km, 343.8km and 347.6km on NE Bank Guloli Mustakil Village is at Ch. 347.6km on NE Bank. Railway Bridge is under Construction at Ch. 349.425. Kalpi Railway Bridge is at Ch. 349.50kkm with Horizontal and vertical clearance 76.20mtr and 1.913mtr. BM Pillar YR 73 is established at Ch. 349.8km on SW Bank. Old Bridge Kanpur to Kalpi is at Ch. 350.2km with Horizontal and vertical Clearance 75.00mtr and 1.835 meter and New Bridge Kanpur to Kalpi is at Ch. 350.3km with Horizontal and Vertical Clearance 75.00mtr and 2.064.

Kalpi town is at 350.0 km Ch. on South West Bank. Daulatpur and Kariyapur Bhognipur are at Ch. 353.0km and 355.5km on South East Bank. Gupakhas Mustakil Village is at Ch. 353.8km on NW Bank. Fishing activities seen in full stretch. No hindrance found in this stretch. Current is very less. Water quality is good. Both the Banks are unprotected. Dry area is from Ch. 330.6km to 307.1kmm 311.3km to 318.2km, 322.7km to 328.4km, 330.6km to 334.8km, 337.6km to 338.1, 342.0km to 343.8km, 347.4km to 348.6km, 350.8km to 353.2km and 357.3km to 359.1km. This maximum area is dry in this stretch. Dredging quantity will be more. Water way can be developed after dredging.

Table 4.31 Water Depth Stretches at Sub Stretch 12 - Ch. 330 km Aharauli to Ch. 360 km Mus. Gurakhas

CH. (km)	OBSERVED (m)	REDUCED (m)	CH. (km)	OBSERVED (m)	REDUCED (m)
331	0.8	0.1	346	3.7	1.1
332	1.9	1.0	347	5.7	4.2
333	1.5	1.0	348	2.2	1.1
334	1.8	1.0	349	3.8	1.5
335	3.1	2.0	350	7.7	7.1
336	7.2	6.7	351	0.4	-0.3
337	16.7	15.5	352	1.8	0.8
338	2.2	-0.3	353	1.8	0.6
339	9.3	7.8	354	4.9	2.2
340	10.7	8.9	355	5.1	3.8
341	2.7	1.0	356	2.7	1.3
342	1.7	0.5	357	2.7	0.3
343	0.7	0.1	358	1.9	0.4
344	3.0	1.0	359	1.8	0.5
345	8.8	6.8	360	2.4	0.9

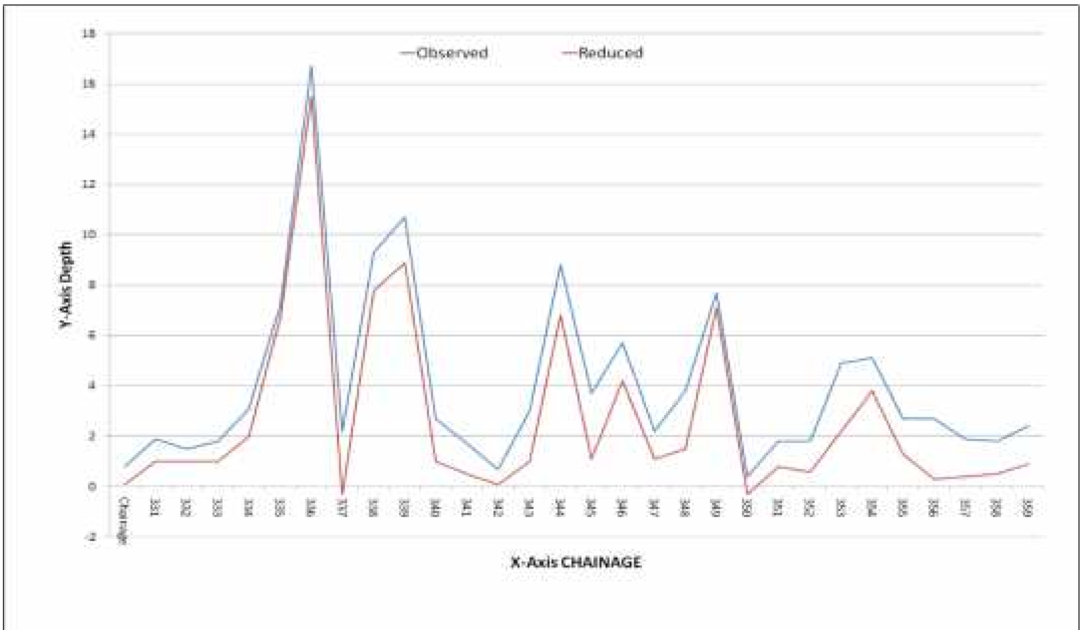


Fig. 4.25 Water Depth Ch. 330 km Aharauli to Ch. 360 km Mustakil Gurakhas

4.10.4 Sub Stretch – 13 Mustakil Gurakhas to Bilaspur (Ch. 360 km - 390 km)

Fig. 4.26 Google map showing Ch. 360 km Mustakil Gurakhas to Ch. 390 km Bilaspur

Table 4.32 Water Depth Stretches at Sub Stretch 13 – Ch. 360 km Mus. Gurakhas to Ch. 390 km Bilaspur

Stretch	Stretch with water depths less than 1.2m (Km)	Stretch with water depths between 1.2m to 1.4m (Km)	Stretch with water depths between 1.5m to 1.7m (Km)	Stretch with water depths between 1.8m to 2.0m (Km)	Stretch with water depths more than 2.0m (Km)
Mustakil Gurakhas to Bilaspur	23.00	1.20	0.60	0.80	4.40

Minimum and Maximum width in this stretch is 96.0mtr and 419.0mtr. Minimum and Maximum depth observed -2.0mtr and 12.8mtr. BM Pillar YR – 72 is established at Ch. 360.1km on North Bank. Shekhpurgura Mustakil village is at Ch. 362.4km on South Banks. Konchmalanga River is connecting at Ch. 362.8km on South Bank. Khartala Bangar village is at Ch. 365.6km on North Bank and Narhan Mustakil is at Ch. 367.3km on SW Bank. BM Pillar YR – 71 is established at Ch. 369.4km on NE Bank. Khoja Rampur Bangar village is at Ch. 376.7km on N Bank. Khoja Rampur Bridge is Under Construction at Ch. 377.3km. BM Pillar YR – 70 is established at Ch.381.6km on North East Bank. Khargui Mustakil Village is at Ch. 383.6km on SW Bank. Baijamau Kachhar village is at Ch. 384.7km on NE Bank. Fishing activities seen all over the stretch where ever water is available. Both the

Banks are unprotected. Water quality is good as there is no any drainage is connecting to River.

Sounding less than 2.0mtr.is from Ch. 360.0km to 364.6km, 368.7km to 369.8km, 370.5km to 372.6km, and dry area from 372.8km to 384.0km and below 2.0mtr depth from Ch. 384km to 386km, 388.0km to 390km. Maximum area is very less sounding. more quantity to be dredge for water way.

Table 4.33 Water Depth Stretches at Sub Stretch 13 – Ch. 360 km Mus. Gurakhas to Ch. 390 km Bilaspur

CH. (km)	OBSERVED(m)	REDUCED(m)	CH. (km)	OBSERVED(m)	REDUCED(m)
361	2.0	1.5	376	3.2	0.2
362	0.8	-0.3	377	1.9	0.5
363	2.6	0.7	378	1.8	0.3
364	2.7	0.6	379	2.8	1.1
365	3.6	1.8	380	1.9	0.0
366	3.0	1.1	381	1.1	0.0
367	6.3	5.3	382	1.1	0.7
368	4.1	1.9	383	0.9	-0.3
369	1.4	0.4	384	3.9	2.1
370	5.6	4.3	385	5.4	3.9
371	1.5	0.2	386	5.4	4.2
372	2.0	1.0	387	10.1	8.7
373	1.6	1.0	388	3.5	2.4
374	0.5	-0.3	389	3.3	1.9
375	1.3	0.0	390	3.5	2.7

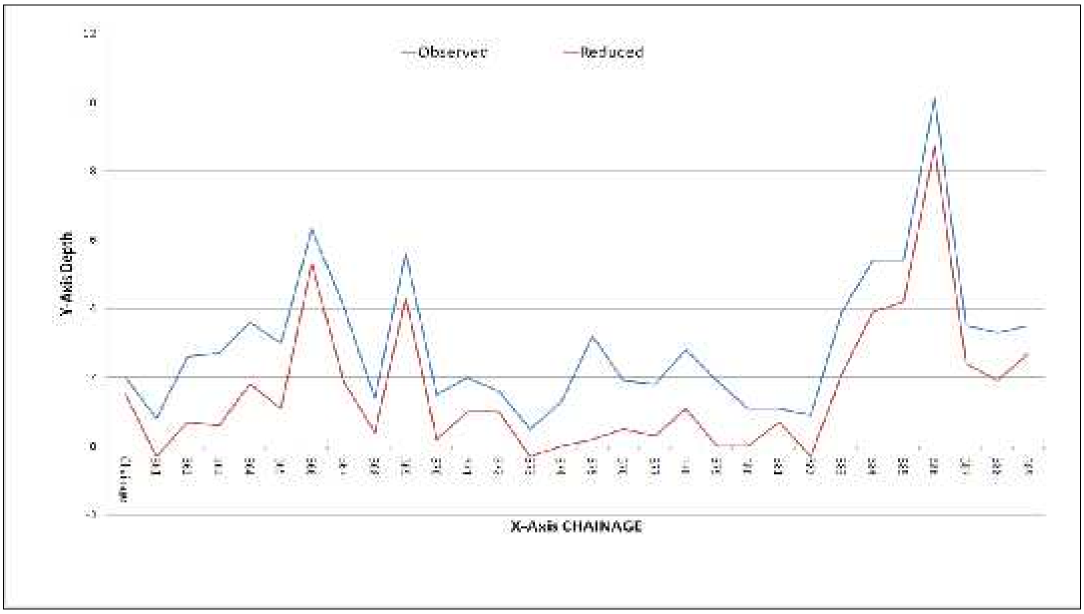


Fig. 4.27 Water Depth Ch. 360 km Mustakil Gurakhas to Ch. 390 km Bilaspur

4.10.5 Sub Stretch – 14 Bilaspur to Sihauli (Ch. 390 km - 420 km)

Fig. 4.28 Google map showing Ch. 390 Km Bilaspur to Ch. 420 Km Sihauli

Table 4.34 Water Depth Stretches at Sub Stretch 14 - Ch. 390 Km Bilaspur to Ch. 420 Km Sihauli

Stretch	Stretch with water depths less than 1.2m (Km)	Stretch with water depths between 1.2m to 1.4m (Km)	Stretch with water depths between 1.5m to 1.7m (Km)	Stretch with water depths between 1.8m to 2.0m (Km)	Stretch with water depths more than 2.0m (Km)
Bilaspurto Sihauli	20.60	0.80	1.00	1.60	6.00

Minimum and Maximum width in this stretch is 136.0mtr and 407mtr. Minimum and Maximum depths observed in this stretch on -1.9mte and 12.9mtr. BM Pillar YR-69 is established at Ch. 390.8km on SE Bank. Maheshpur Village is at Ch. 394.5km on SE Bank. River takes U turn from Ch. 394.0km to 398.0km. Bhupaiyapur Harkishan village is at Ch. 398.7km on NW Bank and Jitamau Mustakil is at Ch. 398.9km on South E Bank. A road is Connecting near this village at Ch. 399.0km. BM Pillar YR – 68 is established at Ch. 402.3km on NE Bank. Gauhani Bangar Village is at Ch. 402.9km on NE Bank. Road is connecting near the Bank at Ch. 402.6km Nainapur Village is at Ch. 407.8km on West Bank. Marthapur Village is at Ch. 409.4km on East bank and Harshankarpur Mustakil Village is at Ch. 410.2km on West Bank. A BM Pillar YR 67 is established at Ch. 411.4km near the Auraya to Jalaun Bridge in NE Bank. A Bridge is at Ch. 411.5km Connecting Awaya to Jalaum with Horizontal and vertical Clearance 25.00mtr and 2.33 mtr.

A temple is at Ch. 411.6km on NE bank .Romai Mustakil Village is at Ch. 416.0km on South Bank. A temple is at Ch. 416.7km on North Bank.

Fishing activities are seen all over the stretch. No hindrance found in this stretch. Water quality is good. Current is very less. No ferry service seen in the stretch. Both the Banks are unprotected. Dry soundings starts from Ch. 390.0 km to 391.3 km, 394.0 km to 396.0 km, 396.0 km to 398.1 km and 401.0 km to 416.4 km. Dry area is more than the area with sufficient water more quantity to be dredged to start water way. So water way can be started after dredging the channel.

Table 4.35 Water Depth Stretches at Sub Stretch 14 – Ch. 390 Km Bilaspur to Ch. 420 Km Sihauli

CH. (km)	OBSERVED(m)	REDUCED(m)	CH. (km)	OBSERVED(m)	REDUCED(m)
391	2.6	2	406	0.6	-0.1
392	6.0	4.5	407	1.6	0.2
393	11.1	10.2	408	2.2	0.1
394	5.5	4.0	409	3.7	2.3
395	3.7	1.6	410	1.3	0.0
396	4.1	3.0	411	3.4	2.1
397	1.1	0.2	412	1.2	0.0
398	3.2	1.6	413	2.7	1.0
399	7.5	5.8	414	2.4	1.6
400	9.5	7.8	415	2.0	-0.2
401	0.9	-0.3	416	1.5	1.2
402	1.6	-0.1	417	4.1	2.6
403	1.8	1.7	418	4.3	2.5
404	1.3	0.2	419	2.4	1.6
405	1.1	0.3	420	1.6	1.0

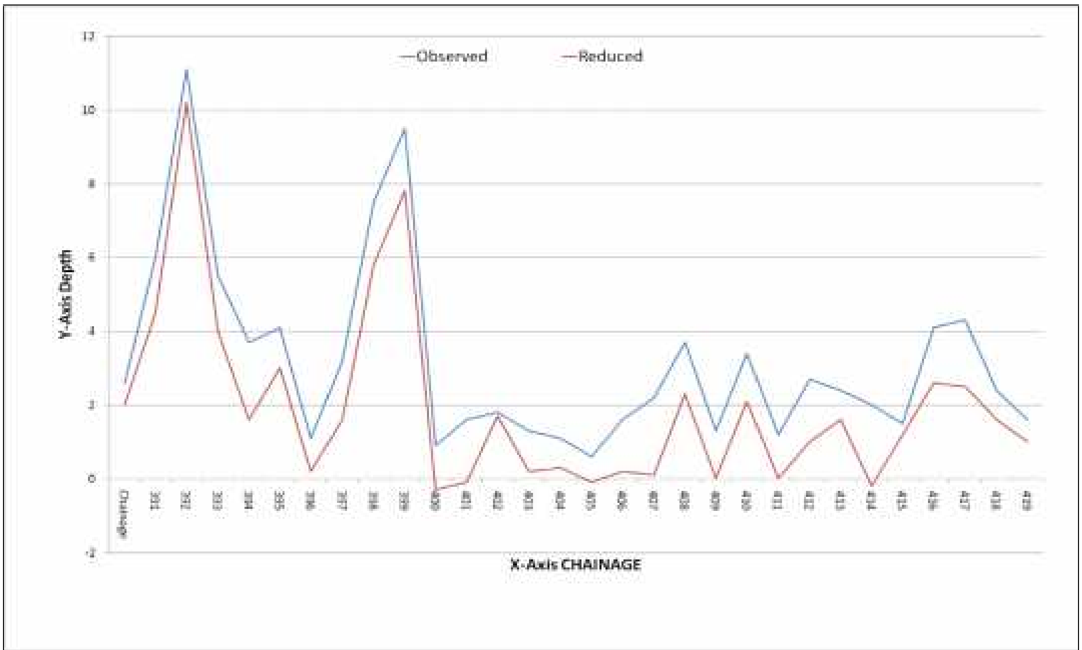


Fig. 4.29 Water Depth Ch. 390 Km Bilaspur to Ch. 420 Km Sihauli

4.10.6 Sub Stretch – 15 Sihauli to Bhareh (Ch. 420 km - 453 km)

Fig. 4.30 Google map showing Ch. 420 km Sihauli to Ch. 453 km Bhareh

Table 4.36 Water Depth Stretches at Sub Stretch 15 – Ch. 420 km Sihauli to Ch. 453 km Bhareh

Stretch	Stretch with water depths less than 1.2m (Km)	Stretch with water depths between 1.2m to 1.4m (Km)	Stretch with water depths between 1.5m to 1.7m (Km)	Stretch with water depths between 1.8m to 2.0m (Km)	Stretch with water depths more than 2.0m (Km)
Sihauli to Samgara	12.00	1.20	0.80	0.80	18.20

Minimum and Maximum width in this stretch is 141.0mtr and 479mtr. Minimum and Maximum depths observed -0.7mtr and 17.6mtr. BM Pillar YR- 66 is established at Ch. 421.6km on NE Bank. Two high tension lines are crossing at Ch. 424.100km and 424.200km with horizontal and vertical clearance of 04.0 mtr. Brijhalpur Village is at Ch. 425.4km on North Bank. High Tension line is crossing at Ch. 425.625km. Patrahi Village is at Ch. 429.1km on SW Bank and Sikharna Village is at Ch. 430.2km on NE Bank. A High Tension line is crossing at 431.6km with 4.0mtr vertical Clearance. Mahatauli Village is at Ch. 431.8 on SW Bank. BM Pillar YR – 65 is established at Ch. 432.7km on NE Bank. Fareh Village is at Ch. 433.6km and Gurha Village is at Ch. 436.3 on SE Bank. High Tension line is crossing at Ch. 437.4km. A temple is at Ch. 438.5km on South Bank. A Juhikha Bridge is at Ch. 438.8 with Horizontal and vertical Clearance 27.0mtr and 2.209mtr Connecting Juhikha to Jagammanpurkanar Village is at Ch. 439.5km and a Temple is at Ch. 439.7km on South Bank. Tatarpurkalan Village is at Ch. 440.4km on North Bank.

kanjausa Village is at Ch. 442.0km and a temple is at 442.50km on SW Bank. Sind River is connecting to Yamuna River at Ch. 442.4km on south west bank. Shamsan Ghat is at Ch. 442.7 and Kaleshwarmahadev Temple at Ch. 442.8km on west Bank. This area is called Panchnada. BM Pillar YR–64 is established at Ch. 443.1km on NE Bank. Most of the land is used for agriculture. Fishing activities found in most of the area. Water quality is good due to confluence of Sindh River. Current is very less. Both the banks are unprotected. Very less depth observed from Ch. 420.0km to 422.8km, 426.6km to 428.2km, 429.1km to 430.0km, 433.4km to 434.5km. In other area sufficient depth is available. No hindrance found in the stretch. Water way can started after dredging in some places.

Table 4.37 Water Depth Stretches at Sub Stretch 15 – Ch. 420 km Sihauli to Ch. 453 km Bhareh

CH. (km)	OBSERVED (m)	REDUCED (m)	CH. (km)	OBSERVED (m)	REDUCED (m)
420	1.6	1.0	437	5.9	4.6
421	1.6	1.0	438	2.3	1.0
422	0.9	-0.2	439	5.0	3.9
423	2.4	1.3	440	6.6	5.5
424	4.3	3.2	441	4.5	2.9
425	5.0	4.5	442	7.7	5.9
426	9.6	7.9	443	3.7	1.7
427	0.4	-0.3	444	2.5	1.0
428	1.2	0.8	445	1.2	0.3
429	2.2	1.4	446	3.5	2.7
430	2.1	1.2	447	5.3	4.7
431	7.9	7.2	448	2.3	1.0
432	4.7	2.9	449	6.6	5.2
433	1.6	0.9	450	4.6	2.9
434	0.5	-0.3	451	4.2	2.8
435	3.2	1.7	452	2.4	1.1
436	2.2	1.1	453	3.6	2.3

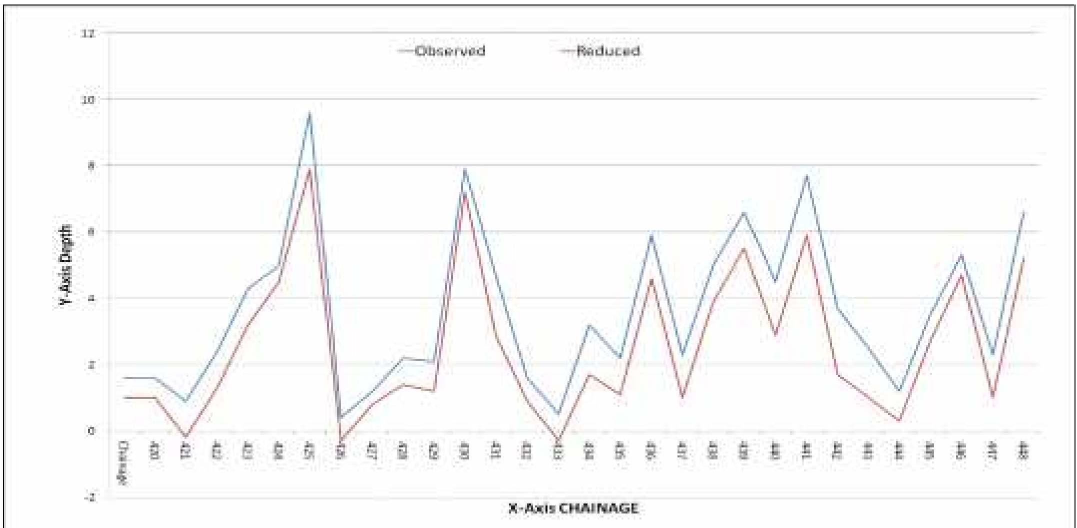


Fig. 4.31 Water Depth Ch. 420 km Sihauli to Ch. 453 km Bhareh

4.11 Waterway description for Stretch-1 (Chambal Mouth to Agra)

4.11.1 Sub Stretch – 16 Bhareh to Dibholi (Ch. 453 km - 480 km)

Fig. 4.32 Google map showing Ch. 453 km Bhareh to Ch. 480 km Dibholi

Table 4.38 Water Depth Stretches at Sub Stretch 16 – Ch. 453 km Bhareh to Ch. 480 km Dibholi

Stretch	Stretch with less than 1.2m depth (km)	Stretch with depths between 1.2 to 1.4m (km)	Stretch with depths between 1.5 to 1.7m (km)	Stretch with depths between 1.8m to 2m (km)	Stretch with more than 2m depth (km)
Samgara to Kharka	27.00	0.00	0.00	0.00	0.00

This stretch of Yamuna River starts from Gurakhasdivara to Kharka. Minimum and Maximum width in this stretch is 64m and 394m, minimum and maximum depth is -0.8m and 8.1m.

BM Pillar YR 63 is established on North West Bank of River at Ch. 454.3km near Sekhapur Gura village, A parallel road is running from Bharat village to Garha Kasda. A sandchur is present at Ch. 547.2km, 461.0km, 462.0km, 463.0km and 464.0km.

BM Pillar YR 62 is established on South East Bank of River at Ch. 464.1km near Khartala village. Guhani Kalan village located at Ch. 465.0km. A Bridge is present at Ch. 469.9km from Chikanagar to Bhikepur. At Ch. 470.0km Kaneshi village is located. Sandchur is present at Ch. 471.6km. Kanichi village is present at Ch. 474.6km.

BM Pillar YR 61 is established on South Bank of River at Ch. 475.8km at Badera village.

Table 4.39 Water Depth Stretches at Sub Stretch 16 – Ch. 453 km Bhareh to Ch. 480 km Dibholi

CH. (km)	OBSERVED(m)	REDUCED(m)	CH. (km)	OBSERVED(m)	REDUCED(m)
453	3.6	2.3	467	1.2	0.3
454	0.8	-0.3	468	0.5	0.0
455	1.0	0.1	469	1.4	-0.1
456	1.2	-0.1	470	0.9	-0.2
457	1.1	-0.3	471	0.8	-0.2
458	0.8	-0.3	472	1.1	0.4
459	0.9	0.1	473	1.1	-0.2
460	1.6	0.4	474	1.2	0.5
461	0.3	-0.3	475	0.7	0.0
462	1.4	0.4	476	0.8	0.0
463	1.0	0.1	477	0.9	0.3
464	0.4	0.3	478	0.8	0.3
465	0.5	-0.2	479	0.9	0.5
466	0.3	-0.2	480	0.9	0.0

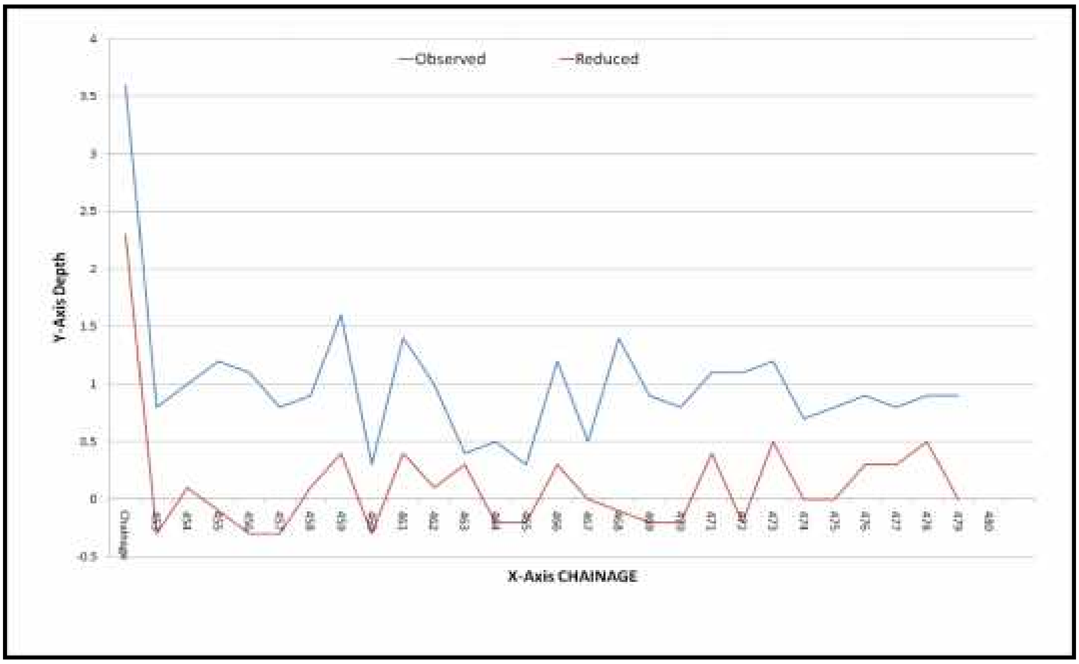


Fig. 4.33 Water Depth Ch. 453 km Bhareh to Ch. 480 km Dibholi

4.11.2 Sub Stretch – 17 Dibholi to Asai (Ch. 480 km - 510 km)

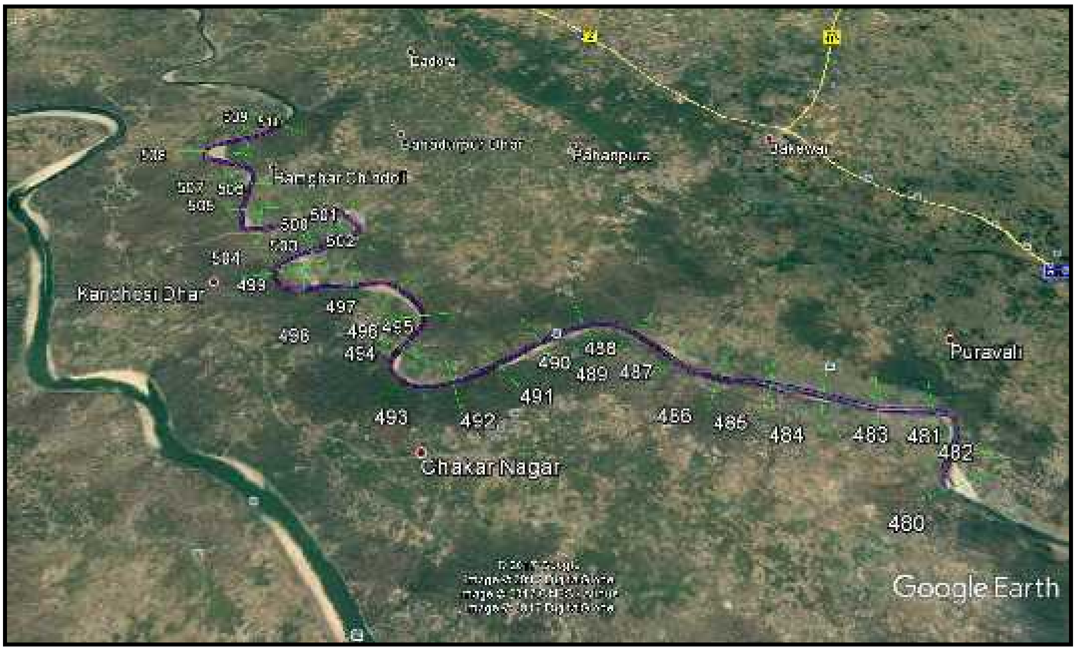


Fig. 4.34 Google map showing Ch. 480 km Dibholi to Ch. 510 km Asai

Table 4.40 Water Depth Stretches at Sub Stretch 17 – Ch. 480 km Dibholi to Ch. 510 km Asai

Stretch	Stretch with water depths less than 1.2m (Km)	Stretch with water depths between 1.2m to 1.4m (Km)	Stretch with water depths between 1.5m to 1.7m (Km)	Stretch with water depths between 1.8m to 2.0m (Km)	Stretch with water depths more than 2.0m (Km)
Dibholi to Asai	30.00	0.00	0.00	0.00	0.00

This stretch of Yamuna River starts from Dibholi to Asai. Minimum and Maximum width in this stretch is 65m and 223m, minimum and maximum depth is -0.9m to 4.6m.

BM Pillar YR 60 is established on South East Bank of River at Ch. 482.9km near Dilip Nagar village. At Ch. 484.6km sandchur is present. A Bridge crossing river at Ch. 489.6km going from Lakhna and Bakaewar to Chikanagar and Hamuntpura. At Ch. 491.0km Kachpura village is present.

BM Pillar YR 59 is established on North East Bank of River at Ch. 495.8km at Nadgawa village. At Ch. 502.2km sandchur is present. Bridge is being constructed at Ch. 503.2km.

BM Pillar YR 58 is established on South East Bank of River at Ch. 503.4km near Nibarri kachhar village. Village Chandouli is present at Ch. 506.4km and a road is passing through this village parallel to river towards village Bahuburpur Dhar.

Table 4.41 Water Depth Stretches at Sub Stretch 17 – Ch. 480 km Dibholi to Ch. 510 km Asai

CH. (km)	OBSERVED (m)	REDUCED (m)	CH. (km)	OBSERVED (m)	REDUCED (m)
481	1.2	0.2	496	0.9	0.2
482	0.8	0.2	497	0.7	0.7
483	1.0	0.0	498	1.0	0.1
484	0.3	0.1	499	1.5	0.6
485	0.7	0.4	500	1.3	0.2
486	0.8	0.7	501	0.6	0.1
487	1.5	0.9	502	1.1	0.5
488	1.0	0.5	503	1.3	0.2
489	0.5	-0.2	504	1.3	0.6
490	0.6	0.1	505	1.4	1.0
491	1.0	0.3	506	1.5	0.4
492	2.7	1.2	507	0.9	-0.1
493	2.8	1.2	508	1.2	0.2
494	1.8	0.7	509	1.0	0.5
495	1.6	0.2	510	1.0	0.6

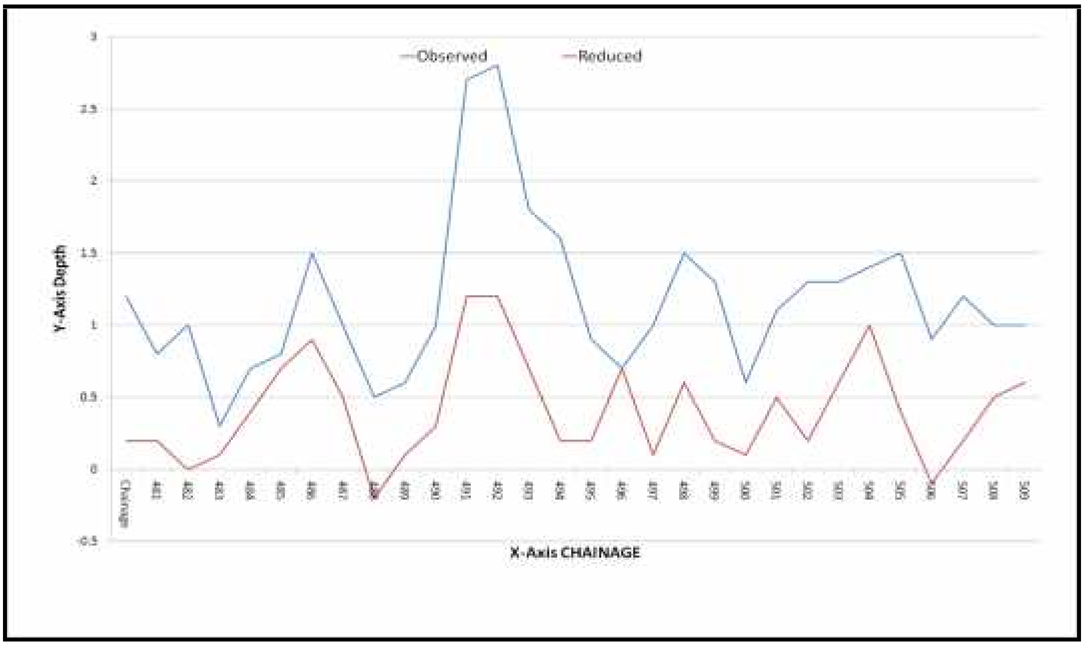


Fig. 4.35 Water Depth Ch. 480 km Dibholi to Ch. 510 km Asai

4.11.3 Sub Stretch – 18 Asai to Pratapher (Ch. 510 km - 540 km)

Fig. 4.36 Google map showing Ch. 510 km Asai to Ch. 540 km Pratapher

Table 4.42 Water Depth Stretches at Sub Stretch 18 – Ch. 510 km Asai to Ch. 540 km Pratapher

Stretch	Stretch with water depths less than 1.2m (Km)	Stretch with water depths between 1.2m to 1.4m (Km)	Stretch with water depths between 1.5m to 1.7m (Km)	Stretch with water depths between 1.8m to 2.0m (Km)	Stretch with water depths more than 2.0m (Km)
Asai to Pratapher	30.00	0.00	0.00	0.00	0.00

This stretch of Yamuna River starts from Asai to Pratapher. Minimum and Maximum width in this stretch is 54m and 227m, minimum and maximum depth is -0.8m to 3.6m.

BM Pillar YR 57 is established on North East Bank of River at Ch. 516.0km at Bigahara Sikandra village. At Ch. 512.2km sandchur is present. Rampura village is at Ch. 515km. Samshan Ghat is present at 516.2km Ch.. High Tension Line is crossing river at Ch. 516.6km with vertical and horizontal clearance of 4.0mand 246.489m. Another High Tension Line is crossing river at Ch. 516.9km with vertical and horizontal clearance of 3.50m and 191.702m. At Ch. 518.6km village Kosanga and Temple is present. Another village Varakhera is present at Ch. 520.0km.
BM Pillar YR 56 is established on South Bank of River at Ch. 527.1km at Khoja Rampur village. At Ch. 527.2km Gwalior-Kanpur bypass highway Bridge present

with horizontal clearance 30m and vertical clearance of 2.121m. At Ch. 527.4km Shamshan ghat is present. Dauoji ghat Etawa is located at 527.9km. At this Ghats 05 nos. of temples are present. Village Sunwara is located at Ch. 529.0km. A temple is present at Ch. 531.0km. Bridge is crossing river at Ch. 531.1km travelling from Etawa town to Bhind Gwalior. Horizontal clearance and vertical clearance of this bridge are 50m and 1.987m C.W.C. office present at Ch. 531.1km. At Ch. 532.6km sandchur is present. At Ch. 534.0km Railway Bridge is crossing river travelling Bhind to Etawah. Horizontal and vertical clearance is 65m and 2.054m.

BM Pillar YR 55 is established on West Bank of River at Ch. 536.3km near Bahuri village. Samshan Ghat is present at Ch. 536.4km.

Table 4.43 Water Depth Stretches at Sub Stretch 18 –
Ch. 510 km Asai to Ch. 540 km Pratapher

CH. (km)	OBSERVED(m)	REDUCED(m)	CH. (km)	OBSERVED(m)	REDUCED(m)
511	1.1	0.5	526	2.3	1.1
512	0.3	-0.3	527	1.2	-0.1
513	0.6	0.0	528	0.5	0.1
514	0.4	0.4	529	0.4	-0.3
515	1.3	0.1	530	0.8	0.4
516	1.2	0.2	531	0.6	-0.1
517	0.9	-0.2	532	1.1	-0.2
518	0.9	-0.1	533	0.1	-0.3
519	0.6	0.0	534	0.9	0.3
520	0.8	0.6	535	1.2	-0.2
521	0.8	0.4	536	0.8	-0.1
522	1.2	0.4	537	1.2	0.2
523	0.8	0.1	538	0.8	0.3
524	0.3	0.3	539	1.6	0.0
525	0.9	0.4	540	1.4	0.7

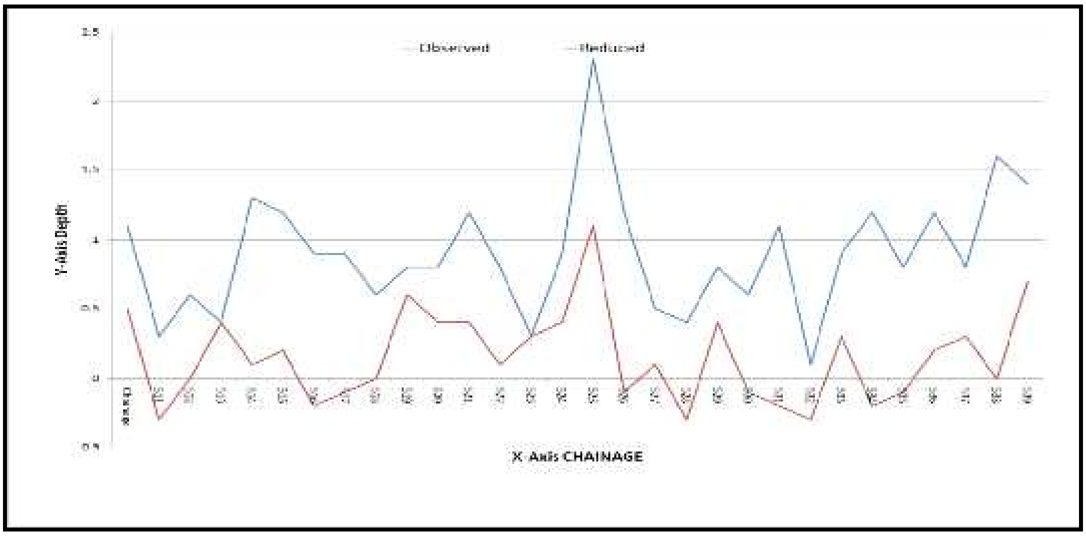


Fig. 4.37 Water Depth Ch. 510 km Asai to Ch. 540 km Pratapher

4.11.4 Sub Stretch – 19 Pratapher to Purabirbal (Ch. 540 km - 570 km)

Fig. 4.38 Google map showing Ch. 540 km Pratapher to Ch. 570 km Purabbirbal

Table 4.44 Water Depth Stretches at Sub Stretch 19 – Ch. 540 km Pratapher to Ch. 570 km Purabbirbal

Stretch	Stretch with water depths less than 1.2m (Km)	Stretch with water depths between 1.2m to 1.4m (Km)	Stretch with water depths between 1.5m to 1.7m (Km)	Stretch with water depths between 1.8m to 2.0m (Km)	Stretch with water depths more than 2.0m (Km)
Pratapher to Purabirbal	30.00	0.00	0.00	0.00	0.00

This stretch of Yamuna River starts from Pratapher to Purabirbal Minimum and Maximum width in this stretch is 68m and 269m, minimum and maximum depth is -0.8m to 10.3m.

BM Pillar YR 54 is established on South Bank of River at Ch. 544.8km at Aswa village. Awa ghat village and a temple are at Ch. 545km. At Ch. 551.8km village Silayata is present. Sandchur is present at Ch. 553.0km 553.8km and 554.4km. Two numbers of temples are present at Ch. 555.2km.

BM Pillar YR 53 is established on South East Bank of River at Ch. 555.8km at Jasohan village. At Ch. 558.6km Bah Jaitpur to Delhi-Kanpur Highway Bridge present with horizontal clearance 29m and vertical clearance of 1.96m. At Ch.

558.8km Kachoura Ghat Village along with 3 Nos. of tramples are present. Ahaira Goan village is located at 559km. Village Guraiya is located at Ch. 564.0km. A sandchur is present at 565.0km.

BM Pillar YR 52 is established on South East Bank of River at Ch. 567.7km near Pachhpura village. Pora Birbal is present at Ch. 570.0km. At Ch. 571.3km Khaniya Bridge is crossing river Bah Jaitpur to Delhi-Kanpur with horizontal clearance of 28.0m and vertical clearance of 2.145 m. At Ch. 573.8km village Sarupur is present. At Ch. 578.1km Sandchur is present.

BM Pillar YR 51 is established on South East Bank of River at Ch. 578.6km at Badaura village.

Table 4.45 Water Depth Stretches at Sub Stretch 19 – Ch. 540 km Prataper to Ch. 570 km Purabbirbal

CH. (km)	OBSERVED(m)	REDUCED(m)	CH. (km)	OBSERVED(m)	REDUCED(m)
541	0.2	-0.3	556	0.7	0.3
542	0.9	-0.1	557	0.4	0.0
543	1.2	0.6	558	1.1	0.7
544	0.6	-0.2	559	0.4	0.0
545	0.3	-0.3	560	0.2	-0.2
546	0.3	0.0	561	1.6	1.1
547	0.6	0.4	562	1.0	0.5
548	0.6	0.3	563	0.3	-0.2
549	0.3	0.0	564	0.9	0.1
550	0.7	0.3	565	0.4	-0.1
551	0.4	0.0	566	2.5	1.7
552	0.5	0.1	567	0.9	0.0
553	0.0	-0.2	568	0.0	-0.3
554	0.7	0.3	569	0.3	-0.3
555	0.2	-0.1	570	0.5	-0.2

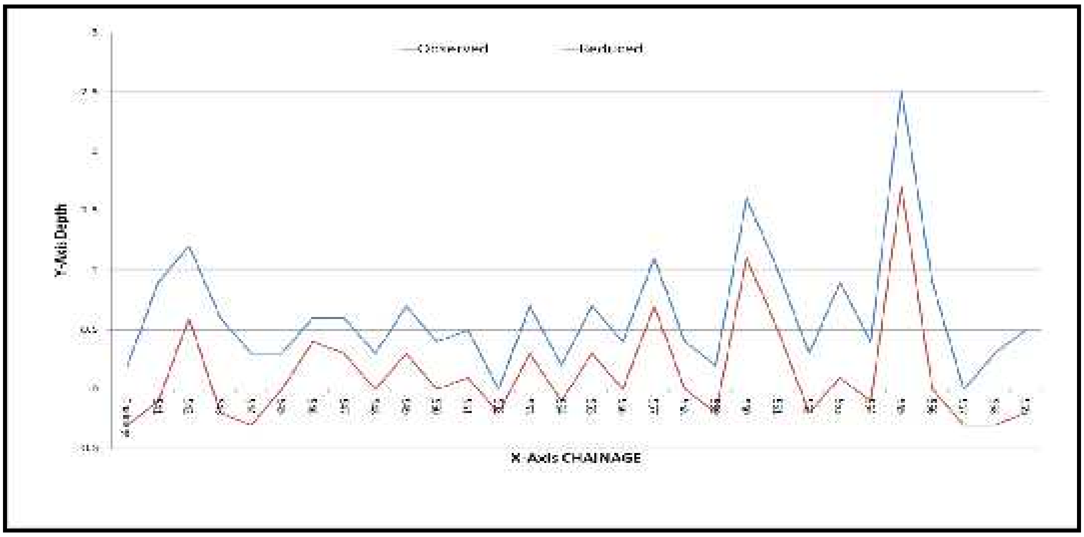


Fig. 4.39 Water Depth Ch. 540 km Prataper to Ch. 570 km Purabbirbal

4.11.5 Sub Stretch – 20 Purabirbal to Sunsar (Ch. 570 km - 600 km)

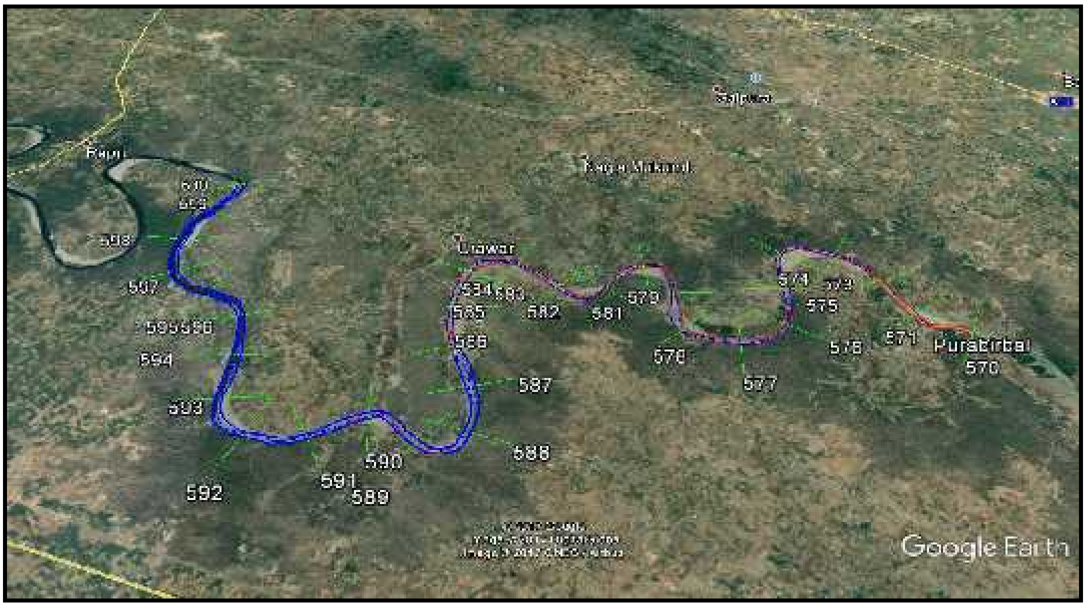


Fig. 4.40 Google map showing Ch. 570 km Purabirbal to Ch. 600 km Sunsar

Table 4.46 Water Depth Stretches at Sub Stretch 20 – Ch. 570 km Purabirbal to Ch. 600 km Sunsar

Stretch	Stretch with water depths less than 1.2m (Km)	Stretch with water depths between 1.2m to 1.4m (Km)	Stretch with water depths between 1.5m to 1.7m (Km)	Stretch with water depths between 1.8m to 2.0m (Km)	Stretch with water depths more than 2.0m (Km)
Purabirbal to Sunsar	30.00	0.00	0.00	0.00	0.00

Third stretch of Yamuna River starts from Prataphер to Purabirbal. Minimum and Maximum width in this stretch is 45m and 343m, minimum and maximum depth is -0.8m to 2.4m.

BM Pillar YR 51 is established on South East Bank of River at Ch. 578.6km at Badaura village. Sandchur is present at Ch. 583.6km and 584.0km. Village Urawar ghat and 2 nos. of temples are present at 584.0km.Sandchur is present at Ch. 584.3km.

This stretch start from Kacchapura to Asraoli Village it include three bridges in that two RCC bridge and one Iron bridge. The starting Ch. 589.517km the river turns right and make the W shape to Ch. 595km it include two bench marks YR 50 at Ch. 586.27 & 49 at Ch. 596.748. The first bridge connects from Urawar to Chandrapura and second bridge connects from Ababakapur to Pharaira.

Water quality in this stretch is very clean and calm. Some Fishing activities were also seen. Lots of migratory birds were also seen due to winter season and availability of fish. In this surrounding area water was there and bathymetric survey had been done. The both side of the river is agricultural land and village no hindrance we got while working in that stretch.

Table 4.47 Water Depth Stretches at Sub Stretch 20 – Ch. 570 km Purabirbal to Ch. 600 km Sunsar

CH. (km)	OBSERVED (m)	REDUCED (m)	CH. (km)	OBSERVED (m)	REDUCED (m)
571	0.1	-0.3	586	0.7	-0.2
572	0.2	-0.1	587	0.2	-0.3
573	0.1	-0.2	588	1.5	0.6
574	0.2	-0.1	589	1.3	1.0
575	0.3	-0.2	590	1.7	0.9
576	1.1	0.1	591	0.9	-0.1
577	0.7	0.0	592	0.6	-0.2
578	0.2	-0.1	593	0.2	-0.1
579	1.1	0.5	594	0.6	0.3
580	0.5	0.2	595	1.0	0.3
581	0.7	-0.1	596	0.5	-0.2
582	0.0	0.0	597	0.4	0.3
583	0.3	-0.2	598	0.5	0.1
584	0.1	0.0	599	1.1	-0.1
585	0.6	0.1	600	1.3	0.0

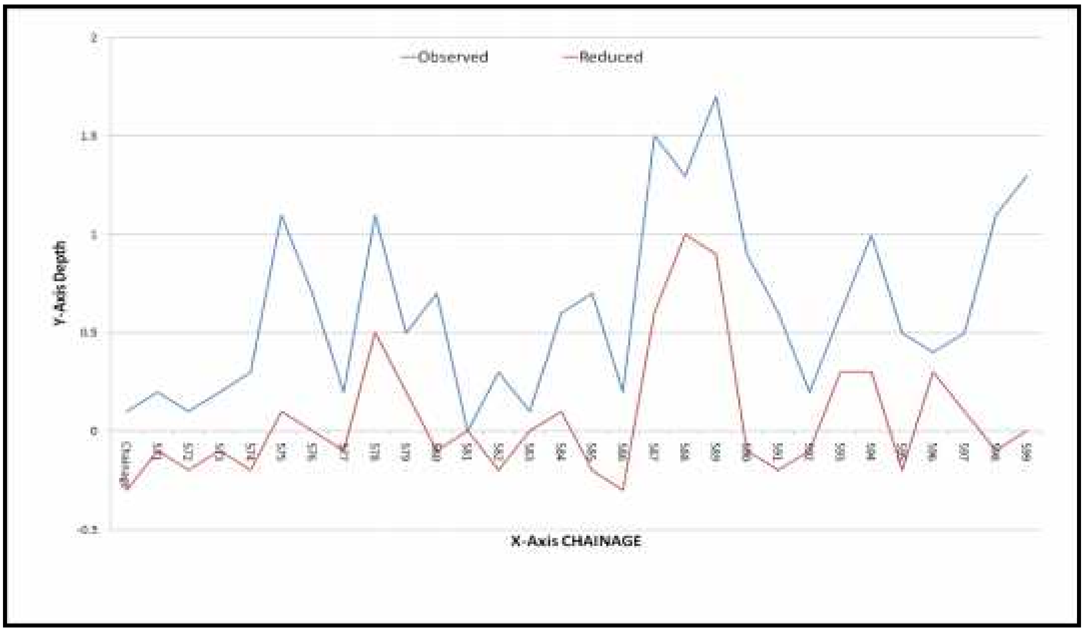


Fig. 4.41 Water Depth Ch. 570 km Purabirbal to Ch. 600 km Sunsar

4.11.6 Sub Stretch – 21 Sunsar to Holipura (Ch. 600 km - 630 km)

Fig. 4.42 Google map showing Ch. 600 km Sunsar to Ch. 630 km Holipura

Table 4.48 Water Depth Stretches at Sub Stretch 21 –
Ch. 600 km Sunsar to Ch. 630 km Holipura

Stretch	Stretch with water depths less than 1.2m (Km)	Stretch with water depths between 1.2m to 1.4m (Km)	Stretch with water depths between 1.5m to 1.7m (Km)	Stretch with water depths between 1.8m to 2.0m (Km)	Stretch with water depths more than 2.0m (Km)
Sunsar to Holipura	30.00	0.00	0.00	0.00	0.00

This stretch start from near Sunar Village, minimum and maximum width in this stretch 108.0mt and 336.7mt, minimum and maximum depth observed are -0.2mt and 5.0mt. Shahzadpur Didauli village is at Ch. 605km on South West Bank. BM Pillar is established at Ch. 605.273km on East Bank. A Temple is at Ch. 611.294km and a Bridge is at Ch. 611.331km connected to Ababakapur to Pharaira. A Police Station is at Ch. 611.350km on South West Bank. A road is connected near the Ch. 611.850km on South West Bank. A temple found at Ch. 612.122km South East Bank. Two Temples is coming in village and one police station near the second bridge from the Ch. is 611.331km near Kalinjar Village.

The Ch. 604 to 607 km eastside whole forest area BM pillar YR-47 is established at Ch. 614.778km at South Bank. Asraoli Village is at Ch. 617.4km on North East Bank.

BM pillar YR – 46 is established at Ch. 625.375km on North Bank. Bateshwar temple is at Ch. 626.84km on East Bank it is a very famous temple and a tourist place also people are visiting the temple throughout the year small boats are available for tourists. Bateshwar Ghat is a RCC Ghat around 450mt length.

Water quality is good, current was very less, fishing activities seen in the stretch. Both the Banks are unprotected except from 626.4 to 626.850km.

This full stretch is dry area, more quality is to be dredged for water way.

Table 4.49 Water Depth Stretches at Sub Stretch 21 – Ch. 600 km Sunsar to Ch. 630 km Holipura

CH. (km)	OBSERVED (m)	REDUCED (m)	CH. (km)	OBSERVED (m)	REDUCED (m)
601	0.4	-0.3	616	0.3	-0.2
602	0.5	0	617	0.4	-0.2
603	0.0	-0.1	618	0.4	0.4
604	0.4	-0.2	619	1.4	1.0
605	0.4	0.1	620	1.1	0.3
606	1.4	0.0	621	1.9	0.9
607	0.8	-0.2	622	0.6	0.0
608	0.5	-0.2	623	0.8	-0.2
609	0.2	0.0	624	0.8	0.1
610	0.0	-0.3	625	0.2	0.1
611	0.7	-0.2	626	1.8	0.2
612	1.5	0.5	627	0.5	0.1
613	0.2	0.0	628	1.0	-0.3
614	0.1	-0.2	629	1.0	0.1
615	0.5	-0.2	630	0.0	-0.3

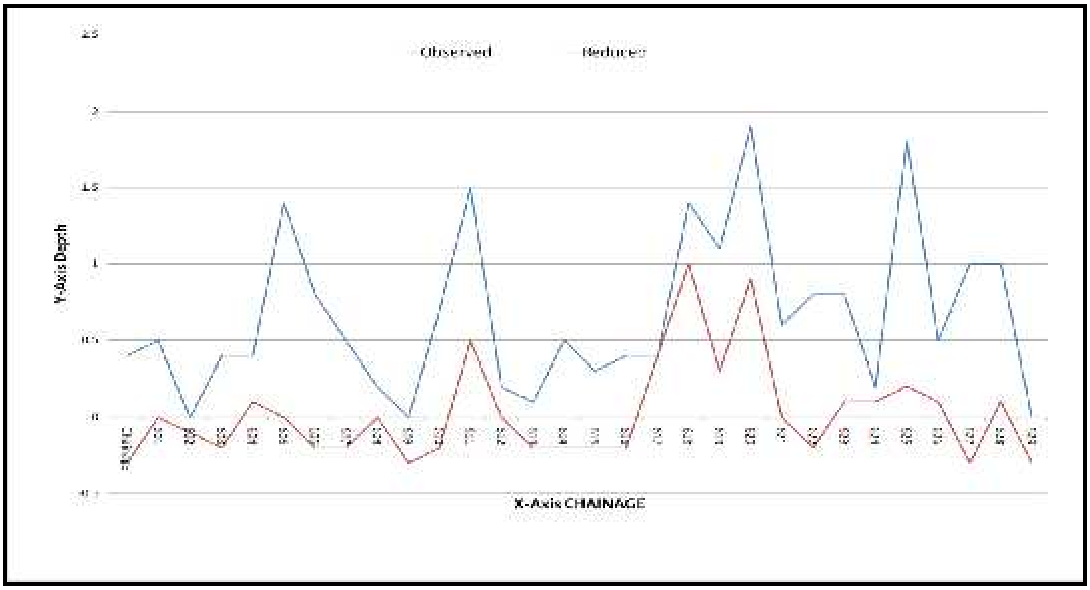


Fig 4.43 Water Depth Ch. 600 km Sunsar to Ch. 630 km Holipura

4.11.7 Sub Stretch – 22 Holipura to Shahidpur (Ch. 630 km - 660 km)

Fig 4.44 Google map showing Ch. 630 km Holipura to Ch. 660 km Shahidpur

Table 4.50 Water Depth Stretches at Sub Stretch 22 –
Ch. 630 km Holipura to Ch. 660 km Shahidpur

Stretch	Stretch with water depths less than 1.2m (Km)	Stretch with water depths between 1.2m to 1.4m (Km)	Stretch with water depths between 1.5m to 1.7m (Km)	Stretch with water depths between 1.8m to 2.0m (Km)	Stretch with water depths more than 2.0m (Km)
Holipura to Shahidpur	30.00	0.00	0.00	0.00	0.00

This stretch starts from Holipura Village, minimum and maximum width in this stretch 62.5mt and 238.3mt, minimum and maximum depth observed are -0.9mt and 1.2mt.

Bitholi village is from the Ch. 630.4km on North South Bank. A Temple is located at the Ch. 635.2km on North East Bank. BM Pillar YR – 45 is established at the Ch. 637.254km on North Bank. A Bridge is at the Ch. of 637.53km it is connected from Abbaspur to Bhitari Village. A temple is from the Ch. 637.8km on North South Bank. High Tension Line (HTL) is at the Ch. 637.90km. A Ch. 643km having a shallow water, Two High Tension Line (HTL) is seen at the Ch. 645.909km and 647.714km.

BM Pillar YR – 44 is established at the Ch. 47.665km on East Bank. A Sikahra Hardaspur village is from the Ch. 648.8km on North East Bank. A RCC Bridge is at Ch. 651.718km is connected from Nagla Rama to Sufipur. High Tension Line (HTL) is at Ch. 651.71km, Luhari Fatehabad village 652km is at West South Bank, another High Tension Line (HTL) is at Ch. 657.369km. BM Pillar is at Ch. 657.757km is at North East Bank.

Water quality is good, current was very less, fishing activities seen in this stretch. Both the banks are unprotected except from 643.00km to 660.00km, this full stretch is dry area. More quality is to be dredged for water ways.

The both side of the river is agricultural land and village no hindrance we got while working in that stretch.

Table 4.51 Water Depth Stretches at Sub Stretch 22 –
Ch. 630 km Holipura to Ch. 660 km Shahidpur

CH. (km)	OBSERVED(m)	REDUCED(m)	CH. (km)	OBSERVED(m)	REDUCED(m)
631	0.7	-0.3	646	0.0	-0.3
632	0.2	-0.3	647	0.0	-0.3
633	0.5	-0.3	648	0.0	-0.3
634	0.7	-0.3	649	0.0	-0.3
635	0.3	-0.3	650	0.0	-0.3
636	0.6	-0.2	651	0.0	-0.3
637	0.5	-0.2	652	0.0	-0.3
638	0.3	-0.3	653	0.0	-0.3
639	1.0	-0.3	654	0.0	-0.3
640	0.8	-0.3	655	0.0	-0.3
641	0.3	-0.3	656	0.0	-0.3
642	0.3	-0.3	657	0.0	-0.3
643	0.1	-0.3	658	0.0	-0.3
644	0.0	-0.3	659	0.0	-0.3
645	0.0	-0.3	660	0.0	-0.3

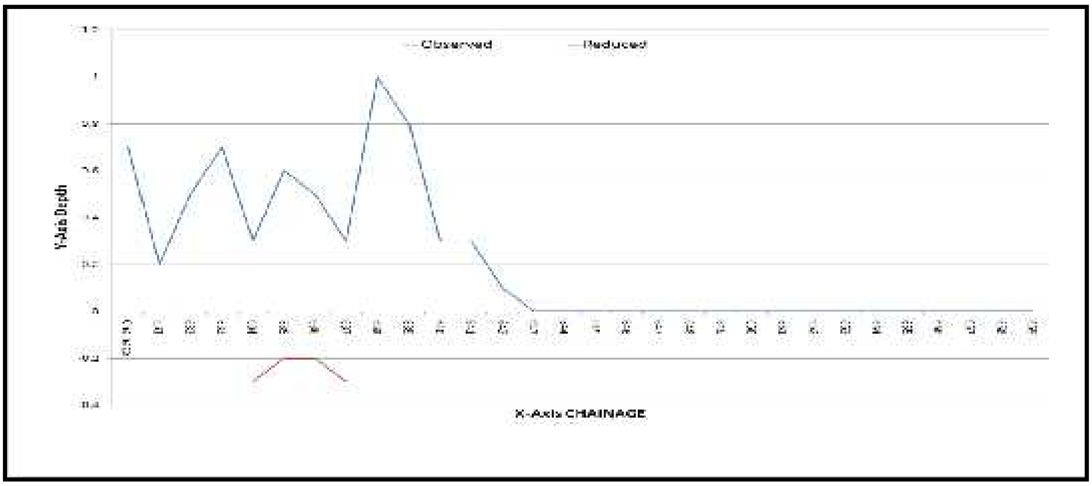


Fig. 4.45 Water Depth Ch. 630 km Holipura to Ch. 660 km Shahidpur

4.11.8 Sub Stretch – 23 Shahidpur to Dhirpur (Ch. 660 km - 690 km)

Fig. 4.46 Google map showing Ch. 600 km Shahidpur to Ch. 690 km Dhirpur

Table 4.52 Water Depth Stretches at Sub Stretch 23 – Ch. 600 km Shahidpur to Ch. 690 km Dhirpur

Stretch	Stretch with water depths less than 1.2m (Km)	Stretch with water depths between 1.2m to 1.4m (Km)	Stretch with water depths between 1.5m to 1.7m (Km)	Stretch with water depths between 1.8m to 2.0m (Km)	Stretch with water depths more than 2.0m (Km)
Shahidpur to Dhirpur	30.00	0.00	0.00	0.00	0.00

This stretch start from Shahidpur Village, minimum and maximum width in this stretch 68.928mt and 468.497mt, minimum and maximum depth is not observed in this stretch. A bridge is at Ch. 660.148km its connectivity from Firozapur Railway Station to Shivaji Nagar Village. A Shankar village is from the Ch. 663.56km on North Bank. A road is connected at the Ch. 663.48km on South Bank, Yaie village is situated at the situated at the Ch. 665.315km on South East Bank.

BM Pillar YR-42 is established at Ch. 667.355km on South Bank. A temple is located at the Ch. 667.8km on South West Bank. A road is connected near the Ch. 668.102km on North East Bank, one more road is connected at the Ch. 673.8km on South East Bank. A Village Usmanpur is located at the Ch. 674.754km on South East Bank.

BM Pillar YR – 41 is established at Ch. 677.421km on North Bank. A road is connected at the Ch. 677.884km on South West Bank. A bridge is from the Ch.

679.576km is connected from Indon Village to Chandvar one more road is connected at the Ch. 683.372km on the North Bank. BM Pillar YR – 40 is established at the Ch. 686.63km on North Bank. A road is connected from the Ch. 687.384km on East Bank. Water quality is good, current was very less, fishing activities not seen in this stretch. Both the banks are total unprotected. This full stretch is dry area, more quality is to be dredged from waterways.

The both side of the river is agricultural land and village no hindrance we got while working in that stretch.

Table 4.53 Water Depth Stretches at Sub Stretch 23 – Ch. 600 km Shahidpur to Ch. 690 km Dhirpur

CH. (km)	OBSERVED (m)	REDUCED (m)	CH. (km)	OBSERVED (m)	REDUCED (m)
661	0.0	-0.3	676	0.0	-0.1
662	0.0	-0.3	677	0.0	-0.1
663	0.0	-0.3	678	0.0	-0.2
664	0.0	-0.3	679	0.0	-0.2
665	0.0	-0.3	680	0.0	-0.3
666	0.0	-0.3	681	0.0	-0.3
667	0.0	-0.3	682	0.0	-0.3
668	0.0	-0.3	683	0.0	-0.3
669	0.0	-0.3	684	0.0	-0.3
670	0.0	-0.1	685	0.0	-0.3
671	0.0	-0.2	686	0.0	-0.3
672	0.0	-0.3	687	0.0	-0.3
673	0.0	-0.3	688	0.0	-0.3
674	0.0	-0.3	689	0.0	-0.3
675	0.0	-0.2	690	0.0	-0.2

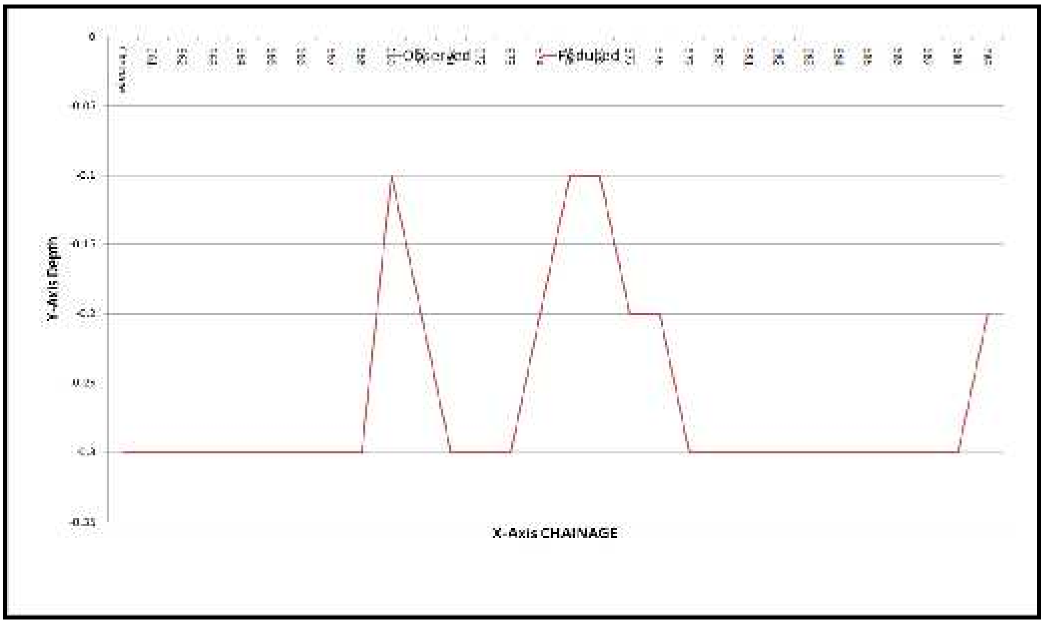


Fig. 4.47 Water Depth Ch. 600 km Shahidpur to Ch. 690 km Dhirpur

4.11.9 Sub Stretch – 24 Dhirpur to Barauli Gujar (Ch. 690 km - 720 km)

Fig. 4.48 Google map showing Ch. 690 km Dhirpur to Ch. 720 km Barauli Gujar

Table 4.54 Water Depth Stretches at Sub Stretch 24 – Ch. 690 km Dhirpur to Ch. 720 km Barauli Gujar

Stretch	Stretch with water depths less than 1.2m (Km)	Stretch with water depths between 1.2m to 1.4m (Km)	Stretch with water depths between 1.5m to 1.7m (Km)	Stretch with water depths between 1.8m to 2.0m (Km)	Stretch with water depths more than 2.0m (Km)
Dhirpur to Barauli Gujar	30.00	0.00	0.00	0.00	0.00

This stretch start from KurrikupaVillage, minimum and maximum width in this stretch 64.096mt and 972.595mt, minimum and maximum depth observed is -0.4mt and 3.3mt.

BM Pillar YR – 39 is established from the Ch. 697.668km on West Bank. Road connectivity is from the Ch. 697.668km on West South Bank, one more road is connected from the Ch. 703.559.

BM Pillar YR – 38 is established at the Ch. 706.722km on South East Bank. A bridge is at the Ch. 708.705km is connected from Bhikanpur Bhanjhera village to Agra Fatehabad road on South Bank. A Mawali Kalan village is at the Ch. 712.394km on West South Bank.

BM Pillar YR – 37 is established at the Ch. 716.495km on West Bank.

Water quality is good, current was very less, fishing activities not seen in this stretch. Both the banks are total unprotected. This full stretch is dry area; more quality is to be dredged from water ways

In all stretch contains water and bathymetric survey and topographic survey has been done.

The both side of the river is agricultural land and village no hindrance we got while working in that stretch.

Table 4.55 Water Depth Stretches at Sub Stretch 24- Ch. 690 km Dhirpur to Ch. 720 km Barauli Gujar

CH. (km)	OBSERVED (m)	REDUCED (m)	CH. (km)	OBSERVED (m)	REDUCED (m)
691	0.0	-0.2	706	1.4	0.4
692	0.0	-0.3	707	0.7	0.1
693	0.0	-0.3	708	0.8	0.2
694	0.0	-0.3	709	1.1	0.4
695	0.0	-0.3	710	1.2	0.7
696	0.0	-0.3	711	0.3	-0.2
697	0.0	-0.3	712	0.8	0.2
698	0.0	-0.3	713	0.5	0.4
699	0.0	-0.3	714	0.9	0.4
700	0.0	0.0	715	0.6	0.2
701	0.0	-0.3	716	0.7	-0.1
702	0.2	-0.3	717	0.5	0.4
703	0.6	-0.1	718	0.1	-0.3
704	1.3	0.9	719	0.6	-0.3
705	2.0	0.9	720	1.9	1.4

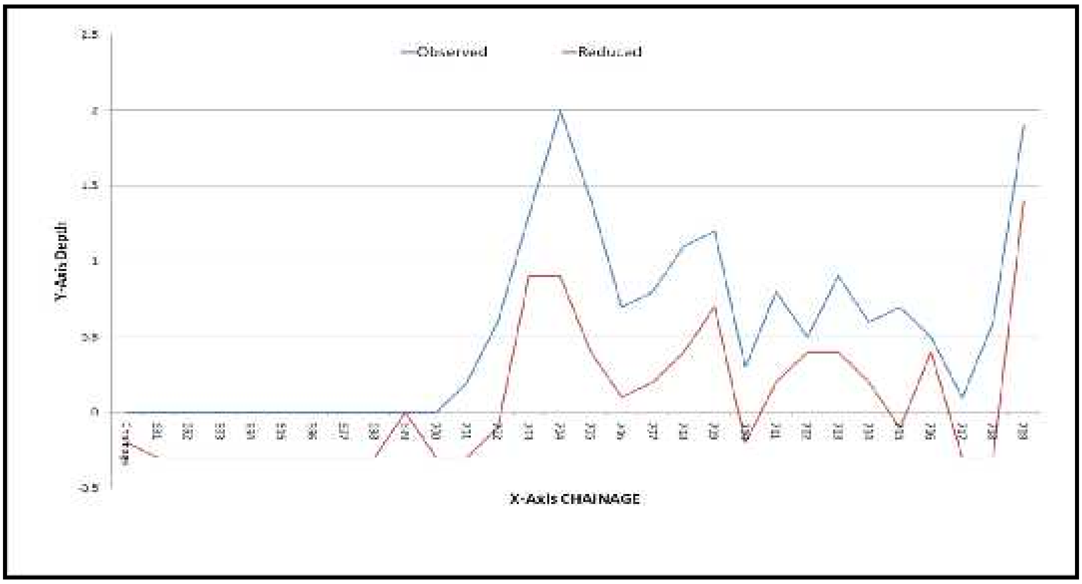


Fig. 4.49 Water Depth Ch. 690 km Dhirpur to Ch. 720 km Barauli Gujar

4.11.10 Sub Stretch – 25 Barauli Gujar to Madanpur (Ch. 720 km - 743 km)

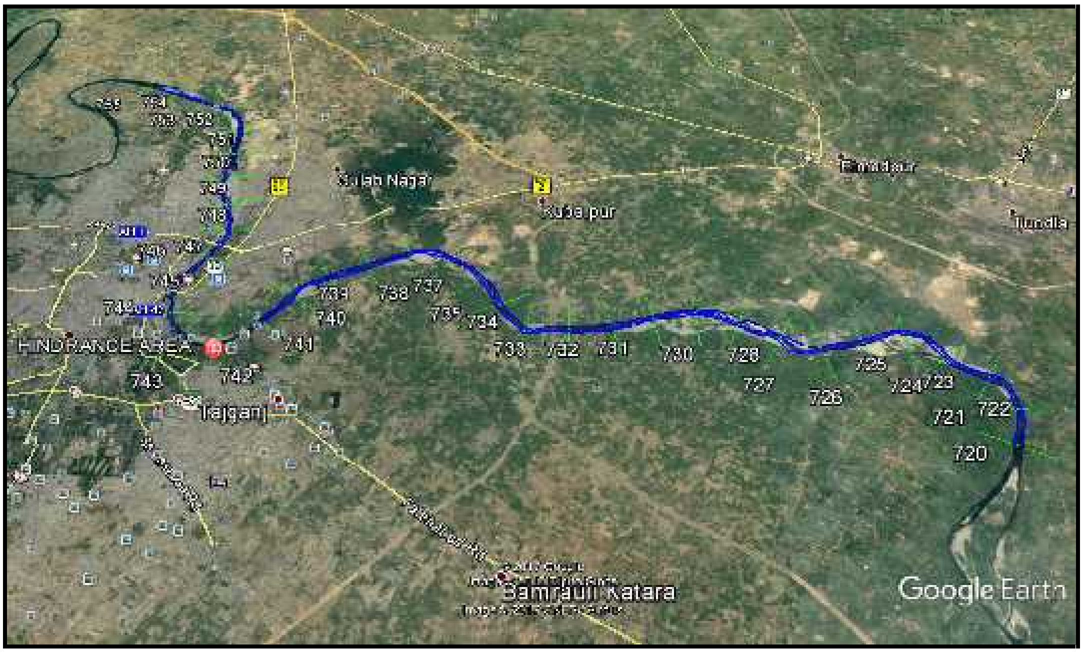


Fig. 4.50 Google map showing Ch. 720 km Barauli Gujar to Ch. 743 km Madanpur

Table 4.56 Water Depth Stretches at Sub Stretch 25 – Ch. 720 km Barauli Gujar to Ch. 743 km Madanpur

Stretch	Stretch with water depths less than 1.2m (Km)	Stretch with water depths between 1.2m to 1.4m (Km)	Stretch with water depths between 1.5m to 1.7m (Km)	Stretch with water depths between 1.8m to 2.0m (Km)	Stretch with water depths more than 2.0m (Km)
Barauli Gujar to Madanpur	23.00	0.00	0.00	0.00	0.00

This stretch starts from Rasulabad village, minimum and maximum width in this stretch 90.045mt and 344.807mt, minimum and maximum depth observed are 0.5mt and 4.9mt. BM Pillar YR – 36 is established at the Ch. 726.385km on South Bank. A Samogar Mustkil at the Ch. 703.584km on the South Bank A pontoon bridge from the Ch. 731.25km, two high tension line (HTL) at the Ch. 731.507km and 731.65km, one bridge is connected at the Ch. 732.36km from Kuberpur to Kondol. Rahan Kalan village is at the Ch. 735.473km is North East Bank. BM Pillar YR – 35 established from the Ch. 738.115km on South Bank, one road is connected at the Ch. 739.00km on North West Bank; one more road is connected at the Ch. 740.62km on South East Bank.

From pillar 34 the river turns to its left and makes u shape. Two railway bridges were observed crossing the Yamuna River within one km stretch while coming downstream from pillar 34. Yamuna bridge railway station is present on the left bank of the river at a distance of 805 m from the river bank. Agra fort is present on the right bank of the river at a distance of 905 m from the river bank. The river slightly turns to its left while coming downstream of the river.

Tajmahal is present on the right bank of river Yamuna. Tajmahal covers 1.2 km of the area of river Yamuna where topography and hydrographic survey was not allowed to execute by the authorities. That's why that area is not covered by the surveyors as we didn't have permission of survey in that area. While going down stream of the river near the right bank, green grass and trees are observed. At distance of 523 m from the river bank Taj protected forest is present which falls under area of Tajganj, Agra is. Further downstream of the river at a distance of 2333 m from Tajmahal the river slightly turns to its right.

The stretch near the Tajmahal is still in pending due to security clearance. The permission for the same was not granted by the admin authority. Same was conveyed to the IWAI and same is still in pending.

Table 4.57 Water Depth Stretches at Sub Stretch 25 – Ch. 720 km Barauli Gujar to Ch. 743 km Madanpur

Ch. (km)	Observed(m)	Reduced(m)
720	1.9	1.4
721	1.0	0.8
722	1.5	0.9
723	0.9	0.2
724	1.0	0.1
725	1.2	-0.1
726	1.2	-0.1
727	0.1	-0.3
728	0.0	-0.3
729	0.4	0.1
730	0.5	0.4
731	0.6	-0.2
732	2.0	0.6
733	0.7	-0.1
734	0.8	0.3
735	0.3	-0.3
736	1.3	0.0
737	0.0	0.0
738	0.9	0.9
739	0.8	0.8
740	0.6	0.6
741	1.6	1.5

4.12 Waterway description for Stretch-4 (Agra to Delhi)

4.12.1 Sub Stretch – 26 Agra Tajmahal to Baipur Ehtmali (Ch. 743km to 768km)

Fig. 4.51 Google map showing Ch. 743 km to Ch. 755 km

Fig. 4.52 Google map showing Ch. 755 km to Ch. 768 km

Coming downstream of the river from piller 34 the river turns to its left and makes u shape. Two railway bridges were observed crossing the Yamuna River within one km stretch while coming downstream from piller 34.

Yamuna bridge railway station is present on the left bank of the river at a distance of 805 m from the river bank. Agra fort is present on the right bank of the river at a distance of 905 m from the river bank. The river slightly turns to its left while coming downstream of the river.

Tajmahal is present on the right bank of river Yamuna. Tajmahal covers 1.2 km of the area of river Yamuna where topography and hydrography was not allowed to execute by the authorities. That's why that area is not covered by the surveyors as we didn't have permission of survey in that area.

While going down stream of the river near the right bank, green grass and trees are observed. At distance of 523 m from the river bank Taj protected forest is present which falls under area of Tajganj, Agra is. Further downstream of the river at a distance of 2333 m from tajmahal the river slightly turns to its right.

Width of this stretch varies from 150.00 mtr to 250.00 mtr. This down stream of Yamuna stretch from Agra to Delhi starts from Agra Tajmahal. Due to presence of highly populated city area all garbages and drainage water is dumped in river.

BM piller YR 34 is established at ch. 746.698 km in Radha Ranichi Bagichi area. Poiya ghat and shamshan bhumi is in West Bank at ch. 752.552 Km., from Poiya Ghat to main road a large area is known as Dayal Bagh of Radha Swami Satsang. People are coming for picnic and recreational purpose at Poiya Ghat. A small portion of land is being used for agriculture from ch. 750.192 to 767.692 Km. A sanchur is formed between ch. 763.282 to 763.482 km.

Between Ch. 758.492 to 760.492 km. and 762.892 to 766.492km Forest land is observed and agricultural land is between Ch. 762.292 to 766.492 km. Nagla Chatura Ghat is at Ch. 764.692km and Ferry service is going on with the help of boats without engine.

People are using this service only to cross the river with Motorbike to avoid long distance travelling through road. Some fishing activities were seen in this stretch. Water quality is not good and also Current observed is very less. Both the Banks of river stretch are unprotected. No obstruction found in this stretch for navigation.

Table 4.58 Water Depth Stretches at Sub Stretch 26 – Ch. 743 km Taj Mahal to Ch. 768 km Baipur Ethmali

Stretch	Stretch with water depths less than 1.2m (Km)	Stretch with water depths between 1.2m to 1.4m (Km)	Stretch with water depths between 1.5m to 1.7m (Km)	Stretch with water depths between 1.8m to 2.0m (Km)	Stretch with water depths more than 2.0m (Km)
Tajmahal to Baipur Ehtmoli	21.10	1.20	1.40	0.65	0.65

Table 4.59 Observed and reduced Bed Profile of the Stretches at Sub Stretch- Ch. 743 km Taj Mahal to Ch. 768 km Baipur Ethmali

CH (km)	OBSERVED (m)	REDUCED (m)
743	1.8	1.8
744	1.4	1.4
745	1.6	1.7
746	1.0	1.0
747	1.0	1.2
748	0.8	0.9
749	0.4	0.4
750	0.5	0.6
751	1.1	1.3
752	0.3	0.3
753	0.7	0.9
754	0.7	0.7
755	0.4	0.4
756	1.4	1.6
757	0.7	0.9
758	1.2	1.3
759	0.8	0.9
760	1.0	1.3
761	1.6	1.9
762	0.9	1.0
763	0.7	0.9
764	1.0	1.1
765	1.4	1.5
766	0.7	0.8
767	0.7	0.8
768	0.7	0.8

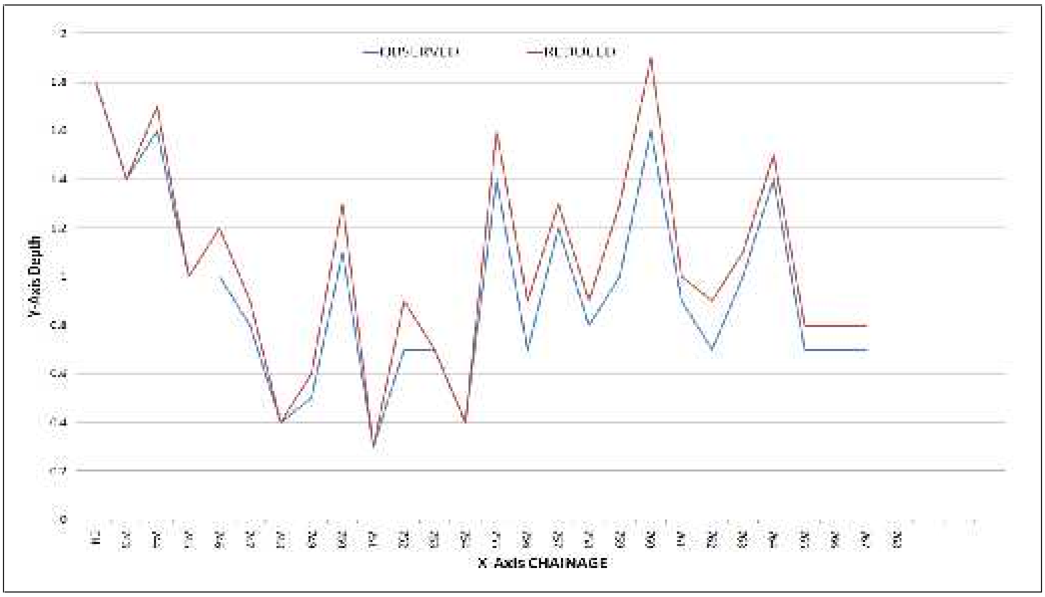


Fig. 4.53 Water Depth Ch. 743 km Taj Mahal to Ch. 768 km Baipur Ethmali

4.12.2 Sub Stretch 27 - Baipur Ehtmali to Kanora Khadar (Ch. 768 km to 793 km)

Fig. 4.54 Google map showing Ch. 768 km Baipur Ethmali to Ch. 793 km Kanora Khadar

Width of this stretch varies from 170.00m to 280.00m with Minimum and Maximum depth is found 0.8 m and 3.7 m during survey period.

A Temple is found on East Bank at Ch. 772.227Km.There is Ram Lal Ashram at Ch. 780.518 Km. a Shamshan Ghat is found at Ch. 781.016Km on East Bank of River. Kailash Temple is at Ch. 781.245 km on East Bank.

It is very famous temple and has become a Tourist Place known as Kailash Gram. Throughout the year people visit this place. A bridge is found at Ch. 781.592km connecting Highway to Dauji via Kailash Gram with horizontal clearance 27.0 mtr and vertical clearance 1.50 mtr.

Sanchur are formed at Ch. from 786.872 to 787.672Km. Bhura Mahadev Temple is at Ch. 783.418Km. Mahipai Khadar village is at Ch. 786.337Km on West Bank. Agriculture land is found on most of the stretch on West Bank.

A bridge is connected from Agra-Mathura highway to Akbara and going to Nera village with horizontal clearance 27.00 mtr and vertical clearance 1.20 mtr at Ch. 789.985Km. Fishing activities found in this stretch by using small dingy boats.

Both the banks are unprotected. Water quality is not good and also Current is very less. No obstruction for Navigation is found in this stretch.

Table 4.60 Water Depth Stretches at Sub Stretch 27 –

Ch. 768 km Baipur Ethmali to Ch. 793 km Kanora Khadar

Stretch	Stretch with water depths less than 1.2m (Km)	Stretch with water depths between 1.2m to 1.4m (Km)	Stretch with water depths between 1.5m to 1.7m (Km)	Stretch with water depths between 1.8m to 2.0m (Km)	Stretch with water depths more than 2.0m (Km)
Baipur Ehtmali to Kanora Khadar	17.10	3.50	1.80	1.70	0.90

Table 4.61 Observed and reduced Bed Profile of the stretch 27 -

Ch. 768 km Baipur Ethmali to Ch. 793 km Kanora khadar

CH (km)	OBSERVED (m)	REDUCED (m)	CH (km)	OBSERVED (m)	REDUCED (m)
768	0.7	0.8	781	1.0	1.3
769	0.8	1.0	782	0.7	0.9
770	1.2	1.3	783	0.7	0.8
771	0.7	0.9	784	0.8	0.9
772	0.7	0.8	785	0.7	0.8
773	2.4	2.6	786	0.7	0.7
774	1.3	1.6	787	0.7	0.8
775	1.7	2.1	788	0.9	1.0
776	0.9	1.2	789	0.6	0.6
777	0.9	1.2	790	0.7	0.8
778	0.7	1.1	791	0.7	0.8
779	0.9	1.2	792	0.7	0.8
780	1.7	1.8	793	0.9	1.2

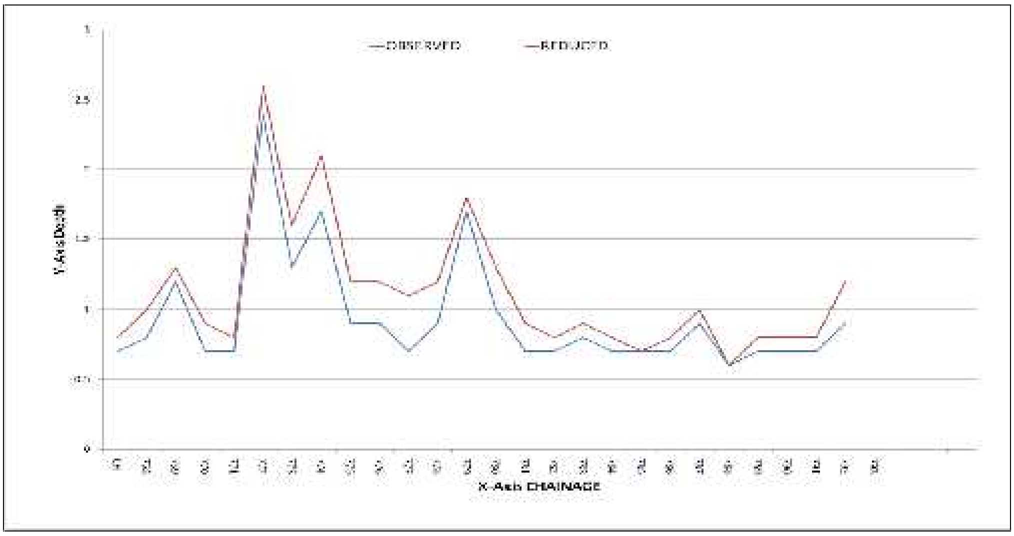


Fig. 4.55 Water Depth Ch. 768 km Baipur Ethamali to Ch. 793 km Kanora Khadar

4.12.3 Sub Stretch 28 - Kanora Khadar to Lahrauli Khadar (Ch. 793 km to 818 km)

Fig. 4.56 Google map showing Ch. 793 km Kanora Khadar to Ch. 818 km Lahrauli Khadar

Width of this stretch varies from 164.00 mtr to 260.00 mtr. The Minimum and Maximum depth found in this stretch 0.7 mtr and 5.2 mtr during the survey.

An approach road is connecting to main road at Ch. 794.122Km. Gujar Mangrol Ghat is a near Ch. 794.042Km and Ferry Service is operating for crossing river with help of without engine boat. Sanchur are formed at Ch. 800.118 km. Chewan Rishi Ashram Temple situated at Ch. 798.417 km.

Forest starts from Ch. 799.107 to 800.492 km. Neel Gay were seen in this forest. Bear Park Forest in the North Bank at Ch. 802.489 Km. Renuka Ghat is present near the Ch. 801.792 km on south Bank. People visit this ghat to take holy Bath. Surdas Ashram is at Ch. 802.192 Km near the Kitam lake of Renuka Village. Kitam Lake ends at Ch. 803.792Km. Sanchur are formed at Ch. 806.892 to 807.042Km. Bear Park building is present at Ch. 803.892Km on West Bank.

There are two good road connectivity in this stretch. Kanjaulijar to Rapura Jar Bridge is present at Ch. 809.336Km with horizontal clearance 27.00 and vertical clearance 1.30, another Churmura Bridge going to Dauji with horizontal clearance 27.00 and vertical clearance 1.40 at Ch. 812.485Km. Both the Bridges are connected to Agra-Mathura highway. Sanchur are formed at Ch. 815.342 Km to 815.457 Km. Non agriculture land found between Ch. 815.092 Km. to 815.292Km on West Bank.

Some fishing activities are found in this stretch. Maximum portion of this stretch is of shallow depth. Both the Banks are unprotected. Current is very less due to Gokul Barrage. Water quality is not good. No obstruction found in this stretch.

Table 4.62 Water Depth Stretches at Sub Stretch
Ch. 793 Kanora Khadar to Ch. 818 km Lahrauli Khadar

Stretch	Stretch with water depths less than 1.2m (Km)	Stretch with water depths between 1.2m to 1.4m (Km)	Stretch with water depths between 1.5m to 1.7m (Km)	Stretch with water depths between 1.8m to 2.0m (Km)	Stretch with water depths more than 2.0m (Km)
Kanora Khadar to Lahrauli Khadar	11.20	9.60	1.50	1.30	1.40

Table 4.63 Observed and reduced Bed Profile of the stretch 28 –
Ch. 793 Kanora Khadar to Ch. 818 km Lahrauli Khadar

CH (km)	OBSERVED (m)	REDUCED (m)	CH (km)	OBSERVED (m)	REDUCED (m)
793	0.9	1.2	806	0.7	1.1
794	1.2	1.6	807	1.2	1.4
795	0.7	1.1	808	0.8	1.2
796	0.9	1.1	809	0.7	1.1
797	1.1	1.4	810	0.7	1.1
798	3.2	3.6	811	0.7	1.1
799	0.5	0.7	812	0.4	0.6
800	1.3	1.6	813	0.8	1.0
801	0.9	1.2	814	0.9	1.1
802	0.5	0.8	815	0.3	0.5
803	1.2	1.5	816	0.5	0.6
804	0.7	1.0	817	0.1	0.2
805	0.8	1.3	818	0.7	0.9

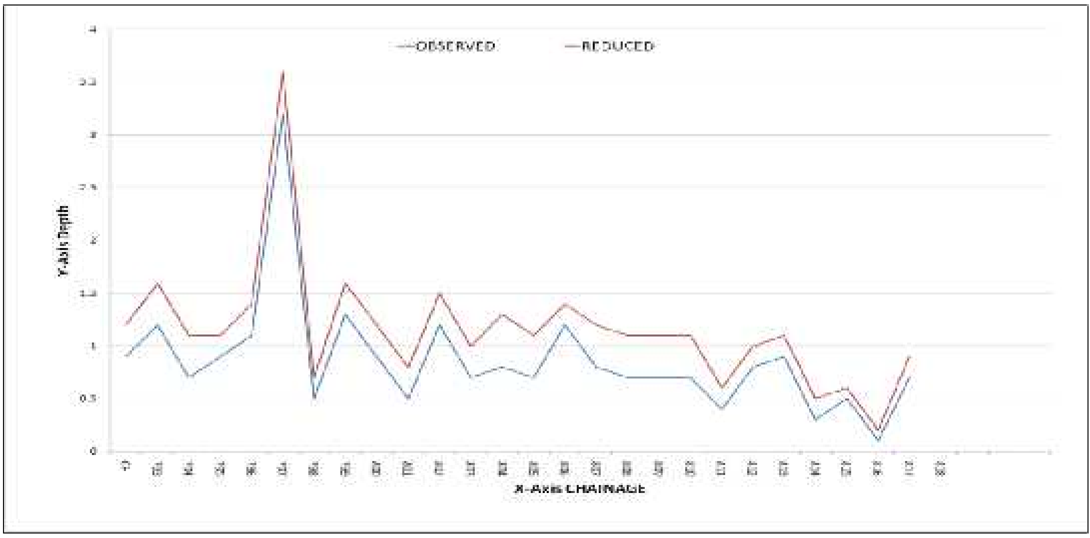


Fig. 4.57 Water Depth Ch. 793 km Kanora Khadar to Ch. 818 km Lahrauli Khadar

4.12.4 Sub Stretch 29 - Lahrauli Khadar to Gokul Barrage (Ch. 818 km to 843 km)

Fig. 4.58 Google map showing Ch. 818 km Lahrauli Khadar to Ch.843 km Gokul Barrage

Width of this stretch varies from 162.00 mtr to 474.00 mtr. The Minimum and Maximum depth found -0.30 mtr & 5.50 mtr during the survey.

Sanchur are formed at Ch. 818.092 km, 818.892 km to 820.692 km, 824.892 km to 825.492 km, 838.972 km to 839.392km. Steep cut edge found near Ch. 821.992km. Forest starts at Ch. 822.492 km. Birds are observed due to presence of fish in this area. A steep cut wall found between the Ch. 830.892 to 831.102 km. Shamshan Ghat is found near the Ch. 830.692km. A single road is connecting to Highway Agra to Delhi. HPCL high pressure line is running near the Ch. 832.692km. Sanchur is formed between Ch. 832.892 and 836.892 km. Temples are situated at Ch. 834.792km and 836.792 km. Brahand Ghat and Boat club are at Ch. 836.692km on East Bank. Road is connected near Brahand Ghat from Gokul Side. High Tension Line is crossing at Ch. 838.082km with 4.00 mtr vertical clearance. A steep cut wall found at Ch. 839.002 km on South Bank. Pistia straliotes (Jal Kumbhi) was spread near the Ch. 839.692 km. Koile Ghat and Rifinery Pump House Bridge are very close to Ch. 839.692km. This Ghat is known for the place from where Shri Vasudev Ji crossed the Yamuna River with Srikrishna from Mathura to Gokul. Visitors at the Temple and Ghat, take Holy bath in Yamuna River especially on Sunday. Shamshan Ghat is at Ch. 839.992km on West Bank. One Temple is present at Ch. 840.392. Baldev Ghat is on East Bank. Sanchur formed at Ch. 840.612 km, 842.292 to 842.692km. A protected wall was found of 160.878mtr length at Ch. 841.032Km. Yasoda Ghat is at Ch. 841.612 on East Bank. Gokul Barrage is at Ch. 842.192km connecting from Mathura to Gokul. Fishing activities are observed some places. Both the Banks are unprotected. Water quality is not good even then people are observed taking bath. Current is very less due to Gokul Barrage.

Table 4.64 Water Depth Stretches at Sub Stretch 29 –
Ch. 818 km Lahrauli Khadar to Ch. 843 km Gokul Barrage

Stretch	Stretch with water depths less than 1.2m (Km)	Stretch with water depths between 1.2m to 1.4m (Km)	Stretch with water depths between 1.5m to 1.7m (Km)	Stretch with water depths between 1.8m to 2.0m (Km)	Stretch with water depths more than 2.0m (Km)
Lahrauli Khadar to Gokul Barrage	21.90	0.70	0.90	1.10	0.40

Table 4.65 Observed and reduced Bed Profile of Sub Stretch 29 –
Ch. 818 km Lahrauli Khadar to Ch. 843 km Gokul Barrage

CH (km)	OBSERVED (m)	REDUCED (m)	CH (km)	OBSERVED (m)	REDUCED (m)
818	0.7	0.9	831	0.9	0.8
819	0.7	0.7	832	1.0	0.8
820	0.3	0.4	833	0.7	0.5
821	0.3	0.5	834	0.7	0.6
822	0.8	1.0	835	0.7	0.4
823	1.6	1.5	836	0.6	0.4
824	1.0	1.1	837	1.5	1.2
825	0.9	0.8	838	0.8	0.5
826	0.8	0.6	839	0.8	0.5
827	0.6	0.6	840	0.9	0.6
828	0.6	0.6	841	0.9	0.6
829	0.7	0.6	842	1.5	1.3
830	1.5	1.6	843	3.7	3.7

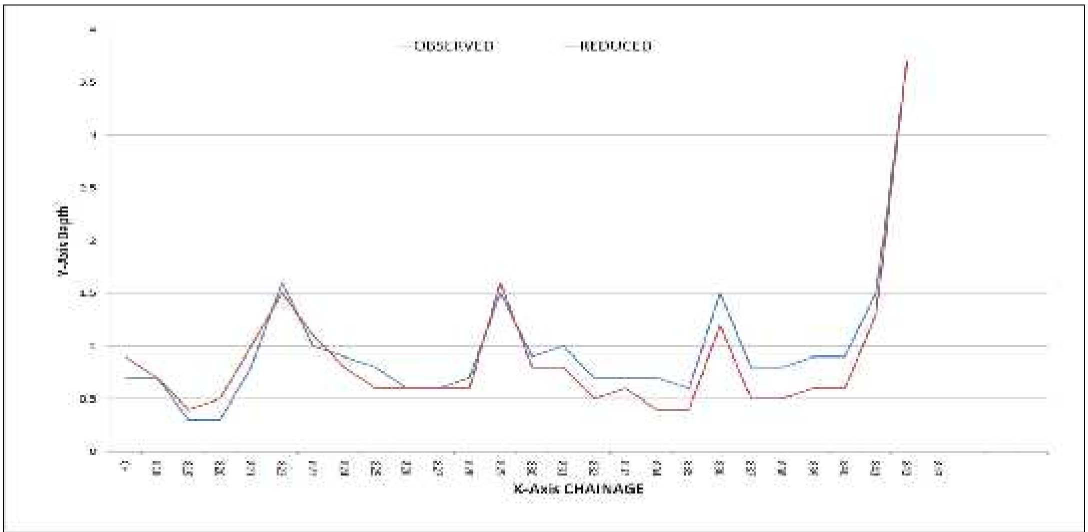


Fig. 4.59 Water Depth Ch. 818 km Lahrauli Khadar to Ch. 843 km Gokul Barrage

4.12.5 Sub Stretch – 30 CH - 843 to CH - 868 Km (Gokul Barrage to Murshidpur)

Fig. 4.60 Google map showing Ch. 843 km Gokul Barrage to Ch. 868 km Murshidpur

Width of this stretch varies from 75.00 mtr to 341.00 mtr with Minimum & Maximum depths are 0.70 mtr and 10.10 mtr. A High Tension Line is crossing at Ch. 843.184 km with 04mtr Vertical clearance. Sanchur are formed at Ch. from 842.692 km to 843.436 km, 844.995km to 848.692km, 848.853 km, 851.115km to 851.327km, 851.692km to 852.427km, 852.534 km to 852.810km, 853.810 km to 854.001 km, 855.862km to 857.583km, 860.573 to 860.806 km. This is a ponding area. Water is stored by Irrigation Department and is being used for agricultural land. There is as big sanchur formed near the Gokul Barrage and made two streams. On the sanchur lot of grass, Jal Kumbhi and some small trees are grown up. Some farmers are cultivating vegetation in summer season on sanchur. A Bund of 758 mtr length has been made by stone pitching on West Bank from Gokul Barrage. New Krishnapuri Bridge is under construction at Ch. 849.462 km with horizontal clearance 39.50mtr and vertical clearance 1.40 mtr, alongside Old Krishnapuri Bridge at Ch. 849.527 km with horizontal clearance 39.50mtr and vertical clearance 1.5 mtr. Bridge is connecting from Mathura to Raya. High Tension Line crossing at Ch. 849.490 km with vertical clearance 4.5mtr.Railway Bridge crossing at Ch. 850.104km with horizontal clearance 26mtr and vertical clearance 1.10mtr. Radhey Ashram is at Ch. 850.134 km on South-West Bank, Vishram Ghat at 850.692 km, Yamuna Ghat at Mathura at Ch. 850.890km, and Shamshan Bhumi at Ch. 851.302 km on East Bank. Near the B M Pillar YR-24Big Peepal Tree is present in front of Gau Ghat & B M Pillar YR-23 at Ch. 859.411Km. Vrindavan to Panigaon Bridge is at Ch. 858.632 km. A High Tension Line crossing at Ch. 853.528 km with 4 mtr clearance, another High Tension Line crossing at Ch. 854.239 km with 5 mtr vertical clearance. Stone Pitching is done from Ch. 857.402 km to Ch. 858.002 km. A High Tension Line is crossing at Ch. 858.492 km. Current is very less due to Gokul Barrage. Both the Banks are unprotected. Gokul Barrage is a big obstruction for Navigation in this stretch. This Barrage needs to be modified for navigation. There is land mass present in the river at Ch. 867.569. Main villages in this stretch are Panighat and Vrindavan. These villages are close to river banks and the inhabitance is peasants. Land is very fertile and agriculture is the main source of income for locals. Main features of this stretch are temple at Ch. 862.854 km, Kutcha Road at Ch. 864.247 km, KC Ghat at Ch. 865.389 km.

Table 4.66 Water Depth Stretches at Sub Stretch 30 –

Ch. 843 km Gokul Barrage to Ch. 868 km Murshidpur

Stretch	Stretch with water depths less than 1.2m (Km)	Stretch with water depths between 1.2m to 1.4m (Km)	Stretch with water depths between 1.5m to 1.7m (Km)	Stretch with water depths between 1.8m to 2.0m (Km)	Stretch with water depths more than 2.0m (Km)
Gokul Barrage to Murshidpur	1.70	0.30	3.60	3.40	16.00

Table 4.67 Observed and reduced Bed Profile of the stretch-30

Ch. 843 km Gokul Barrage to Ch. 868 km Murshidpur

CH (km)	OBSERVED (m)	REDUCED (m)	CH (km)	OBSERVED (m)	REDUCED (m)
843	3.7	3.7	856	1.1	1.5
844	2.9	2.9	857	1.3	1.8
845	5.1	5.0	858	1.4	1.8
846	4.3	4.2	859	4.5	4.5
847	1.9	1.9	860	1.9	2.3
848	2.8	2.8	861	1.1	1.5
849	1.9	1.9	862	1.0	1.3
850	2.7	2.8	863	1.5	1.9
851	2.8	2.9	864	0.9	1.2
852	1.6	1.6	865	1.0	1.2
853	0.7	0.7	866	0.8	1.3
854	1.2	1.2	867	1.3	1.7
855	2.7	2.8	868	0.6	1.0

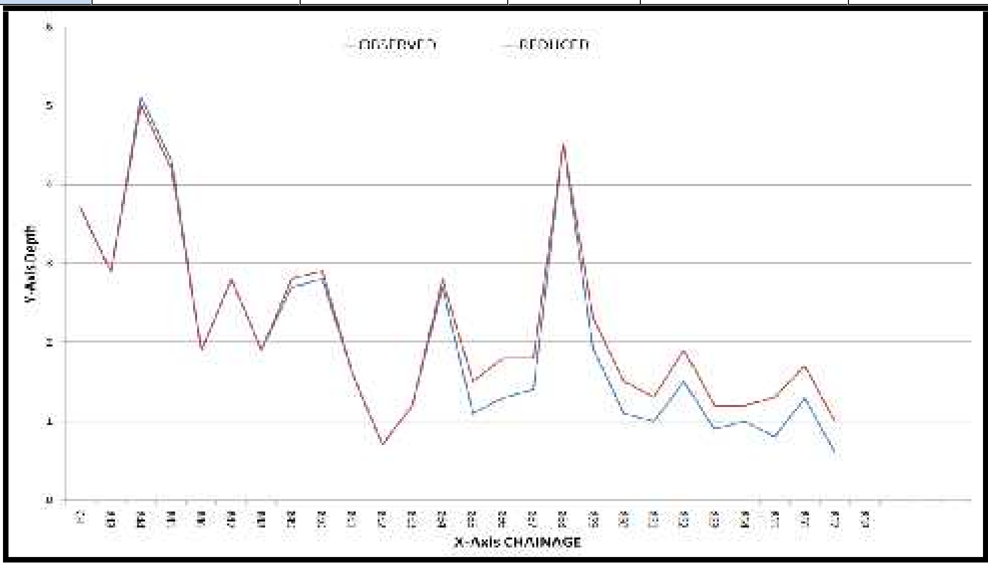


Fig 4.61 Water Depth Ch. 843 km Gokul Barrage to Ch. 868 km Murshidpur

4.12.6 Sub Stretch 31 - Murshidpur to Auhawa Bangar (Ch. 868 km to 893 km)

Fig. 4.62 Google map showing Ch. 868 km Murshidpur to Ch. 893 km Auhawa Bangar

Width of this stretch varies from 67.00mtr to 229.00mtr and the Minimum and Maximum depth is found 1.1mtr and 5.2 mtr during survey period.

This section of the surveyed area are of village namely Maat, Murshidpur and Sharegaon and is surrounded by other Villages which does not fall under survey reach, the village is Gulalpur. The land is agricultural in nature. Main features in section are Temple, Ch. 871.061 at right bank, Maat water pump house Ch. 871.085, High tension line Ch. 866.592 and there is land mass in the river at Ch. 892.585 and it is mentioned in the drawing. The bench mark pillar established in this section is Pillar Nos. 22, 21 & Pillar No. 20 at Chs. 870.93, 881.289 and 890.717 respectively.

Table 4.68 Water Depth Stretches at Sub Stretch 31 – Ch. 868 km Murshidpur to Ch. 893 km Auhawa Bangar

Stretch	Stretch with water depths less than 1.2m (Km)	Stretch with water depths between 1.2m to 1.4m (Km)	Stretch with water depths between 1.5m to 1.7m (Km)	Stretch with water depths between 1.8m to 2.0m (Km)	Stretch with water depths more than 2.0m (Km)
Murshidpur to Auhawa Bangar	0.00	2.20	1.10	8.30	13.40

Table 4.69 Observed and reduced Bed Profile of the stretch 31 – Ch. 868 km Murshidpur to Ch.893 km Auhawa Bangar

CH (km)	OBSERVED (m)	REDUCED (m)
868	0.6	1.0
869	0.8	1.2
870	1.9	2.6
871	1.3	1.7
872	1.0	1.5
873	0.6	0.7
874	0.8	1.4
875	1.0	1.6
876	1.0	1.6
877	1.1	1.7
878	1.7	2.5
879	0.7	1.1
880	1.4	2.1
881	0.2	0.5
882	1.9	2.5
883	1.9	2.6
884	1.4	2.0
885	2.7	3.1
886	1.8	2.1
887	2.7	3.2
888	1.9	2.4
889	1.8	2.2
890	-1.0	-0.7
891	1.9	2.4
892	-0.6	-0.3
893	1.9	2.2

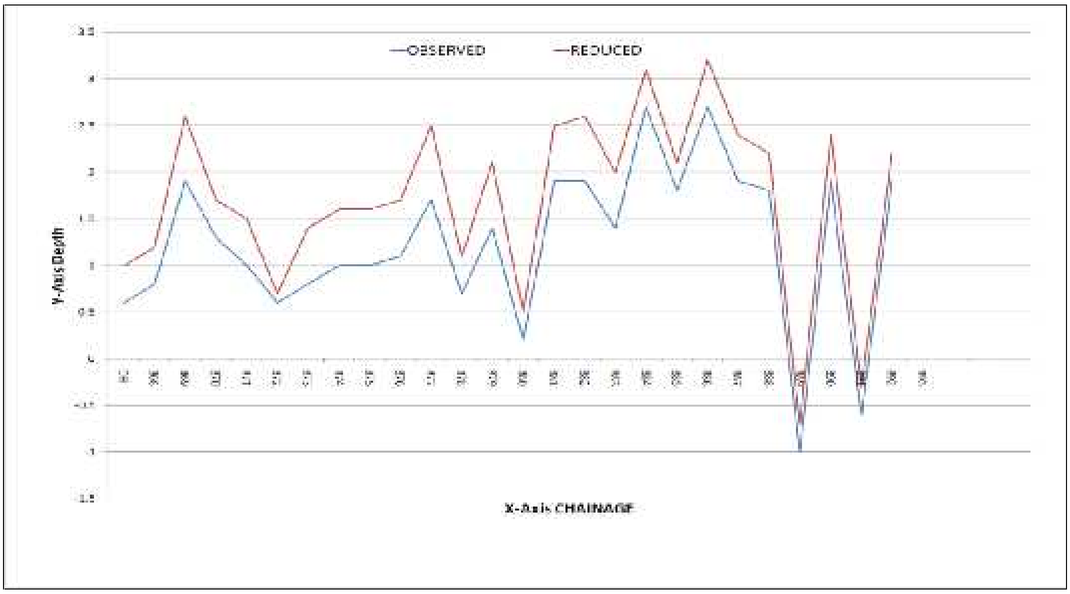


Fig 4.63 Water Depth Ch. 868 km Murshhidpur to Ch. 893 km Auhawa Bangar

4.12.7 Sub Stretch 32 - Auhawa Bangar to Basai Shergarh Khadar (Ch. 893 to 918 km)

Fig. 4.64 Google map showing Ch. 893 km Auhawa Bangar to Ch. 918 km Basai Shergarh Khadar

Width of this stretch varies from 70.00mtr to 203.00mtr with Minimum and Maximum depth is found 1.3mtr and 13.2mtr during survey period. This stretch is coming in the Sheregaon area at Ch. 892.964 on left bank, and has many villages which is not in the area of survey and gets flooded during monsoon period. The main features of these village are Temple at Ch. 892.916 at left bank and electric pole at 893.016, three Nos. of river bund in left bank at Chs. 893.019,893.277,893.334 respectively and one more temple at Ch. 893.299 on left bank of the river. Bench Mark Pillar No19 is established at change 901.362 on right bank and land mass at Ch. 904.324. Pillar no 18 is also established in this section at Ch. 911.146Km (Right bank). Temple is situated in Ch. No 914.492. Village Ova is falling in this stretch at Ch. 919.979 with river bunds are at Chs. 914.250, 914.373and 914.432. Small trees were observed in this stretch near the Village. There is a road bridge connecting across the river in Shergarh town that connects Agra Delhi highway which is 11Km away at Ch. 916.921having horizontal clearance 32.0 mtrs. , Vertical clearance 1.4 mtrs, Length 598.15 mtrs width 10.5 mtrs and having 16 Nos. of piers.

Table 4.70 Water Depth Stretches at Sub Stretch 32 – Ch. 893 km Auhawa Bangar to Ch. 918 km Basai Shergarh Khadar

Stretch	Stretch with water depths less than 1.2m (Km)	Stretch with water depths between 1.2m to 1.4m (Km)	Stretch with water depths between 1.5m to 1.7m (Km)	Stretch with water depths between 1.8m to 2.0m (Km)	Stretch with water depths more than 2.0m (Km)
Auhawa Bangar to Basai Shergarh Khadar	0.00	0.80	1.80	3.20	19.20

Table 4.71 Observed and reduced Bed Profile of the stretch 32 – Ch. 893 km Auhawa Bangar to Ch. 918 km Basai Shergarh Khadar

CH (km)	OBSERVED (m)	REDUCED (m)
893	1.9	2.2
894	1.8	3.3
895	1.2	2.8
896	0.9	2.2
897	0.9	2.0
898	0.4	1.5
899	0.9	2.0
900	1.0	2.2
901	0.6	0.6
902	0.9	2.0
903	1.1	2.4
904	3.4	4.2
905	0.7	1.1
906	2.6	4.6
907	4.0	4.9
908	5.2	6.8
909	-0.8	-1.0
910	0.9	2.0
911	0.7	1.5
912	0.5	2.4
913	0.5	2.5
914	0.4	1.3
915	0.4	1.1
916	0.4	2.3
917	0.5	2.1
918	0.4	3.0

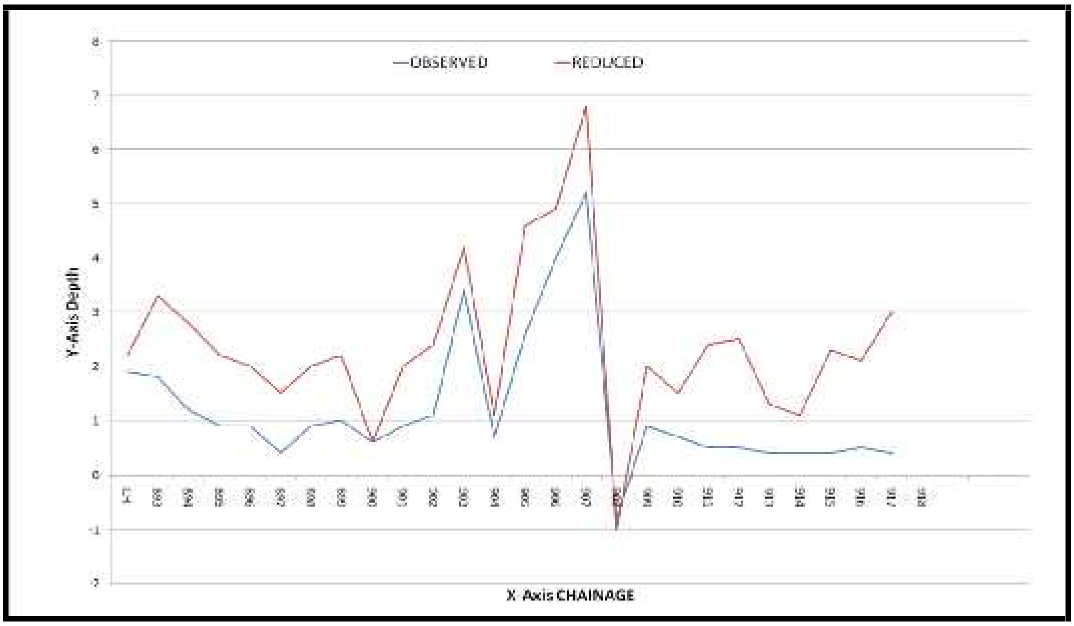


Fig. 4.65 Water Depth Ch. 893 km Auhawa Bangar to Ch. 918 km Basai Shergarh Khadar

4.12.8 Sub Stretch 33 - Basai Shergarh Khadar to Shahpur Khadar (Ch. 918 to 943 km)

Fig. 4.66 Google map showing Ch. 918 km Basai Shergarh Khadar to Ch. 943 km Shahpur Khadar

Width of this stretch varies from 57.00mtr to 230.00mtr with Minimum and Maximum depth is found 1.5mtr and 7.2 mtr during survey period.

This Stretch includes the villages Rampur Ferojpur main adda at Ch. 922.146Km and 928.196Km. Main features are Temple at Ch. 927.796Km, electric pole at Ch. 928.319Km High tension line at 936.292Km, village Munjoi at Ch. 936.412Km river bund 936.587, temple at Ch. 936.822Km, Pucca Road 936.928Km these all are on left bank. Bench mark pillars established are Pillar 15 at Ch. 941.172Km, Pillar16 at 930.087Km and Pillar17 at 920.791Km.This stretch is agricultural area.

Table 4.72 Water Depth Stretches at Sub Stretch 33 –
Ch. 918 km Basai Shergarh Khadar to Ch. 943 km Shahpur Khadar

Stretch	Stretch with water depths less than 1.2m (Km)	Stretch with water depths between 1.2m to 1.4m (Km)	Stretch with water depths between 1.5m to 1.7m (Km)	Stretch with water depths between 1.8m to 2.0m (Km)	Stretch with water depths more than 2.0m (Km)
Basai Shergarh Khadar to Shahpur Khadar	0.00	0.00	0.60	2.20	22.20

Table 4.73 Observed and reduced Bed Profile of the stretch 33 - Ch. 918 Basai Shergarh Khadar to Ch. 943 km Shahpur Khadar

CH (km)	OBSERVED (m)	REDUCED (m)
918	0.4	3
919	1.8	4.2
920	-0.2	0.5
921	1.9	4
922	1.2	3.7
923	1.9	4.4
924	0.5	2.7
925	0.6	2
926	0.7	2.6
927	2.5	3.9
928	2.9	4.6
929	3.9	6
930	1.5	3.6
931	0.4	2.4
932	0.4	2
933	0.9	1.9
934	1.6	3.6
935	0.7	2.6
936	1.5	3.2
937	1.3	2.5
938	0.9	1.8
939	0.8	1.9
940	0.8	1.4
941	1.1	2.4
942	1.1	2.4
943	0.5	1.8

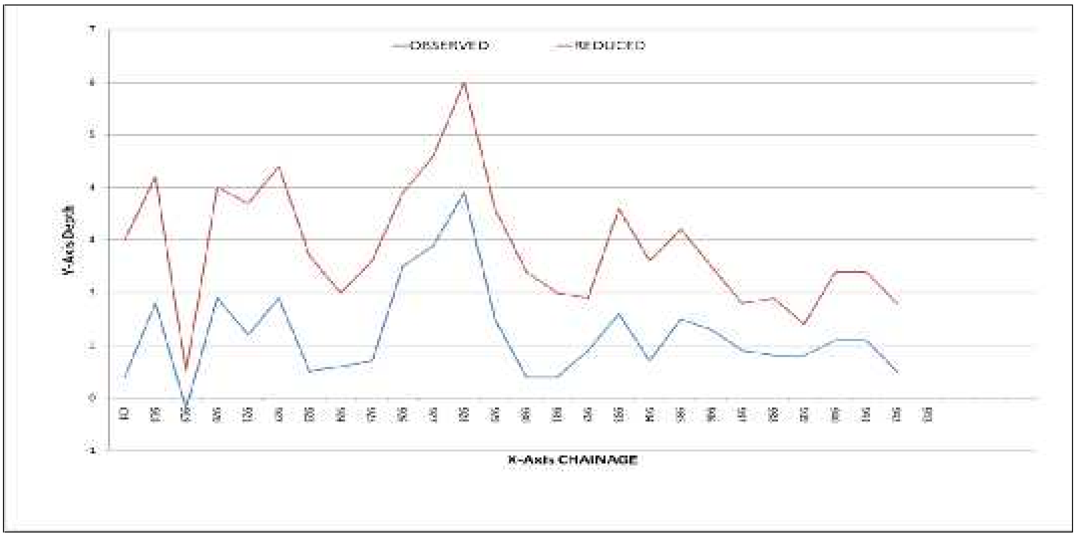


Fig. 4.67 Water Depth Ch. 918 km Basai Shergarh Khadar to Ch.943 km Shahpur Khadar

4.12.9 Sub Stretch 34 - Shahpur Khadar to Sultanpur (Ch. 943 km to 973 km)

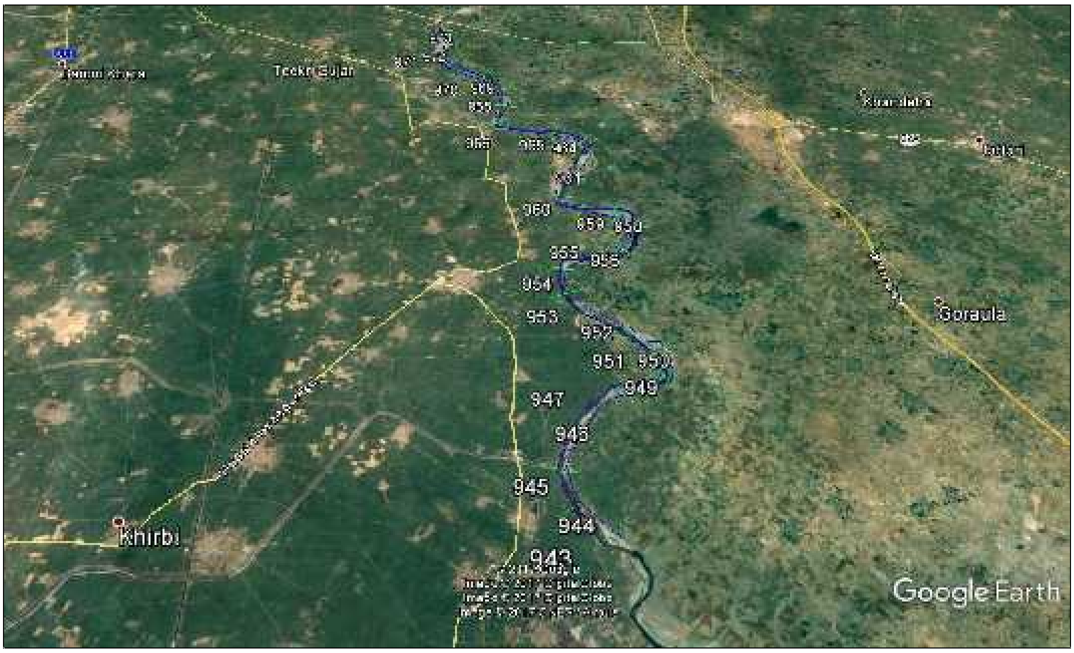


Fig. 4.68 Google map showing Ch. 943 km Shahpur Khadar to Ch. 973 km Sultanpur

Width of this stretch varies from 143.00mtr to 552.00mtr and the Minimum and Maximum depth is found 0.5mtr and 10.3 mtr during survey period. This is comes in Sai gaon Ghat Ch. 944.811Km and there is temple at Ch. 944.898Km, High tension line at Ch. 945.194Km and another high tension line at 972.021Km.

This is forest area and some portion is cultivable land the Ch. of forest area is 971.522Km. Bench mark pillar No. 12 is at Ch. 970.450Km, Pillar No13 is at Ch. is 961.759Km and Pillar No 14 is at Ch. 950.464Km.

Table 4.74 Water Depth Stretches at Sub Stretch 34 – Ch. 943 km Shahpur Khadar to Ch. 973 km Sultanpur

Stretch	Stretch with water depths less than 1.2m (Km)	Stretch with water depths between 1.2m to 1.4m (Km)	Stretch with water depths between 1.5m to 1.7m (Km)	Stretch with water depths between 1.8m to 2.0m (Km)	Stretch with water depths more than 2.0m (Km)
Shahpur Khadar to Sultanpur	0.20	0.20	0.20	2.80	26.60

Table 4.75 Observed and reduced Bed Profile of Sub stretch 34 – Ch. 943 km Shahpur Khadar to Ch. 973 km Sultanpur

CH (km)	OBSERVED (m)	REDUCED (m)
943	0.5	1.8
944	0.9	2.5
945	3.0	4.5
946	3.4	4.9
947	2.9	3.2
948	3.9	4.2
949	4.8	5.1
950	3.8	4.1
951	5.1	5.5
952	2.5	2.9
953	3.8	4.1
954	4.7	5.1
955	2.9	3.2
956	3.7	4.0
957	4.7	5.1
958	4.5	5.1
959	3.3	3.8
960	8.1	8.7
961	2.5	3.1
962	2.1	2.7
963	1.1	1.5
964	2.6	3.2
965	2.0	2.6
966	3.5	4.1
967	2.9	3.3
968	1.7	2.0
969	2.8	3.1
970	1.7	2.1
971	2.1	2.4
972	0.2	0.4
973	-0.2	-0.1

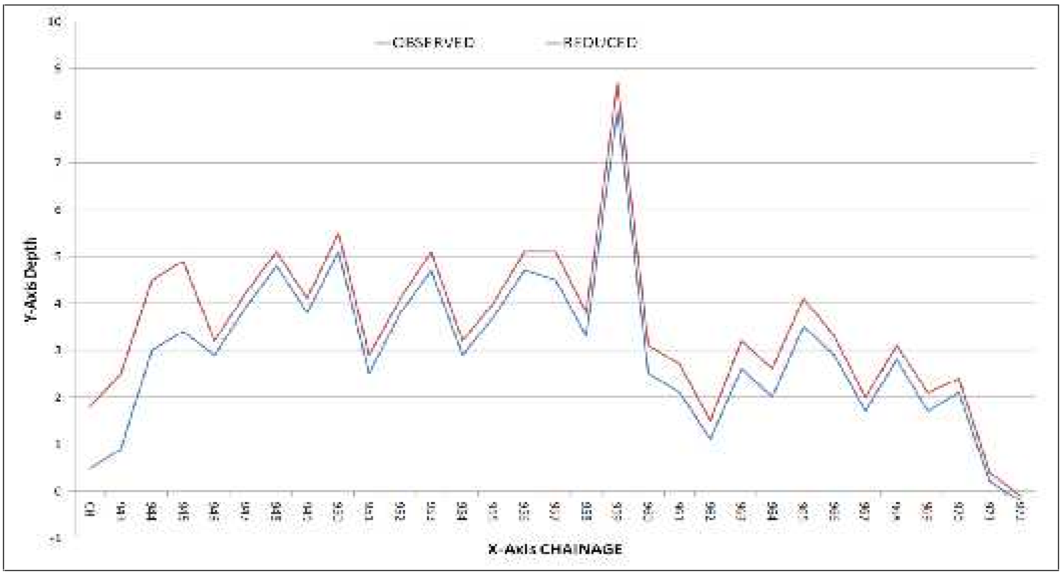


Fig. 4.69Water Depth Ch. 943 km Shahpur Khadar to Ch. 973 km Sultanpur

4.12.10 Sub Stretch 35 - Sultanpur to Makanpur (Ch. 973 km to 998 km)

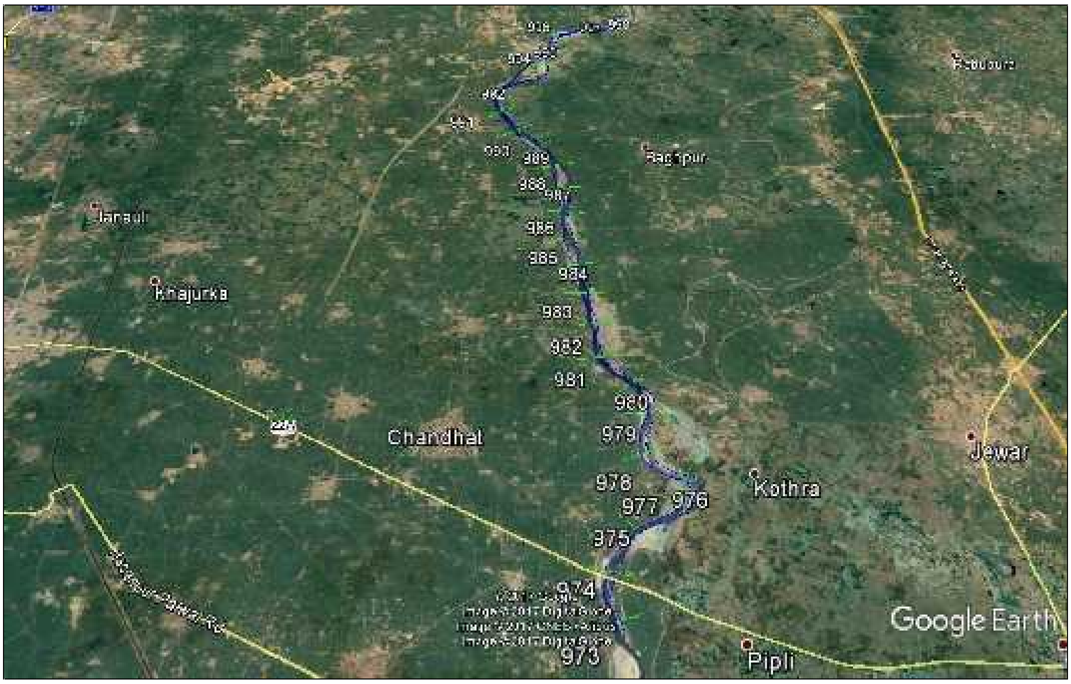


Fig. 4.70 Google map showing Ch. 973 km Sultanpur to Ch. 998 km Makanpur

Width of this stretch varies from 90.00mtr to 320.00mtr with Minimum and Maximum depth is found 0.7mtr and 4.2 mtr during survey period. After travelling 560m from Ch. No.996.692 the river turn to its left. While going down stream of the river Chhauise is present on the right bank of the river at a distance of 662m from Ch. No. 995.692 Km at which again joins at a distance of 864m from the Ch. No. 993.692Km while going down stream of the river. After travelling 580m from Ch. No. 992.692 the river turns into its left while downstream. Mohiapur is present on the left bank of the river at a distance of 614m from the Ch. No. 991.692. Under construction Highway Bridge crosses Yamuna River at distance of 444m from the Ch. No. 990.692 downstream of the river. Dhamthri is present on the right bank of the river at a distance of 668m from the Ch. No. 985.692Km downstream. Dostpur is present on the left bank of this river at a downstream of 922m from the Ch. no. 983.692Km. Pipli is present on the right bank of the river at a distance of 353m from the Ch. no. 980.692Km. From Ch. 978.692 to 974.692 the river turn towards left and makes U shape while coming downstream. Highway bridge is present on the river at a distance of 583m from Ch. no. 974.692Km.After moving 343m downstream of the river from the bridge the river slightly turn on to its left. Rahimpurkanagla is present on right bank of the river at a distance of 453m from the Ch. no. 973.692Km. Coming downstream from Ch. No. 973.692Km the river becomes narrow at a distance of 905m from Ch. 972.692Km to 971.692Km the river turn and makes u shape. Sultanpur is present on the right bank of the river at a distance of 140m from the Ch. no. 971.692Km. While coming down stream of the river at Ch. 970.692Km the river turn to its left and makes an arc from Ch. 970.692Km to 966.692Km. Shamsapur is present on the right bank of the river at a distance of 503 m from the Ch. 968.692Km and Gharwara is present on the left bank of the river at a distance of 1110 m from Ch.

968.692Km while coming down stream of the river. Maharajgarh is present on the left bank of the river at a distance of 947m from Ch. No. 967.692Km. At a distance of 646 m from Ch. No. 766.692Km the river turns to its left and also a narrow water stream joins the river at a distance of 714 m from the Ch. No. 966.692. Kishanpur is present on the left bank of the river at a distance of 849 m from the Ch. No. 965.692Km while going downstream of the river. At a distance of 868 m from the Ch. No. 963.692Km the river again turns to its right while coming down stream of the river.

Table 4.76 Water Depth Stretches at Sub Stretch 35 – Ch. 973 km Sultanpur to Ch. 998 km Makanpur

Stretch	Stretch with less than 1.2m depth	Stretch with depths between 1.2 to 1.4m	Stretch with depths between 1.5 to 1.7m	Stretch with depths between 1.8 to 2m	Stretch with more than 2m depth
Sultanpur to Makanpur	21.70	2.00	0.90	0.40	0.00

Table 4.77 Observed and reduced Bed Profile of the stretch 35 – Ch. 973 km Sultanpur to Ch. 998 km Makanpur

CH (km)	OBSERVED (m)	REDUCED (m)	CH (km)	OBSERVED (m)	REDUCED (m)
973	-0.2	-0.1	986	-0.7	-0.7
974	0.4	0.6	987	0.9	0.5
975	0.7	0.8	988	0.7	1.2
976	0.8	0.5	989	0.6	0.3
977	1.7	1.5	990	0.7	0.4
978	1.3	1.3	991	1.5	1.1
979	0.9	0.6	992	1.0	0.6
980	0.6	0.9	993	1.2	1.8
981	0.9	0.6	994	0.6	0.7
982	0.3	0.3	995	0.5	1.0
983	0.8	0.4	996	1.0	1.2
984	0.5	0.2	997	1.3	1.5
985	0.7	0.9	998	1.3	1.3

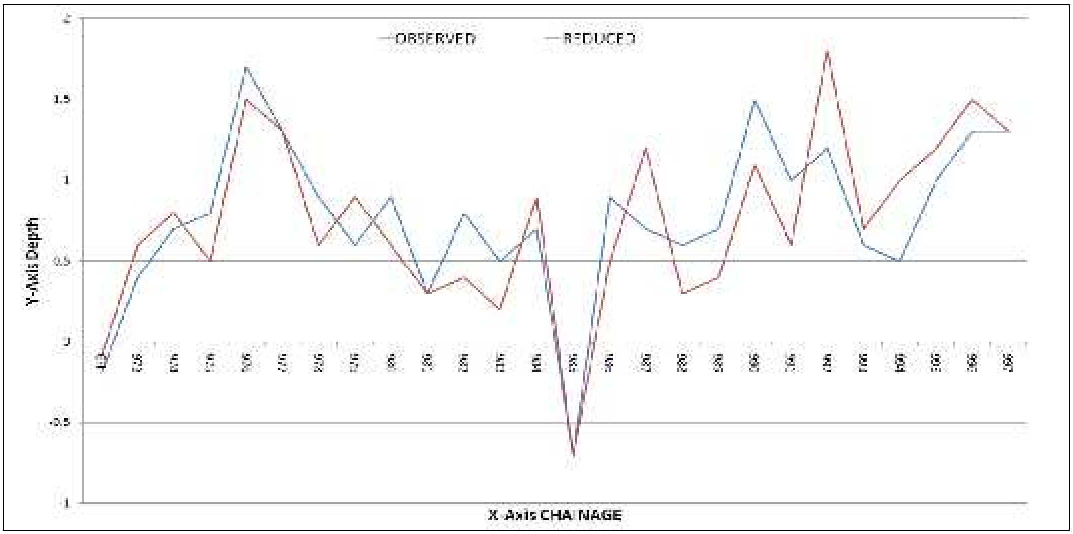


Fig. 4.71 Water Depth Ch. 973 km Sultanpur to Ch. 998 km Makanpur

4.12.11 Stretch – 36 CH – 998 to CH - 1023 Km (Makanpur to Tilori Khadar)

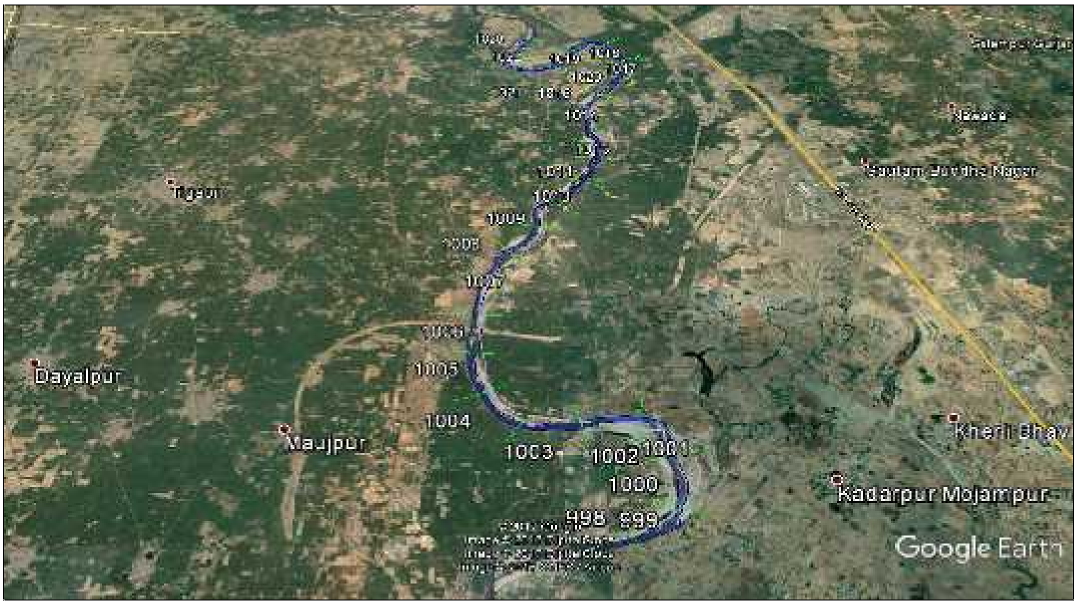


Fig. 4.72 Google map showing Ch. 998 km Makanpur to Ch. 1023 km Tilori khadar

Width of this stretch varies from 70.00mtr to 770.00mtr with Minimum and Maximum depth is found 1.3mtr and 3.8 mtr during survey period.

Coming down stream, Yamuna River divides into two streams at a distance of 741 from the Ch. No. 1023.692Km and both the stream again joins at a distance of 700m from the Ch. no. 1022.692Km.

After travelling 158m from the Ch. No. 1021.692Km the river turn to its left at downstream. From Ch. No. 1020.692 Km to 1014.692 the river turn to right and makes U shape while going down stream of river. Gharbara is present on the left bank of the river at a distance of 924m from Ch. No. 1018.692Km Indian grand prix is present on the left bank of the river at a distance of 117m from the Ch. No. 1018.692Km At Ch. No. 1014.692Km the river slightly starts moving to its left while coming down stream.

Akbarpur and Mozzamabad Majrakhpur are present on the right bank of the river at a distance of 904m and 1072m from Ch. no. 1014.692Km. SRS retreat form which is in Akbarpur is present on the right bank of the river at a distance of 750m from the Ch. no. 1014.692Km.

Gharora is present on the right bank of 2419m from the Ch. no. 1010.692Km. Dalelgash is present on the right bank of the river at distance of 823m from the Ch. no. 1008.692Km. While going down stream of the river on the right bank of the river Chanpur is present this is at a distance of 600m from the Ch. No. 1007.692Km. From Ch. No. 1004.692Km to 1002.692Km the river turn to its left .After travelling 258m from Ch. No. 1003.692 to 996.692the river turn to right and makes u shape while going down stream of the river.

Table 4.78 Water Depth Stretches at Sub Stretch 36 –
Ch. 998 km Makanpur to Ch. 1023 km Tilori Khadar

Stretch	Stretch with water depths less than 1.2m (Km)	Stretch with water depths between 1.2m to 1.4m (Km)	Stretch with water depths between 1.5m to 1.7m (Km)	Stretch with water depths between 1.8m to 2.0m (Km)	Stretch with water depths more than 2.0m (Km)
Makanpur to Tilori Khadar	12.30	5.00	5.70	1.50	0.50

Table 4.79 Observed and reduced Bed Profile of the stretch 36 –
Ch. 998 km Makanpur to Ch. 1023 km Tilori Khadar

CH (km)	OBSERVED (m)	REDUCED (m)	CH (km)	OBSERVED (m)	REDUCED (m)
998	1.3	1.3	1011	1.2	1.2
999	1.3	1.3	1012	1.5	1.6
1000	0.8	1.1	1013	1.0	1.5
1001	0.4	0.4	1014	0.8	1.1
1002	0.8	1.3	1015	0.8	1.5
1003	0.4	1.0	1016	0.8	0.8
1004	0.6	0.9	1017	0.5	0.5
1005	0.0	0.0	1018	0.6	0.5
1006	1.4	1.4	1019	1.4	1.4
1007	0.6	1.4	1020	1.4	1.3
1008	0.7	0.7	1021	1.4	1.3
1009	1.0	1.7	1022	0.7	0.6
1010	0.3	0.9	1023	0.7	0.7

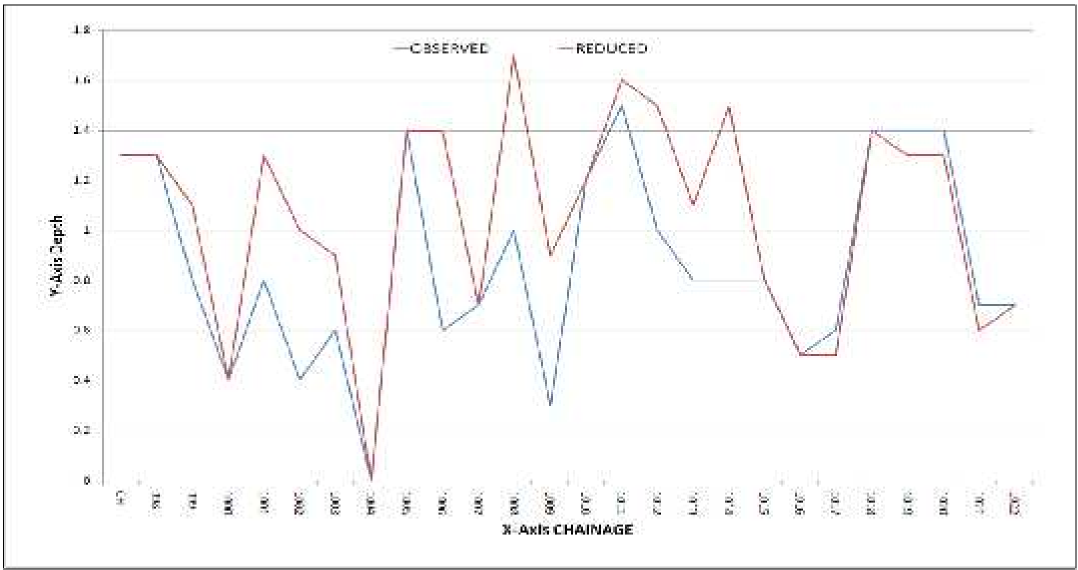


Fig. 4.73 Water Depth Ch. 998 km Makanpur to Ch. 1023 km Tilori Khadar

4.12.12 Sub Stretch 37 - Tilori Khadar to Sector 150, Noida (Ch. 1023 km to 1048 km)

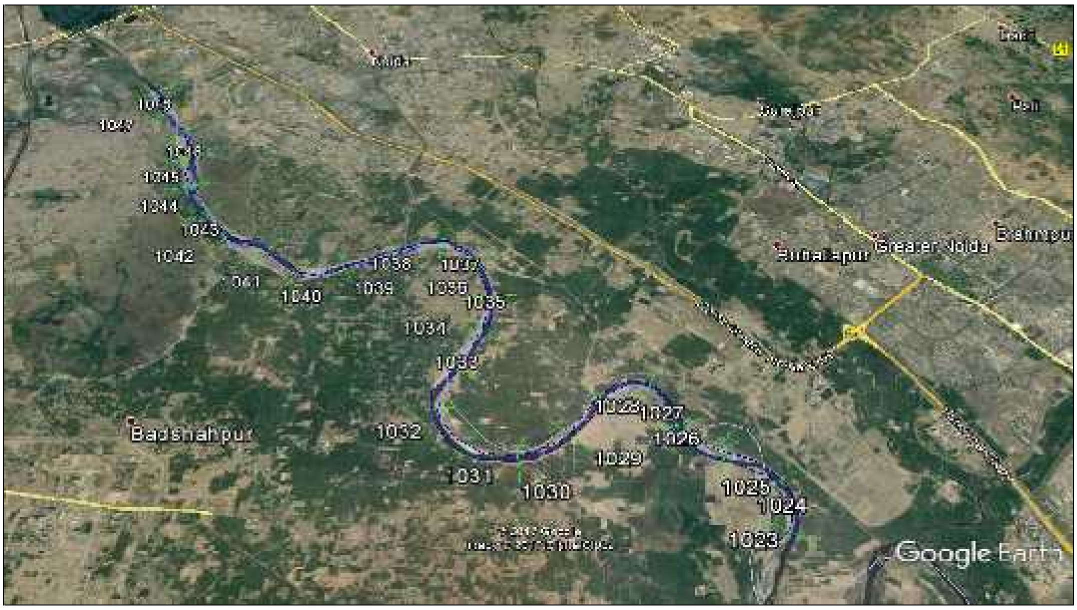


Fig. 4.74 Google map showing Ch. 1023 km Tilori Khadar to Ch. 1048 km Sector-150, Noida

Width of this stretch varies from 150.00mtr to 720.00mtr with Minimum and Maximum depth is found 0.8mtr and 4.3 mtr during survey period.

Major place coming in this stretch is Noida. Coming downstream of river Yamuna on the right bank Muhammadi masjid is present which 727m from the Ch. is no. 1046.692Km. After coming 550 m downstream of river Yamuna the river slightly turns to its left. After travelling 1187 m from the Ch. No. 1045.692 Golden field is present on the left bank of the river. Coming downstream of river Yamuna encroachment in air force land at Agwanpur area at tipat range is present which is at a distance of 1228 m from the Ch. No. 1044.692. At Ch. No. 1043.692Km the river slightly turns to its left and after travelling at 2 km the river Yamuna again turns to its right. Coming down stream of river Yamuna on left bank Sai farms and flora farms are present which are at a distance of 260 m and 1028 m respectively from the Ch. No. 1041.692Km. After travelling 690 m from Ch. No. 1040.692 the river bends to its left. Varinda farm is present on the left bank of the river while coming downstream which is at a distance of 273 m from the Ch. No. 1038.692Km. From Ch. No. 1037.692 to 1035.692 the river again turns to its right and after travelling further few kms the river turns to its right from Ch. No. 1040.692Km to 1032.692Km. Mahwatpur is present on the right bank of the river at a distance of 982 m from the Ch. No. 1032.692Km. The river again turns to its left from Ch. No. 1030.692Km to 1028.692Km. Shikargah is present on the left bank of the river which is at a distance of 749 m from the Ch. No. 1029.692Km at downstream. From Ch. No. 1029.692Km to 1025.692Km the river again turns and makes u shape. The river again turns to its right from Ch. No. 1024.692Km to 1022.692Km moving towards downstream of the river.

Table 4.80 Water Depth Stretches at Sub Stretch 37 – Ch. 1023 km Tilori Khadar to Ch. 1048 km Sector -150, Noida

Stretch	Stretch with water depths less than 1.2m (Km)	Stretch with water depths between 1.2m to 1.4m (Km)	Stretch with water depths between 1.5m to 1.7m (Km)	Stretch with water depths between 1.8m to 2.0m (Km)	Stretch with water depths more than 2.0m (Km)
Tilori Khadar to sector 150,Noida	18.30	0.00	0.80	0.00	5.90

Table 4.81 Observed and reduced Bed Profile of the stretch 37 – Ch. 1023 km Tilori Khadar to Ch. 1048 km Sector-150, Noida

CH (km)	OBSERVED (m)	REDUCED (m)	CH (km)	OBSERVED (m)	REDUCED (m)
1023	0.7	0.7	1036	-0.4	-0.4
1024	2.0	2	1037	0.2	0.2
1025	0.3	0.3	1038	0.2	0.2
1026	0.0	0.0	1039	0.6	0.6
1027	1.8	2.7	1040	0.4	0.4
1028	2.7	4.7	1041	0.8	0.8
1029	0.8	2.9	1042	0.9	0.9
1030	0.7	1.4	1043	0.6	0.6
1031	2.3	3.3	1044	0.7	0.7
1032	1.1	-0.2	1045	0.6	0.6
1033	-0.2	-0.5	1046	0.1	0.1
1034	-0.5	0.1	1047	-0.1	-0.1
1035	0.1	0.1	1048	0.7	0.7

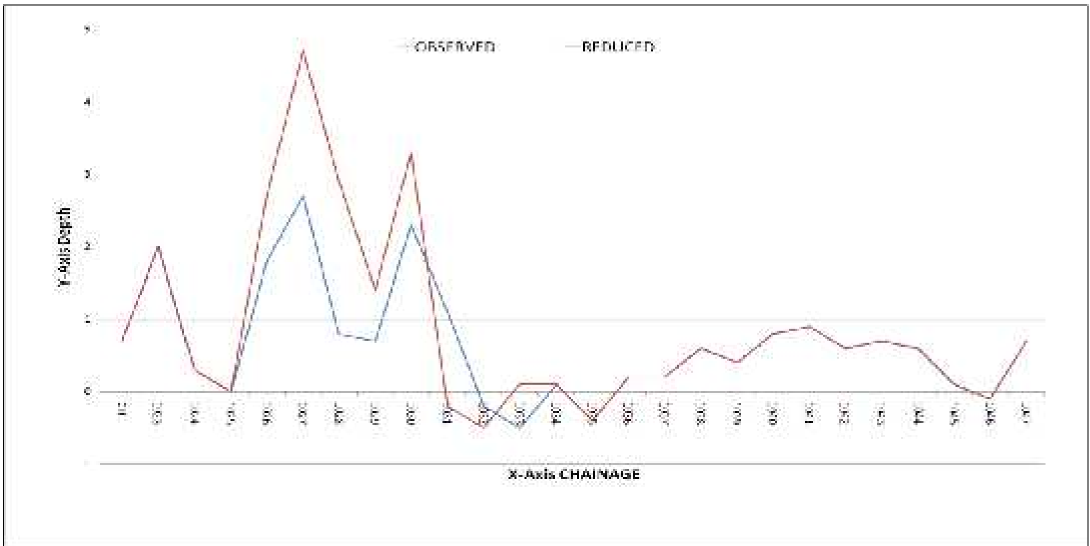


Fig. 4.75 Water Depth Ch. 1023 km Tilori Khadar to Ch. 1048 km Sector-150, Noida

4.12.13 SubStretch 38 - Sector 150, Noida to Wazirabad (Ch. 1048 km to 1074 km)

Fig. 4.76 Google map showing Ch. 1048 km Sector-150, Noida to 1074 km Wazirabad

Width of this stretch varies from 55.00mtr to 568.00mtr and the Minimum and Maximum depth is found 0.8mtr and 8.1 mtr during survey period.

After travelling 160m downstream on Yamuna River, under construction bridge is present and on the left bank of the river 67m from the Ch. No. 1073.692Km at downstream. A forest is present which is near cremation ghat. On the right bank in downstream there is PWD office at 527m from the Ch. No. 1073.692Km and also a Balak Ram hospital on the left bank of the river. On the right bank of river at downstream Majnukatila is present which is at a distance of 278m from Ch. No. 1072.692Km. There is a road highway bridge at a distance of 301m from the Ch. no. 1072.692Km. Going down stream on the right bank of river Tennis court is present which is in Indraprastha College at civil lines at a distance of 843m from Ch. No. 1071.692 Km. From Ch. No. 1069.692Km to 1067.692Km the Yamuna River is slightly bends .Metro Bridge is present on the river at a distance of 297m from the Ch. No. 1069.692Km. At downstream of the river on right bank there is Red fort which is at a distance of 645m from Ch. No. 1068.692Km and also a metro bridge is passing through Yamuna river at a distance of 508 m from the Ch. No. 1068.692Km. At downstream of the river pontoon highway bridge is present which is at a distance of 697m from Ch. No. 1066.692.A Highway Bridge ITO is Present on Yamuna River at a distance of 623m from Ch. No. 1063.692 Km downstream. At Ch. No. 1062.692Km the river again bends to its left and metro bridge also passes across the river at a distance of 470 m from Ch. No. 1062.692Km coming downstream.

Going downstream of river Yamuna there is Pragati Maidan on the right bank of the river which is 821m from the Ch. No. 1061.692. Railway Bridge also crosses the river at a distance of 495m from Ch. no. 1061.692Km. Nizamuddin Highway Bridge passes through Yamuna River at a distance of 787m from the Ch. No. 1060.692Km.Railway Bridge also passes through this river at a distance of 836m from Ch. No. 1060.692 Km coming downstream of the river. Coming downstream of river Yamuna on the right bank there is Humayun's tomb which is at a distance of 530m from the Ch. No. 1059.692Km. After travelling 180m downstream from Ch. No. 1058.692Km there is bridge on Yamuna River which is under construction. At a distance of 514m from Ch. No.1056.692Km coming downstream of river Yamuna there is a highway bridge, which is known as DND toll road or Delhi Noida direct flyway. Coming down stream of river Yamuna Okhla bird Park and wild life sanctuary is present which is at a distance of 686m from the Ch. No. 1053.692Km. At a distance of 714m from Ch. No. 1052.692downstream of river Yamuna a highway bridge is present and another bridge is present at a distance of 730m from Ch. No. 1052.692Km which is under construction.

Table 4.82 Water Depth Stretches at Sub Stretch 38 – Ch. 1048 km Sector-150, Noida to Ch. 1074 km Wazirabad

Stretch	Stretch with water depths less than 1.2m (Km)	Stretch with water depths between 1.2m to 1.4m (Km)	Stretch with water depths between 1.5m to 1.7m (Km)	Stretch with water depths between 1.8m to 2.0m (Km)	Stretch with water depths more than 2.0m (Km)
Sector 150, Noida to Wazirabad	13.50	1.20	2.20	2.70	6.40

Table 4.83 Observed and reduced Bed Profile of the stretch 38 - Ch. 1048 km Sector-150, Noida to Ch. 1074 km Wazirabad

CH (km)	OBSERVED (m)	REDUCED (m)
1048	0.7	0.7
1049	0.6	0.6
1050	0.7	0.7
1051	0.8	0.8
1052	1.0	1.0
1053	4.2	4.0
1054	4.5	5.1
1055	3.1	2.8
1056	2.9	2.6
1057	1.2	0.9
1058	1.7	1.4
1059	2.0	2.1
1060	2.5	2.2

CH (km)	OBSERVED (m)	REDUCED (m)
1061	1.3	1.0
1062	1.9	1.8
1063	0.7	1.1
1064	2.3	2.4
1065	2.9	2.6
1066	1.6	1.6
1067	2.5	2.3
1068	1	0.7
1069	2.5	2.2
1070	2	1.7
1071	0.8	0.6
1072	1.2	0.9
1073	2.2	1.9
1074	1.5	1.4

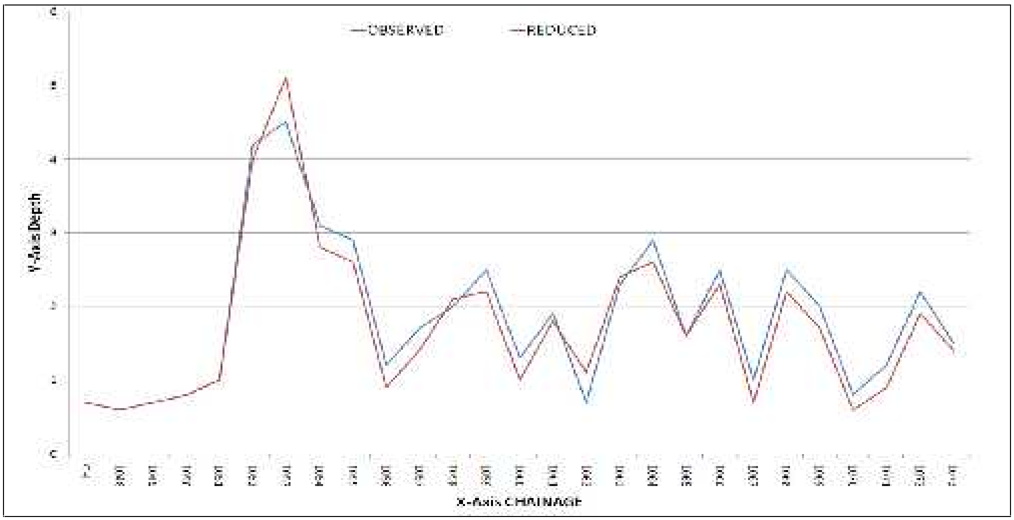


Fig. 4.77 Water Depth Ch. 1048 km Sector-150, Noida to Ch. 1074 km Wazirabad

4.12.14 Sub Stretch 39 - Wazirabad to Jagatpur (Ch. 1074 km to 1081 km)

Fig. 4.78 Google map showing Ch. 1074 km Wazirabad to Ch. 1081 Km Jagatpur

The width of the river in this stretch varies from 80m to 400m (near Wazirabad Barrage U/S). This upstream stretch of Wazirabad Barrage is ponding area of the Barrage. There are two shallow patches in this stretch. The first patch is from Ch. 1077.05 km to Ch. 1077.15 km which is 40 m in width. The another first patch is from Ch. 1077.53 km to Ch. 1077.83 km which is 40 m in width. There are two approaching roads for this terminal. One is from Harampur village and another is from Elayachipur village. There are two shallow patches in this stretch, first starts from Ch. 1079.65 km to Ch. 1080.65 km. Water quality in this stretch is very clean and calm. The current in this river stretch was zero due to no flow in the river. It may increase during the water discharged from the Dam. During the survey, there was no water discharge from the Dam. This stretch can be developed for tourism activities.

Table 4.84 Water Depth Stretches at Sub Stretch 39 – Ch. 1074 km Wazirabad to Ch. 1081 km Jagatpur

Stretch	Stretch with water depths less than 1.2m (Km)	Stretch with water depths between 1.2m to 1.4m (Km)	Stretch with water depths between 1.5m to 1.7m (Km)	Stretch with water depths between 1.8m to 2.0m (Km)	Stretch with water depths more than 2.0m (Km)
Wazirabad Barrage to U/S Jagatpur	0.00	0.00	1.20	1.50	4.30

Table 4.85 Observed and reduced Bed Profile of the stretch 39 – Ch. 1074 km Wazirabad to Ch. 1081 km Jagatpur

CH (km)	OBSERVED (m)	REDUCED (m)
1074	4.1	4.3
1075	2.5	2.7
1076	2.5	2.7
1077	1.8	1.9
1078	2.3	2.5
1079	6.1	6.5
1080	1.3	1.7
1081	0.2	0.4

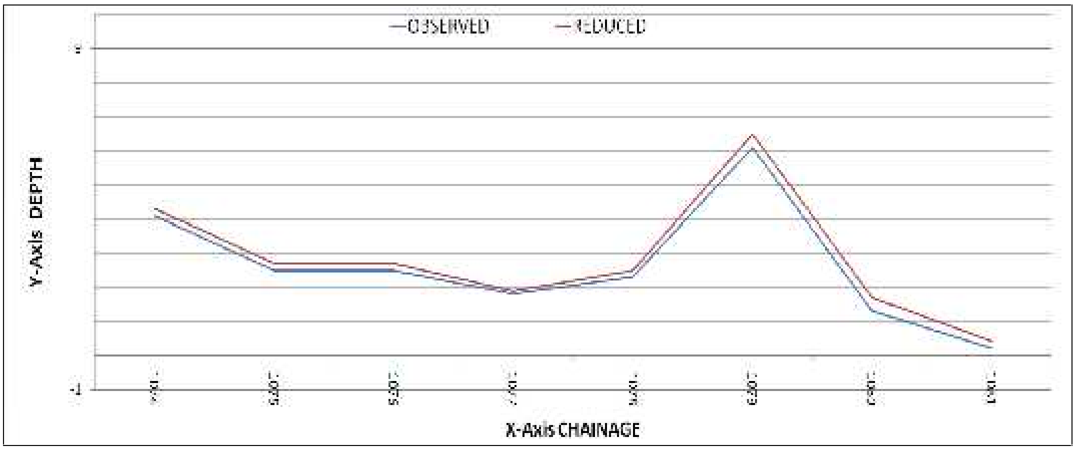


Fig. 4.79 Water Depth Ch. 1074 km Wazirabad to Ch. 1081 km Jagatpur

4.13 Digital Terrain Modeling

The digital terrain modeling has been carried out in the practice of creating a digital representation of ground topography and terrain. Such elevation data has been collected in such a precise digital form as to allow the creation of digital models of the topography of the land.

The field data observations (scattered Data of elevation) have been loaded into Hydrodyn-Software and interpolated on the FEM mesh. The results i.e. elevations, FEM mesh, Scattered elevation data and interpolated elevation contours are plotted in 20 segments and shown graphically for each segment:

Table 4.86 Segment details

Point	Starting GIS Coordinates		Ending GIS Coordinates	
	Latitude	Longitude	Latitude	Longitude
Segment-1	25°25'19.7075"N	081°53'27.9889"E	25°20'53.1487"N	081°44'43.7786"E
Segment-2	25°20'53.1487"N	081°44'43.7786"E	25°16'33.8307"N	081°31'28.0925"E
Segment-3	25°16'33.8307"N	081°31'28.0925"E	25°20'49.4968"N	081°20'42.2089"E
Segment-4	25°20'49.4968"N	081°20'42.2089"E	25°24'15.7086"N	081°08'49.5562"E
Segment-5	25°24'15.7086"N	081°08'49.5562"E	25°31'25.7772"N	081°03'33.7698"E
Segment-6	25°31'25.7772"N	081°03'33.7698"E	25°36'34.4227"N	080°57'16.2599"E
Segment-7	25°36'34.4227"N	080°57'16.2599"E	25°42'45.3823"N	080°35'37.1561"E
Segment-8	25°42'45.3823"N	080°35'37.1561"E	25°50'17.4988"N	080°28'45.7926"E
Segment-9	25°50'17.4988"N	080°28'45.7926"E	25°54'48.7247"N	080°24'44.2748"E
Segment-10	25°54'48.7247"N	080°24'44.2748"E	25°56'07.2912"N	080°12'00.3999"E
Segment-11	25°56'07.2912"N	080°12'00.3999"E	26°04'07.3197"N	080°04'32.0081"E
Segment-12	26°04'07.3197"N	080°04'32.0081"E	26°08'38.2031"N	079°56'09.2407"E
Segment-13	26°08'38.2031"N	079°56'09.2407"E	26°07'49.5018"N	079°45'19.5765"E
Segment-14	26°07'49.5018"N	079°45'19.5765"E	26°14'52.4449"N	079°37'48.0057"E
Segment-15	26°14'52.4449"N	079°37'48.0057"E	26°20'52.3584"N	079°32'00.2289"E
Segment-16	26°20'52.3584"N	079°32'00.2289"E	26°24'09.4085"N	079°21'08.4302"E
Segment-17	26°24'09.4085"N	079°21'08.4302"E	26°28'33.1900"N	079°16'10.1230"E
Segment-18	26°28'33.1900"N	079°16'10.1230"E	26°32'50.6930"N	079°12'47.5527"E
Segment-19	26°32'50.6930"N	079°12'47.5527"E	26°37'29.3555"N	079°03'57.9869"E
Segment-20	26°37'29.3555"N	079°03'57.9869"E	26°44'32.4859"N	079°00'17.0570"E
Segment-21	26°44'32.4859"N	079°00'17.0570"E	26°47'20.7570"N	078°52'05.0210"E
Segment-22	26°47'20.7570"N	078°52'05.0210"E	26°54'42.1985"N	078°43'50.8919"E
Segment-23	26°54'42.1985"N	078°43'50.8919"E	26°56'29.4389"N	078°37'27.5763"E
Segment-24	26°56'29.4389"N	078°37'27.5763"E	26°56'19.1559"N	078°31'35.0939"E
Segment-25	26°56'19.1559"N	078°31'35.0939"E	27°01'30.4630"N	078°26'20.8642"E
Segment-26	27°01'30.4630"N	078°26'20.8642"E	27°05'59.8961"N	078°19'59.9805"E
Segment-27	27°05'59.8961"N	078°19'59.9805"E	27°06'27.3515"N	078°15'26.1656"E
Segment-28	27°06'27.3515"N	078°15'26.1656"E	27°10'36.2909"N	078°11'27.7996"E
Segment-29	27°10'36.2909"N	078°11'27.7996"E	27°14'11.0555"N	078°01'53.2902"E
Segment-30	27°14'11.0555"N	078°01'53.2902"E	27°16'51.5752"N	077°56'55.7997"E
Segment-31	27°16'51.5752"N	077°56'55.7997"E	27°15'17.8065"N	077°52'52.0552"E
Segment-32	27°15'17.8065"N	077°52'52.0552"E	27°23'25.0650"N	077°47'30.7433"E
Segment-33	27°23'25.0650"N	077°47'30.7433"E	27°30'08.5583"N	077°41'25.2663"E
Segment-34	27°30'08.5583"N	077°41'25.2663"E	27°38'35.7147"N	077°41'57.1208"E

Point	Starting GIS Coordinates		Ending GIS Coordinates	
	Latitude	Longitude	Latitude	Longitude
Segment-35	27°38'35.7147"N	077°41'57.1208"E	27°47'02.1122"N	077°42'12.2616"E
Segment-36	27°47'02.1122"N	077°42'12.2616"E	27°50'04.0473"N	077°36'09.2358"E
Segment-37	27°50'04.0473"N	077°36'09.2358"E	27°56'44.9392"N	077°32'39.6441"E
Segment-38	27°56'44.9392"N	077°32'39.6441"E	28°06'10.8914"N	077°29'07.6658"E
Segment-39	28°06'10.8914"N	077°29'07.6658"E	28°17'06.4158"N	077°29'54.2567"E
Segment-40	28°17'06.4158"N	077°29'54.2567"E	28°25'35.6954"N	077°27'56.5075"E
Segment-41	28°25'35.6954"N	077°27'56.5075"E	28°32'07.7182"N	077°19'36.2358"E
Segment-42	28°32'07.7182"N	077°19'36.2358"E	28°43'05.9583"N	077°14'22.4430"E
Segment-43	28°43'05.9583"N	077°14'22.4430"E	28°45'53.0064"N	077°14'12.2847"E

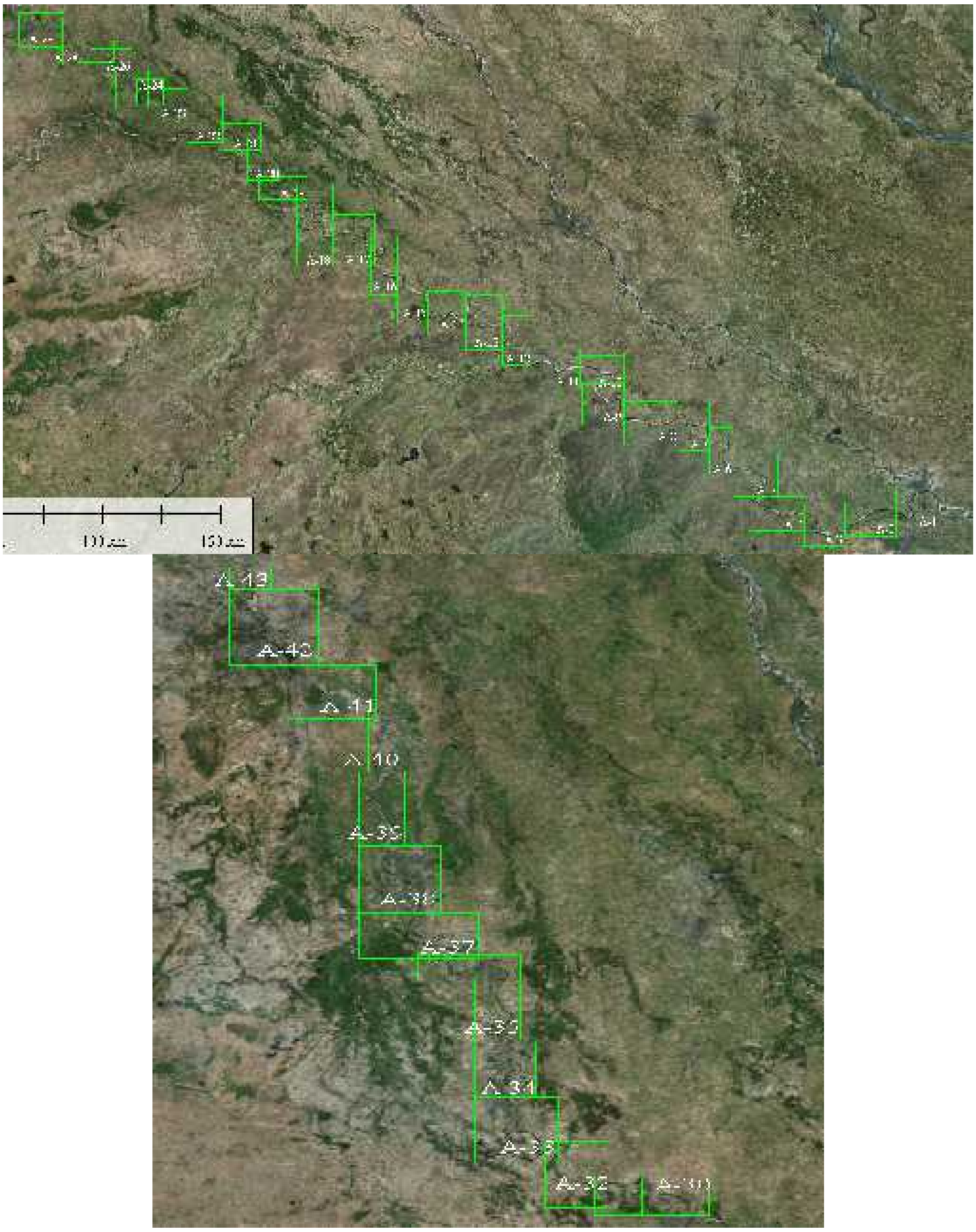


Fig. 4.80 Segment details

The details of the all segment A1 to A43 of digital terrain modeling are given in Annexure 4.7

4.14 Summary of Topographic and Hydrographic Survey

The entire stretch of River Yamuna (NW110) has been divided in four stretches as earlier stated. During field survey the observed water depth has been reduced w.r.t Chart Datum (CD) and the graphs has been plotted to show the variation of bed level, sounding datum, water level & high flood level to correlate each other and ascertain water availability. The following graphs depict the same.

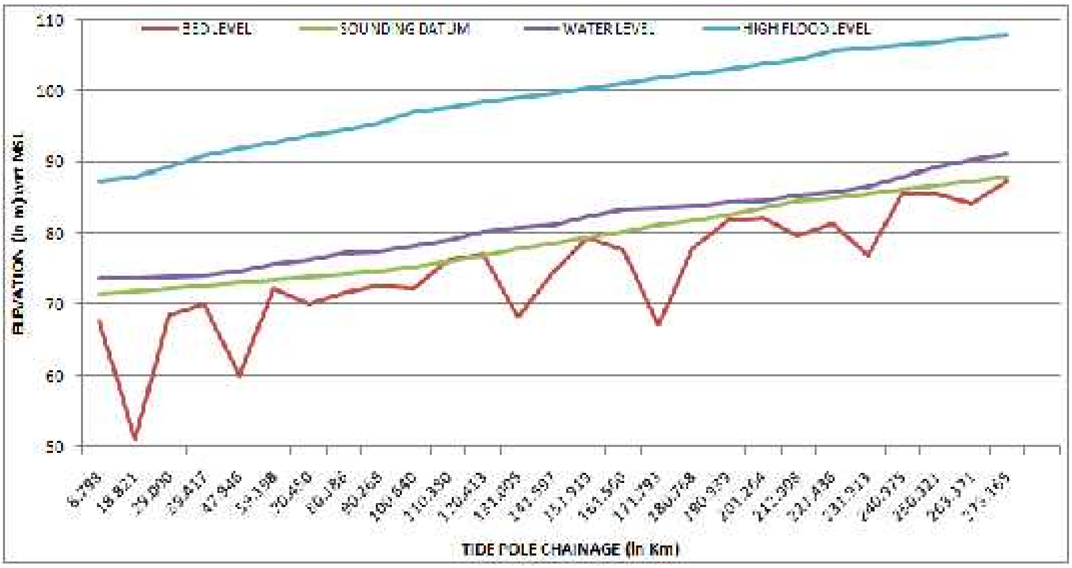


Fig. 4.81 Water Depth Variation in Stretch 1

From the above graph it seen that the water depth variation in stretch-1 (Prayagraj to Betwa Mouth) are to the tune of 0.8 m 3.2 m.

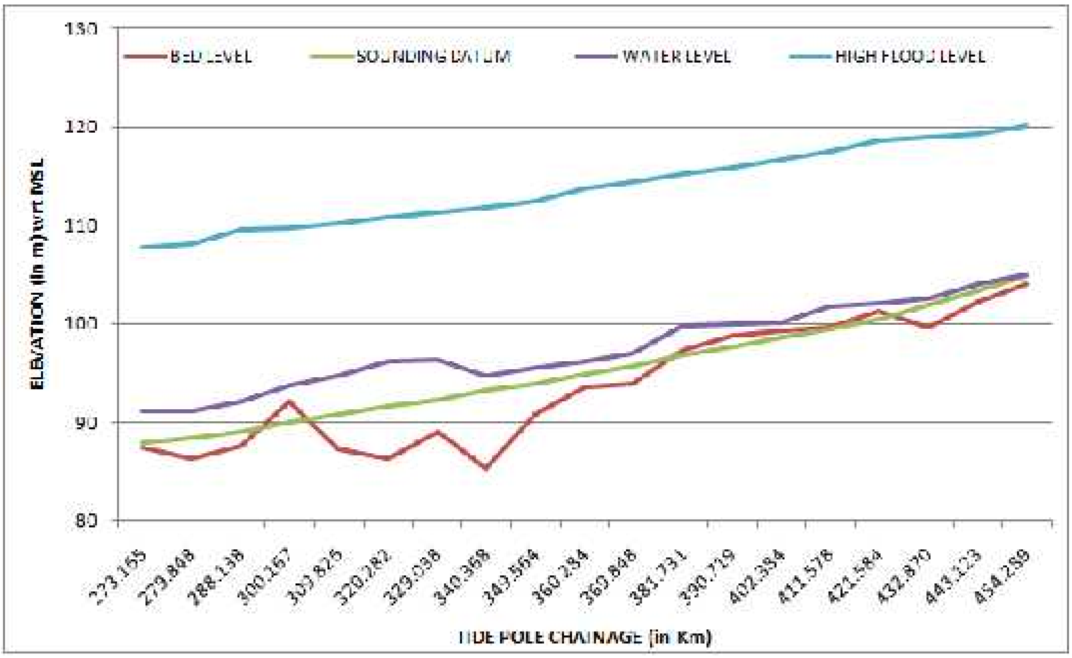


Fig. 4.82 Water Depth Variation in Stretch 2

From the above graph it seen that the water depth variation in stretch-2 (Betwa Mouth to Chambal Mouth) are to the tune of 0.2 m 4.5m.

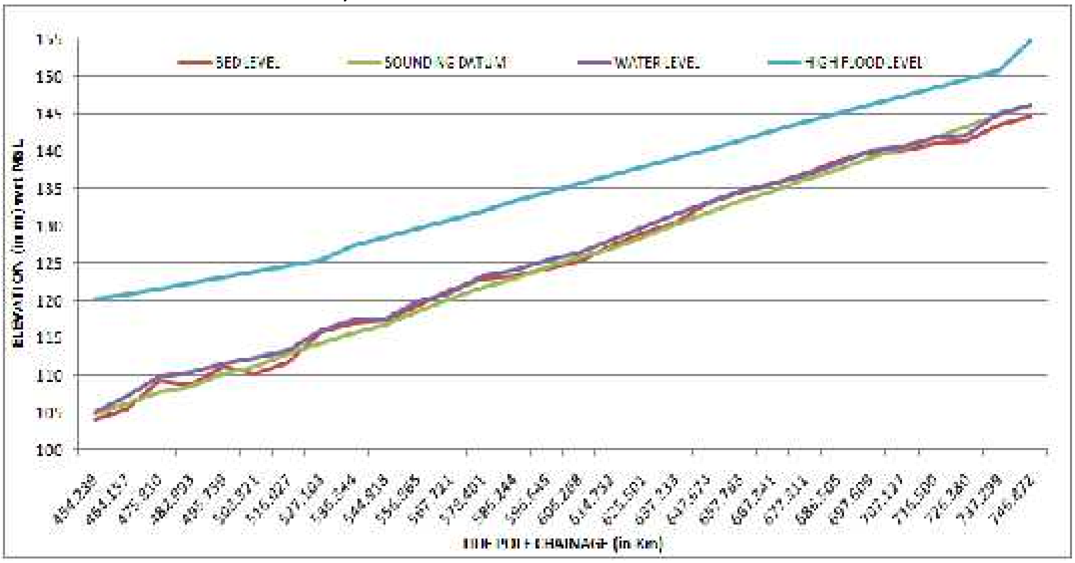


Fig. 4.83 Water Depth Variation in Stretch 3

From the above graph it clearly seen that the water depth variation in stretch-3 (Chambal Mouth to Agra) are to the tune of 0.08 m 2.21m.

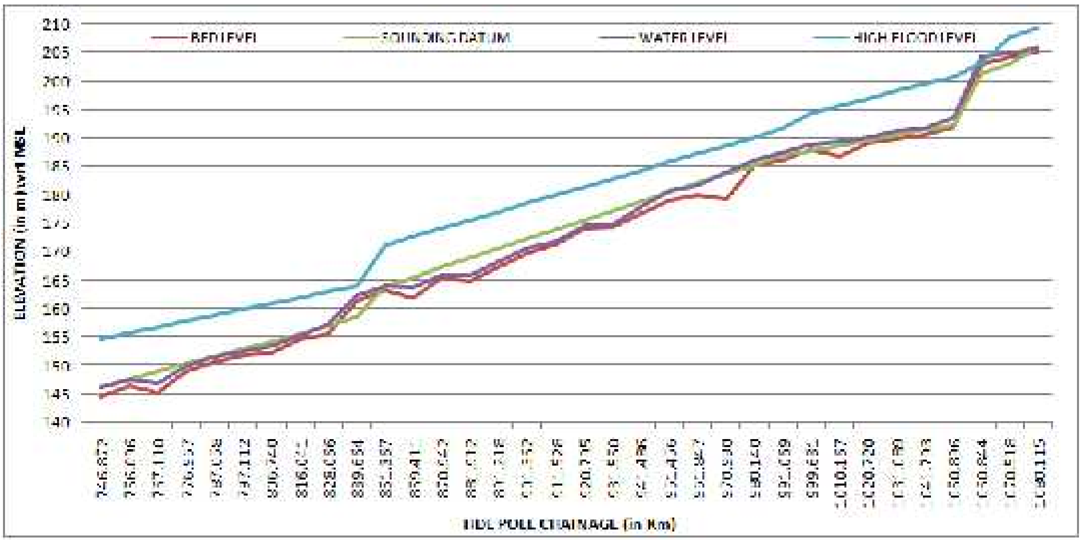


Fig. 4.84 Water Depth Variation in Stretch 3

From the above graph it clearly seen that the water depth variation in stretch-4 (Agra to Delhi) are in the tune of 0.07 m 3.85m. Also, Stretch and sub stretch wise summarized water depth available during survey period is given in below table:

Table 4.87 Stretch- 1 Prayagraj to River Betwa Mouth

LAD (m)	<1.2	1.2-1.4	1.5-1.7	1.8-2.0	>2.0	Total (km)
Sub Stretch -1 (0-30)	0.6	1.8	0	0.2	27.4	30
Sub Stretch-2 (30 - 60)	7.2	1.0	2.0	1.0	18.8	30
Sub Stretch-3 (90-120)	12.4	1.0	0.4	0.2	16.0	30

LAD (m)	<1.2	1.2-1.4	1.5-1.7	1.8-2.0	>2.0	Total (km)
Sub Stretch-4 (120-150)	18.2	0.6	0	0.4	10.8	**30**
Sub Stretch-5 (150-180)	9.4	1.2	0	1.2	18.2	**30**
Sub Stretch-6 (180-210)	7.6	1.6	1.6	0.8	18.4	**30**
Sub Stretch-7 (210-240)	4.2	4.6	0.8	0.6	19.8	**30**
Sub Stretch-8 (240-272)	4.6	0.4	0.8	0.6	23.6	**30**
Sub Stretch-9 (240-272)	13.4	1.4	1.4	1.0	14.8	**32**
Total (km)	**77.6**	**13.6**	**7.0**	**6.0**	**167.8**	**272**

Table 4.88 Stretch- 2 River Betwa Mouth to River Chambal Mouth

LAD (m)	<1.2	1.2-1.4	1.5-1.7	1.8-2.0	>2.0	Total (km)
Sub Stretch -10 (273-300)	15.6	0.8	1.0	1.4	9.2	**28**
Sub Stretch-11 (300 - 330)	19.8	0.8	0.4	0.8	8.2	**30**
Sub Stretch-12 (330-360)	18.2	1.2	0	0.6	10.0	**30**
Sub Stretch-13 (360-390)	23.0	1.2	0.6	0.8	4.4	**30**
Sub Stretch-14 (390-420)	20.6	0.8	1.0	1.6	6.0	**30**
Sub Stretch-15 (420-453)	12.0	1.2	0.8	0.8	18.2	**33**
Total (km)	**109.2**	**6.0**	**3.8**	**6.0**	**56.0**	**181**

Table 4.89 Stretch- 3 River Chambal Mouth to Agra

LAD (m)	<1.2	1.2-1.4	1.5-1.7	1.8-2.0	>2.0	Total (km)
Sub Stretch -16 (453-480)	27	0	0	0	0	**27**
Sub Stretch-17 (480- 510)	30	0	0	0	0	**30**
Sub Stretch-18 (510-540)	30	0	0	0	0	**30**
Sub Stretch-19 (540-570)	30	0	0	0	0	**30**
Sub Stretch-20 (570-600)	30	0	0	0	0	**30**
Sub Stretch-21 (600-630)	30	0	0	0	0	**30**
Sub Stretch-22 (630-660)	30	0	0	0	0	**30**
Sub Stretch-23 (660-690)	30	0	0	0	0	**30**
Sub Stretch-24 (690-720)	30	0	0	0	0	**30**
Sub Stretch-25 (720-743)	17	1	1.5	2	1.5	**23**
Total (km)	**284.0**	**1.0**	**1.5**	**2.0**	**1.5**	**290**

Table 4.90 Stretch-4 Agra to Delhi

LAD (m)	<1.2	1.2-1.4	1.5-1.7	1.8-2.0	>2.0	Total (km)
Sub Stretch -26 (743-768)	21.1	1.2	1.4	0.65	0.65	**25**
Sub Stretch-27 (768- 793)	17.1	3.5	1.8	1.7	0.9	**25**
Sub Stretch-28 (793-818)	11.2	9.6	1.5	1.3	1.4	**25**
Sub Stretch-29 (818-843)	21.9	0.7	0.9	1.1	0.4	**25**

LAD (m)	<1.2	1.2-1.4	1.5-1.7	1.8-2.0	>2.0	Total (km)
Sub Stretch-30 (843-868)	1.7	0.3	3.6	3.4	16.0	25
Sub Stretch-31 (868-893)	0	2.2	1.1	8.3	13.4	25
Sub Stretch-32 (893-918)	0	0.8	1.8	3.2	19.2	25
Sub Stretch-33 (918-943)	0	0	0.6	2.2	22.2	25
Sub Stretch-34 (943-973)	0.2	0.2	0.2	2.8	26.6	30
Sub Stretch-35 (973-998)	21.7	2.0	0.9	0.4	0	25
Sub Stretch-36 (998-1023)	12.3	5.0	5.7	1.5	0.5	25
Sub Stretch-37 (1023-1048)	18.3	0	0.8	0	5.9	25
Sub Stretch-38 (1048-1074)	13.5	1.2	2.2	2.7	6.4	26
Sub Stretch-39 (1074-1089)	4.5	0.8	1.4	1.0	7.3	15
Total (km)	**143.5**	**27.5**	**23.9**	**30.3**	**120.8**	**346**

4.15 Water and Soil Samples analysis and Results

Water sample at every 10 km interval of the entire stretch of River Yamuna (NW110) has been collected. There are total 108 locations where water sample are collected at mid depth of River Yamuna to analyze for sediment concentration. The analysis of the water samples has been carried out and the results are given in table below:

Table 4.91 Water Sample Analysis Result

Stretch Name	S. No.	PH	Total Depth (M)	Sediment Concentration (PPM)
				At Mid-Depth
Stretch 1	YR01	7.89	0.7	140
	YR02	7.92	1.6	120
	YR03	7.94	2.3	130
	YR04	7.96	2.9	190
	YR05	7.90	1.9	220
	YR06	7.88	3.2	280
	YR07	7.89	2.8	120
	YR08	7.90	1.7	160
	YR09	7.96	2.5	170
	YR10	7.92	1.3	170
	YR11	7.87	2.8	160
	YR12	7.80	2.3	1198
	YR13	7.83	3.1	2050
	YR14	8.11	2.2	906
	YR15	8.19	1.9	988
	YR16	8.00	2.2	632
	YR17	7.90	2.6	509

	YR18	8.10	1.2	426
	YR19	7.83	2.4	409
	YR20	7.65	3.1	394
	YR21	6.95	1.4	332
	YR22	7.54	1.5	317
	YR23	7.34	1.3	471
	YR24	7.18	1.2	926
	YR25	7.10	1.5	338
	YR26	7.03	1.7	218
	YR27	7.34	2.0	194
	YR28	7.18	1.4	150
	YR29	7.25	1.0	342
	YR30	7.42	0.8	476
	YR31	7.15	0.7	255
	YR32	7.25	0.7	126
	YR33	7.55	1.4	293
	YR34	7.22	1.5	401
Stretch 2	YR 35	6.95	1.4	1080
	YR 36	7.16	1.6	2011
	YR 37	8.00	0.8	904
	YR 38	7.83	0.8	987
	YR 39	8.12	0.8	630
	YR 40	6.88	0.8	507
	YR 41	7.24	0.8	424
	YR 42	8.20	0.8	407
	YR 43	8.15	0.8	394
	YR 44	6.95	0.8	330
	YR 45	8.09	1.4	432
	YR 46	7.86	0.6	407
	YR 47	7.52	1.2	384
	YR 48	7.12	0.8	329
	YR 49	8.15	1.6	319
	YR 50	7.93	0.6	215
	YR 51	7.64	2.2	303
	YR 52	8.39	2.0	298
	YR 53	8.08	1.6	218
	YR 54	8.49	1.6	180
	YR 55	8.46	1.8	59
	YR 56	7.61	2.0	92
	YR 57	8.00	1.6	64
	YR 58	7.59	2.0	213
	YR 59	7.90	2.2	336

	YR 60	7.44	1.8	303
	YR 61	7.63	1.6	344
	YR 62	7.70	1.4	349
	YR 63	6.94	0.9	378
Stretch 3	YR 64	7.53	3.6	171
	YR 65	7.40	2.8	190
	YR 66	7.27	2.0	93
	YR 67	7.43	5.6	392
	YR 68	7.03	3.9	514
	YR 69	7.44	2.2	540
	YR 70	7.40	2.4	150
	YR 71	7.76	1.6	95
	YR 72	7.27	2.6	415
	YR 73	7.39	2.6	580
	YR 74	7.24	2.4	147
	YR 75	6.93	5.0	524
	YR 76	7.13	2.5	165
	YR 77	7.01	6.4	110
	YR 78	7.21	3.0	590
	YR 79	6.86	6.0	204
	YR 80	7.93	3.4	292
	YR 81	7.16	2.6	594
Stretch 4	YR 82	7.19	6.0	125
	YR 83	7.44	3.6	125
	YR 84	7.38	2.4	296
	YR 85	7.50	7.3	92
	YR 86	7.31	4.8	340
	YR 87	7.87	6.8	485
	YR 88	7.40	2.5	345
	YR 89	7.59	2.8	215
	YR 90	7.34	6.0	280
	YR 91	7.08	10.0	360
	YR 92	7.24	3.9	41
	YR 93	7.36	3.1	152
	YR 94	7.33	6.0	158
	YR 95	7.05	6.6	130
	YR 96	7.50	3.0	115
	YR 97	7.24	3.0	348
	YR 98	7.37	6.0	190
	YR 99	7.44	1.3	395
	YR 100	7.40	4.4	273
	YR 101	7.50	5.4	35

	YR 102	7.89	3.2	109
	YR 103	7.38	4.0	65
	YR 104	7.00	3.0	105
	YR 105	7.50	4.8	103
	YR 106	7.48	7.6	174
	YR 107	7.37	6.2	115
	YR 108	7.59	8.4	232

Similarly, Soil samples at every 10 km interval of the entire stretch of River Yamuna (NW110) has been collected. There are total 108 locations where soil samples are collected to analyze for nature of River bed material and particle size. The results of grain size distribution analysis of over 500 samples collected is presented as Annexure 4.8. In 1081 km reach of River Yamuna river at every 20 km interval samples of river bed material (deep channel & shoal) and slopes of both banks (bank toe, mid and top) were taken and analysed for grain size distribution. Minimum 8 to 10 samples were collected at each selected chainage/section.

- The deep channel in most of reach of the river Yamuna under consideration is composed of fine sand (85 to 95 %) , silt & clay (5 to 15 %) and occasionally gravel (1 %).
- Shoals on river bed are also mostly composed of fine sand (30 to 95 %) and silt & clay (5 to 70 %) with occasional presence of gravel.
- The river banks are composed of 70 to 95 % silt & clay and 5 to 30 % fine sand and sometimes occasional presence of gravel.
- The large percentage of fine material seen in suspended sediment has origin in fine material (sand/silt/clay) in catchment, river bed and banks.

4.16 Geotechnical Investigation

4.16.1 General

In order to find out sub soil data for planning of facilities it was considered necessary to undertake geotechnical investigations at the project site. The main objective of the investigations is to ascertain the subsoil condition at the proposed site and to make foundation investigation of the proposed structure based on the findings of field and laboratory investigations. The investigations have been carried out by sinking/drilling boreholes of different depths and conducting related laboratory tests on soil samples. The following laboratory tests were conducted (as applicable to particular soil type) on the soil samples collected from the boreholes:

a) Grain Size analysis
b) Index properties
c) Shrinkage Limit
d) Natural Moisture Content

e) Bulk and Dry Density
f) Specific Gravity
g) Void Ratio
h) Free Swelling Index
i) Unconsolidated Undrained Triaxial Shear Test
j) Direct Shear Test
k) Consolidation Test
l) Crushing Strength of rock samples
m) Slake durability of rock samples
n) Porosity of rock samples
o) Triaxial Test
p) U.C.C Test

4.16.2 Field Investigations & Laboratory Tests

The field investigations were carried out during January to March 2019 at proposed locations and consist of total 29 nos. of Boreholes. The details of Borehole locations and depths of Boreholes are tabulated below:

Table 4.92 Details of Boreholes

Chainage (Km)	BH No.	Geographical		Depth of Bore Hole below Ground Level / River Bed Level (m)
		Northing	Easting	
4.2	1	*25°25'15.43"N*	*81°51'00.02"E*	30.00
	2	*25°25'19.73"N*	*81°51'58.25"E*	30.00
98.0	3	*25°23'23.10"N*	*81°09'34.83"E*	30.00
	4	*25°23'20.00"N*	*81°09'31.95"E*	30.00
349.2	5	*26°07'42.29"N*	*79°45'47.29"E*	30.00
349.8	6	*26° 13'41.54"N*	*79°38'57.60"E*	30.00
371.0	7	*26°13'23.88"N*	*79°38'37.30"E*	30.00
431.0	8	*26°25'10.16"N*	*79°18'27.76"E*	30.00
471.0	9	*26°32'27.65"N*	*79°13'52.72"E*	30.00
501.0	10	*26°37'35.02"N*	*79°04'14.87"E*	30.00
531.0	11	*26°44'39.07"N*	*78°59'21.19"E*	30.00
561.0	12	*26°52'10.38"N*	*78°48'43.56"E*	30.00
591.0	13	*26°52'48.32"N*	*78°39'07.20"E*	30.00
621.0	14	*26°58'18.86"N*	*78°30'50.31"E*	30.00
651.0	15	*27°01'59.70"N*	*78°26'14.26"E*	30.00
681.0	16	*27°07'32.09"N*	*78°21'52.20"E*	30.00
711.0	17	*27°04'58.56"N*	*78°13'29.15"E*	30.00
731.0	18	*27°10'53.83"N*	*78°08'03.89"E*	30.00
	19	*27°10'51.86"N*	*78°08'04.81"E*	30.00
751.0	20	*27°14'22.69"N*	*78°01'50.81"E*	30.00
781.0	21	*27°14'18.72"N*	*77°56'09.38"E*	30.00
811	22	*27°17'55.86"N*	*77°49'10.37"E*	30.00
858.5	23	*27°33'56.89"N*	*77°42'28.46"E*	30.00
872	24	*27°37'05.22"N*	*77°42'34.18"E*	30.00
902	25	*27°47'57.41"N*	*77°42'13.55"E*	30.00

Chainage (Km)	BH No.	Geographical		Depth of Bore Hole below Ground Level / River Bed Level (m)
		Northing	Easting	
962	26	*28°01'12.65"N*	*77°31'53.23"E*	30.00
992	27	*28°14'10.49"N*	*77°27'13.84"E*	30.00
1022	28	*28°24'19.43"N*	*77°28'04.33"E*	30.00
1049	29	*28°31'46.38"N*	*77°19'52.50"E*	30.00

The sub-surface investigation was carried out as per IS: 1892-1979. The boring was carried out using two rotary rigs. The rig deployed had an arrangement for driving and extracting of casing, boring, and drilling by mud circulation method, conducting SPT tests.

The boreholes of 150mm diameter were conducted by deploying the rotary rigs. Position fixing was carried out by Differential Global Positioning System (DPGS) with horizontal positional accuracy of + 10 m. Casing was used to support sides of borehole. Stabilisation of boreholes was achieved by flush jointed seamless casing as well as bentonite slurry.

Standard Penetration Tests (SPT) were conducted in soil at maximum intervals of 1.5m in accordance with IS: 2131-1981 by using the Standard split-barrel sampler as per IS: 9640-1980. The 'N' values or “penetration resistance” were obtained by counting the number of blows required to drive the sampler from 15cm to 45cm penetrations. The N values are indicative of the relative density of cohesionless soils and consistencies of cohesive soils.

Undisturbed samples were collected immediately after the SPT. Each sample retrieved from SPT spoon was inspected for visual identification of strata as per IS-1498. Sampling was done in each borehole by driving two-tier thin walled sampler of 100mm internal diameter and 450mm length. The area ratio of the tube was kept as 10 to 12%. After withdrawal, lower tube was retained and sealed with wax. The samples were undertaken as per IS: 2132.

In addition, disturbed samples were taken at suitable intervals of depths and at changes of stratum in order to examine, physically, the nature of all strata. They were collected from the Augur and the barrel of the split spoon sampler after the Standard Penetration Tests. All the samples were preserved in polythene bags, duly numbered and N values mentioned for proper identification.

Select soil samples were subjected to laboratory testing. Laboratory tests on SPT samples included mechanical analysis and Atterberg Limits conducted according to IS : 2720 relevant parts.

Based upon the findings at the site and depending upon the laboratory test results obtained the bore-logs are finalized and is presented. The laboratory tests results as well as the corresponding graphs and charts are also presented.

4.16.3 Soil Properties

Laboratory test has been carried out of the sample collected during SPT. The details of the test and various engineering property of soil has been tested are presented from Annexure 4.9 to Annexure 4.15 and photographs collected during the geotechnical Investigation is given in Annexure 4.16. From a study of the laboratory test results, the engineering properties of different strata can be summarized as follows:

Table 4.93 Soil Properties of Boreholes BH 1 Near Jamuna Bridge, Allahabad (Embankment)

Stratum & Thickness (m)	Description of Soil	Liquid Limit %	Plastic Limit %	N Value	Y_b KN/m^3	Shear Parameters		(m_v) m^2/kN×10^{-4} Range (kPa)		
				Field N value		C (kPa)	Φ (degree)	25-50	50-100	100-200
IA 7.00	Medium stiff / stiff brownish grey silty clay to clayey silt with nodules and rusty spots (CH-CI)	47	23	9	18.4	56	-	2.30	2.70	2.60
IIIA 6.00	Very stiff brownish grey sandy silty clay with traces of kankar (CL-CI)	35	17	20	19	107	-	1.40	1.75	1.55
III 7.00	Dense yellowish blue silty sand with traces of mica(SM)	NP	NP	30	19.0*	-	33*	E = 35 MPa, μ = 0.35*		
IV >10.45	Very dense yellowish blue silty coarse sand with traces of mica (SM-SP)	NP	NP	54	20.0*	-	34*	E =50 MPa, μ = 0.35*		

** Suggested Value*

Table 4.94 Soil Properties of Boreholes BH 2 Near Jamuna Bridge, Allahabad (River Bed)

Stratum & Thickness (m)	Description of Soil	Liquid Limit %	Plastic Limit %	N Value Field N value	Y_b KN/m^3	Shear Parameters C (kPa)	Shear Parameters Φ (degree)	Modulus of Elasticity (MPa)
I 1.50	Loose brownish grey silty fine sand(SM)	NP	NP	8	17.5*	-	30*	E = 9.0 MPa, μ = 0.35*
II 12.50	Medium dense brownish grey silty medium sand with traces of mica(SM)	NP	NP	16	18.0*	-	31*	E = 20 MPa, μ = 0.35*
III 7.00	Dense yellowish brown silty medium sand with traces of mica(SM).	NP	NP	30	19.0*	-	33*	E = 35 MPa, μ = 0.35*
IV >9.45	Very dense yellowish blue silty coarse sand with traces of mica(SM-SP).	NP	NP	60	20.0*	-	34*	E =50 MPa, μ = 0.35*

** Suggested Value*

Table 4.95 Soil Properties of Boreholes BH 3 Embankment,Mahewa Khachhar Kaushambhi(Embankment)

Stratum & Thickness (m)	Description of Soil	Liquid Limit %	Plastic Limit %	N Value Field N value	Y_b KN/m^3	Shear Parameters		(m_v) $m^2/kN \times 10^{-4}$ Range(kPa)		
						C (kPa)	Φ (degree)	25-50	50-100	100-200
I 2.50	Loose brownish grey silty fine sand	NP	NP	7	17.5*	-	30*	E = 9.0 MPa, μ = 0.35*		
II 4.50	Medium dense brownish grey silty medium sand with traces of mica	NP	NP	16	18.0*		31*	E = 20 MPa, μ = 0.35*		

Stratum & Thickness (m)	Description of Soil	Liquid Limit %	Plastic Limit %	N Value Field N value	Y_b KN/m^3	Shear Parameters C (kPa)	Shear Parameters Φ (degree)	(m_v) m^2/kN×10^{-4} Range(kPa) 25-50	50-100	100-200
IIIA 7.00	Stiff to very stiff yellowish blue silty clay with kankars and rusty brown spots (CH).	58	20	19	19.0*	76	-	1.80	1.50	1.07
IVA >16.45	Hard yellowish blue to greyish brown silty clay with kankars and rusty brown spots (CH).	72	18	32	19.5*	150	-	0.7	0.70	0.70

** Suggested Value*

Table 4.96 Soil Properties of Boreholes BH 4 Mahewa Khachhar Kaushambhi(River Bed)

Stratum & Thickness (m)	Description of Soil	Liquid Limit %	Plastic Limit %	N Value Field N value	Y_b KN/m^3	Shear Parameters C (kPa)	Shear Parameters Φ (degree)	(m_v) m^2/kN×10^{-4} Range(kPa) 25-50	50-100	100-200
II 7.00	Medium dense to dense brownish grey to yellowish blue silty medium sand with traces of mica(SM).	NP	NP	20	18.0		32*	E = 20 MPa, μ = 0.35		
IIIA 13.50	Stiff to very stiff yellowish blue silty clay with kankars and rusty brown spots(CH)..	58	21	13	19.0*	64		1.40	1.40	1.25
IVA >9.95	Hard yellowish blue to greyish brown silty clay with kankars and rusty brown spots(CH).	70	17	36	19.5*	150		0.7*	0.7*	0.7*

** Suggested Value*

Table 4.97 Soil Properties of Boreholes BH 5 Dilauliya Kachhar, Kanpur Dehat

Stratum & Thickness (m)	Description of Soil	Liquid Limit %	Plastic Limit %	N Value	Y_b KN/m^3	Shear Parameters		Modulus of Elasticity(MPa)
				Field N value		C (kPa)	Φ (degree)	
II 10.00	Medium dense brownish grey to yellowish blue silty medium sand with traces of mica(SM).	NP	NP	15	18.0*	-	31*	E = 20 MPa, μ = 0.35*
III 7.00	Dense yellowish brown silty sand with traces of mica(SM)	NP	NP	37	19.0*	-	33*	E = 35 MPa, μ = 0.35*
IV >13.45	Very dense yellowish brown silty sand with traces of mica(SM,SM-SP)	NP	NP	53	20.0*	-	34*	E =50 MPa, μ = 0.35*

** Suggested Value*

Table 4.98 Soil Properties of Boreholes BH 6 Kalpi Jalaun

Stratum & Thickness (m)	Description of Soil	Liquid Limit %	Plastic Limit %	N Value	Y_b KN/m^3	Shear Parameters		Modulus of Elasticity (MPa)
				Field N value		C (kPa)	Φ (degree)	
I 4.00	Very loose/loose brownish grey silty fine sand(SM).	NP	NP	7	17.5*	-	30*	E = 8.0 MPa, μ = 0.35*
II 7.00	Medium dense brownish grey silty medium sand with traces of mica(SM)	NP	NP	15	18.0*	-	31*	E = 20 MPa, μ = 0.35*
III 11.00	Dense brownish grey/ yellowish blue silty sand with traces of mica(SM)	NP	NP	36	19.0*	-	33*	E = 35 MPa, μ = 0.35*
IV >8.45	Very dense yellowish blue silty sand with traces of mica(SM-SP).	NP	NP	51	20.0*	-	34*	E =50 MPa, μ = 0.35*

** Suggested Value*

Table 4.99 Soil Properties of Boreholes BH 7 Dahelkhand Dewara Village,Kalpli

Stratum & Thickness (m)	Description of Soil	Liquid Limit %	Plastic Limit %	N Value Field N value	Y_b KN/m^3	Shear Parameters C (kPa)	Shear Parameters Φ (degree)	Modulus of Elasticity(MPa)
I 4.00	Loose brown silty fine sand	NP	NP	8	17.5*	-	30*	E = 8.0 MPa, μ = 0.35*
II 9.00	Medium dense brown silty medium sand with traces of mica(SM)	NP	NP	14	18.0*	-	31*	E = 20 MPa, μ = 0.35*
III 9.00	Dense yellowish brown silty sand with traces of mica(SM)	NP	NP	35	19.0*	-	33*	E = 35 MPa, μ = 0.35*
IV >8.45	Very dense yellowish brown silty sand with traces of mica(SM-SP)	NP	NP	55	20.0*	-	34*	E =50 MPa, μ = 0.35*

** Suggested Value*

Table 4.100 Soil Properties of Boreholes BH 8 Pura Jalan

Stratum & Thickness (m)	Description of Soil	Liquid Limit %	Plastic Limit %	N Value Field N value	Y_b KN/m^3	Shear Parameters C (kPa)	Shear Parameters Φ (degree)	Modulus of Elasticity (MPa)
I 4.00	Loose brown silty fine sand	NP	NP	5	17.5*	-	29*	E = 6.0 MPa, μ = 0.35*
II 10.00	Medium dense brown silty medium sand with traces of mica(SM)	NP	NP	15	18.0*	-	31*	E = 20 MPa, μ = 0.35*
III 12.00	Dense yellowish brown silty sand with traces of mica(SM).	NP	NP	33	19.0*	-	33*	E = 35 MPa, μ = 0.35*
IV >4.45	Very dense yellowish brown silty sand with traces of mica(SM).	NP	NP	55	20.0*	-	34*	E =50 MPa, μ = 0.35*

** Suggested Value*

Table 4.101 Soil Properties of Boreholes BH 9 Garha Kasda Village, Etawah

Stratum & Thickness (m)	Description of Soil	Liquid Limit %	Plastic Limit %	N Value Field N value	Y_b KN/m^3	Shear Parameters C (kPa)	Shear Parameters Φ (degree)	Modulus of Elasticity (MPa)
I 3.00	Loose brownish grey silty fine sand(SM).	NP	NP	7	17.5*	-	29*	E = 6.0 MPa, μ = 0.35*
II 12.00	Medium dense brownish grey silty medium sand with traces of mica(SM)	NP	NP	15	18.0*	-	31*	E = 20 MPa, μ = 0.35*
III 6.00	Dense brownish grey/yellowish blue silty sand with traces of mica(SM)	NP	NP	30	19.0*	-	33*	E = 35 MPa, μ = 0.35*
IV >9.45	Very dense yellowish blue silty sand with traces of mica(SM-SP)	NP	NP	50	20.0*	-	34*	E =50 MPa, μ = 0.35*

** Suggested Value*

Table 4.102 Soil Properties of Boreholes BH 10 Bilahati Village, Etawah

Stratum & Thickness (m)	Description of Soil	Liquid Limit %	Plastic Limit %	N Value Field N value	Y_b KN/m^3	Shear Parameters C (kPa)	Shear Parameters Φ (degree)	(m_v) m^2/kN×10^{-4} Range(kPa) 25-50	50-100	100-200
IIIA 7.00	Stiff to very stiff brownish grey silty clay/clayey silt with rusty brown spots(CH-CI)	55	23	16	18.3	81	-	1.40	1.80	1.63
IVA 6.00	Very stiff / hard yellowish grey sandy silty clay / sandy clayey silt with kankar(CL-CI)	36	18	28	19.5	112	-	0.8	0.8	0.8
III 6.00	Dense yellowish blue clayey silty sand with traces of mica(SM).	NP	NP	46	19.0*	-	33*	E = 35 MPa, μ = 0.35*		

Stratum & Thickness (m)	Description of Soil	Liquid Limit %	Plastic Limit %	N Value Field N value	Y_b KN/m^3	Shear Parameters		(m_v) m^2/kN×10^{-4} Range(kPa)		
						C (kPa)	Φ (degree)	25-50	50-100	100-200
IV >11.45	Very dense yellowish brown silty medium sand with traces of mica(SM)	NP	NP	52	20.0*	-	34*	E =50 MPa, μ = 0.35*		

** Suggested Value*

Table 4.103 Soil Properties of Boreholes BH 11 Bhind-Etawah Bridge(NH-92), Etawah

Stratum & Thickness (m)	Description of Soil	Liquid Limit %	Plastic Limit %	N Value Field N value	Y_b KN/m^3	Shear Parameters		Modulus of Ekasticity (MPa)
						C (kPa)	Φ (degree)	
I 5.00	Very loose / loose dense brown silty sand with traces of mica	NP	NP	6	17.5*	-	29*	E = 6.0 MPa, μ = 0.35*
II 9.00	Medium dense brownish grey silty medium sand with traces of mica	NP	NP	20	18.0*	-	31*	E = 20 MPa, μ = 0.35*
III 12.00	Dense brownish grey/yellowish brown silty medium sand with traces of mica	NP	NP	33	19.0*	-	33*	E = 35 MPa, μ = 0.35*
IV >4.45	Very dense yellowish brown silty sand with traces of mica.	NP	NP	56	20.0*	-	34*	E =50 MPa, μ = 0.35*

** Suggested Value*

Table 4.104 Soil Properties of Boreholes BH 12 Guraiya Village, Etawah

Stratum & Thickness (m)	Description of Soil	Liquid Limit %	Plastic Limit %	N Value Field N value	Y_b KN/m^3	Shear Parameters		(m_v) m^2/kN×10^{-4} Range(kPa)		
						C (kPa)	Φ (degree)	25-50	50-100	100-200
II 4.00	Medium dense brownish grey silty sand with traces of mica.	NP	NP	10	18.0*	-	31*	E = 12 MPa, μ = 0.35*		

Stratum & Thickness (m)	Description of Soil	Liquid Limit %	Plastic Limit %	N Value Field N value	Y_b KN/m^3	Shear Parameters C (kPa)	Shear Parameters Φ (degree)	(m_v) $m^2/kN\times10^{-4}$ Range(kPa) 25-50	50-100	100-200
IVA 13.00	Very stiff to hard bronwish grey sandy silty clay with traces of kankar			25	19.0	120	-	0.9	0.9	0.9
IV >13.45	Very dense yellowish blue silty coarse sand with traces of mica.	NP	NP	52	20.0*	-	34*	E =50 MPa, μ = 0.35*		

** Suggested Value*

Table 4.105 Soil Properties of Boreholes BH 13 Kachhora Bridge, Agra

Stratum & Thickness (m)	Description of Soil	Liquid Limit %	Plastic Limit %	N Value Field N value	Y_b KN/m^3	Shear Parameters C (kPa)	Shear Parameters Φ (degree)	(m_v) $m^2/kN\times10^{-4}$ Range(kPa) 25-50	50-100	100-200
IA 7.00	Medium stiff/stiff brownish grey silty clay with kankar and rusty spots(CI occasionally CH).	46	23	10	18.2	49		1.38	1.75	1.58
IIIA 10.00	Very stiff to hard bronwish grey sandy silty clay with traces of kankar	36	17	24	19.0	100	-	1.38	1.35	1.28
IV >13.45	Very dense yellowish blue silty coarse sand with traces of mica.	NP	NP	52	20.0*	-	34*	E =50 MPa, μ = 0.35*		

** Suggested Value*

Table 4.106 Soil Properties of Boreholes BH 14 Budhera Village, Firozabad

Stratum & Thickness (m)	Description of Soil	Liquid Limit %	Plastic Limit %	N Value Field N value	γ_b KN/m^3	Shear Parameters C (kPa)	Shear Parameters Φ (degree)	(m_v) $m^2/kN\times10^{-4}$ Range(kPa) 25-50	50-100	100-200
IIIA 10.00	Stiff to very stiff brown silty clay/clayey silt with kankar and rusty spots(CH).	59	20	17	18.8	82	-	1.70	1.45	1.33
IVA 9.00	Very stiff/hard yellowish grey sandy silty clay/sandy clayey silt with kankar(CI-CL)	37	18	32	20.0	150*	-	0.7	0.7	0.7
IV >11.45	Very dense yellowish brown silty medium sand with traces of mica.	NP	NP	52	20.0*	-	34*	E =50 MPa, μ = 0.35*		

** Suggested Value*

Table 4.107 Soil Properties of Boreholes BH 15 Luhari Fatehabad Bridge (near Yamuna exp. way), Agra

Stratum & Thickness (m)	Description of Soil	Liquid Limit %	Plastic Limit %	N Value Field N value	γ_b KN/m^3	Shear Parameters C (kPa)	Shear Parameters Φ (degree)	(m_v) $m^2/kN\times10^{-4}$ Range(kPa) 25-50	50-100	100-200
II 8.00	Medium dense brownish grey silty medium sand with traces of mica(SM)	NP	NP	15	18.0*	-	31*	E = 20 MPa, μ = 0.35*		
III 9.00	Dense brownish grey / yellowish blue silty medium sand with traces of mica(SM)	NP	NP	32	19.0*	-	33*	E = 35 MPa, μ = 0.35*		

Stratum & Thickness (m)	Description of Soil	Liquid Limit %	Plastic Limit %	N Value Field N value	Y_b KN/m^3	Shear Parameters C (kPa)	Shear Parameters Φ (degree)	(m_v) m^2/kN×10^{-4} Range(kPa) 25-50	50-100	100-200
IVA 4.00	Hard yellowish brown very low plastic sandy clayey silt with kankar and gravels(CL)	34	17	33	20.0	153	-	0.7	0.7	0.7
III 5.00	Dense yellowish brown silty medium sand with traces of mica(SM-SP)	NP	NP	42	19.0*	-	33*	E = 35 MPa, μ = 0.35*		
IV >4.45	Very dense yellowish blue silty coarse sand with traces of mica(SM-SP)	NP	NP	52	20.0*	-	34*	E =50 MPa, μ = 0.35*		

** Suggested Value*

Table 4.108 Soil Properties of Boreholes BH 16 Indon Village, Firozabad

Stratum & Thickness (m)	Description of Soil	Liquid Limit %	Plastic Limit %	N Value Field N value	Y_b KN/m^3	Shear Parameters C (kPa)	Shear Parameters Φ (degree)	(m_v) m^2/kN×10^{-4} Range(kPa) 25-50	50-100	100-200
II 7.00	Medium dense brownish grey silty sand with mica.(SM)	NP	NP	16	18.0*	-	31*	E = 20 MPa, μ = 0.35*		
III 4.00	Dense yellowish brown clay sand with traces of mica(SM)	NP	NP	31	19.0*	-	33*	E = 35 MPa, μ = 0.35*		
IV 5.00	Very dense yellowish brown silty coarse sand with traces of mica(SM)	NP	NP	53	20.0*	-	34*	E =50 MPa, μ = 0.35*		
IVA >14.45	Hard brown sandy silty clay / sandy clayey silt with gravels and kankars(CL-CI)	39	18	35	19.1	150	-	0.7	0.7	0.7

** Suggested Value*

Table 4.109 Soil Properties of Boreholes BH 17 Mewali Kalan Village,near Yamuna Exp.Way, Agra

Stratum & Thickness (m)	Description of Soil	Liquid Limit %	Plastic Limit %	N Value Field N value	Y_b KN/m^3	Shear Parameters C (kPa)	Shear Parameters Φ (degree)	Modulus of Elasticity (MPa)
I 3.00	Very Loose/loose brownish grey silty fine sand	NP	NP	7	17.5*	-	29*	E = 8.0 MPa, μ = 0.35*
II 8.00	Medium dense brownish grey silty medium sand with traces of mica	NP	NP	15	18.0*	-	31*	E = 20 MPa, μ = 0.35*
III 7.00	Dense brownish grey / yellowish blue silty medium sand with traces of mica	NP	NP	36	19.0*	-	33*	E = 35 MPa, μ = 0.35*
IV >12.45	Very dense yellowish blue silty coarse sand with traces of mica	NP	NP	50	20.0*	-	34*	E =50 MPa, μ = 0.35*

** Suggested Value*

Table 4.110 Soil Properties of Boreholes BH 18 Etmadpur Madra, Agra(Embankment)

Stratum & Thickness (m)	Description of Soil	Liquid Limit %	Plastic Limit %	N Value Field N value	Y_b KN/m^3	Shear Parameters C (kPa)	Shear Parameters Φ (degree)	Modulus of Elasticity(MPa)
II 4.00	Medium dense brownish grey silty medium sand with traces of mica	NP	NP	28	18.0*	-	31*	E = 20 MPa, μ = 0.35*
III 9.00	Dense yellowish brown silty sand with traces of mica	NP	NP	34	19.0*	-	33*	E = 35 MPa, μ = 0.35*
IV >17.45	Very dense yellowish blue silty coarse sand with traces of mica	NP	NP	54	20.0*	-	34*	E =50 MPa, μ = 0.35*

** Suggested Value*

Table 4.111 Soil Properties of Boreholes BH 19 Etmadpur Madra, Agra(River Bed)

Stratum & Thickness (m)	Description of Soil	Liquid Limit %	Plastic Limit %	N Value Field N value	Y_b KN/m^3	Shear Parameters C (kPa)	Shear Parameters Φ (degree)	Modulus of Elasticity (MPa)
I 1.50	Very Loose/loose brownish grey silty fine sand	NP	NP	-	17.5	-	-	-
II 9.50	Medium dense brownish grey silty medium sand with traces of mica	NP	NP	17	18.0*	-	31*	E = 20 MPa, µ = 0.35*
III 9.00	Dense brownish grey / yellowish blue silty medium sand with traces of mica	NP	NP	32	19.0*	-	33*	E = 35 MPa, µ = 0.35*
IV >10.45	Very dense yellowish blue silty coarse sand with traces of mica	NP	NP	55	20.0*	-	34*	E =50 MPa, µ = 0.35*

** Suggested Value*

Table 4.112 Soil Properties of Boreholes BH 20 Manoharpur, Agra

Stratum & Thickness (m)	Description of Soil	Liquid Limit %	Plastic Limit %	N Value Field N value	Y_b KN/m^3	Shear Parameters C (kPa)	Shear Parameters Φ (degree)	Modulus of Elasticity (MPa)
II 8.00	Medium dense brown to greyish brown silty sand with traces of mica	NP	NP	17	18.0*	-	31*	E = 20 MPa, µ = 0.35*
III 11.00	Dense brownish grey / yellowish blue silty medium sand with traces of mica	NP	NP	32	19.0*	-	33*	E = 35 MPa, µ = 0.35*
IV >11.45	Very dense yellowish blue silty coarse sand with traces of mica	NP	NP	55	20.0*	-	34*	E =50 MPa, µ = 0.35*

** Suggested Value*

Table 4.113 Soil Properties of Boreholes BH 21 District Road Bridge, Agra

Stratum & Thickness (m)	Description of Soil	Liquid Limit %	Plastic Limit %	N Value	Y_b KN/m^3	Shear Parameters		Modulus of Elasticity (MPa)
				Field N value		C (kPa)	Φ (degree)	
I 1.50	Very Loose/loose brown silty fine sand	NP	NP	6	17.5*	-	29*	E = 8.0 MPa, µ = 0.35*
II 6.50	Medium dense brownish grey silty medium sand with traces of mica	NP	NP	15	18.0*	-	31*	E = 20 MPa, µ = 0.35*
III 10.00	Dense brownish grey / yellowish blue silty medium sand with traces of mica	NP	NP	33	19.0*	-	33*	E = 35 MPa, µ = 0.35*
IV >12.45	Very dense yellowish blue silty coarse sand with traces of mica	NP	NP	54	20.0*	-	34*	E =50 MPa, µ = 0.35*

** Suggested Value*

Table 4.114 Soil Properties of Boreholes BH 22 Manoharpur, Agra

Stratum & Thickness (m)	Description of Soil	Liquid Limit %	Plastic Limit %	N Value	Y_b KN/m^3	Shear Parameters		Modulus of Elasticity(MPa)
				Field N value		C (kPa)	Φ (degree)	
II 5.00	Medium dense brownish grey silty sand with traces of mica	NP	NP	17	18.0*	-	31*	E = 20 MPa, µ = 0.35*
III 8.00	Dense brownish grey / yellowish blue silty medium sand with traces of mica	NP	NP	35	19.0*	-	33*	E = 35 MPa, µ = 0.35*
IV >17.45	Very dense yellowish brown silty coarse sand with traces of mica	NP	NP	54	20.0*	-	34*	E =50 MPa, µ = 0.35*

** Suggested Value*

Table 4.115 Soil Properties of Boreholes BH 23 Vrindavan, Mathura

Stratum & Thickness (m)	Description of Soil	Liquid Limit %	Plastic Limit %	N Value Field N value	Y_b KN/m³	Shear Parameters C (kPa)	Shear Parameters Φ (degree)	Modulus of Elasticity(MPa)
II 13.00	Medium dense brownish grey silty sand with traces of mica	NP	NP	16	18.0*	-	31*	E = 20 MPa, μ = 0.35*
III 7.00	Dense brownish grey / yellowish blue silty medium sand with traces of mica	NP	NP	33	19.0*	-	33*	E = 35 MPa, μ = 0.35*
IV >10.45	Very dense yellowish blue silty coarse sand with traces of mica	NP	NP	53	20.0*	-	34*	E =50 MPa, μ = 0.35*

** Suggested Value*

Table 4.116 Soil Properties of Boreholes BH 24 Dangoli Khader, Mathura

Stratum & Thickness (m)	Description of Soil	Liquid Limit %	Plastic Limit %	N Value Field N value	Y_b KN/m³	Shear Parameters C (kPa)	Shear Parameters Φ (degree)	Modulus of Elasticity(MPa)		
I 1.50	Very Loose/loose brownish grey silty fine sandSM)	NP	NP	6	17.5*	-	29*	E = 8.0 MPa, μ = 0.35*		
II 6.50	Medium dense brownish grey silty medium sand with traces of mica(SM)	NP	NP	15	18.0*	-	31*	E = 20 MPa, μ = 0.35*		
IVA 6.00	Hard yellowish brown sandy clayey silt with gravels(CI).	39	18	34	20.0	150	-	0.7	0.7	0.7
IV >16.45	Very dense yellowish blue silty coarse sand with traces of mica(SM-SP)	NP	NP	58	20.0*	-	34*	E =50 MPa, μ = 0.35*		

** Suggested Value*

Table 4.117 Soil Properties of Boreholes BH 25 Sultanpur Khadar, Mathura

Stratum & Thickness (m)	Description of Soil	Liquid Limit %	Plastic Limit %	N Value	Y_b KN/m^3	Shear Parameters		(m_v) m^2/kN×10^{-4} Range(kPa)		
				Field N value		C (kPa)	Φ (degree)	25-50	50-100	100-200
II 5.00	Medium dense brownish grey silty medium sand with traces of mica. (SM)	NP	NP	6	17.5	-	29*	E = 8 MPa, μ = 0.35*		
IIIA 6.00	Stiff brownish grey silty clay/clayey silt with nodules.	47	23	19	18.4	90	-	1.90	1.70	1.67
IVA 9.00	Very stiff / Hard yellowish grey sandy silty clay with nodules.	33	17	33	20.0	150	-	0.7	0.7	0.7*
III 5.00	Dense yellowish blue clayey silty sand with traces of mica(SM)	NP	NP	49	19.0*	-	33*	E = 35 MPa, μ = 0.35*		
IV >5.45	Very dense yellowish brown silty medium sand with traces of mica(SM-SP)	NP	NP	60	20.0*	-	34*	E =50 MPa, μ = 0.35*		

** Suggested Value*

Table 4.118 Soil Properties of Boreholes BH 26 Sherpur Village/Tappal Town, Aligarh

Stratum & Thickness (m)	Description of Soil	Liquid Limit %	Plastic Limit %	N Value	Y_b KN/m^3	Shear Parameters		(m_v) m^2/kN×10^{-4} Range(kPa)		
				Field N value		C (kPa)	Φ (degree)	25-50	50-100	100-200
I 3.50	Loose brownish grey silty sand(SM)	NP	NP	8	17.5*	-	29*	E = 6.0 MPa, μ = 0.35*		
II 4.50	Medium dense brownish grey silty medium sand with traces of mica(SM)	NP	NP	15	18.0*	-	31*	E = 20 MPa, μ = 0.35*		

Stratum & Thickness (m)	Description of Soil	Liquid Limit %	Plastic Limit %	N Value Field N value	Y_b KN/m^3	Shear Parameters C (kPa)	Shear Parameters Φ (degree)	(m_v) m^2/kN×10^{-4} Range(kPa) 25-50	50-100	100-200
III 8.00	Dense brownish grey / yellowish blue silty medium sand with traces of mica(SM)	NP	NP	35	19.0*	-	33*	E = 35 MPa, μ = 0.35*		
IV 6.00	Very dense yellowish brown silty medium sand with traces of mica(SM-SP)	NP	NP	53	20.0*	-	34*	E =50 MPa, μ = 0.35*		
IVA >8.45	Very hard yellowish brown sandy clayey silt with nodules and mica.(CL-CI)	34	17	67	20.0*	-	150*	0.7	0.7	0.7

** Suggested Value*

Table 4.119 Soil Properties of Boreholes BH 27 Mohna Town, Faridabad

Stratum & Thickness (m)	Description of Soil	Liquid Limit %	Plastic Limit %	N Value Field N value	Y_b KN/m^3	Shear Parameters C (kPa)	Shear Parameters Φ (degree)	Modulus of Elasticity(MPa)
I 2.00	Loose brownish grey silty sand(SM).	NP	NP	8	17.5*	-	30*	E = 8 MPa, μ = 0.35*
III 6.00	Dense bownish grey / yellowish blue silty medium sand with traces of mica(SM).	NP	NP	35	19.0*	-	33*	E =35 MPa, μ = 0.35*
IV >22.45	Very dense yellowish brown silty medium sand with traces of mica(SM-SP)	NP	NP	53	20.0*	-	34*	E =50 MPa, μ = 0.35*

** Suggested Value*

Table 4.120 Soil Properties of Boreholes BH 28 Sector-150, Noida, Faridabad- Gautam

Stratum & Thickness (m)	Description of Soil	Liquid Limit %	Plastic Limit %	N Value Field N value	Y_b KN/m^3	Shear Parameters C (kPa)	Shear Parameters Φ (degree)	(m_v) $m^2/kN \times 10^{-4}$ Range(kPa) 25-50	50-100	100-200
IIIA 2.00	Very stiff brown sandy clayey silt with traces of mica(CL)	30	17	23	19.0	-	-	-	-	-
III 11.00	Dense brownish grey / yellowish blue silty medium sand with traces of mica(SM)	NP	NP	42	19.0*	-	33*	E = 35 MPa, µ = 0.35*		
IV >17.45	Very dense yellowish brown silty coarse sand with traces of mica(SM-SP)	NP	NP	53	20.0*	-	34*	E =50 MPa, µ = 0.35*		

** Suggested Value*

Table 4.121 Soil Properties of Boreholes BH 29 Madanpur Khadar, Delhi(Embankment)

Stratum & Thickness (m)	Description of Soil	Liquid Limit %	Plastic Limit %	N Value Field N value	Y_b KN/m^3	Shear Parameters C (kPa)	Shear Parameters Φ (degree)	Modulus of Elasticity(MPa)
I 1.50	Very Loose/loose brownish grey silty fine sand(SM)	NP	NP	-	17.5*	-	-	-
II 6.50	Medium dense brownish grey silty medium sand with traces of mica(SM)	NP	NP	15	18.0*	-	31*	E = 20 MPa, µ = 0.35*
III 10.00	Dense brownish grey / yellowish blue silty medium sand with traces of mica(SM)	NP	NP	36	19.0*	-	33*	E = 35 MPa, µ = 0.35*

Stratum & Thickness (m)	Description of Soil	Liquid Limit %	Plastic Limit %	N Value Field N value	Y_b KN/m^3	Shear Parameters C (kPa)	Shear Parameters Φ (degree)	Modulus of Elasticity(MPa)
IV >12.45	Very dense yellowish blue silty coarse sand with traces of mica(SM-SP)	NP	NP	54	20.0*	-	34*	E =50 MPa, μ = 0.35*

** Suggested Value*

Table 4.122 Soil Properties of Boreholes BH 30 Madanpur Khadar, Delhi(River bed)

Stratum & Thickness (m)	Description of Soil	Liquid Limit %	Plastic Limit %	N Value Field N value	Y_b KN/m^3	Shear Parameters C (kPa)	Shear Parameters Φ (degree)	Modulus of Elasticity(MPa)
I 1.50	Very Loose/loose brownish grey silty fine sand(SM)	NP	NP	-	17.5*	-	-	-
II 12.00	Medium dense brownish grey silty medium sand with traces of mica(SM)	NP	NP	15	18.0*	-	31*	E = 20 MPa, μ = 0.35*
III 10.00	Dense yellowish blue silty medium sand with traces of mica(SM)	NP	NP	36	19.0*	-	33*	E = 35 MPa, μ = 0.35*
IV >7.45	Very dense yellowish blue silty coarse sand with traces of mica(SM-SP)	NP	NP	54	20.0*	-	34*	E =50 MPa, μ = 0.35*

** Suggested Value*

Where,
E = Modulus of Elasticity, μ = Poisson's Ratio, Y_b = Bulk density, C = Cohesion Value
Φ = Angle of internal friction, m_v = Coefficient of volume compressibility

4.16.4 Foundation Recommendations

Foundation of a structure is to be designed from considerations of superstructure loading as well as subsoil condition at the site. Suitable foundations for a structure should satisfy the following basic design criteria:

a) There must be adequate factor of safety of the foundations against any possible bearing capacity failure and
b) The settlement of the foundations must be within permissible limits.

From the considerations of superstructure loading and subsoil condition, deep foundation in the form of RCC bored cast-in-situ piles has been investigated. Pile toe may be kept at different depth for different zone, below the lowest bed level (LBL) with appropriate cut-off level for piles. The ultimate load carrying capacity (Q_u) of a pile foundation has been estimated as given below

$$Q_u = A_p (0.5 x D x \gamma x N_\gamma + P_d x N_q) + \sum \alpha\, C\, A_s + K\, P_{di} \tan\delta\, A_{si}$$

where, A_P = Cross-sectional area of pile toe, D = Pile stem diameter,
γ = Effective unit weight of soil at pile toe,
P_d = Effective overburden pressure at pile toe,
N_γ & N_q = Bearing capacity factors depending upon the angle of internal friction (Φ) of soil at pile toe,
∑ = Summation for n layers in which pile is installed,
α = Reduction factor, C = Average cohesion of soil,
As = Surface area of pile stem, K = Coefficient of earth pressure = 1.5,
P_{di} = Effective overburden pressure for the i^{th} layer;
δ = Angle of wall friction between pile and soil in degrees (may be taken equal to Φ) and
A_{si} = Surface area of pile stem in the i^{th} layer.

For working out safe load carrying capacity in compression and in tension FOS of 2.5 may be used on the ultimate load capacity. Values of safe load carrying capacity of RCC Bored Cast in situ pile for different diameters have been estimated and shown for different zones in the tables below:

Table 4.123 Pile Capacities for BH1

Pile Dia (mm)	Safe Vertical Capacity in Compression (KN)	Safe Vertical Capacity in Tension(KN)	Shaft Length(m)	Bored Length(m)	Fixed Head Condition	
					Depth of Fixity(m)	Lateral Capacity(KN)
600	375	200	8.50	10.00	5.64	58
700	450	250	8.50	10.00	6.58	68
600	900	550	18.50	20.00	5.64	58
700	1200	700	18.50	20.00	6.58	68
800	1600	850	18.50	20.00	7.52	78
900	2000	1000	18.50	20.00	8.46	87
1000	2550	1200	18.50	20.00	9.40	97
1200	3750	1550	18.50	20.00	11.28	116
600	1400	900	28.50	30.00	5.64	58
700	1950	1200	28.50	30.00	6.58	68
800	2550	1550	28.50	30.00	7.52	78
900	3300	1900	28.50	30.00	8.46	87
1000	4150	2300	28.50	30.00	9.40	97

Pile Dia (mm)	Safe Vertical Capacity in Compression (KN)	Safe Vertical Capacity in Tension(KN)	Shaft Length(m)	Bored Length(m)	Fixed Head Condition	
					Depth of Fixity(m)	Lateral Capacity(KN)
1200	6150	3150	28.50	30.00	11.28	116
750	1900	1100	24.50	26.00	7.05	73
1000	3600	1800	24.50	26.00	9.40	97
1200	5400	2500	24.50	26.00	11.28	116

Cut-off-level = 1.50m below EGL;

Note: Pile capacity must be verified by initial load tests

Calculation is based upon considering 5mm of deflection at pile cut-off

Table 4.124 Pile Capacities for BH2

Pile Dia (mm)	Safe Vertical Capacity in Compression (KN)	Safe Vertical Capacity in Tension(KN)	Shaft Length(m)	Bored Length(m)	Fixed Head Condition	
					Depth of Fixity(m)	Lateral Capacity(KN)
600	Founding layer is not encountered at pile tip level.		8.50	10.00		
700			8.50	10.00		
800			8.50	10.00		
900			8.50	10.00		
1000			8.50	10.00		
1200			8.50	10.00		
600	750	450	18.50	20.00	5.27	71
700	1050	600	18.50	20.00	5.97	91
800	1400	750	18.50	20.00	6.64	113
900	1800	900	18.50	20.00	7.29	136
1000	2250	1050	18.50	20.00	7.94	161
1200	3400	1350	18.50	20.00	9.18	216
600	1250	800	28.50	30.00	5.27	71
700	1700	1050	28.50	30.00	5.97	91
800	2300	1350	28.50	30.00	6.64	113
900	2950	1700	28.50	30.00	7.29	136
1000	3750	2050	28.50	30.00	7.94	161
1200	5600	2850	28.50	30.00	9.18	216
750	1700	1000	24.50	26.00	7.05	73
1000	3200	1600	24.50	26.00	7.94	161
1200	4900	2200	24.50	26.00	9.18	216

Cut-off-level = 1.50m below EGL;

Note: Pile capacity must be verified by initial load tests.

Calculation is based upon considering 5mm of deflection at pile cut-off

Table 4.125 Pile Capacities for BH3

Pile Dia (mm)	Safe Vertical Capacity in Compression (KN)	Safe Vertical Capacity in Tension(KN)	Shaft Length(m)	Bored Length(m)	Fixed Head Condition	
					Depth of Fixity(m)	Lateral Capacity(KN)
600	Founding layer is not encountered at pile tip level.		8.50	10.00		
700			8.50	10.00		
800			8.50	10.00		
900			8.50	10.00		
1000			8.50	10.00		
1200			8.50	10.00		
600	650	400	18.50	20.00	5.27	71
700	800	500	18.50	20.00	5.97	91
800	950	550	18.50	20.00	6.64	113
900	1100	650	18.50	20.00	7.29	136
1000	1300	700	18.50	20.00	7.94	161
1200	1650	850	18.50	20.00	9.18	216
600	1000	700	28.50	30.00	5.27	71
700	1200	800	28.50	30.00	5.97	91
800	1400	950	28.50	30.00	6.64	113
900	1600	1050	28.50	30.00	7.29	136
1000	1850	1200	28.50	30.00	7.94	161
1200	2300	1400	28.50	30.00	9.18	216
750	1100	700	24.50	26.00	7.05	73
1000	1600	1000	24.50	26.00	7.94	161
1200	2000	1200	24.50	26.00	9.18	216

Cut-off-level = 1.50m below EGL;

Note: Pile capacity must be verified by initial load tests.
Calculation is based upon considering 5mm of deflection at pile cut-off

Table 4.126 Pile Capacities for BH4

Pile Dia (mm)	Safe Vertical Capacity in Compression (KN)	Safe Vertical Capacity in Tension(KN)	Shaft Length(m)	Bored Length(m)	Fixed Head Condition	
					Depth of Fixity(m)	Lateral Capacity(KN)
600	Founding layer is not encountered at pile tip level.		8.50	10.00		
700			8.50	10.00		
800			8.50	10.00		
900			8.50	10.00		
1000			8.50	10.00		
1200			8.50	10.00		
600	600	450	18.50	20.00	5.03	82

Pile Dia (mm)	Safe Vertical Capacity in Compression (KN)	Safe Vertical Capacity in Tension(KN)	Shaft Length(m)	Bored Length(m)	Fixed Head Condition	
					Depth of Fixity(m)	Lateral Capacity(KN)
700	700	500	18.50	20.00	5.68	105
800	800	600	18.50	20.00	6.33	130
900	950	650	18.50	20.00	6.95	157
1000	1050	750	18.50	20.00	7.56	186
1200	1350	900	18.50	20.00	8.75	250
600	1000	700	28.50	30.00	5.03	82
700	1200	850	28.50	30.00	5.68	105
800	1450	950	28.50	30.00	6.33	130
900	1650	1100	28.50	30.00	6.95	157
1000	1850	1200	28.50	30.00	7.56	186
1200	2350	1450	28.50	30.00	8.75	250
750	1150	700	24.50	26.00	6.01	118
1000	1600	1000	24.50	26.00	7.56	186
1200	2100	1200	24.50	26.00	8.75	250

Cut-off-level = 1.50m below EGL;

Note: Pile capacity must be verified by initial load tests.

Calculation is based upon considering 5mm of deflection at pile cut-off

Table 4.127 Pile Capacities for BH5

Pile Dia (mm)	Safe Vertical Capacity in Compression (KN)	Safe Vertical Capacity in Tension(KN)	Shaft Length(m)	Bored Length(m)	Fixed Head Condition	
					Depth of Fixity(m)	Lateral Capacity(KN)
600	Founding Stratum is not encountered at the founding level		8.50	10.00		
700			8.50	10.00		
800			8.50	10.00		
900			8.50	10.00		
1000			8.50	10.00		
1200			8.50	10.00		
600	750	450	18.50	20.00	5.27	71
700	1100	650	18.50	20.00	5.97	91
800	1500	800	18.50	20.00	6.64	113
900	1950	950	18.50	20.00	7.29	136
1000	2450	1150	18.50	20.00	7.94	161
1200	3650	1500	18.50	20.00	9.18	216
600	1250	800	28.50	30.00	5.27	71
700	1800	1100	28.50	30.00	5.97	91
800	2400	1450	28.50	30.00	6.64	113

Pile Dia (mm)	Safe Vertical Capacity in Compression (KN)	Safe Vertical Capacity in Tension(KN)	Shaft Length(m)	Bored Length(m)	Fixed Head Condition	
					Depth of Fixity(m)	Lateral Capacity(KN)
900	3100	1800	28.50	30.00	7.29	136
1000	3950	2200	28.50	30.00	7.94	161
1200	5950	3000	28.50	30.00	9.18	216
750	1750	1000	24.50	26.00	7.05	73
1000	3400	1700	24.50	26.00	7.94	161
1200	5100	2300	24.50	26.00	9.18	216

Cut-off-level = 1.50m below EGL;

Note: Pile capacity must be verified by initial load tests.
Calculation is based upon considering 5mm of deflection at pile cut-off

Table 4.128 Pile Capacities for BH6

Pile Dia (mm)	Safe Vertical Capacity in Compression (KN)	Safe Vertical Capacity in Tension(KN)	Shaft Length(m)	Bored Length(m)	Fixed Head Condition	
					Depth of Fixity(m)	Lateral Capacity(KN)
600	Founding Stratum not encountered at pile tip level		8.50	10.00		
700			8.50	10.00		
800			8.50	10.00		
900			8.50	10.00		
1000			8.50	10.00		
1200			8.50	10.00		
600	750	450	18.50	20.00	5.49	63
700	1050	600	18.50	20.00	6.21	81
800	1400	750	18.50	20.00	6.91	100
900	1850	900	18.50	20.00	7.59	121
1000	2300	1100	18.50	20.00	8.26	143
1200	3450	1400	18.50	20.00	9.56	191
600	1150	800	28.50	30.00	5.49	63
700	1600	1050	28.50	30.00	6.21	81
800	2150	1350	28.50	30.00	6.91	100
900	2800	1700	28.50	30.00	7.59	121
1000	3550	2100	28.50	30.00	8.26	143
1200	5250	2900	28.50	30.00	9.56	191
750	1700	950	24.50	26.00	6.56	90
1000	3250	1600	24.50	26.00	8.26	143
1200	4900	2200	24.50	26.00	9.56	191

Cut-off-level = 1.50m below EGL;

Note: Pile capacity must be verified by initial load tests.
Calculation is based upon considering 5mm of deflection at pile cut-off

Table 4.129 Pile Capacities for BH7

Pile Dia (mm)	Safe Vertical Capacity in Compression (KN)	Safe Vertical Capacity in Tension(KN)	Shaft Length(m)	Bored Length(m)	Fixed Head Condition	
					Depth of Fixity(m)	Lateral Capacity(KN)
600	Founding layer is not encountered at pile tip level.		8.50	10.00		
700			8.50	10.00		
800			8.50	10.00		
900			8.50	10.00		
1000			8.50	10.00		
1200			8.50	10.00		
600	750	425	18.50	20.00	5.49	63
700	1000	550	18.50	20.00	6.21	81
800	1350	700	18.50	20.00	6.91	100
900	1750	875	18.50	20.00	7.59	121
1000	2250	1050	18.50	20.00	8.26	143
1200	3400	1350	18.50	20.00	9.56	191
600	1200	800	28.50	30.00	5.49	63
700	1700	1050	28.50	30.00	6.21	81
800	2250	1350	28.50	30.00	6.91	100
900	2900	1675	28.50	30.00	7.59	121
1000	3700	2050	28.50	30.00	8.26	143
1200	5600	2800	28.50	30.00	9.56	191
750	1650	900	24.50	26.00	6.56	90
1000	3200	1600	24.50	26.00	8.26	143
1200	4850	2200	24.50	26.00	9.56	191

Cut-off-level = 1.50m below EGL;

Note: Pile capacity must be verified by initial load tests.
Calculation is based upon considering 5mm of deflection at pile cut-off

Table 4.130 Pile Capacities for BH8

Pile Dia (mm)	Safe Vertical Capacity in Compression (KN)	Safe Vertical Capacity in Tension(KN)	Shaft Length(m)	Bored Length(m)	Fixed Head Condition	
					Depth of Fixity(m)	Lateral Capacity(KN)
600	Founding layer is not encountered at pile tip level.		8.50	10.00		
700			8.50	10.00		
800			8.50	10.00		
900			8.50	10.00		
1000			8.50	10.00		
1200			8.50	10.00		
600	725	400	18.50	20.00	5.49	63

Pile Dia (mm)	Safe Vertical Capacity in Compression (KN)	Safe Vertical Capacity in Tension(KN)	Shaft Length(m)	Bored Length(m)	Fixed Head Condition	
					Depth of Fixity(m)	Lateral Capacity(KN)
700	1025	575	18.50	20.00	6.21	81
800	1350	725	18.50	20.00	6.91	100
900	1750	875	18.50	20.00	7.59	121
1000	2225	1000	18.50	20.00	8.26	143
1200	3350	1300	18.50	20.00	9.56	191
600	1200	750	28.50	30.00	5.49	63
700	1650	1000	28.50	30.00	6.21	81
800	2200	1300	28.50	30.00	6.91	100
900	2850	1650	28.50	30.00	7.59	121
1000	3600	2000	28.50	30.00	8.26	143
1200	5500	2750	28.50	30.00	9.56	191
750	1550	900	24.50	26.00	6.56	90
1000	2850	1500	24.50	26.00	8.26	143
1200	4300	2100	24.50	26.00	9.56	191

Cut-off-level = 1.50m below EGL;

Note: Pile capacity must be verified by initial load tests.
Calculation is based upon considering 5mm of deflection at pile cut-off

Table 4.131 Pile Capacities for BH9

Pile Dia (mm)	Safe Vertical Capacity in Compression (KN)	Safe Vertical Capacity in Tension(KN)	Shaft Length(m)	Bored Length(m)	Fixed Head Condition	
					Depth of Fixity(m)	Lateral Capacity(KN)
600	Founding level is not encountered at the pile tip level.		8.50	10.00		
700			8.50	10.00		
800			8.50	10.00		
900			8.50	10.00		
1000			8.50	10.00		
1200			8.50	10.00		
600	750	450	18.50	20.00	5.49	63
700	1000	550	18.50	20.00	6.21	81
800	1350	700	18.50	20.00	6.91	100
900	1750	850	18.50	20.00	7.59	121
1000	2200	1000	18.50	20.00	8.26	143
1200	3325	1300	18.50	20.00	9.56	191
600	1200	750	28.50	30.00	5.49	63
700	1700	1000	28.50	30.00	6.21	81

Pile Dia (mm)	Safe Vertical Capacity in Compression (KN)	Safe Vertical Capacity in Tension(KN)	Shaft Length(m)	Bored Length(m)	Fixed Head Condition	
					Depth of Fixity(m)	Lateral Capacity(KN)
800	2250	1350	28.50	30.00	6.91	100
900	2900	1650	28.50	30.00	7.59	121
1000	3650	2000	28.50	30.00	8.26	143
1200	5500	2750	28.50	30.00	9.56	191
750	1650	900	24.50	26.00	6.56	90
1000	3100	1600	24.50	26.00	8.26	143
1200	4800	2100	24.50	26.00	9.56	191

Cut-off-level = 1.50m below EGL;

Note: Pile capacity must be verified by initial load tests.
Calculation is based upon considering 5mm of deflection at pile cut-off

Table 4.132 Pile Capacities for BH10

Pile Dia (mm)	Safe Vertical Capacity in Compression (KN)	Safe Vertical Capacity in Tension(KN)	Shaft Length(m)	Bored Length(m)	Fixed Head Condition	
					Depth of Fixity(m)	Lateral Capacity(KN)
600	375	200	8.50	10.00	5.14	77
700	450	250	8.50	10.00	6.00	90
600	900	550	18.50	20.00	5.14	77
700	1225	700	18.50	20.00	6.00	90
800	1600	850	18.50	20.00	6.86	102
900	2050	1050	18.50	20.00	7.71	115
1000	2600	1250	18.50	20.00	8.57	128
1200	3800	1550	18.50	20.00	10.29	154
600	1400	900	28.50	30.00	5.03	75
700	1950	1250	28.50	30.00	5.86	88
800	2600	1550	28.50	30.00	6.70	100
900	3350	1950	28.50	30.00	7.54	113
1000	4200	2350	28.50	30.00	8.38	125
1200	6200	3200	28.50	30.00	10.05	150
750	1950	1100	24.50	26.00	6.28	94
1000	3700	1900	24.50	26.00	8.38	125
1200	5450	2500	24.50	26.00	10.05	150

Cut-off-level = 1.50m below EGL;

Note: Pile capacity must be verified by initial load tests.
Calculation is based upon considering 5mm of deflection at pile cut-off

Table 4.133 Pile Capacities for BH11

Pile Dia (mm)	Safe Vertical Capacity in Compression (KN)	Safe Vertical Capacity in Tension(KN)	Shaft Length(m)	Bored Length(m)	Fixed Head Condition	
					Depth of Fixity(m)	Lateral Capacity(KN)
600	Founding stratum is not encountered at pile tip level		8.50	10.00		
700			8.50	10.00		
800			8.50	10.00		
900			8.50	10.00		
1000			8.50	10.00		
1200			8.50	10.00		
600	700	400	18.50	20.00	5.49	63
700	900	550	18.50	20.00	6.21	81
800	1150	700	18.50	20.00	6.91	100
900	1400	850	18.50	20.00	7.59	121
1000	1700	1000	18.50	20.00	8.26	143
1200	2250	1300	18.50	20.00	9.56	191
600	1100	750	28.50	30.00	5.49	63
700	1550	1000	28.50	30.00	6.21	81
800	2050	1300	28.50	30.00	6.91	100
900	2650	1600	28.50	30.00	7.59	121
1000	3350	1950	28.50	30.00	8.26	143
1200	5000	2700	28.50	30.00	9.56	191
750	1500	900	24.50	26.00	6.56	90
1000	2800	1500	24.50	26.00	8.26	143
1200	4200	2050	24.50	26.00	9.56	191

Cut-off-level = 1.50m below EGL;

Note: Pile capacity must be verified by initial load tests.
Calculation is based upon considering 5mm of deflection at pile cut-off

Table 4.134 Pile Capacities for BH12

Pile Dia (mm)	Safe Vertical Capacity in Compression (KN)	Safe Vertical Capacity in Tension(KN)	Shaft Length(m)	Bored Length(m)	Fixed Head Condition	
					Depth of Fixity(m)	Lateral Capacity(KN)
600	300	150	8.50	10.00	5.27	71
700	400	200	8.50	10.00	5.97	91
600	750	450	18.50	20.00	5.27	71
700	1000	550	18.50	20.00	5.97	91
800	1250	650	18.50	20.00	6.64	113
900	1600	800	18.50	20.00	7.29	136
1000	2000	900	18.50	20.00	7.94	161

Pile Dia (mm)	Safe Vertical Capacity in Compression (KN)	Safe Vertical Capacity in Tension(KN)	Shaft Length(m)	Bored Length(m)	Fixed Head Condition	
					Depth of Fixity(m)	Lateral Capacity(KN)
1200	3000	1200	18.50	20.00	9.18	216
600	1300	850	28.50	30.00	5.27	71
700	1800	1100	28.50	30.00	5.97	91
800	2350	1350	28.50	30.00	6.64	113
900	3000	1700	28.50	30.00	7.29	136
1000	3800	2000	28.50	30.00	7.94	161
1200	5750	2800	28.50	30.00	9.18	216
750	1700	950	24.50	26.00	7.05	73
1000	3300	1550	24.50	26.00	7.94	161
1200	4950	2100	24.50	26.00	9.18	216

Cut-off-level = 1.50m below EGL;

Note: Pile capacity must be verified by initial load tests.
Calculation is based upon considering 5mm of deflection at pile cut-off

Table 4.135 Pile Capacities for BH13

Pile Dia (mm)	Safe Vertical Capacity in Compression (KN)	Safe Vertical Capacity in Tension(KN)	Shaft Length(m)	Bored Length(m)	Fixed Head Condition	
					Depth of Fixity(m)	Lateral Capacity(KN)
600	350	200	8.50	10.00	5.67	52
700	450	250	8.50	10.00	6.62	61
600	800	500	18.50	20.00	5.83	53
700	1050	600	18.50	20.00	6.80	61
800	1350	750	18.50	20.00	7.78	70
900	1700	850	18.50	20.00	8.75	79
1000	2100	1000	18.50	20.00	9.72	88
1200	3100	1300	18.50	20.00	11.66	105
600	1350	900	28.50	30.00	5.83	53
700	1850	1150	28.50	30.00	6.80	61
800	2400	1400	28.50	30.00	7.78	70
900	3100	1700	28.50	30.00	8.75	79
1000	3850	2100	28.50	30.00	9.72	88
1200	5800	2900	28.50	30.00	11.66	105
750	1800	1000	24.50	26.00	7.29	66
1000	3300	1600	24.50	26.00	9.72	88
1200	5050	2200	24.50	26.00	11.66	105

Cut-off-level = 1.50m below EGL;

Note: Pile capacity must be verified by initial load tests.

Calculation is based upon considering 5mm of deflection at pile cut-off

Table 4.136 Pile Capacities for BH14

Pile Dia (mm)	Safe Vertical Capacity in Compression (KN)	Safe Vertical Capacity in Tension(KN)	Shaft Length(m)	Bored Length(m)	Fixed Head Condition	
					Depth of Fixity(m)	Lateral Capacity(KN)
600	350	225	8.50	10.00	5.13	78
700	450	375	8.50	10.00	5.98	90
600	750	500	18.50	20.00	5.13	78
700	950	600	18.50	20.00	5.98	90
800	1150	700	18.50	20.00	6.84	103
900	1325	800	18.50	20.00	7.69	116
1000	1550	925	18.50	20.00	8.54	129
1200	2000	1150	18.50	20.00	10.25	155
600	1400	900	28.50	30.00	5.13	78
700	1850	1150	28.50	30.00	5.98	90
800	2450	1450	28.50	30.00	6.84	103
900	3100	1750	28.50	30.00	7.69	116
1000	3900	2050	28.50	30.00	8.54	129
1200	5900	2800	28.50	30.00	10.25	155
750	1800	1000	24.50	26.00	6.41	97
1000	3350	1600	24.50	26.00	8.54	129
1200	5100	2100	24.50	26.00	10.25	155

Cut-off-level = 1.50m below EGL;

Note: Pile capacity must be verified by initial load tests.

Calculation is based upon considering 5mm of deflection at pile cut-off

Table 4.137 Pile Capacities for BH15

Pile Dia (mm)	Safe Vertical Capacity in Compression (KN)	Safe Vertical Capacity in Tension(KN)	Shaft Length(m)	Bored Length(m)	Fixed Head Condition	
					Depth of Fixity(m)	Lateral Capacity(KN)
600	325	150	8.50	10.00	5.27	71
700	425	175	8.50	10.00	5.97	91
600	725	450	18.50	20.00	5.27	71
700	950	600	18.50	20.00	5.97	91
800	1250	700	18.50	20.00	6.64	113
900	1550	850	18.50	20.00	7.29	136
1000	1600	1000	18.50	20.00	7.94	161
1200	2100	1200	18.50	20.00	9.18	216
600	1200	800	28.50	30.00	5.27	71
700	1600	1050	28.50	30.00	5.97	91

Pile Dia (mm)	Safe Vertical Capacity in Compression (KN)	Safe Vertical Capacity in Tension(KN)	Shaft Length(m)	Bored Length(m)	Fixed Head Condition	
					Depth of Fixity(m)	Lateral Capacity(KN)
800	2150	1300	28.50	30.00	6.64	113
900	2750	1650	28.50	30.00	7.29	136
1000	3400	1950	28.50	30.00	7.94	161
1200	5000	2600	28.50	30.00	9.18	216
750	1600	950	24.50	26.00	7.05	73
1000	2900	1500	24.50	26.00	7.94	161
1200	4300	1950	24.50	26.00	9.18	216

Cut-off-level = 1.50m below EGL;

Note: Pile capacity must be verified by initial load tests.
Calculation is based upon considering 5mm of deflection at pile cut-off

Table 4.138 Pile Capacities for BH16

Pile Dia (mm)	Safe Vertical Capacity in Compression (KN)	Safe Vertical Capacity in Tension(KN)	Shaft Length(m)	Bored Length(m)	Fixed Head Condition	
					Depth of Fixity(m)	Lateral Capacity(KN)
600	325	150	8.50	10.00	5.27	71
700	425	175	8.50	10.00	5.97	91
600	750	500	18.50	20.00	5.27	71
700	950	600	18.50	20.00	5.97	91
800	1150	750	18.50	20.00	6.64	113
900	1400	900	18.50	20.00	7.29	136
1000	1600	1000	18.50	20.00	7.94	161
1200	2050	1200	18.50	20.00	9.18	216
600	1050	700	28.50	30.00	5.27	71
700	1350	950	28.50	30.00	5.97	91
800	1600	1100	28.50	30.00	6.64	113
900	1900	1300	28.50	30.00	7.29	136
1000	2200	1450	28.50	30.00	7.94	161
1200	2700	1750	28.50	30.00	9.18	216
750	1300	900	24.50	26.00	7.05	73
1000	2000	1300	24.50	26.00	7.94	161
1200	2500	1500	24.50	26.00	9.18	216

Cut-off-level = 1.50m below EGL;

Note: Pile capacity must be verified by initial load tests.
Calculation is based upon considering 5mm of deflection at pile cut-off

Table 4.139 Pile Capacities for BH17

Pile Dia (mm)	Safe Vertical Capacity in Compression (KN)	Safe Vertical Capacity in Tension(KN)	Shaft Length(m)	Bored Length(m)	Fixed Head Condition	
					Depth of Fixity(m)	Lateral Capacity(KN)
600	Founding stratum is not encountered at the pile tip level		8.50	10.00		
700			8.50	10.00		
800			8.50	10.00		
900			8.50	10.00		
1000			8.50	10.00		
1200			8.50	10.00		
600	750	450	18.50	20.00	5.27	71
700	1050	600	18.50	20.00	5.97	91
800	1400	750	18.50	20.00	6.64	113
900	1850	900	18.50	20.00	7.29	136
1000	2300	1100	18.50	20.00	7.94	161
1200	3500	1400	18.50	20.00	9.18	216
600	1200	800	28.50	30.00	5.27	71
700	1600	1100	28.50	30.00	5.97	91
800	2200	1400	28.50	30.00	6.64	113
900	2800	1700	28.50	30.00	7.29	136
1000	3600	2100	28.50	30.00	7.94	161
1200	5300	2900	28.50	30.00	9.18	216
750	1700	1000	24.50	26.00	7.05	73
1000	3300	1700	24.50	26.00	7.94	161
1200	5000	2300	24.50	26.00	9.18	216

Cut-off-level = 1.50m below EGL;

Note: Pile capacity must be verified by initial load tests.
Calculation is based upon considering 5mm of deflection at pile cut-off

Table 4.140 Pile Capacities for BH18

Pile Dia (mm)	Safe Vertical Capacity in Compression (KN)	Safe Vertical Capacity in Tension(KN)	Shaft Length(m)	Bored Length(m)	Fixed Head Condition	
					Depth of Fixity(m)	Lateral Capacity(KN)
600	400	150	8.50	10.00	4.59	108
700	500	200	8.50	10.00	5.19	138
600	900	550	18.50	20.00	4.59	108
700	1300	700	18.50	20.00	5.19	138
800	1750	900	18.50	20.00	5.78	171
900	2300	1050	18.50	20.00	6.35	207

Pile Dia (mm)	Safe Vertical Capacity in Compression (KN)	Safe Vertical Capacity in Tension(KN)	Shaft Length(m)	Bored Length(m)	Fixed Head Condition	
					Depth of Fixity(m)	Lateral Capacity(KN)
1000	2900	1250	18.50	20.00	6.91	244
1200	4400	1600	18.50	20.00	7.99	327
600	1400	900	28.50	30.00	4.59	108
700	1950	1200	28.50	30.00	5.19	138
800	2600	1600	28.50	30.00	5.78	171
900	3350	1950	28.50	30.00	6.35	207
1000	4250	2400	28.50	30.00	6.91	244
1200	6400	3300	28.50	30.00	7.99	327
750	2000	1100	24.50	26.00	6.41	97
1000	3700	1900	24.50	26.00	6.91	244
1200	5600	2600	24.50	26.00	7.99	327

Cut-off-level = 1.50m below EGL;

Note: Pile capacity must be verified by initial load tests.
Calculation is based upon considering 5mm of deflection at pile cut-off

Table 4.141 Pile Capacities for BH19

Pile Dia (mm)	Safe Vertical Capacity in Compression (KN)	Safe Vertical Capacity in Tension(KN)	Shaft Length(m)	Bored Length(m)	Fixed Head Condition	
					Depth of Fixity(m)	Lateral Capacity(KN)
600	Founding stratum is not encountered at the pile tip level		8.50	10.00		
700			8.50	10.00		
800			8.50	10.00		
900			8.50	10.00		
1000			8.50	10.00		
1200			8.50	10.00		
600	750	450	18.50	20.00	5.27	71
700	1050	600	18.50	20.00	5.97	91
800	1450	750	18.50	20.00	6.64	113
900	1850	950	18.50	20.00	7.29	136
1000	2350	1100	18.50	20.00	7.94	161
1200			18.50	20.00	9.18	216
600	1250	800	28.50	30.00	5.27	71
700	1700	1050	28.50	30.00	5.97	91
800	2350	1400	28.50	30.00	6.64	113
900	3050	1750	28.50	30.00	7.29	136
1000	3850	2150	28.50	30.00	7.94	161
1200	5800	2950	28.50	30.00	9.18	216

Pile Dia (mm)	Safe Vertical Capacity in Compression (KN)	Safe Vertical Capacity in Tension(KN)	Shaft Length(m)	Bored Length(m)	Fixed Head Condition	
					Depth of Fixity(m)	Lateral Capacity(KN)
750	1700	1000	24.50	26.00	7.05	73
1000	3300	1700	24.50	26.00	7.94	161
1200	5000	2300	24.50	26.00	9.18	216

Cut-off-level = 1.50m below EGL;

Note: Pile capacity must be verified by initial load tests.
Calculation is based upon considering 5mm of deflection at pile cut-off

Table 4.142 Pile Capacities for BH20

Pile Dia (mm)	Safe Vertical Capacity in Compression (KN)	Safe Vertical Capacity in Tension(KN)	Shaft Length(m)	Bored Length(m)	Fixed Head Condition	
					Depth of Fixity(m)	Lateral Capacity(KN)
600	325	150	8.50	10.00	5.27	71
700	425	175	8.50	10.00	5.97	91
600	800	500	18.50	20.00	5.27	71
700	1150	650	18.50	20.00	5.97	91
800	1500	800	18.50	20.00	6.64	113
900	1950	1000	18.50	20.00	7.29	136
1000	2450	1150	18.50	20.00	7.94	161
1200	3600	1500	18.50	20.00	9.18	216
600	1300	850	28.50	30.00	5.27	71
700	1850	1150	28.50	30.00	5.97	91
800	2450	1500	28.50	30.00	6.64	113
900	3200	1850	28.50	30.00	7.29	136
1000	4000	2200	28.50	30.00	7.94	161
1200	6000	3050	28.50	30.00	9.18	216
750	1800	1100	24.50	26.00	7.05	73
1000	3500	1800	24.50	26.00	7.94	161
1200	5200	2400	24.50	26.00	9.18	216

Cut-off-level = 1.50m below EGL;

Note: Pile capacity must be verified by initial load tests.
Calculation is based upon considering 5mm of deflection at pile cut-off

Table 4.143 Pile Capacities for BH21

Pile Dia (mm)	Safe Vertical Capacity in Compression (KN)	Safe Vertical Capacity in Tension(KN)	Shaft Length(m)	Bored Length(m)	Fixed Head Condition	
					Depth of Fixity(m)	Lateral Capacity(KN)
600	325	150	8.50	10.00	5.27	71

Pile Dia (mm)	Safe Vertical Capacity in Compression (KN)	Safe Vertical Capacity in Tension(KN)	Shaft Length(m)	Bored Length(m)	Fixed Head Condition	
					Depth of Fixity(m)	Lateral Capacity(KN)
700	425	175	8.50	10.00	5.97	91
600	800	450	18.50	20.00	5.27	71
700	1100	650	18.50	20.00	5.97	91
800	1500	800	18.50	20.00	6.64	113
900	1950	950	18.50	20.00	7.29	136
1000	2450	1150	18.50	20.00	7.94	161
1200	3650	1500	18.50	20.00	9.18	216
600	1300	850	28.50	30.00	5.27	71
700	1800	1100	28.50	30.00	5.97	91
800	2450	1450	28.50	30.00	6.64	113
900	3150	1800	28.50	30.00	7.29	136
1000	4000	2200	28.50	30.00	7.94	161
1200	5950	3050	28.50	30.00	9.18	216
750	1800	1050	24.50	26.00	7.05	73
1000	3450	1750	24.50	26.00	7.94	161
1200	5200	2400	24.50	26.00	9.18	216

Cut-off-level = 1.50m below EGL;

Note: Pile capacity must be verified by initial load tests.
Calculation is based upon considering 5mm of deflection at pile cut-off

Table 4.144 Pile Capacities for BH22

Pile Dia (mm)	Safe Vertical Capacity in Compression (KN)	Safe Vertical Capacity in Tension(KN)	Shaft Length(m)	Bored Length(m)	Fixed Head Condition	
					Depth of Fixity(m)	Lateral Capacity(KN)
600	400	150	8.50	10.00	5.27	71
700	500	200	8.50	10.00	5.97	91
600	900	500	18.50	20.00	5.27	71
700	1300	700	18.50	20.00	5.97	91
800	1750	900	18.50	20.00	6.64	113
900	2300	1050	18.50	20.00	7.29	136
1000	2900	1250	18.50	20.00	7.94	161
1200	4400	1650	18.50	20.00	9.18	216
600	1400	900	28.50	30.00	5.27	71
700	1950	1250	28.50	30.00	5.97	91
800	2600	1600	28.50	30.00	6.64	113
900	3350	1950	28.50	30.00	7.29	136

Pile Dia (mm)	Safe Vertical Capacity in Compression (KN)	Safe Vertical Capacity in Tension(KN)	Shaft Length(m)	Bored Length(m)	Fixed Head Condition	
					Depth of Fixity(m)	Lateral Capacity(KN)
1000	4250	2400	28.50	30.00	7.94	161
1200	6400	3300	28.50	30.00	9.18	216
750	1900	1100	24.50	26.00	7.05	73
1000	3700	1900	24.50	26.00	7.94	161
1200	5500	2600	24.50	26.00	9.18	216

Cut-off-level = 1.50m below EGL;

Note: Pile capacity must be verified by initial load tests.
Calculation is based upon considering 5mm of deflection at pile cut-off

Table 4.145 Pile Capacities for BH23

Pile Dia (mm)	Safe Vertical Capacity in Compression (KN)	Safe Vertical Capacity in Tension(KN)	Shaft Length(m)	Bored Length(m)	Fixed Head Condition	
					Depth of Fixity(m)	Lateral Capacity(KN)
600	Founding Strata is not encountered at the pile tip level		8.50	10.00		
700			8.50	10.00		
800			8.50	10.00		
900			8.50	10.00		
1000			8.50	10.00		
1200			8.50	10.00		
600	700	400	18.50	20.00	5.27	71
700	950	500	18.50	20.00	5.97	91
800	1350	700	18.50	20.00	6.64	113
900	1800	900	18.50	20.00	7.29	136
1000	2300	1050	18.50	20.00	7.94	161
1200	3450	1400	18.50	20.00	9.18	216
600	1200	750	28.50	30.00	5.27	71
700	1600	1000	28.50	30.00	5.97	91
800	2250	1350	28.50	30.00	6.64	113
900	3000	2900	28.50	30.00	7.29	136
1000	3800	2100	28.50	30.00	7.94	161
1200	5700	2900	28.50	30.00	9.18	216
750	1600	900	24.50	26.00	7.05	73
1000	3300	1700	24.50	26.00	7.94	161
1200	5000	2300	24.50	26.00	9.18	216

Cut-off-level = 1.50m below EGL;

Note: Pile capacity must be verified by initial load tests.
Calculation is based upon considering 5mm of deflection at pile cut-off

Table 4.146 Pile Capacities for BH24

Pile Dia (mm)	Safe Vertical Capacity in Compression (KN)	Safe Vertical Capacity in Tension(KN)	Shaft Length(m)	Bored Length(m)	Fixed Head Condition	
					Depth of Fixity(m)	Lateral Capacity(KN)
600	300	150	8.50	10.00	5.27	71
700	400	175	8.50	10.00	5.97	91
600	850	450	18.50	20.00	5.27	71
700	1150	600	18.50	20.00	5.97	91
800	1600	750	18.50	20.00	6.64	113
900	2100	900	18.50	20.00	7.29	136
1000	2700	1100	18.50	20.00	7.94	161
1200	4150	1400	18.50	20.00	9.18	216
600	1300	850	28.50	30.00	5.27	71
700	1800	1100	28.50	30.00	5.97	91
800	2450	1450	28.50	30.00	6.64	113
900	3200	1800	28.50	30.00	7.29	136
1000	4050	2200	28.50	30.00	7.94	161
1200	6150	3050	28.50	30.00	9.18	216
750	1800	1000	24.50	26.00	7.05	73
1000	3500	1700	24.50	26.00	7.94	161
1200	5300	2400	24.50	26.00	9.18	216

Cut-off-level = 1.50m below EGL;

Note: Pile capacity must be verified by initial load tests.
Calculation is based upon considering 5mm of deflection at pile cut-off

Table 4.147 Pile Capacities for BH25

Pile Dia (mm)	Safe Vertical Capacity in Compression (KN)	Safe Vertical Capacity in Tension(KN)	Shaft Length(m)	Bored Length(m)	Fixed Head Condition	
					Depth of Fixity(m)	Lateral Capacity(KN)
600	Founding Strata is not encountered at the pile tip level		8.50	10.00		
700			8.50	10.00		
800			8.50	10.00		
900			8.50	10.00		
1000			8.50	10.00		
1200			8.50	10.00		
600	650	450	18.50	20.00	5.54	61
700	800	500	18.50	20.00	6.47	72
800	950	600	18.50	20.00	7.39	82
900	1150	675	18.50	20.00	8.32	92
1000	1300	750	18.50	20.00	9.24	102

Pile Dia (mm)	Safe Vertical Capacity in Compression (KN)	Safe Vertical Capacity in Tension(KN)	Shaft Length(m)	Bored Length(m)	Fixed Head Condition	
					Depth of Fixity(m)	Lateral Capacity(KN)
1200	1650	850	18.50	20.00	11.09	123
600	1200	750	28.50	30.00	5.54	61
700	1600	950	28.50	30.00	6.47	72
800	2100	1200	28.50	30.00	7.39	82
900	2750	1450	28.50	30.00	8.32	92
1000	3450	1750	28.50	30.00	9.24	102
1200	5300	2400	28.50	30.00	11.09	123
750	1450	800	24.50	26.00	6.60	89
1000	2700	1300	24.50	26.00	9.24	102
1200	4000	1750	24.50	26.00	11.09	123

Cut-off-level = 1.50m below EGL;

Note: Pile capacity must be verified by initial load tests.
Calculation is based upon considering 5mm of deflection at pile cut-off

Table 4.148 Pile Capacities for BH26

Pile Dia (mm)	Safe Vertical Capacity in Compression (KN)	Safe Vertical Capacity in Tension(KN)	Shaft Length(m)	Bored Length(m)	Fixed Head Condition	
					Depth of Fixity(m)	Lateral Capacity(KN)
600	300	150	8.50	10.00	5.49	63
700	400	175	8.50	10.00	6.21	81
600	800	500	18.50	20.00	5.49	63
700	1050	650	18.50	20.00	6.21	81
800	1350	800	18.50	20.00	6.91	100
900	1650	1000	18.50	20.00	7.59	121
1000	2000	1150	18.50	20.00	8.26	143
1200	2650	1500	18.50	20.00	9.56	191
600	1100	800	28.50	30.00	5.49	63
700	1400	1000	28.50	30.00	6.21	81
800	1750	1250	28.50	30.00	6.91	100
900	2150	1500	28.50	30.00	7.59	121
1000	2500	1750	28.50	30.00	8.26	143
1200	3350	2250	28.50	30.00	9.56	191
750	1400	1000	24.50	26.00	6.56	90
1000	2300	1550	24.50	26.00	8.26	143
1200	3050	3050	24.50	26.00	9.56	191

Cut-off-level = 1.50m below EGL;

Note: Pile capacity must be verified by initial load tests.
Calculation is based upon considering 5mm of deflection at pile cut-off

Table 4.149 Pile Capacities for BH27

Pile Dia (mm)	Safe Vertical Capacity in Compression (KN)	Safe Vertical Capacity in Tension(KN)	Shaft Length(m)	Bored Length(m)	Fixed Head Condition	
					Depth of Fixity(m)	Lateral Capacity(KN)
600	450	150	8.50	10.00	4.48	117
700	600	200	8.50	10.00	5.06	149
600	1000	550	18.50	20.00	4.48	117
700	1400	750	18.50	20.00	5.06	149
800	1900	950	18.50	20.00	5.63	185
900	2400	1150	18.50	20.00	6.19	223
1000	3100	1350	18.50	20.00	6.73	264
1200	4650	1750	18.50	20.00	7.79	353
600	1450	950	28.50	30.00	4.48	117
700	2050	1300	28.50	30.00	5.06	149
800	2750	1700	28.50	30.00	5.63	185
900	3600	2100	28.50	30.00	6.19	223
1000	4500	2550	28.50	30.00	6.73	264
1200	6700	3450	28.50	30.00	7.79	353
750	2100	1200	24.50	26.00	5.35	167
1000	3900	2100	24.50	26.00	6.73	264
1200	5900	2800	24.50	26.00	7.79	353

Cut-off-level = 1.50m below EGL;

Note: Pile capacity must be verified by initial load tests.
Calculation is based upon considering 5mm of deflection at pile cut-off

Table 4.150 Pile Capacities for BH28

Pile Dia (mm)	Safe Vertical Capacity in Compression (KN)	Safe Vertical Capacity in Tension(KN)	Shaft Length(m)	Bored Length(m)	Fixed Head Condition	
					Depth of Fixity(m)	Lateral Capacity(KN)
600	400	200	8.50	10.00	4.48	117
700	500	225	8.50	10.00	5.06	149
800	600	250	8.50	10.00	5.63	185
600	1000	550	18.50	20.00	4.48	117
700	1400	750	18.50	20.00	5.06	149
800	1850	950	18.50	20.00	5.63	185
900	2400	1100	18.50	20.00	6.19	223
1000	3050	1350	18.50	20.00	6.73	264
1200	4600	1700	18.50	20.00	7.79	353

Pile Dia (mm)	Safe Vertical Capacity in Compression (KN)	Safe Vertical Capacity in Tension(KN)	Shaft Length(m)	Bored Length(m)	Fixed Head Condition	
					Depth of Fixity(m)	Lateral Capacity(KN)
600	1500	1000	28.50	30.00	4.48	117
700	2050	1300	28.50	30.00	5.06	149
800	2700	1650	28.50	30.00	5.63	185
900	3500	2050	28.50	30.00	6.19	223
1000	4450	2500	28.50	30.00	6.73	264
1200	6600	3400	28.50	30.00	7.79	353
750	2100	1200	24.50	26.00	5.35	167
1000	3900	2000	24.50	26.00	6.73	264
1200	5800	2700	24.50	26.00	7.79	353

Cut-off-level = 1.50m below EGL;

Note: Pile capacity must be verified by initial load tests.
Calculation is based upon considering 5mm of deflection at pile cut-off

Table 4.151 Pile Capacities for BH29

Pile Dia (mm)	Safe Vertical Capacity in Compression (KN)	Safe Vertical Capacity in Tension(KN)	Shaft Length(m)	Bored Length(m)	Fixed Head Condition	
					Depth of Fixity(m)	Lateral Capacity(KN)
600	400	150	8.50	10.00	5.38	67
700	500	175	8.50	10.00	6.08	86
600	800	450	18.50	20.00	5.38	67
700	1100	650	18.50	20.00	6.08	86
800	1500	800	18.50	20.00	6.77	107
900	1950	1000	18.50	20.00	7.43	129
1000	2450	1150	18.50	20.00	8.09	152
1200	3650	1500	18.50	20.00	9.36	204
600	1300	850	28.50	30.00	5.38	67
700	1800	1150	28.50	30.00	6.08	86
800	2450	1450	28.50	30.00	6.77	107
900	3150	1800	28.50	30.00	7.43	129
1000	4000	2200	28.50	30.00	8.09	152
1200	5950	3000	28.50	30.00	9.36	204
750	1800	1050	24.50	26.00	6.43	96
1000	3450	1800	24.50	26.00	8.09	152
1200	5200	2400	24.50	26.00	9.36	204

Cut-off-level = 1.50m below EGL;

Note: Pile capacity must be verified by initial load tests.
Calculation is based upon considering 5mm of deflection at pile cut-off

Table 4.152 Pile Capacities for BH30

Pile Dia (mm)	Safe Vertical Capacity in Compression (KN)	Safe Vertical Capacity in Tension(KN)	Shaft Length(m)	Bored Length(m)	Fixed Head Condition	
					Depth of Fixity(m)	Lateral Capacity(KN)
600	Founding Strata is not encountered at the pile tip level		8.50	10.00		
700			8.50	10.00		
800			8.50	10.00		
900			8.50	10.00		
1000			8.50	10.00		
1200			8.50	10.00		
600	750	450	18.50	20.00	5.38	67
700	1050	600	18.50	20.00	6.08	86
800	1400	750	18.50	20.00	6.77	107
900	1800	900	18.50	20.00	7.43	129
1000	2250	1050	18.50	20.00	8.09	152
1200	3400	1300	18.50	20.00	9.36	204
600	1200	800	28.50	30.00	5.38	67
700	1700	1000	28.50	30.00	6.08	86
800	2250	1350	28.50	30.00	6.77	107
900	2900	1650	28.50	30.00	7.43	129
1000	3700	2000	28.50	30.00	8.09	152
1200	5600	2800	28.50	30.00	9.36	204
750	1600	950	24.50	26.00	6.43	96
1000	3100	1600	24.50	26.00	8.09	152
1200	4600	2200	24.50	26.00	9.36	204

Cut-off-level = 1.50m below EGL;

Note: Pile capacity must be verified by initial load tests.
Calculation is based upon considering 5mm of deflection at pile cut-off

4.16.5 Foundation Protection

The following precautions are recommended to protect subsurface concrete and reinforcement.

Minimum Grade of Reinforced Concrete	:	M30
Type of Cement	:	PPC
Minimum Cement Content	:	400 kg/m^3
Maximum Water Cement Ratio	:	0.45
Minimum Cover to Reinforcement	:	50mm

CHAPTER – 5

RIVER NAVIGATION IMPROVEMENT WORKS

5.1 Classification of Waterway

In India, the inland waterways are classified into seven categories for rivers by the Inland Waterways Authority of India (IWAI) vide Government of India (GOI) Gazette Notification dated 26th January 2007 & 07th November 2016 including amendments for safe passage of self-propelled vessels up to 2000 Dead Weight Tonnage (DWT) and tug barge formation in push tow units of carrying capacity up to 8000 tonnes. The classification of waterways for Rivers is given below.

Table 5.1 Inland Waterway classification for Rivers

Class of Waterway	Rivers				
	Minimum Depth	Bottom Width	Bend Radius	Vertical Clearance	Horizontal Clearance
I.	1.2 m	30 m	300 m	4 m	30 m
II.	1.4 m	40 m	500 m	5 m	40 m
III.	1.7 m	50 m	700 m	6 m	50 m
IV.	2.0 m	50 m	800 m	8 m	50 m
V.	2.0 m	80 m	800 m	8 m	80 m
VI.	2.75 m	80 m	900 m	10 m	80 m
VII.	2.75 m	100 m	900 m	10m	100 m

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

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

A. Vertical Clearance for Power Cables / Telephone Lines for all Classes

- Telephone lines and Low Voltage lines 16.5 m
- High Voltage Transmission lines not exceeding 110 KV – 19 m
- High Voltage Transmission lines exceeding 110 KV – 19 m + 1 cm per each KV. In case of underground pipe / power lines and other cables norms to be decided as per conditions and navigational requirement

B. Reference level for vertical clearance for different types of channels

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

C. Type of vessels to be used in different class waterways

Table 5.2 Type of vessels to be used in different class of waterways

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

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

5.2 Development Options

The waterway development must

i. provide reliable navigation conditions during all seasons of the year;
ii. have good consideration for safety of navigation;
iii. prefer using low-impact river training measures, like dredging or low-impact design of embankment protection above high-impact works, where possible;

iv. include navigation locks with sufficient capacity for swift lock passages;
v. provide an infrastructure of ports, and, therefore, include the planning of the port locations, their capacities, connection to railway and road networks;
vi. provide offshore constructions which are resistant to most extreme waves;
vii. contain measures that prevent negative impacts on groundwater levels and soil conditions in the adjacent terrains;
viii. provide flood protection to surrounding areas;
ix. consider all types of environmental impacts of the waterway in operation and during construction, including impacts on flora, fauna, and landscape quality; and
x. include mitigating and compensating measures for environmental damage.

As brought out earlier in Chapter 4 para4.2.1, the whole stretch of River Yamuna NW 110 from Jagatpur, Delhi to Prayagraj Sangam is divided in 4 stretches as follows:

(i)	**Stretch 1**	**Prayagraj(Ch. 0.0 Km) to River Betwa Mouth (Ch. 272 Km)**
(ii)	**Stretch 2**	**River Betwa Mouth (Ch. 272 Km) to River Chambal Mouth (Ch. 453 Km)**
(iii)	**Stretch 3**	**River Chambal Mouth (Ch. 453 Km) to Agra (Ch. 743 Km)**
(iv)	**Stretch 4**	**Agra (Ch. 743 Km) to Delhi to (Ch. 1089 Km)**

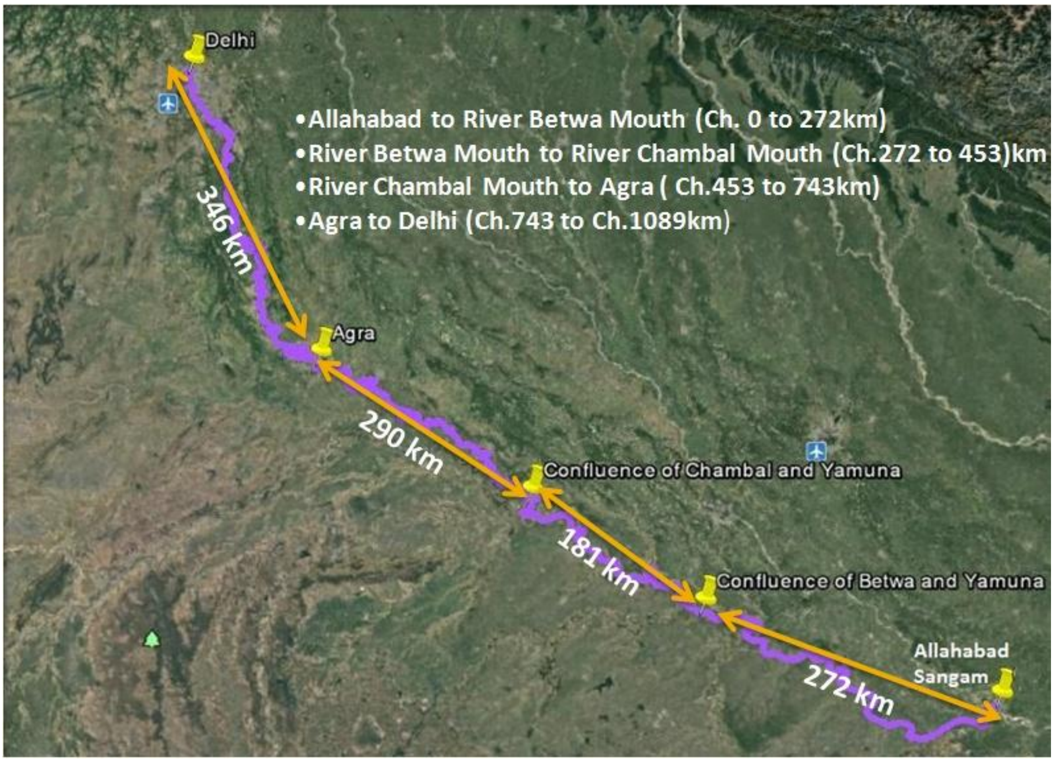


Fig. 5.1 Stretches of River Yamuna NW110

Prima facie, three development options are considered as indicated and discussed here under. This is followed by discussions on merits, demerits and feasibility aspects in respect of each option, so as to facilitate selection of a suitable alternative and exclude others that have unacceptable demerits and feasibility. Thus, options that are considered in these studies are as under:

Short – immediate term Options

(i) River dredging works
(ii) River re – directive Works
(iii) River Resistive Works

Medium – long term Option

(iv) Construction of level reaches through barrages, weirs and or similar structures / interventions.
(v) Requirement of part of River rejuvenation

5.2.1 Short – immediate term Options

The River Yamuna is an alluvial river and is characterised by large variation in flood and lean season discharges, heavy sediment load and unstable eroding banks. The flood plain of river extends more than 3 kms at some places. However, during the lean season when the discharge is comparatively low the river meanders within the flood plain.

During the flood season of June to September adequate water depth (>2.5m) is available. The water starts falling from the month of October. As the water level falls shallow stretches (< 2.5m) appear along the waterways which are termed as "Shoal". Along the River Yamuna (from Delhi to Prayagraj) a number of rivers such as Chambal, Betwa, Ken etc. meet. These river confluences require special attention with reference to the navigation in the river. In addition to the confluences other problems associated with the river are formation of shoals, braiding, meandering etc.

(i) River dredging works

The data analysis of River Yamuna depicts that on an average the minimum 2.5 m water depth is available for 35 days in stretch 1 & stretch 2 and for 105 days in stretch 3 & stretch 4. If no dredging is undertaken, the nature will maintain a minimum depth by itself called 'Natural Minimum Depth '(NMD). In the river Yamuna the NMD decreases from Prayagraj towards Delhi i.e. from lower reaches to upper reaches of the river. Average NMD observed in various stretches of the waterway is as under:-

Table 5.3 Stretch wise Average Natural Minimum Depth

S. No.	Stretch	Average Natural Minimum Depth (m)
1.	Prayagraj to River Betwa Mouth (Ch. 0 to 272 km)	1.0
2.	River Betwa Mouth to River Chambal Mouth (Ch.272 to 453 km)	0.7
3.	River Chambal Mouth to Agra (Ch.453 to 743 km)	0.3
4.	Agra to Delhi (Ch.743 to Ch.1081 km)	0.5

In view of this situation being not able to meet the requirements adequately, one of the options available will be to reduce the bed level of the River Yamuna NW 110 in the entire stretch. Through this arrangement it is expected that the minimum desired depth of 2.5 m water levels in River Yamuna is maintained.

Among the methods of regulation of rivers for navigation and removal of natural obstructions, dredging is a common remedy. With all training measures it becomes necessary, sometimes to keep the channel open for navigation by resorting to dredging. Natural scour is useful in its own way, but it may not be able maintain depths throughout the year, mainly because the condition in rivers change from season to season. Dredging is a useful auxiliary method, and there are few ports and navigational channels which are maintained without the aid of systematic dredging.

The shoals are randomly distributed over the entire stretch of the waterway from Delhi to Prayagraj. However, number of shoals increases as we go from lower reaches to upper reaches of the waterway. To maintain a target depth in respective stretches these shoals to be removed by execution of Dredging.

Table 5.4 Stretch wise shoal Length for different class of waterways

in km

S. No.	Stretch	Shoal Length For 2.5 m Dredging	Shoal Length For Class IV	Shoal Length For Class III	Shoal Length For Class II	Shoal Length For Class I
1.	Prayagraj to River Betwa Mouth (Ch. 0 to 272 km)	151.4	117.2	105.9	88.6	75.2
2.	River Betwa Mouth to River Chambal Mouth (Ch.272 to 453 km)	149.8	134.3	127.7	112.4	102.2
3.	River Chambal Mouth to Agra (Ch.453 to 743 km)	289.2	289.2	288.4	285.2	283
4.	Agra to Delhi (Ch.743 to Ch.1081 km)	294.4	230.4	216.1	184.7	153.1
Total Shoal Length (in Km)		**884.8**	**771.1**	**738.1**	**670.9**	**613.5**

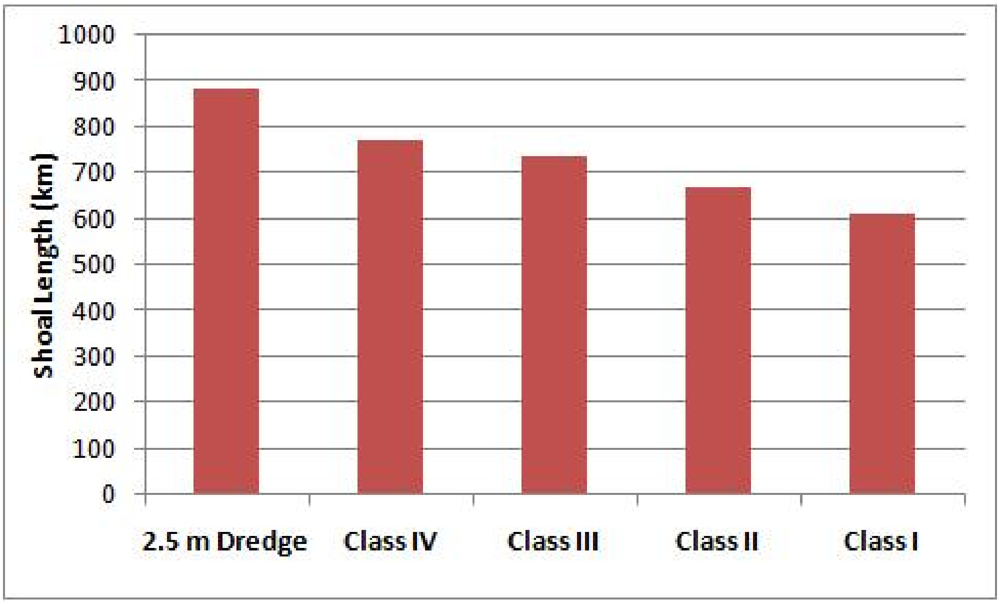


Fig. 5.2 Total shoal Length to be dredged for different class of waterways

As per the hydrographic surveys carried out for the project, it is seen that the existing bed levels of the river are quite flat and the stretch wise variation in the entire stretch is given below

Table 5.5 Stretch wise Bed Level Variation

S. No.	Stretch	Bed Level (m)		Variation (m)
		From	To	
1.	Prayagraj to River Betwa Mouth (Ch. 0 to 272 km)	66.24	85.48	19.24
2.	River Betwa Mouth to River Chambal Mouth (Ch.272 to 453 km)	85.48	99.78	14.30
3.	River Chambal Mouth to Agra (Ch.453 to 743 km)	99.78	142.35	42.57
4.	Agra to Delhi (Ch.743 to Ch.1081 km)	142.35	204.86	62.51
Total Variation (in m)				**138.62**

Hydrographic Surveys conducted in the River Yamuna NW 110 indicates that the bed slope of the river is very flat in stretch 1 and stretch 2 while moderately flat in stretch 3 and stretch 4 and the average stretch wise bed slope is given in Table below

Table 5.6 Stretch wise Average Slope

S. No.	Stretch	Average Slope
1.	Prayagraj to River Betwa Mouth (Ch. 0 to Ch. 272 km)	1:14100
2.	River Betwa Mouth to River Chambal Mouth	1:12600

S. No.	Stretch	Average Slope
	(Ch.272 to Ch. 453 km)	
3.	River Chambal Mouth to Agra (Ch.453 to Ch. 743 km)	1:6900
4.	Agra to Delhi (Ch.743 to Ch.1081 km)	1:6400

However, while designing the proposed bed slopes for the dredged channel in the river, similar slopes are kept/recommended except stretch 4 where slope of 1 : 6900 has been proposed in consideration with a self sustainable channel so that eventually there is minimum accretion or erosion in the dredged channel.

From the data available for bed material size and sustainable velocities, it is observed that the channel bed will be safe during both the monsoon as well as lean season period flow conditions. However taking into account the existing bathymetry of the River Yamuna desired depths and economics of the dredging, bed slopes as given above have been suggested/adopted for the purpose. In light of the above discussions it is expected that with the proposed slope river bed there would be no problems relating to accretion, erosion and generation of velocity beyond limits, which may affect the navigation. There are some possibilities of siltation in the channel during monsoon period due to movement of bed material and flow of topsoil from surrounding areas. Similarly, there may be minor variations in the quantities to be dredged depending upon the fluctuations in the River Yamuna water levels.

The quantity of dredging to be carried out is quite moderate per unit length of the river. Dredged material will be placed alongside banks at locations identified by IWAI and where River is shallow and for deep channel it will be retained within the river system as in case of NW1.

Stretch wise Riverbed levels, Proposed dredged Level, Minimum available water levels are analysed, charted and given in following figures

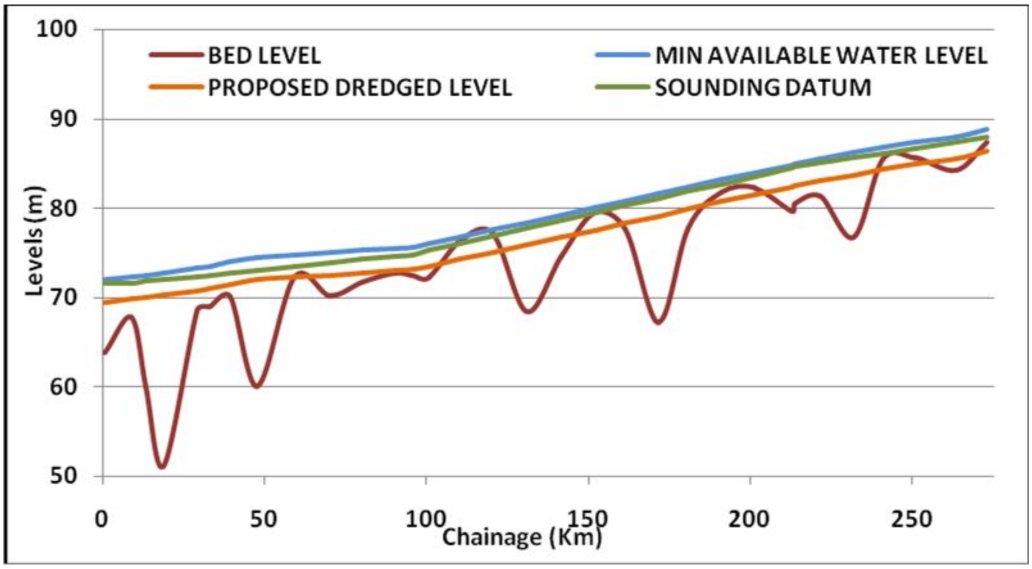


Fig. 5.3 Dredging Profile Prayagraj to River Betwa Mouth (Ch. 0 to Ch. 272 km)

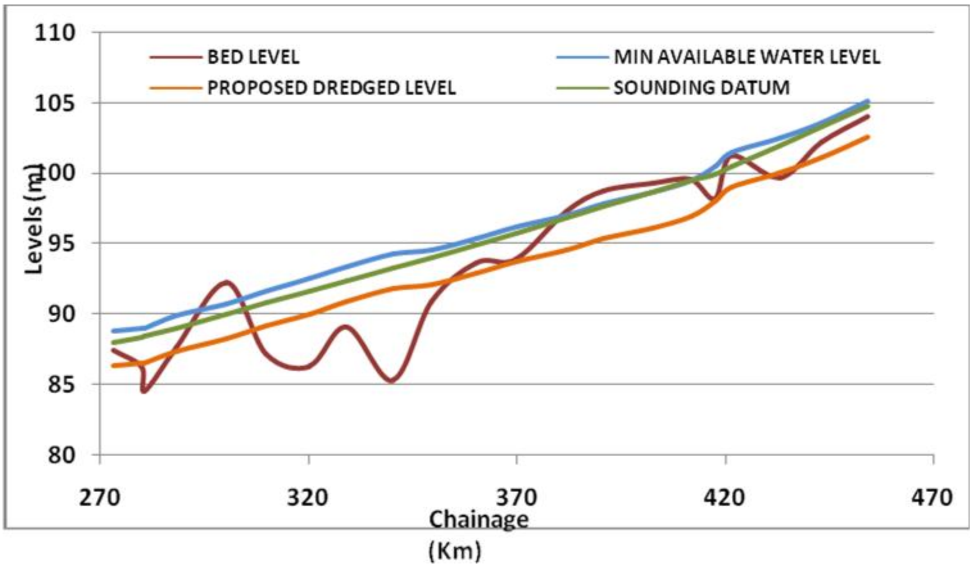


Fig. 5.4 Dredging Profile River Betwa Mouth to River Chambal Mouth (Ch.272 to Ch.453 km)

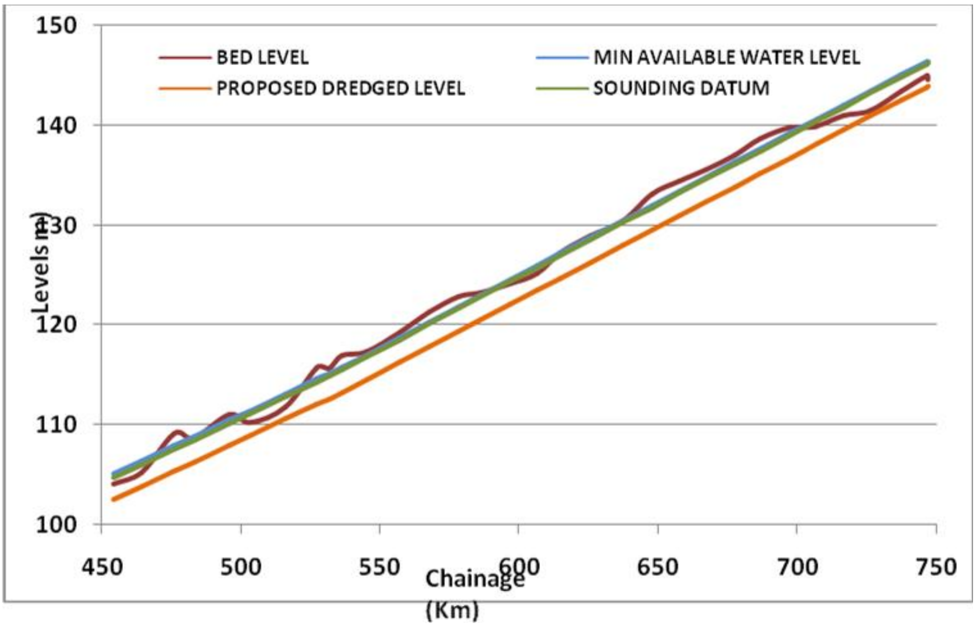


Fig.5.5 Dredging Profile River Chambal Mouth to Agra (Ch.453 to Ch. 743 km)

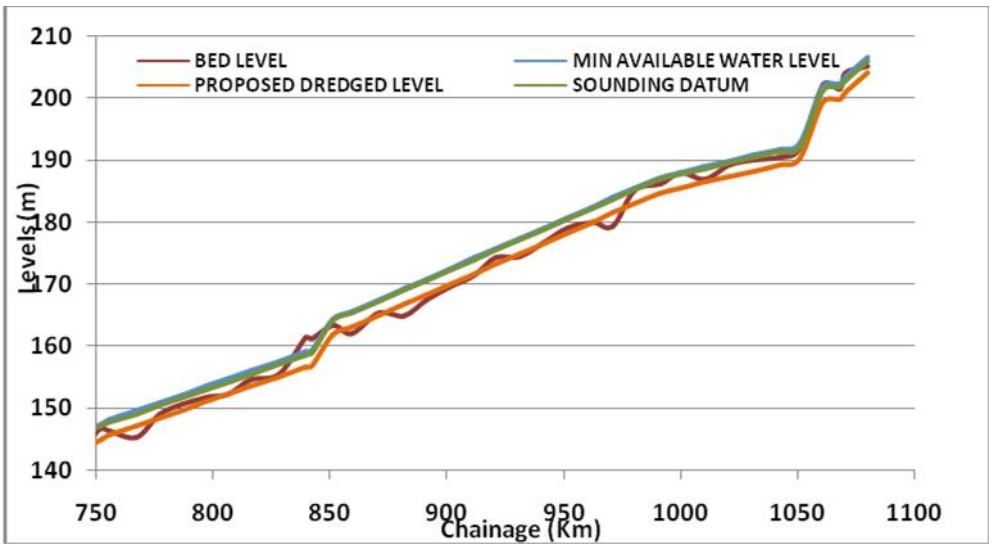


Fig.5.6 Dredging Profile Agra to Delhi (Ch.743 to Ch.1081 km)

Dredging quantity has been calculated for the different stretches design channels using Hypack Cross section and volume program. The same is tabulated below:

Table 5.7 Stretch wise Dredging Quantity for Different class of waterways

in Million Cubic Meter (in MCM)

Sr. No.	Stretch	Quantity for 2.5m depth	Quantity For Class IV	Quantity For Class III	Quantity For Class II	Quantity For Class I
1	Prayagraj to River Betwa Mouth (Ch. 0 to 272 km)	17.39	6.62	5.08	2.88	1.69
2	River Betwa Mouth to River Chambal Mouth (Ch.272 to 453 km)	24.61	9.76	7.85	4.51	2.86
3	River Chambal Mouth to Agra (Ch.453 to 743 km)	74.31	32.94	27.24	17.09	11.08
4	Agra to Delhi (Ch.743 to Ch.1081 km)	34.73	11.21	7.9	3.75	1.94
Total Dredging Quantity		**151.04**	**60.53**	**48.07**	**28.23**	**17.57**

Note: Dredging quantity for the last stretch as given in the above table is only for upto Ch.1051 Km

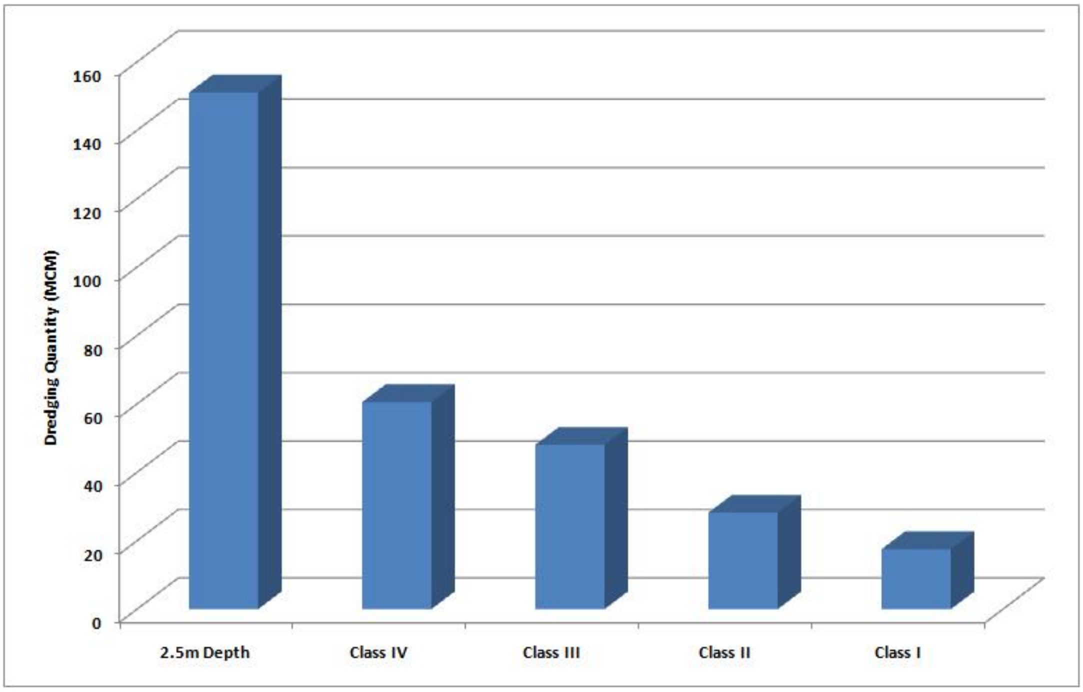


Fig. 5.7 Dredging quantity for different class of waterways

To achieve the authorized water depth (2.5m), dredging will play a vital role since the tackling of shoals through bandalling may not suffice the requirement and bandalling may not give the required results in certain cases specially when there is lesser depth in the entire channel and when the shoal formation is more than 300 m and current is slack. Dredging is particularly important for keeping waterway navigable for the designated period (330 days).Cutter sections dredgers with suitable pumping and disposal capacity is prima facie preferred for above quantities. The dredging methods being adopted, in vogue, are cutter suction dredging, Hydraulic surface dredging, trailing suction hydraulic dredging, manual dredging etc. In the rivers cutter suction dredging and hydraulic surface dredging are mainly adopted. The following factors govern the selection of a dredger for a particular work:

- Site characteristics and conditions
- Nature of soil to be excavated
- The nature of dredged material to be transported
- Environmental factors

The selection of the dredging plant largely depends upon the characteristics of the site such as accessibility, minimum and maximum depth of water, location and accessibility of disposal site, dimensions of the dredging area, proximity to the structures, accuracy of dredging required etc. and the meteorological and riverine conditions, traffic etc. and the dredging plants and equipment for a particular site is selected based on site specific information. In present case dredging in shallow areas is involved therefore either dredgers requiring only draft available are selected or dredgers which are able to dredge ahead of their hull such as cutter suction, grab and bucket dredgers are selected so that they can dredge from deep water moving towards shallower depths making room for their movement, or a combination of two types of dredgers are deployed. Similarly, current is the main condition which affects the working of the dredger.

Currents mainly affect the manoeuvrability of the dredger and are important when dredging in confined areas. Dipper, backhoe and bucket dredgers given sufficient anchorage can work in current upto 3 knots. In strong current the positioning of grab in case of grab dredgers becomes difficult. In strong currents the production of bucket and grab dredgers also reduces drastically. The cutter suction dredgers suffer from current in two respects; lateral; pressure on the dredger and the floating pipeline. The large cutter suction dredgers can work in the current upto 2 knots. The magnitude of the peak flood current and peak lean currents are observed as 2.00 and 0.50 m/s respectively. It is observed that the average flood and lean currents are of comparable magnitude and are of the order of 1.0 m/s indicating that dredging may be possible most of the time as far as current is concerned.

Also, the subsoil conditions assessed from the Geo-technical investigations carried out for the purpose indicate that the soil available in the river basin and along the banks of the river can be conveniently dredged using conventional dredging process such as a cutter section dredger.

From the foregoing discussions, in view of current and wind prevailing at the site it may be assumed that the dredgers would be able to work for about 300 days in the year. For dredging shoals in River Yamuna Self-propelled Cutter Section Dredgers (CSD) are proposed to achieve authorized water depth.

Table 5.8 Parameters for Dredger, Allied Vessels & Equipment

Sl. No.	Equipment	Minimum Capacity
1.	Cutter Suction Dredger	500 m^3/hr of solids
2.	Work Boats/Tugs	For towing dredging unit/anchor shifting etc.
3.	Accommodation Boats (if required)	To accommodate crew and supervisory staff separately (if required)
4.	Any other vessel	As required
5.	Vessel and equipment for survey works	As required

Cutter Section Dredger has a powerful cutter for dislodging the soil particles in addition to the hydraulic suction and transportation arrangements. The main advantages of the cutter suction dredger are as under:

- The ability to dredge a very wide range of material by pumping with water directly to the disposal or reclamation area.
- The ability to operate in shallow water and to produce a uniform level bottom with high rates of production.
- The ability, in case of modern dredgers to dredge to a pre-defined profile e.g. in channels.

(ii) River re – directive Works

A redirective structure, as the name implies, uses the river's energy and manages that energy in a way that benefits the system, such as to enhance the navigation channel. Redirective structures are usually a series of dikes placed along the inside of a river bend where sediment usually deposits. Dikes function continually at lower river stages; however, the effects of dikes will decrease or "wash out" when overtopped at higher river stages. The major functions of dikes are to

a) concentrate the river's energy into a single channel to control the location and increase the depth of the navigation channel, and
b) Affect the erosion land depositional characteristics of the river to reshape the dimensions of the navigation channel.

a) Dikes

Dikes have been known by a variety of names throughout the years, such as groins (or groynes), contracting dikes, transverse dikes, cross dikes, spur dikes, spur dams, cross dams, wing dams, and spurs.

A dike is defined as a structure placed approximately perpendicular to the bank line to prevent bank erosion and protect structures along the bank; realign a river reach; constrict a channel to increase depth, cut offside channels and chutes; and concentrate the flow.

The dikes may be either of piles, stones, rock-fill or sand and may be either submersible or non-submersible. Dikes are very helpful in constricting a wide river channel for the improvement of depth for navigation

Type of Dikes

Attracting Dikes: These are the Dikes which attract flow towards the bank and are aligned in a direction pointing downstream. In a river where there is a heavy attack on one bank, it may be desirable to construct the attracting dikes on the opposite bank in conjunction with a repelling dike on the affected bank

Deflecting dike: Where the dike, usually of short length changes only the direction of flow without repelling it, is known as a deflecting spur and gives only local protection

Repelling dike: A dike pointing upstream has the property of repelling the river flow away from it and hence it is termed as repelling spur.

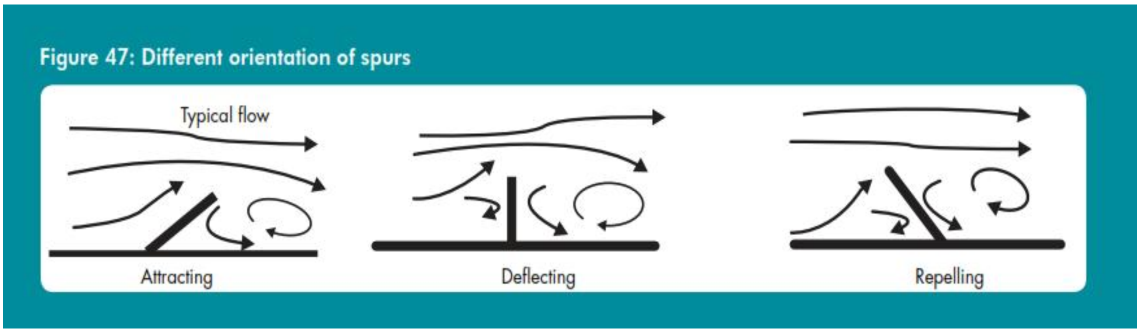


Fig. 5.8 Types of Spurs

Experience of rivers in many countries shows similarly that groynes facing downstream cause trouble. These groynes endanger adjacent banks, since silting between successive groynes is absent and hence are not recommended. Repelling groynes are usually successful in achieving desired results if they are properly located with due regard to their position in relation to meander length. It is recommended to test them in hydraulic models before adopting them in practice.

To enhance the River Navigability Redirective structures such as dike are planned and no of dikes required to enhance the water level by contracting the width of River. The no. of dikes required are given below:

Table 5.9 Nos. of Dikes Required for River re – directive Works

Sr. No.	Stretch (km)	Width of River in Lean Season	Length of the Dike	Spacing of Dikes	No. of Dikes
1.	**0 - 50**	515.3	415	830.6	60
2.	**50 - 100**	452.2	352	704.4	70

Sr. No.	Stretch (km)	Width of River in Lean Season	Length of the Dike	Spacing of Dikes	No. of Dikes
3.	**100 - 150**	405.6	306	611.2	81
4.	**150 - 200**	506.0	406	812	61
5.	**200 - 250**	445.4	345	690.8	71
6.	**250 - 300**	424.0	324	648	76
7.	**300 - 350**	349.6	250	499.2	99
8.	**350 - 400**	244.2	144	288.4	172
9.	**400 - 450**	328.6	229	457.2	108
10.	**450 - 500**	132.4	32	64.8	771
11.	**500 - 550**	100.8	0	0	0
12.	**550 - 600**	148.2	48	96.4	518
13.	**600 - 650**	177.4	77	154.8	322
14.	**650 - 700**	155.6	56	111.2	449
15.	**700 - 750**	184.2	84	168.4	296
16.	**750 - 800**	154.8	55	109.6	455
17.	**800 - 850**	200.8	101	201.6	247
18.	**850 - 900**	116.4	16	32.8	1523
19.	**900 - 950**	201.6	102	203.2	245
20.	**950 - 1000**	194.4	94	188.8	264
21.	**1000 - 1050**	195.4	95	190.8	261
22.	**1050 - 1089**	268.3	168	336.6	148
Total					**6297**

From the above, it is interpreted that total length of dike required throughout the NW 110 to enhance the depth of water would be to the tune of 500 thousand metes which would be uneconomical and time consuming. Also, this option would be viable option only where continuous flow is available in the river round the year or around 80-90% of the required water depth is available round the year. With provision of dikes water depth of merely few centimetres can be increased without dredging the channel.

b) Bandalling

Bandals are commonly used low cost structures for improvement of navigation depth in rivers. Bandals are designed to confine the low water flow in a single channel for maintaining required navigation depth. A bandal consist of framework of bamboos driven in to the river bed, set 6m apart by means of horizontal ties and supported by struts at every 1.2 m. Bamboo matting are tied with coir ropes at water levels to the bamboo framework. The bamboo used on the framework are generally 3 to 6m in length and the matting is 0.9m wide strengthened at the edges bye strips of split bamboo.

Bandals are placed at an angle of 30^o to 40^o inclined downstream. They check the flow and cause sand to be deposited parallel to and behind the bandals. Thus a channel confined between bandals is formed with sand banks on either side and the whole discharge of the river is directed through this channel.

To achieve the authorized water depth (2.5m), dredging will play a vital role since the tackling of shoals through bandalling may not suffice the requirement and bandalling may not give the required results in certain cases specially when there is lesser depth in the entire channel and when the shoal formation is more than 300 m and current is slack.

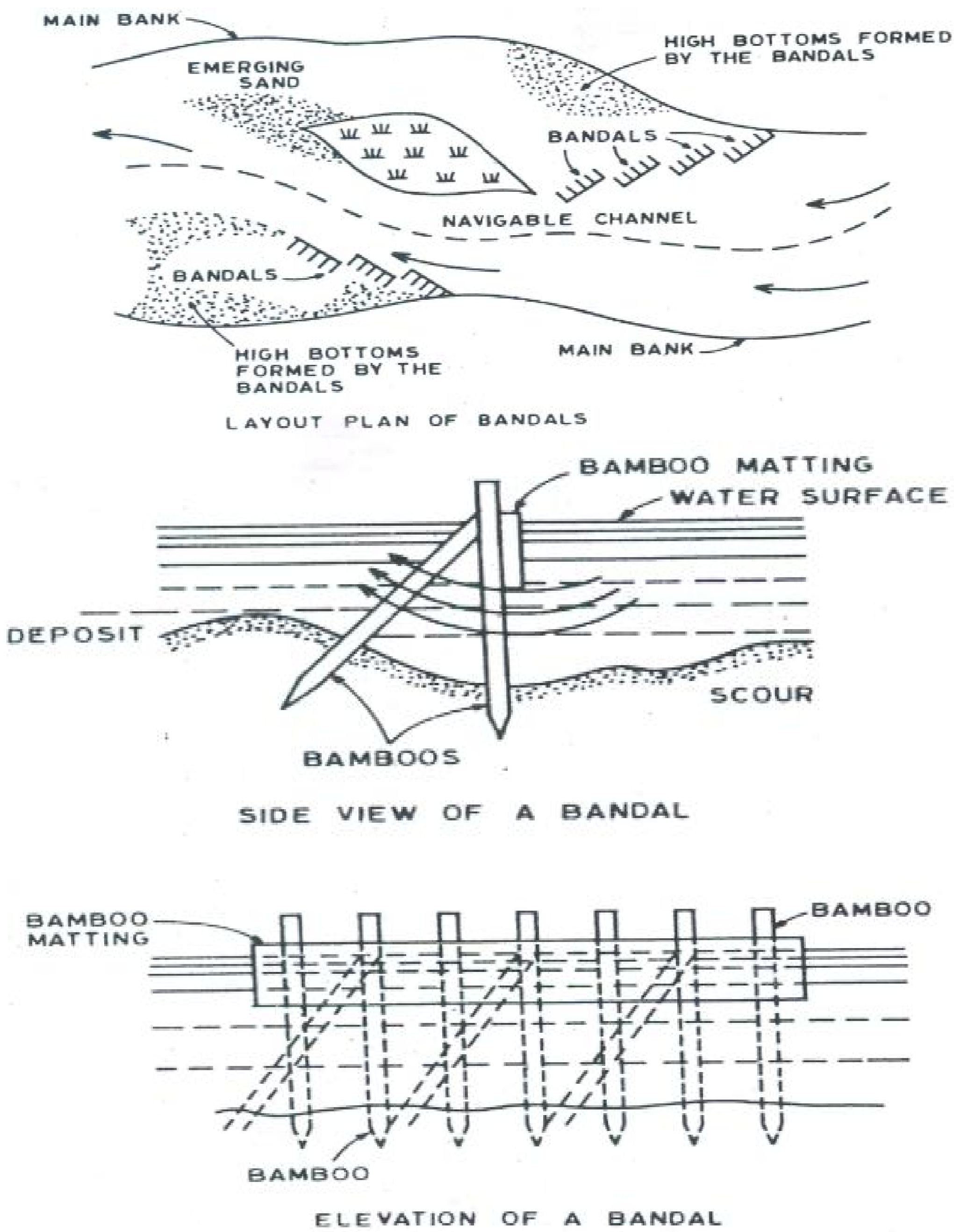
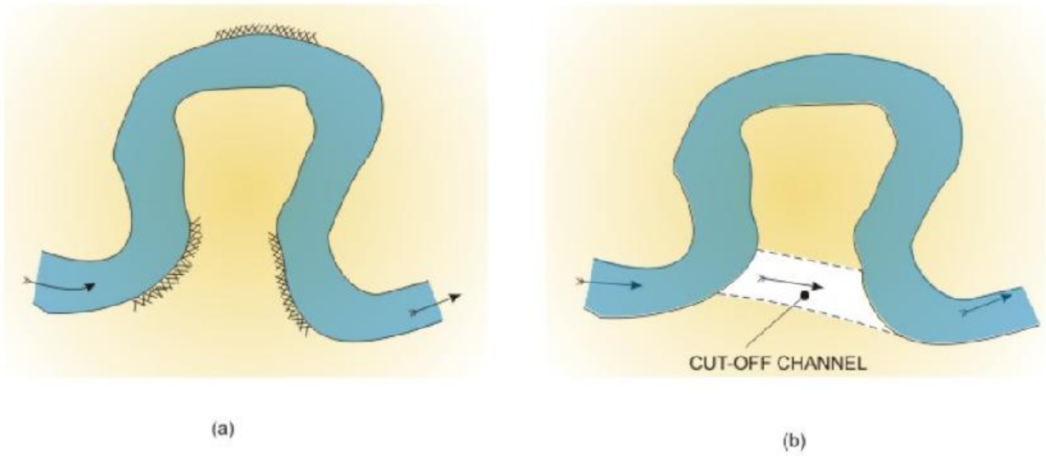


Fig. 5.9 Bandalling in rivers

c) Cut-offs

Cut offs have also been extensively used for improvement of navigation. A cut off is developed by river meandering to acute condition in the form of hair-pin bends. Under favorable condition these bends becomes large loops with narrow necks. The narrowing of the neck reaches a limit when, a break trough occurs and chute channel known as cut-off forms across the neck.

Cut off results in violent changes in river regime. As the river tortuosity is decreased the river slope upstream of the cut off steepens and flood levels are lowered. The cut-offs are not enough by themselves. While they correct the instability and in efficiency at sharp bends and loops, where much head is lost by excessive river length, they do little to correct conditions in the reaches between these bend. It becomes necessary therefore to do extensive work between cut offs to improve the alignment width and depth of the channel by supplementary training works. Such works involves two procedures viz., directing the flow and closing of pockets found at unduly wide points of the channel by training groynes of dredged sand fill. Revetment at places, where erosion is likely to take place, should also be provided. The objective is the creation of a uniform river width and establishment where feasible of a central river channel, deep enough to maintain itself by normal scour action. A typical instance of cut off is shown in fig. below



(a) Meandering river with possible threat of bank erosion(marked as xxxxx)
(b) An engineered cut-off channel

Fig. 5.10 River Meandering

d) Guide bunds or banks

Alluvial rivers in flood plains spread over a very large area during floods and it would be very costly to provide bridges or any other structure across the entire natural spread. It is necessary to narrow down and restrict its course to flow axially through the diversion structure. Guide bunds are provided for this purpose of guiding the river flow past the diversion structure without causing damage to it and its approaches. They are constructed on either or both on the upstream and downstream of the structure and on one or both the flanks as required.

Guide bunds can be classified according to their form in plan as (i) divergent, (ii) convergent, and (iii) parallel and according to their geometrical shape as straight and elliptical with circular or multi-radii curved head. These are shown in Fig given below:

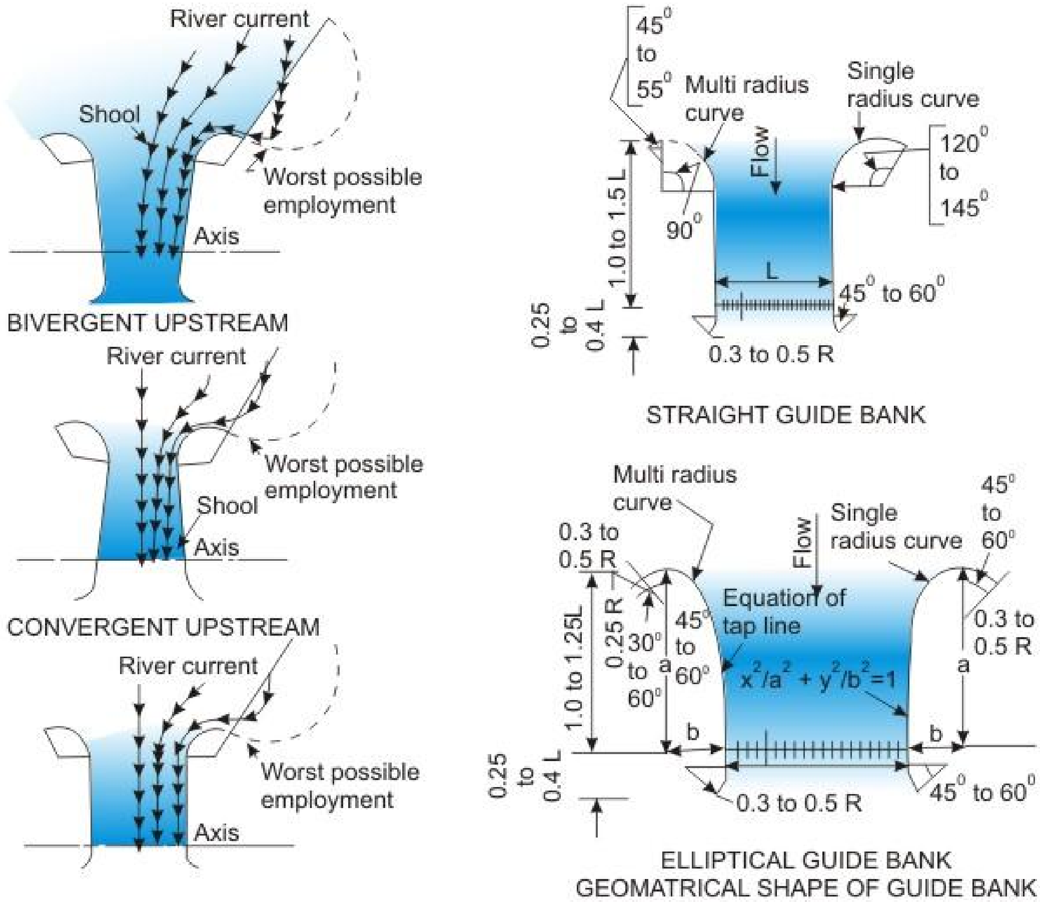


Fig. 5.11 Types of guide banks and typical dimensions

In the case of divergent guide bunds, the approach embankment gets relatively less protection under worst possible embayment and hence divergent guide bunds require a longer length for the same degree of protection as would be provided by parallel guide bunds. They also induce oblique flow on to the diversion structure and give rise to tendency of shoal formation in the centre due to larger waterway between curved heads. However, in the case of oblique approaching flow, it becomes obligatory top provide divergent guide bunds to keep the flow active in the spans adjacent to them.

The convergent guide bunds have the disadvantage of excessive attack and heavy scour at the head and shoaling all along the shank rendering the end bays inactive. Parallel guide bunds with suitable curved head have been found to give uniform flow from the head of guide bunds to the axis of the diversion structure.

In the case of elliptical guide bunds, due to gradual change in the curvature, the flow is found to hug the bunds all along their lengths whereas in the case of straight guide bunds, separation of flow is found to occur after the curved head, leading to obliquity of flow. Elliptical guide bunds have also been found to provide better control on development and extension of meander loop towards the approach embankment.

(iii) River Resistive Works

A resistive structure acts to maintain the status quo of the system, such as to reduce bank erosion. Resistive structures are primarily used to prevent bank erosion and channel migration on the outside of a river bend, and to establish or maintain a desired channel alignment.

a) Revetment

The most common form of river training structure is the revetment or bank protection. It is composed of a layer of erosion-resistant material that covers the erodible material of the river banks, and sometimes also the bed of the river. Various materials may be used for this purpose, including grouts and geotextiles. The choice of the most suitable material should be made at an early stage in the project. Armour stone can be directly placed onto the bank or bed to be protected.

However, it is generally good practice to place it on an under layer that provides a transition between the coarse armour stone of the cover layer and the fine erodible material of the foundation. The under layer may be made of crushed rock or gravel that prevents subsoil from being eroded through the voids of the protection. Geo-textiles may be used as a part of the filtering system, either with or instead of the granular filter. The under layer reduces both the risk of the foundation material being washed through the armour layer and of the cover layer punching into the subsoil.

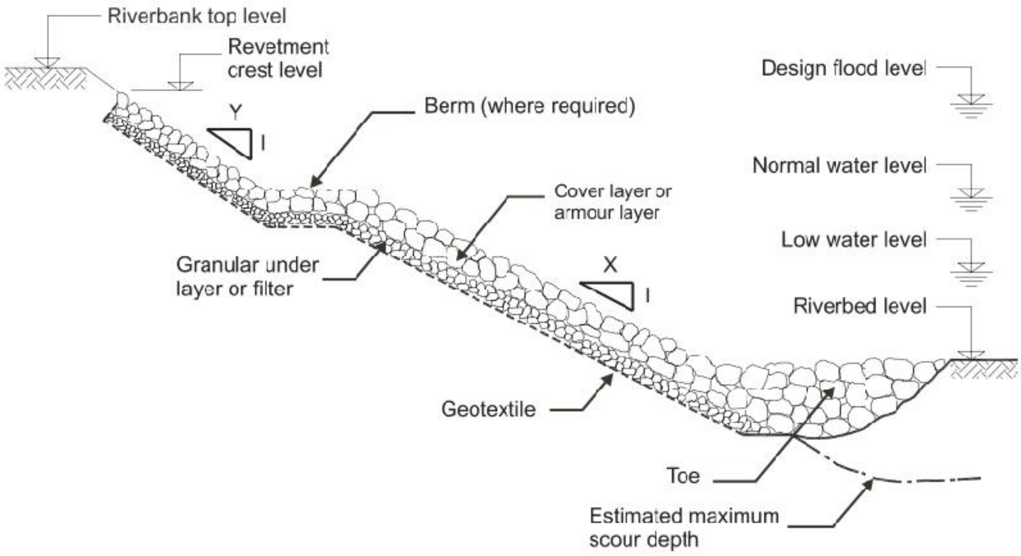


Fig. 5.12 Typical Revetment

Bank protection should be provided if found necessary along the proposed structures i.e. Bridges, barrages and terminals.

Existing Protection works

Following table gives the detail of existing bank protection works along the River Yamuna.

Table 5.10 Existing Protection works

Sl. No.	Chainage (Km)	Length of Protection Works (Km)	Condition
1.	279.00	1.0km	Protected
2.	376.00	2.0km	Protected
3.	626.40	1.8km	Protected
4.	841.03	758.0m	Protected
5.	857.40	168.9m	Protected

Proposed bank protection

No bank protection is required in such a big river for fairway development on the basis of topographic and hydrographic survey of Yamuna River. However, bank protection shall be provided along the proposed structures i.e. Bridges, barrages and terminals. Bank protection shall also be provided at the following critical locations:

Table 5.11 Proposed Bank Protections

Sl. No.	Chainage (km)	Length of Protection work (m)	River Bank
1.	1023.5	500	Left Bank
2.	1025.5	500	Right Bank
3.	1000.5	400	Left Bank
4.	998.5	500	Left Bank
5.	977.7	300	Right Bank
6.	976.6	400	Left Bank

e) Retards

These are the structures constructed spanning a river section. They are used principally to protect eroding concave banks and are constructed by sinking old barges weighted with stones by putting woven wire fence supported on wooden parts or by putting bundles of poles across the river cross section. The structures may be maintained by wires tied to anchors placed upstream. Retarders are lower in cost than spurs and revetment, but are not equally definite in operation. Care in placement and understanding of river behavior is required for their use.

5.2.2 Medium – long term Option

Construction of level reaches through barrages, weirs and or similar structures / interventions

A meeting was held between the officers of IWAI and Irrigation Department, Uttar Pradesh on 5th October 2018 in the conference room of Canal Guest House Okhla, when WAPCOS officers were also present. During discussions the officers of Irrigation Department informed that they are proposing a barrage on River Yamuna on the downstream of Tajmahal near Agra. It was further informed that the barrage shall be constructed for navigation as per requirement of Inland Waterway Authority of India (IWAI). The salient feature of the proposed barrage is as follows:

Table 5.12 Salient Features of the Taj Barrage Project

1.	Name of the project,	CONSTRUCTION OF CONVENTIONAL BARRAGE FOR SECURING THE FOUNDATION OF TAJMAHAL,IMPROVEMENT IN WATER LEVEL OF AGRA, BEAUTIFICATION, NAVIGATION ON RIVER YAMUNA AT 1.50 KM D/S OF TAJMAHAL, AGRA
2.	Location	1.50 Km Downstream of Tajmahal Agra 27011'05.2" N 78003'16.5" E
3.	Design flood (m3/s)	11000m^3/s
4.	Length (m)	475m
5.	Pond Level	146.00m
	Crest Level	143.50m
6.	Height of Barrage	2.5m
7.	Navigation	From Gokul barrage to Tajmahal
8.	Maximum water level (m)	154.920 m at CWC Gauge site Poiya Ghat, Agra
9.	Spillway bays	
	(a) Total length (m)	398m
	(b)Crest level (m)	143.50m
	(c)Number and Type of gates	22 Vertical Gates
10.	Under Sluice Bays	Also Navigation
	(a)Total length (m)	110
	(b)Crest level (m)	142.50m
	(c)Number of gates	6
11.	Guide bunds/afflux bunds	
	(a)Guide bunds	Guide bundh shall be provided at both banks of river at EL 155.56m
12.	Cost of the Project	Rs. 706.83 Crores

Two bays have been proposed for navigation purpose and shall be constructed as per requirement of Inland Waterway Authority of India.

Under this option it is proposed to construct barrages with Navigation locks across River Yamuna at approx. every 30 km (60 Km between first 2 barrages) beginning 1st barrage from Ch. 371 Km at Kalpi to Ch. 1022 at Greater NOIDA as shown below

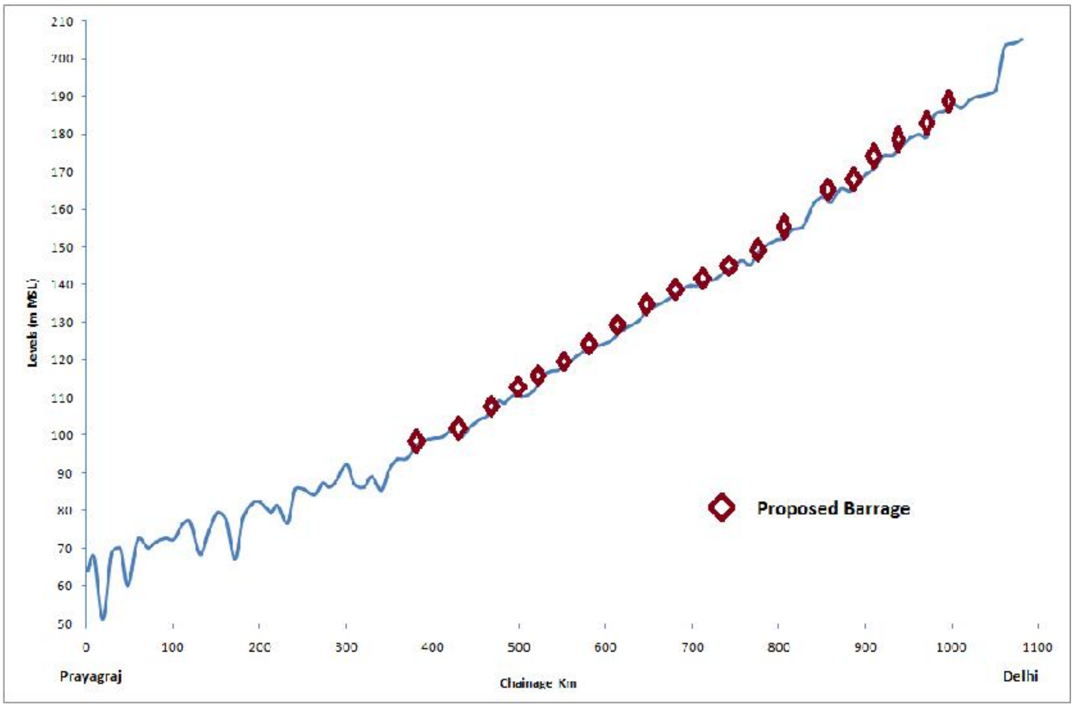


Fig. 5.13 Location Proposed Barrages

Table 5.13 Details of Location of barrages showing Chainage/Coordinates/Places

Sl. No.	Stretch	Ch. (Km)	Co-Ordinates	Locations			
				Nearby Landmarks	Tehsil	District	State
1.	**River Betwa Mouth To River Chambal Mouth**	371	**26°13'24.31"N/ 79°38'33.47"E**	Dahelkh and Dewara Village	Kalpi	Jalaun	Uttar Pradesh
2.		431	**26°25'10.07"N/ 79°18'19.42"E**	Pura	Madhogarh (Mangadpura)	Jalaun	Uttar Pradesh
3.	**River Chambal Mouth To Agra**	471	**26°32'22.38"N/ 79°13'55.54"E**	GarhaKasda Village	Chakarnagar	Etawah	Uttar Pradesh
4.		501	**26°37'34.01"N/ 79° 04'15.14"E**	Bilahati Village	Chakarnagar	Etawah	Uttar Pradesh
5.		531	**26°44'38.55"N/ 78°59'20.65"E**	Bhind-Etawah Bridge (Nh92)	Etawah	Etawah	Uttar Pradesh
6.		561	**26°52'10.30"N/ 78°48'42.96"E**	Guraiya Village	Jaswantnagar	Etawah	Uttar Pradesh
7.		591	**26°52'47.40"N/ 78°39'6.15"E**	Kachhora Bridge	Bah	Agra	Uttar Pradesh
8.		621	**26°58'17.31"N/ 78°30'53.24"E**	Budhera Village	Shikohabad	Firozabad	Uttar Pradesh
9.		651	**27°2'3.50"N/ 78°26'13.9"E**	LuhariFatehabad Bridge (Near Yamuna Exp. Way)	Fatehabad	Agra	Uttar Pradesh
10.		681	**27° 7'29.24"N/ 78°21'53.68"E**	Indon Village	Firozabad	Firozabad	Uttar Pradesh
11.		711	**27° 5'1.40"N/ 78°13'31.58"E**	MewaliKalan Village (Near Yamuna Exp.Way)	Fatehabad	Agra	Uttar Pradesh

Sl. No.	Stretch	Ch. (Km)	Co-Ordinates	Locations			
				Nearby Landmarks	Tehsil	District	State
12.	Agra To Delhi	751	27°14'22.71"N/ 78° 1'50.37"E	Manoharpur	Agra	Agra	Uttar Pradesh
13.		781	27°14'19.33"N/ 77°56'10.35"E	District Road Bridge	Agra	Agra	Uttar Pradesh
14.		811	27°17'55.42"N/ 77°49'10.03"E	Bhadaya Village	Mathura	Mathura	Uttar Pradesh
15.		872	27°37'5.30"N/ 77°42'34.42"E	DangoliKhader	Mat	Mathura	Uttar Pradesh
16.		902	27°47'59.05"N/ 77°42'5.70"E	Sultanpur Khadar	Mat	Mathura	Uttar Pradesh
17.		932	27°51'4.02"N/ 77°36'7.24"E	Firozpur Banger/ Inayatgarh Village	Mat	Mathura	Uttar Pradesh
18.		962	28° 1'12.83"N/ 77°31'53.91"E	Sherpur Village / Tappal Town	Khair	Aligarh	Uttar Pradesh
19.		992	28°14'9.43"N/ 77°27'18.40"E	Mohna Town	Ballabgarh	Faridabad	Haryana
20.		1022	28°24'20.69"N/ 77°28'1.19"E	Sector-150, Noida	Gautam Buddha Nagar	Faridabad -Gautam Buddha Nagar	Haryana -Uttar Pradesh

The barrage sites are so located that the authorized water depth (2.5m) is maintained. The proposal consists of construction of barrages with navigation locks including vertical lift gates enabling a requite ponding level to maintain authorized water depth of 2.5m during lean season as shown below:

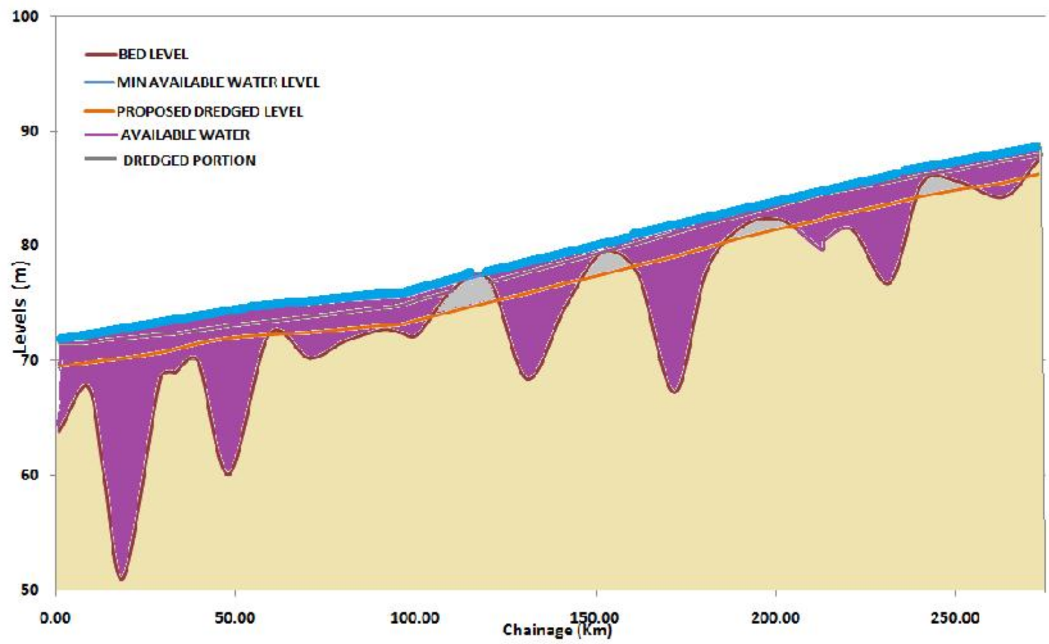


Fig. 5.14 No Barrage in Stretch-1 (Ch. 0km to Ch. 272 km)

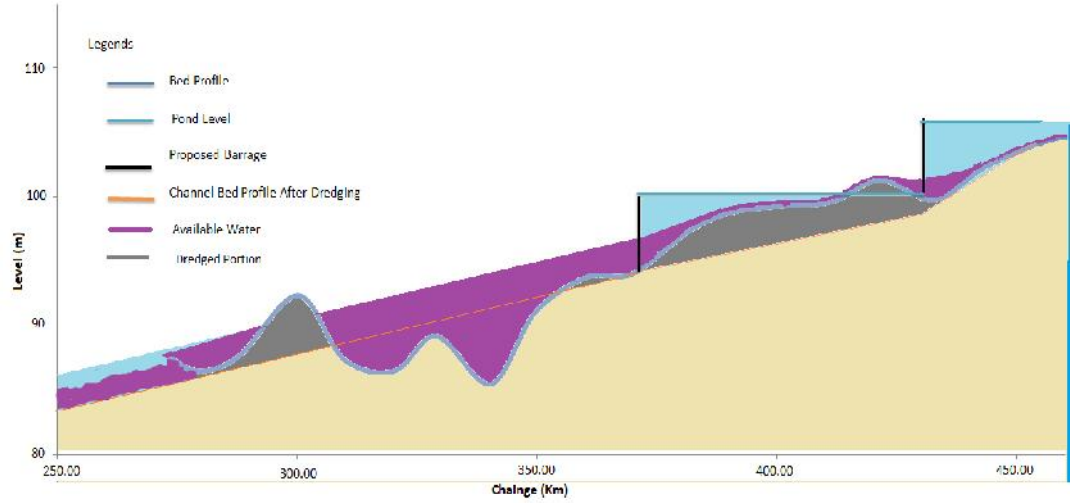


Fig. 5.15 Barrage Location for Stretch-2 (Ch. 272 km to Ch. 453 km)

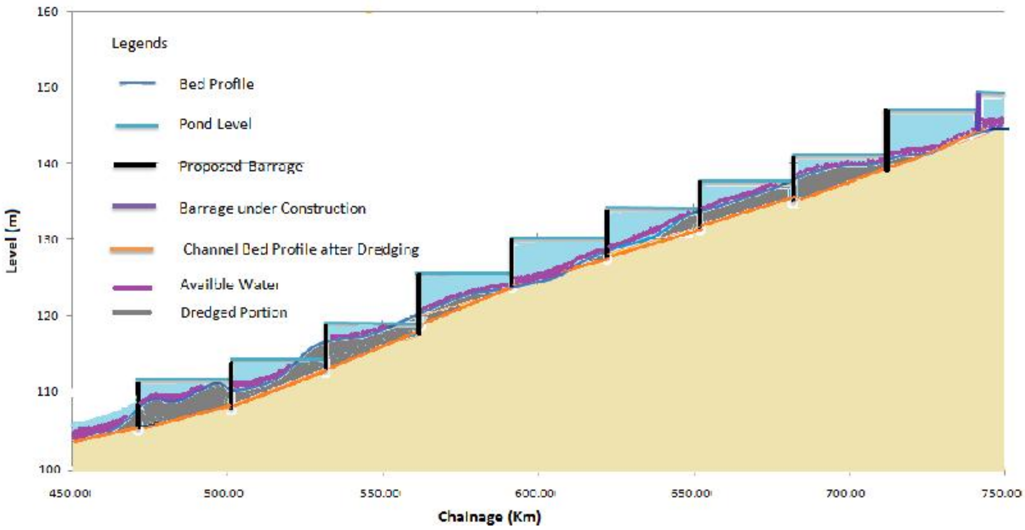


Fig. 5.16 Barrage Location for Stretch-3 (Ch. 453 km to Ch. 743 km)

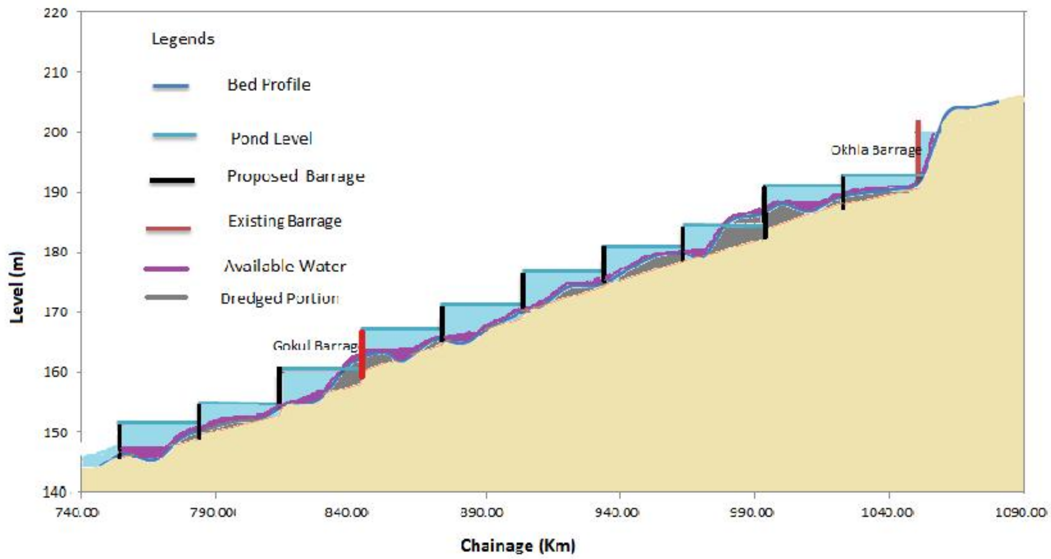


Fig. 5.17 Barrage Location for Stretch-4 (Ch. 743 km to Ch. 1081 km)

For that purpose it is proposed to store rain water at Barrages. The barrages are so located that the stipulated 2.5m depth is available round the year. The bed slope and hydrology of the river has been taken into consideration while locating the barrages. After data analysis it is found theoretically that 20 Nos. of barrages along with navigation locks would be required for the storage of water to maintain the 2.5m depth of water for navigation. The ponding levels are so designed that storage level of water would remain within the banks. This means that habitation/villages/agriculture fields would not be affected due to submergence. Storage can be made in the out falling rivers, if necessity arises, to avoid any submergence on the upstream side and without encroaching the rights of the beneficiaries. Two nos. Cross regulators on River Betwa and Chambal have been provided to store the water on the upstream side and to regulate the flow in river Yamuna whenever required. This will also avoid the flooding in the upstream area of River Betwa and Chambal.

Proposing barrages along with dredging is more feasible in River Yamuna. Therefore, it is recommended to consider this option for development of navigation in the River Yamuna.

During hydrographic/bathymetric survey of the river stretch it was found that there are number of shoals in River Yamuna. Details of these shoals are as follows:

Table 5.14 Stretch wise Total Shoal for dredging along with Barrage

S. No.	Stretch	Shoal Length (in km) For 2.5 m Dredging	Shoal Length (in km) For Class IV	Shoal Length (in km) For Class III	Shoal Length (in km) For Class II	Shoal Length (in km) For Class I
1.	Prayagraj to River Betwa Mouth (Ch. 0 to 272 km)	151.4	115.2	106.2	91.6	78
2.	River Betwa Mouth to River Chambal Mouth (Ch.272 to 453 km)	141	131.2	124.8	115.2	110.8
3.	River Chambal Mouth to Agra (Ch.453 to 743 km)	189	161	154	134	127
4.	Agra to Delhi (Ch.743 to Ch.1081 km)	232	180	150	81	72
Total Shoal Length (in Km)		**713.4**	**587.4**	**535**	**421.8**	**387.8**

Dredging quantity for each stretches for different class of waterways are presented in the following tables:

***Table 5.15 Dredging Quantity for Different class of waterways by considering dredging* along with Barrage**

Sr. No.	Stretch	Quantity for 2.5m depth	Quantity For Class IV	Quantity For Class III	Quantity For Class II	Quantity For Class I
1	Prayagraj to River Betwa Mouth (Ch. 0 to 272 km)	17.39	6.62	5.08	2.88	1.69
2	River Betwa Mouth to River Chambal Mouth (Ch.272 to 453 km)	17.96	7.71	6.31	3.84	2.43
3	River Chambal Mouth to Agra (Ch.453 to 743 km)	8.31	3.61	2.67	1.5	0.86
4	Agra to Delhi (Ch.743 to Ch.1081 km)	7.98	3.09	2.14	1.16	0.71
Total Dredging Quantity		**51.64**	**21.03**	**16.2**	**9.38**	**5.69**

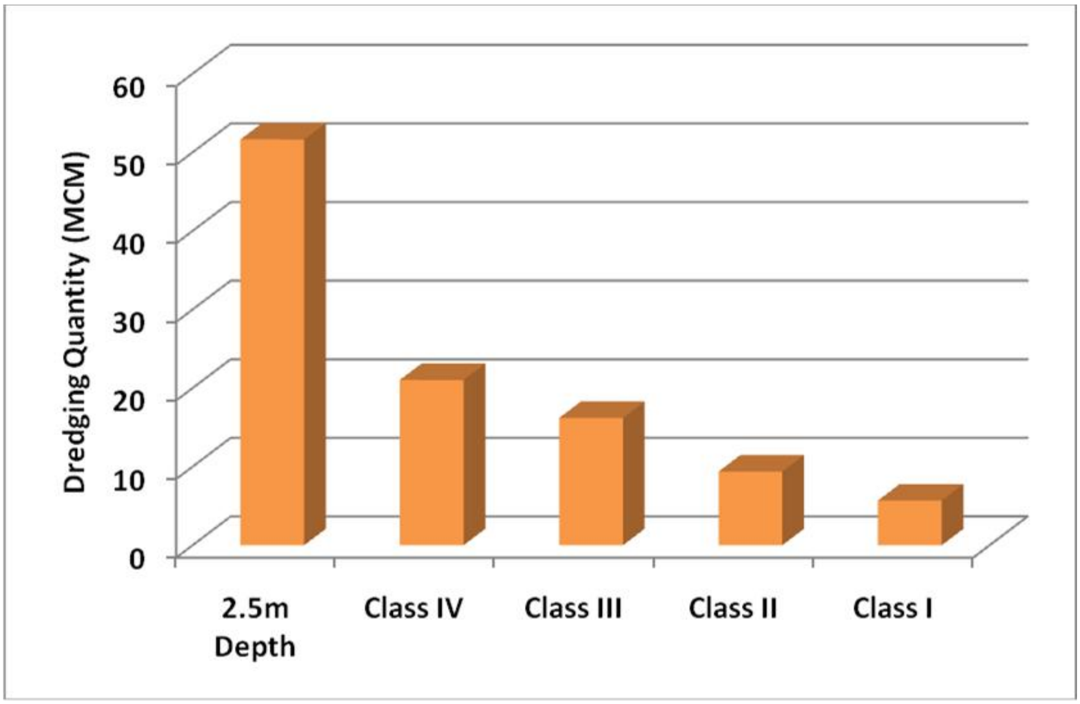


Fig. 5.18 Graph showing dredging quantity for different class of waterways by considering dredging along with barrage

Additional dredging quantities required for locations having bend radius less than 700m would be 3.17 MCM.

(v) Requirement of part of River rejuvenation

As such no river part is considered for rejuvenation in the present study, the same may be taken up at implementation stage by project authorities.

5.3 Bends

The radius of a bend in the waterway must be large enough for both commercial vessels and recreational craft in view of restrictions to:

- the rudder angle needed to take the bend
- the reduction in speed (loss of momentum) in the bend
- any course corrections required
- loss of visibility

Minimum bend radius for commercial vessels

As per the classification of waterways by IWAI min bend radius required for different class of waterways are given in the table 5.1 of this chapter. Also, the details of critical section where bend radius is not meeting the min required criteria is given in the chapter 4. At these sections extra width of the channel is required as per the following:

Width increment

Since vessels take up more width due to their crab angle on a bend, a greater waterway width is required on bends to ensure smooth, safe navigation. The path width in a bend depends on the bend radius and whether or not a vessel is laden. If the bow angle ß is greater than 30º, the following increment applies to the waterway width in the keel plane of a laden vessel (loaded vessel):

$$\Delta_{B1} = C_1.L^2/R$$

In the keel plane of an empty ship, the width increment is:

$$\Delta_{B1} + \Delta_{B2} = (C_1 + C_2).L^2/R$$

Where, C_1Bend widening factor for Laden Vessel
C_2 Bend widening factor for empty Vessel
L Length of vessel
R Bent Radius

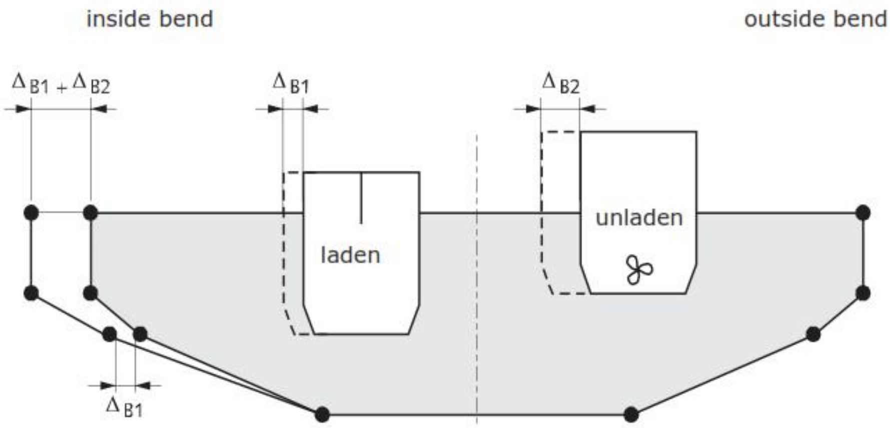


Table 5.16 Extra Widths Required at Bend

Ch. (Km)	Bend Radius (m)	Extra With (m)	Ch. (Km)	Bend Radius (m)	Extra With (m)	Ch. (Km)	Bend Radius (m)	Extra With (m)	Ch. (Km)	Bend Radius (m)	Extra With (m)
55.5	370	20	526.5	560	15	667.5	600	15	902.3	375	20
133	650	10	527.5	450	15	677	620	10	903.5	560	15
143	500	15	528.4	420	20	680.5	470	15	908	350	20
149.4	600	15	530.6	700	10	687	430	20	908.6	260	20
289	410	20	536.2	420	20	689	380	20	909.4	310	20
337.4	500	15	539	300	20	702.6	430	20	921	380	20
351.4	540	15	541	320	20	705.8	700	10	922.6	205	20
369.2	350	20	561.5	400	20	710	400	20	926.5	465	15
401	465	15	564.5	380	20	717	680	10	934.9	480	15
433.5	700	10	566.3	300	20	722	600	15	937	360	20
453.5	330	20	567.3	520	15	723.6	740	10	938.5	355	20
460	340	20	573.7	445	15	733	440	15	940.8	455	15
467	280	20	580	320	20	757.6	330	20	941.6	290	20
470.5	520	15	581.4	420	20	761.4	370	20	942.3	400	20
473.3	405	20	588.5	310	20	773	320	20	949	340	20
474.5	670	10	589.8	455	15	778	560	15	954	700	10
475.9	270	20	600	380	20	785.5	490	15	957.7	460	15
480.2	420	20	603	590	15	789	320	20	959.6	320	20
481.7	270	20	607.5	750	10	797.1	680	10	963	380	20
493.6	430	20	611.7	505	15	798	250	20	966	420	20
499	420	20	613.5	500	15	808	710	10	976.5	350	20
501.3	270	20	619.7	600	15	823.3	680	10	992	590	15
502.2	340	20	621	560	15	830	680	10	996	330	20
504.3	270	20	625	450	15	840.5	480	15	1001	450	15
508	600	15	626.8	700	10	860	300	20	1018	320	20
510.7	600	15	635	750	10	861.5	400	20	1021.3	380	20

5.4 Navigation Marking/ Navigation Aids

The terms Aids to Navigation, Nav-aids and Navigational aids used interchangeably, are all meant to convey marks, including floating marks, such as buoys and beacons, transit and clearing marks as well as signalling systems, radio aids and communications, electronic systems, radar etc. which are installed on land or in water for guidance to all ships for safe and regulated navigation in the channels, anchorages, berths, docks etc. It is envisaged that navigation will be carried out throughout the year, by day and night except during times of high wind speeds and low visibility. For day navigation, channel is demarcated by conventional bamboo marks but when frequency of IWT mode increases it becomes essential to provide night navigation facilities.

Marine Lantern @ 2km C/C is recommended along the river Yamuna. Designed aid is on the basis of light intensity, soil condition and wind direction and velocity

RIS (River Information System):

LIST OF EQUIPMENTS:

Base Station
1) AIS Base Station with Hot stand
2) Mono pole tower
3) Porta Cabin 20'X 8'X8'
4) VHF sets with Antenna
5) Leased Line – Wide Area Network
6) Metrological Equipment
7) Gen Set 10 KVA
8) UPS (UPS APC- SRC6KUXI-6KVA
9) BSNL Leased line

Control Station Servers
1) Central RIS Operating Processor
2) Central Monitoring and Storage Processor
3) Web Server & Time Server
4) Workstation
5) Operator Display 52" LED Wide Screen + With operator display
6) RIS Software
7) Installation, testing, Training and commissioning

5.5 Modification Requirement in existing Bridges / Cables / Dams / Barrages / Locks / Weirs Anicuts / Aqueducts

There are total 86nos bridges are found during survey across the River Yamuna under study stretch of 1089km from Jagatpur (6 km u/s of Wazirabad barrage in Delhi) to Sangam at Prayagraj, including 7 nos of Pantoon Bridges, 15nos Road Bridge under construction and 14nos Railway bridges among then two rail bridges are under construction. At all bridges the Vertical clearance varies 2.106 m to 14.15 meter above NHFL. Horizontal clearance for bridges varies from 20 to 260m. There are total 43 nos HT/Electric lines across the river Yamuna under the study stretch, vertical clearance ranges from 12m to 15m above HFL and Horizontal clearance ranges from 191.7m to 888.4m and whereas it is 1151m at CH 983.7km. **Modification of bridges is not practically feasible. Demolition & reconstruction bridges are suggested which are not having requisite horizontal and vertical clearance.** The barrages namely Gokul barrage, Okhla barrage, ITO barrage and Wazirabad barrage existing at chainage 842.3 km, 1052 km, 1063.1 km and 1074.1 km respectively.

Table 5.17 Status of horizontal and vertical clearance for bridges

Class of Waterway	Required VC(in meter)	No. of Bridges for qualifying VC	Required HC(in meter)	No. of Bridges for qualifying HC
Class-I	4	46	30	36
Class-II	5	35	40	22

Class of Waterway	Required VC(in meter)	No. of Bridges for qualifying VC	Required HC(in meter)	No. of Bridges for qualifying HC
Class-III	6	22	50	11
Class-IV	8	3	50	11
Class-V	8	0	80	0
Class-VI	8	0	80	0
Class-VII	8	0	100	0

Note: Detailed Sheet is given in Annexure 5.1

Table 5.18 No. of Bridges to be demolished for different class of waterways

Class of Waterway	No. of Bridges for qualifying VC	No. of Bridges for qualifying HC	No. of Bridges to be demolished
Class-I	46	36	30
Class-II	35	22	47
Class-III	22	11	56
Class-IV	3	11	60
Class-V	0	0	0
Class-VI	0	0	0
Class-VII	0	0	0

Table 5.19 Status of horizontal and vertical clearance for HT/Electric lines

Class of Waterway	Required VC As per IWAI Specifications (m)	No. of HT/Electric Lines for qualifying VC	Required HC(in meter)	No. of HT/Electric Lines for qualifying HC
Class-I	• Telephone lines and Low Voltage lines 16.5 m • High Voltage Transmission lines not exceeding 110 KV – 19 m • High Voltage Transmission lines exceeding 110 KV – 19 m + 1 cm per each KVin case of underground pipe / power lines and other cables norms to be decided as per conditions and navigational requirement	0	30	43
Class-II			40	43
Class-III			50	43
Class-IV			50	43
Class-V			80	43
Class-VI			80	43
Class-VII			100	43

Table 5.20 No. of HT/Electric Lines to be demolished for Different class of waterways

Class of Waterway	No. of HT/Electric Linesfor qualifying VC	No. of HT/Electric Lines for qualifying HC	No. of HT/Electric Lines to be demolished
Class-I	0	43	43
Class-II	0	43	43
Class-III	0	43	43
Class-IV	0	43	43
Class-V	0	43	43
Class-VI	0	43	43
Class-VII	0	43	43

5.6 Land Acquisition

Navigational channel is within the boundary of river throughout the stretch from Delhi to Prayagraj. Hence land acquisition is not required for fairway development in River Yamuna.

CHAPTER – 6

MARKET ASSESSMENT

6.1 General

The market analysis to identify opportunities for River Transportation is essential. This would enable planning of optimum size infrastructure with scope for future expansion. It would also enable identification of type of terminals to be created, location of terminal and volume of passenger or cargo proposed to be handled. River Yamuna NW 110 has a long stretch starting from Prayagraj to New Delhi. It is marked by uneven water depth, uneven width and flow of river restricting transportation prospects. There are well developed roadways and railways, parallel to the identified stretch of River Yamuna NW 110. Roadways and railways in this route are run by government bodies, such as Indian Railways and UPSRTC (Uttar Pradesh State Road Transportation Corporation), which are subsidised. IWAI will develop water transport to augment the existing nodes of transportation. This Market Assessment Chapter has been prepared with an objective to identify various nodes and origin & destination points, with need for water transportation. The study identifies both origin and destination of cargo on the hinterland of River Yamuna. Shifting the present mode of transportation from Roadways to waterways would enable decongestion of road and enable transportation using environment- friendly mode.

River Yamuna merges with River GangaNW 1 at Sangam, Prayagraj. The river stretch from Prayagraj to Kolkata is a part of River Ganga NW 1. Water transport is active in small segments of NW 1. Government has mandated IWAI to implement Inland water Navigation on the complete stretch. NW 1 connects to two major sea ports, namely Kolkata and Haldia. Both the ports act as gateway to several landlocked regions of North, East and Central India. The study also evaluates potential to connect NW 110 with NW 1 upto Kolkata. This would enable cargo and passenger transportation by combining inland waterways and coastal movement.

It is essential to identify commodities and raw materials that are likely to be moved by waterways before physical infrastructure for development of waterways is created. Hence, consultant has undertaken detailed traffic assessment to identify following

- Existing and upcoming industries likely to come-up in future. A quick assessment of raw materials required by industries has been undertaken.
- Any commodity traded using ICDs, could be diverted to proposed waterways for transportation to industries in the hinterland.
- Disposable income available with population in the city/town located on the banks of river based on macro-economic data.

- Requirements related to the commodities that are procured from domestic market and could be transported using river route.

NW 110 is proposed to be developed as alternate mode of transportation for cargo and passenger movement. This development would helpto decongest traffic of road and railway by shifting it to waterway. This landlocked northern region uses only roadway and railway as primary means of transportation for EXIM trade. Development of NW 110 could open a new door of opportunity for industries as well as local commuters. Project study determines all possibilities of decongesting and diverting present traffic to waterway backed with detailed logistics and financial analysis.

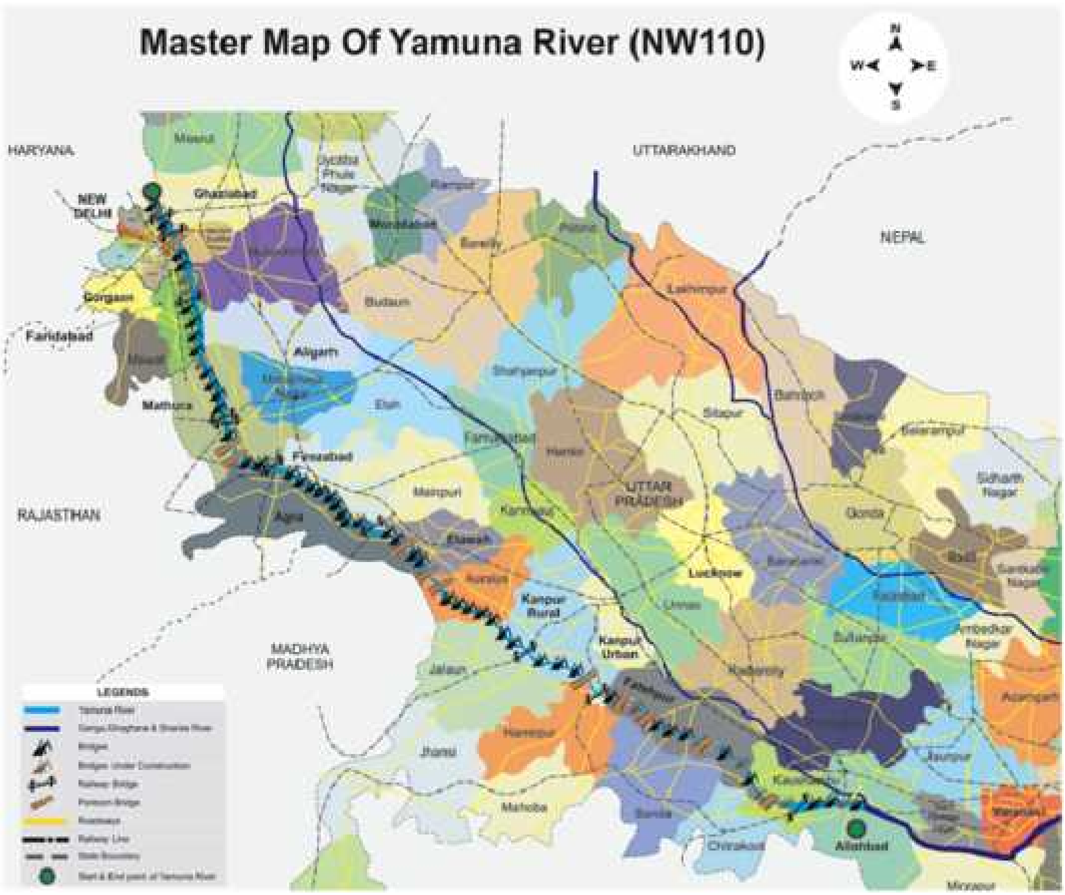


Fig. 6.1 Macro Map of Yamuna

6.2 Hinterland Analysis

Delhi and Uttar Pradesh constitute predominant parts of primary hinterland for NW 110. River Yamuna stretch considered for this study passes through these states. A small area from west of NW 110 (less than 50 Km) of Madhya Pradesh, Rajasthan and Haryana falls under secondary or tertiary catchment area.

The Hinterland map below depicts broad areas to be considered for this study, NW 1, NW 110 connectivity and nearby ports in East coast of India that are used for EXIM purpose by nearby landlocked region. Hinterland of NW 110 could participate in the EXIM trade, using a combination of NW 1 and NW 110. Apart from these, JNPT is also a major port that handles container traffic originated from northern region for export/import purpose.

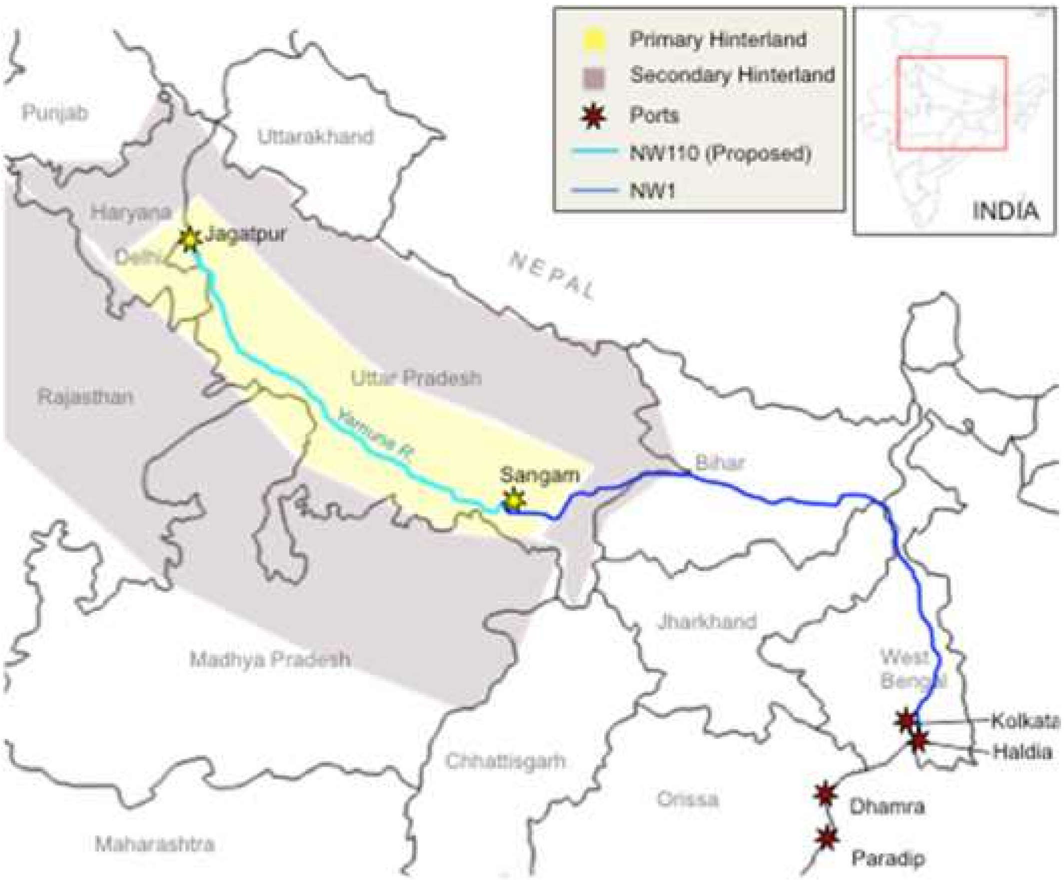


Fig. 6.2 Hinterland of NW 110

6.3 Demography Analysis

Following image has mapping of all the talukas located in Uttar Pradesh along with talukas of Rajasthan, Haryana and Madhya Pradesh. All these talukas are located within a distance of 100 km away from River Yamuna. River Yamuna passes through Uttar Pradesh and New Delhi; hence a detailed analysis by mapping all the talukas along with population has been undertaken. The size of bubbles, marked on the map shows the volume variation of population.

This mapping has been used to study population and their locations in detail. This map forms base for identifying population and industries logistically convenient to use river Yamuna for transportation. Talukas located at far of locations would have higher logistics cost due to longer last mile or first mile connectivity. Traveling to river either as person or brining cargo to the river would take substantial share of time to reach final destinations. This scenario could be illustrated using an example.

Fig. 6.3 Taluka wise Demography of Yamuna River Hinterland

Source: Census, 2011

Table 6.1 Demography of overall hinterland of Yamuna

State	No. of Districts		Population ('000)		Households ('000)	
	Total	Hinterland	Total	Hinterland	Total	Hinterland
Delhi	9	5	16,788	1,874	3,436	357
Uttar Pradesh	(75*) 71	18	1,99,812	30141	33,448	5117
Haryana	21	7	25,351	4901	4,858	865
Madhya Pradesh	50	11	72,627	13287	15,093	2772
Rajasthan	33	5	68,548	8705	18,071	1495
Total	**184**	**46**	**3,83,127**	**58,908**	**74,906**	**10,606**

Source: Census, 2011, *Present Scenario

A person/cargo originating from Lucknow for Etawah would have to travel about 160 kms to reach Yamuna at Chilla Ghat. Person/cargo would have to travel in the river that has a length longer than rail or road due to its curves. The person/cargo would have to again travel about 60 kms to reach the final destination. A direct travel of about 228 kms along with road, parallel to Yamuna from Lucknow to Etawah would take lower time and lesser distance with lower cost.

Hence, for the above mentioned reasons, local hinterland distance of about 100 kms has been considered for local cargo. It constitutes about 9% of the total length of river Yamuna stretch. A person/cargo would have to cumulatively travel a maximum about 18% of the total stretch of river Yamuna as 1st mile and last mile connectivity. This rule has been extended to upto 200 kms of hinterland, wherever origin and destination pairs involve NW-1 (River Ganga) and the total river chainage is more than 2,000 kms.

6.4 Economic Analysis

A detailed understanding of the local economy along with economic mapping with the river is essential for planning water transportation on river Yamuna. The Economic analysis forms critical component due to diverse nature of economic activities undertaken in the 5 states falling in the hinterland of river Yamuna. The analysis considers all key industries along with quantitative and qualitative impacts of transportation decision. Some of the regions, such as Delhi, part of Uttar Pradesh, part of Haryana has very high share in service sector. The prospect of cargo transportation is directly not possible for such industries. There is some scope of indirect transportation requirements. Personnel employed in the service sector of Delhi NCR have higher per capita income, leading to higher disposable funds with them. They would consume more compared to other working groups. Higher consumption would fuel transportation of items of necessities and luxury. This indirect scope for water transportation in river Yamuna would get covered while evaluating container transportation scope in the river. The economic analysis for identified regions, which are highly dependent on manufacturing, agriculture, etc., would provide direct scope for water transportation. Transportation of agricultural products on river and raw materials such as fertiliser would provide opportunities. Some of the states falling in the hinterland have high movement of minerals as raw materials. They could be evaluated for shifting to waterways.

6.5 Opportunity Prospects

Prospects for transportation on Yamuna could broadly be divided into 2 categories namely, Cargo and Passenger. Two types of cargo are considered, finished products from existing industries and bulk material from mines and agriculture. Passenger segment could be divided into two categories, local residents and tourists. Local residents travel regularly for work related activities. Some local residents travel occasionally also for other purpose, like farming, visiting commercial centers etc. Tourists usually visit Taj Mahal, Sangam, some heritage sites in the region etc.

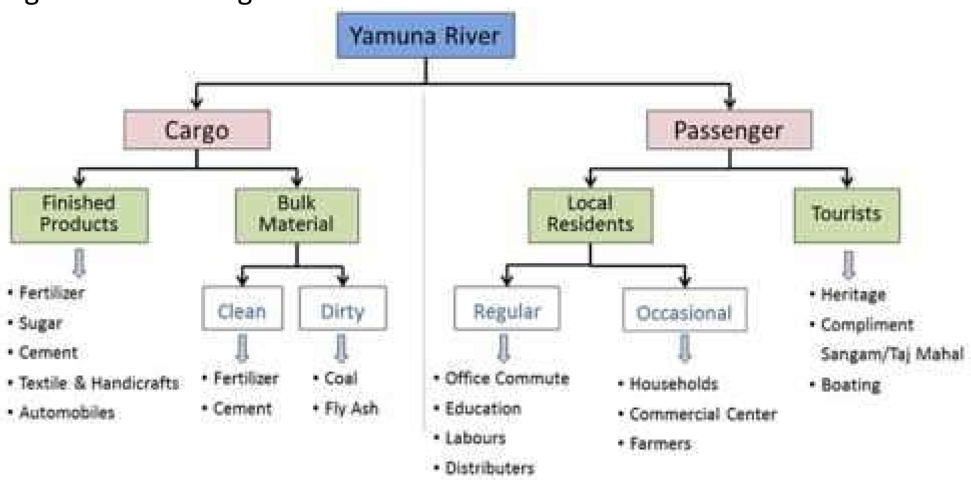


Fig. 6.4 Opportunity for Water Transportation in Yamuna (NW-110)

6.5.1 Cargo

A detailed analysis of cargo being transported, using organised as well as unorganised sector has been undertaken to evaluate prospect for model shift of cargo on river Yamuna. The industrial sector of Uttar Pradesh and other states falling in the hinterland of river Yamuna has been studied. Origin and Destination analysis of their raw materials as well as finished products has been studied. The objective of the study is to evaluate commodities that move in bulk form over a larger distance. These commodities and their location have been mapped with respect to river Yamuna. The cargo to be transported has been divided into 2 categories, namely bulk commodities and finished products. The categorisation has been undertaken based on the volume of cargo, classification of cargo into clean cargo and dirty cargo and probable mode of transporting these cargoes. This classification has been done to accommodate variation in type of vessel to be deployed on the river, type of the terminal, its location and infrastructure that would have to be planned. Finished products are mostly carried in containers or break bulk form. Bulk materials are carried in large volumes. The handling mechanism proposed at the terminal would be different for finished product and bulk materials.

Several bulk materials have been identified for transportation on river Yamuna. They include minerals, such as Coal and other types of minerals, food grains, fertiliser, etc. Cargo transported as bulk materials is further divided into 2 subcategories, based on the nature of cargo. The terminal infrastructures and location of terminals have to be separate for clean cargo and dirty cargo. The terminal proposed for handling bulk clean cargo could also handle finished products, though the material handling equipment on the terminal would be different.

6.5.2 Passenger

Transportation of passengers could be broadly divided between transportation required for people residing locally and transportation for tourists. The transport infrastructure for both the categories would be similar and hence have been clubbed together.

Local passengers include office goers, students, labourers and distributers who travel for work purpose. Occasional passengers include household people, farmers and people of commercial centres who do not travel on a daily basis. They travel when requirements arise.

6.6 Market Survey Cargo Transportation

Development of sustainable transportation infrastructure for mass transportation requires availability of large volume cargo. Cargo availability and transportation should be sustainable over a period of time. River Industries meet both the requirements. The movement of cargo is fixed for industries, at least for the raw materials. Hence, assessment of industries located around hinterland of River Yamuna is essential.

The industries require large volumes of raw materials. Sometimes, these raw materials are procured from far of locations. The movement of raw materials to industries is sustainable over a period of time. There could be a possibility of distributing finished products or semi finished products generated from industries to the hinterland. Industrial analysis in the hinterland of Yamuna becomes essential to identify all the cargoes that are moving in that region. Shifting of identified cargoes to River Yamuna could be evaluated based on the industry requirements and their transportation needs. Cargo from industries would play a larger role in commercial viability of cargo transportation infrastructure on River Yamuna. All efforts should be made to evaluate shifting of cargo to River Yamuna either on their own by providing reasonable incentives.

This chapter undertakes detailed analysis of industries located in Delhi and Uttar Pradesh along 3 other states falling in the hinterland of Yamuna. All the industries have been mapped along with identification of the origin of their raw materials and destination for final distribution of finished products. This identification would help to pursue cargo that could be shifted to river Yamuna.

6.6.1 Coal / Thermal Power Plants

Thermal Power plants of Uttar Pradesh could provide maximum opportunity for transportation of coal and fly ash on the river Yamuna. There have been several restrictions on thermal power plants in India. Government of India has committed to stop generating electricity from thermal power plants by the year 2100. There have been strict environmental restrictions on existing and upcoming thermal power plants. All the expansion plans and installation of new thermal power plants have virtually stopped for the following reasons,

- ✓ Restriction on electricity prices along with rising coal prices had rendered some of the proposed thermal power plants commercially viable.
- ✓ Implementation of environment protection and regulation has restricted expansion of existing plants.

For above reasons, new plants are unlikely to be commissioned in near future. However, the existing thermal power plants would continue to operate. Thermal Power plants operating in India use both domestic as well as imported coal from international markets. The calorific value of domestic coal in India is very low. It has higher ash content. This leads to lower efficiency of thermal power plants. Some of the super critical thermal power plants, designed for better quality of coal find it difficult to operate. Therefore, there is a mix of coal procured domestically and internationally used in thermal power plants.

The government of India passed guidelines to procure to increase production of domestic coal. They also instructed local thermal power plants to import coal locally. This had led to fall in imports of coal across country. Last one year has witnessed gradual revival of coal imports by thermal power plants. There are two fundamental reasons for this, which are mentioned below

- ✓ The domestic coal producer, predominantly Coal India, has not been able to sustain high production year-on-year.
- ✓ The users, thermal power plants, have witnessed fall in production of electricity induced by fall in efficiency by use of low grade coal.

Hence, import of thermal coal it is likely to continue is likely to revive in future. Thermal power plants would continue to use domestic coal as well as imported coal.

A mix of domestic coal and imported coal would primarily be used as fuel for thermal power plants. Some of the thermal power plants in UP are located quite close to the River Yamuna. The coal procured by them from domestic coal fields is located about 300 km away from river. Railway is the only mode of transportation presently. The transportation of coal could be shifted to waterways, using a combination of rail for 1st/last mile connectivity, NW 1 and NW 110.

- **Delhi**

  Indraprastha Power Generation Co. Ltd. (IPGCL) is one of the major coal based Power-generating utilities in Delhi. Rajghat Power Station was a Coal-based thermal power plant of IPGCL with 135 MW installed capacity. The coal for this plant used to come from Northern Coalfields Limited (NCL) and Bina Coal mines. Both the units were shut down in December 2015 as they were very old. After closing of IPGCL, Badarpur TPP was the coal based power plant that provided power to Delhi with installed capacity of 720 MW and functioning capacity of its 2 units stands at 210 MW each. This plant was temporarily closed in Nov 2016 for 10 days due to environmental issues.

- **Uttar Pradesh**

  Around 95.16% of electricity is generated through thermal power in Uttar Pradesh. The majority of power generated in Uttar Pradesh is dependent on coal. The limited availability and high price of coal have aggravated the dwindling power situation in Uttar Pradesh. National Thermal Power Corporation (NTPC), a Public sector undertaking and other state level power generating companies operate coal-based thermal power plants. Apart from NTPC and other state level operators, some private companies are also operating power plants in Uttar Pradesh. India’s vast coal reserves supply raw material for the commercial energy demand of UP. The states that supply coal to UP power plants are Jharkhand, Orissa and Madhya Pradesh. The figure below depicts major thermal power plants situated in Uttar Pradesh.

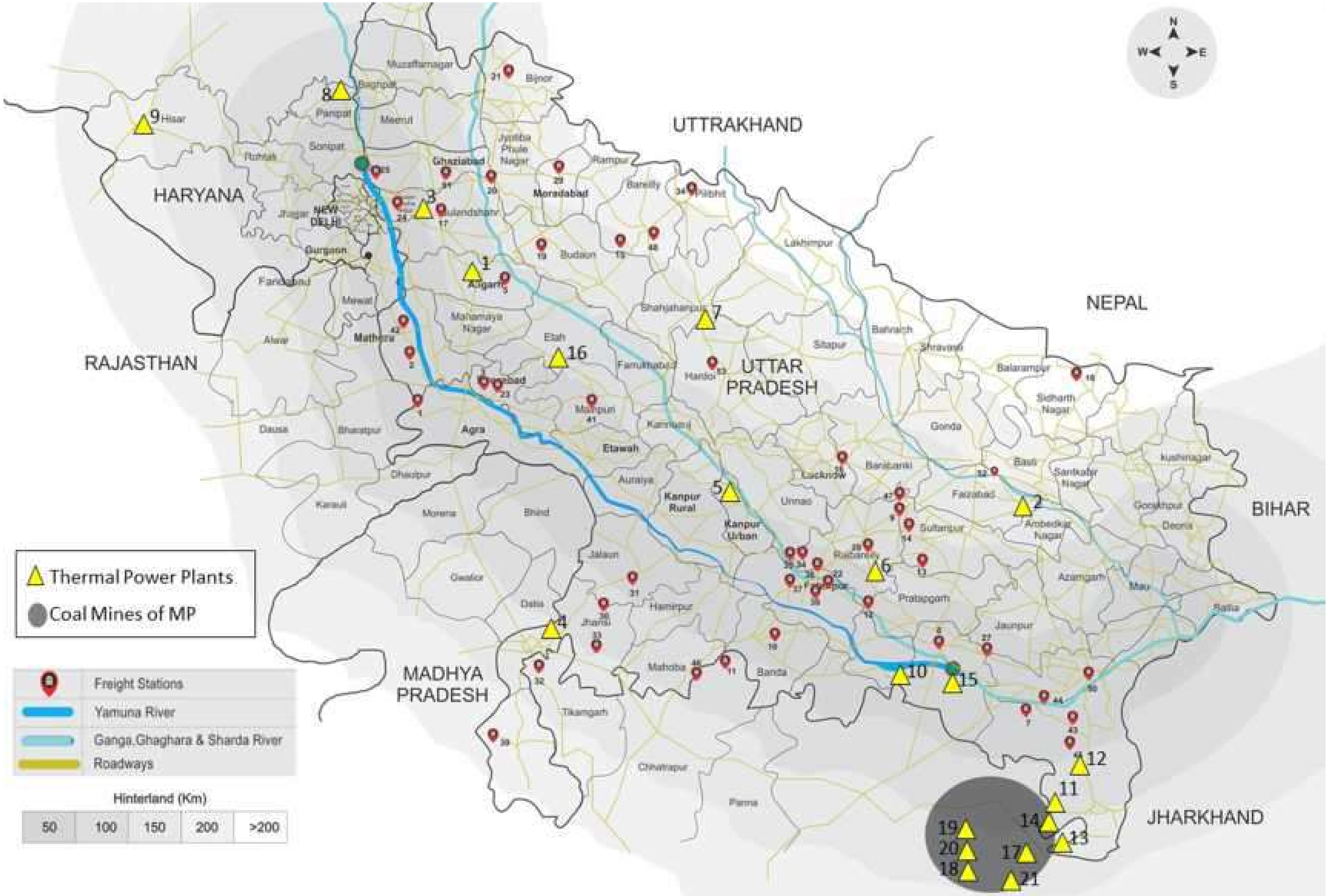


Fig. 6.5 Thermal Power Plants in the Hinterland

Table 6.2 Opportunity for Coal from TPP in UP

Sr. No. on Map	Power Station	Location	Installed Capacity (MW)	Annual Coal Requirement ('000 T)	Coal Source	Distance of Plant from NW110 (km)	Distance of mines to NW (Km)	Opportunity	Reasoning
N.T.P.C									
3	NTPC Dadri	Dadri, GBN	1,820	8,128	Piparwar Mines	38	183		Domestic coal could be procured from Piparwar Mines. Imported coal can be transported from Haldia.
2	NTPC Tanda	Vidyutnagar	440	2,498	North Karanpura Coal Fields	160	190		Domestic coal could be procured from North Karnpur Coal fields.
6	Feroz Gandhi Unchahar	Unchahar	1,050	5,005	North Karanpura Coal Fields	81	190		
13	Rihand TPP	Rihand	3,000	14,695	NCL	187	190		These power plants are nearer to Ganga river (NW 1 Stretch).
UPRVUNL									
1	Harduaganj	Harduaganj	665	2,981	BCCL & ECL	73	140		Domestic coal could be procured from BCCL / ECL.
5	Panki Thermal	Panki, Kanpur	210	917	BCCL / ECL	68	140		
4	Parichha TPP	Parichha, Jhansi	1140	4,859	BCCL / ECL	131	140		Domestic coal could be procured from BCCL/ECL. Imported coal could be transported from Haldia.
11	Anpara TPP	Anpara	6,118	21,457	NCL / Khadia, Kakria	187	190		These power plants are nearer to Ganga river (NW 1 Stretch).
12	Obra TPP	Obra							
14	Shaktinagar	Shaktinagar							

Sr. No. on Map	Power Station	Location	Installed Capacity (MW)	Annual Coal Requirement ('000 T)	Coal Source	Distance of Plant from NW110 (km)	Distance of mines to NW (Km)	Opportunity	Reasoning
	TPP				&Beena / ECL/ Dudhichua/ Amloric				
15	Meja TPS (P)	Prayagraj	1,320	5,630	NCL	39	507		Domestic coal could be taken from NCL & imported coal from Haldia.
16	Jawaharpur TPP (P)	Malawan, Etah	1,320	5,630	CCL / NCL / SECL	93	211		Domestic coal could be procured from NCL, whereas Imported coal is transported using Haldia.
Other Owners (UP) - Reliance & Prayagraj Power Generation									
7	Rosa Thermal	Rosa, Shahjahanpur	1,200	5,211	Ashoka Coal Mines (CCL)	200	211		It is situated away from Yamuna Stretch.
10	Bara TPP (Prayagraj)	Bara, Prayagraj	1,980	8,445	Northern Coal Fields (MP)	38	190		Domestic coal can be procured from NCL, whereas Imported coal is transported using Haldia. Fly Ash can be exported to Singapore / Bangladesh via Haldia.

Fly ash from thermal power plants of UP could also be a potential commodity for moving through the proposed waterway. Fly ash from some of the thermal power plants as shown in the below table could be moved using the waterway in river Yamuna.

Table 6.3 Opportunity for Fly Ash in UP

('000 T)

Sr. No. on Map	Power Station	Location	Installed Capacity (MW)	Ash Generation	Ash Utilisation	Distance from NW110 (km)	Opportunity	Reasoning
				N.T.P.C				
3	NTPC	Dadri, GBN	1,820	2,607	2,705	38	✗	The generated fly ash is fully utilised.
2	NTPC Tanda	Vidyutnagar	440	1,035	574	160	✓	There is almost 5 lakh tonnes of fly ash unutilised. It can be exported to Bangladesh/Singapore via NW 110.
6	Feroz Gandhi	Raebareli	1,050	1,925	1,361	81	✓	
13	Rihand	Rihand	3,000	4,831	493	187	✗	These power plants are nearer to river Ganga (NW 1 Stretch).
				UPRVUNL				
1	Harduaganj	Harduaganj	665	997	1,196	73	✗	The generated fly ash is fully utilised.
5	Panki	Kanpur	210	312	782	68	✗	
4	Parichha	Jhansi	1,140	2,042	1,112	131	✓	Approximately 9.3 Lakh tonnes of unutilised fly Ash can be exported to Singapore / Bangladesh via Haldia.
11	Anpara	Anpara						These power plants are nearer to river Ganga (NW 1 Stretch).
12	Obra TPP	Obra	6,118	8,203	937	187	✗	
14	Shaktinagar	Shaktinagar						
15	Meja TPS (P)	Prayagraj	1,320	-	-	39	✓	Fly Ash can be exported to Singapore / Bangladesh via Haldia.
16	Jawaharpur TPP (P)	Malawan, Etah	1,320	-	-	93	✓	
			Other Owners (UP) - Reliance & Prayagraj Power Generation					
7	Rosa TPP	Shahjahanpur	1,200	1,344	601	200	✓	Imported Coal can be transported from Haldia via NW 1 & NW 110.
10	Bara TPP	Prayagraj	1,980	-	-	38	✓	Fly Ash can be exported to Singapore / Bangladesh via Haldia.

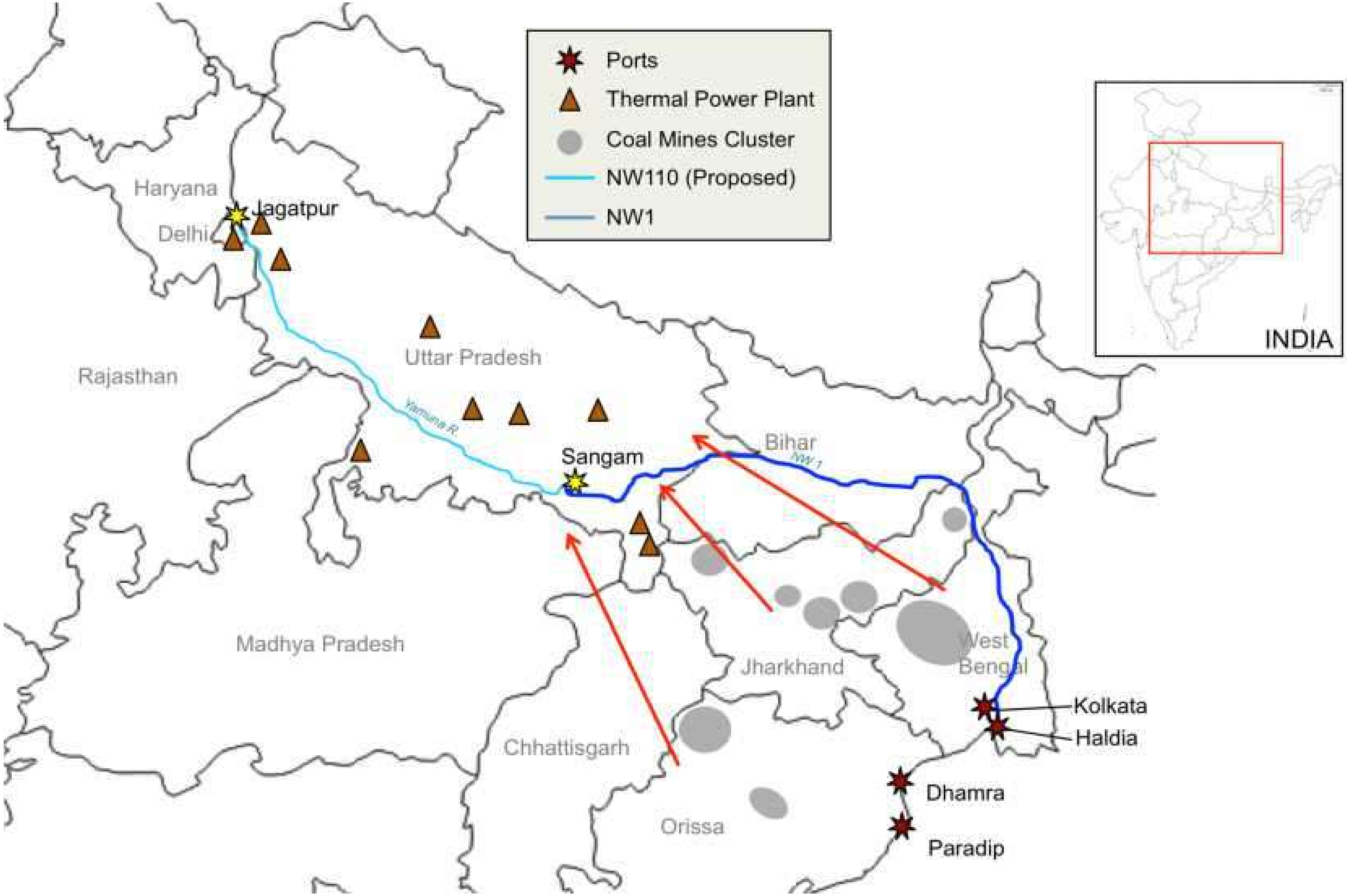


Fig. 6.6 Coal Movement to TPP of UP in hinterland of Yamuna

- **Other States in Yamuna Hinterland**

The table in this section shows opportunity for coal and fly ash movement from the existing thermal power plants in Haryana and Madhya Pradesh. There is no opportunity for coal and fly ash movement from these TPP to the proposed waterway. Madhya Pradesh has a few thermal power plants in Singrauli district, but all of them are located beyond 100 km from river Yamuna. Other districts of MP which are considered for the study do not have thermal power plants. Essar Power Mahan plant is located in Singrauli in MP. It was shut between Sept 2014 and May 2016 due to cancelled license. In May 2016, it resumed its operation, but in 2018, the company decided to handover this mine to the Government and withdraw its investment made so far. This plant would not provide any opportunity for NW 110 as it is located far from river Yamuna. Another plant, JP Nigrie takes coal from Amelia mine, which is located in MP; therefore there would not be any opportunity for river Yamuna for transportation of coal through waterways.

Almost all the thermal power plants have railway connectivity with the coal mines. Railway is economic and more convenient mode of transportation for these plants. Use of waterway for transportation of coal is not viable for these plants, as for a short distance, multiple handling of coal with multiple modes of transportation would increase time and the cost of transportation. Hence, these plants would not provide any opportunity to the proposed waterway in Yamuna.

Table 6.4 Opportunity for Coal from TPP in Other Hinterland States

No. on Map	Power Station	Location, State	Installed Capacity (MW)	Annual Coal Required ('000 T)	Coal Source	Distance of Plant from NW110 (km)	Distance of mines to NW110 (km)	Reasoning (No Opportunity)
Owners - HPGCL, NTPC, Essar, JP, Reliance Power								
8	Panipat Thermal	Panipat Haryana	1,360	3,149	BCCL / CCL	92	282	It is not in the hinterland of river Yamuna.
9	RGTPP	Hissar Haryana	1,200	4,005	CCL / NCL	187	190	It is not in the hinterland of river Yamuna.
17	Vindhyanchal STPS	Singrauli, MP	4,760	20,701	Singrauli/ NCL	224	222	NCL Mines are nearer to the plants. These power stations are not in the hinterland of Yamuna.
18	Essar Power Mahan	Bandhaura MP	1,200	398	Singrauli/ NCL	232	222	
19	Mahan Aluminium	Dhaudar MP	900	3,838	Mahan Coal	194	222	
20	JP Nigrie	Suhira, MP	1,320	5,629	Amelia North	232	222	
21	Sasan UMPP	Singrauli, MP	3,960	16,889	Moher/ Amlohri	225	218	

Table 6.5 Opportunity for Fly Ash in Other States in Hinterland of Yamuna

('000 T)

No. on Map	Power Station	Location	Installed Capacity (MW)	Ash Generation	Ash Utilisation	Distance of Plant from NW110 (km)	Reasoning (No Opportunity)
8	Panipat Thermal	Panipat, Haryana	1,360	1,316	1,288	92	It is not in the hinterland of river Yamuna.
9	RGTPP	Hissar, Haryana	1,200	1,463	1,369	187	It is not in the hinterland of river Yamuna.
17	Vindhyanchal STPS	Singrauli, MP	4,760	7,311	1,951	224	These power stations are not in the hinterland of river Yamuna.
18	Essar Power Mahan	Bandhaura, MP	1,200	158	121	232	
19	Mahan Aluminium	Dhaudar, MP	900	933	-	194	
20	JP Nigrie TPP	Suhira, MP	1,320	1,398	-	232	
21	Sasan UMPP	Singrauli, MP	3,960	4,123	-	225	

6.6.2 Cements

India is a developing country with requirement for large scale infrastructure development across the country. Hinterland of river Yamuna has five states, including Delhi, Uttar Pradesh, Haryana, Madhya Pradesh and small parts of Rajasthan. Delhi, being capital of India, is developed due to large-scale investments on infrastructure. However, other states of hinterland, such as Uttar Pradesh, Haryana, etc. still need large-scale infrastructure development. Cement is one of the primary components, required for all types of infrastructure development. The hinterland of Yamuna has cement plants, which procure their raw materials locally and distribute their finished products, i.e. cement in the hinterland. However some of the cement plants procure raw materials from far-off locations. A detailed analysis of cement plants along with their capacity, expansion plans, and annual production would enable identification of plant along with Origin- Destination pairs of cargo. Suitable infrastructure could be proposed on River Yamuna to make it commercially attractive for companies to shift their cargo transportation from road or rail to waterways. This section undertakes a detailed analysis of cement plants located in the hinterland of river Yamuna and evaluates shifting their cargo to waterways.

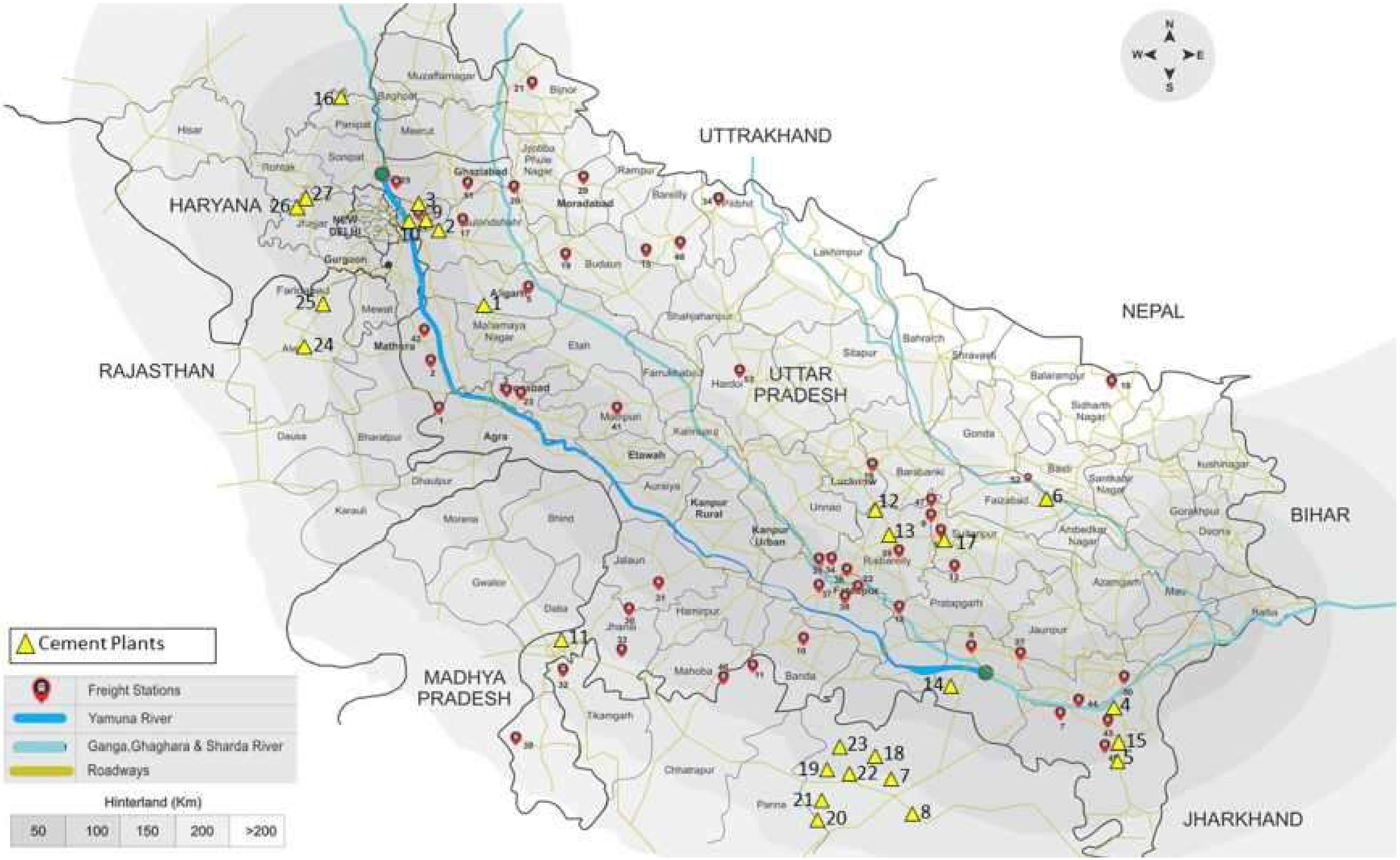


Fig. 6.7 Cement Plants in the hinterland

* **Uttar Pradesh**

UP ranks 9th in the production of Cement in India with installed capacity of more than 8.3 MMTPA. UP produces more than 7 MMTPA cement. Limestone, which is the raw material for Cement, is found in Guruma-Kanach- Bapuhari in Mirzapur district and Kajrahat in Sonebhadra district. Availability of raw material is abundant in Bundelkhand area. The major factor of being a leading cement producing states is easy access to raw material from Bundelkhand area.

The above map depicts the major cement plants located in Uttar Pradesh. Major cement companies in UP are establishing new cement plants & expanding their existing plants. From last few years, UP has been the second largest cement consumer with demand of 14.12 mn tonnes cement, which is 11.10% of all India's cement consumption.

Table 6.6 Cement Plants in UP

Sr. No.	Cement Plant	Location	Installed Capacity (Mn.TPA)	Reasoning (No Opportunity)
1.	UltraTech	Aligarh	1.30	Ultra Tech procures imported coal via rail from Gujarat. Its Dadri plant procures clinker from Chorgarh, Rajasthan. Limestone mines are situated near the plants. Dadri plants serve Delhi region and other plants serve nearby region. Thus no opportunity exists for waterway movement through NW 110.
2.		Sikandarabad	-	
3.		GBN	1.30	
4.		Varanasi	-	
5.		Sonebhadra	1.60	
6.		Tanda	-	
7.	Bela Cement Works	Rewa	2.60	Sonebhadra has availability of coal and ash, which are source of raw materials for cement. Produced cement is locally consumed, thus no opportunity exists. Ambuja cement at GBN procures raw materials from Dalra Ghat, Himachal Pradesh. Cement from this plant is mostly locally distributed and rest of the produced cement istransported to Moradabad/Rampur/ Bulandshahr.
8.	Jaypee Sidhi Cement Plant	Sidhi	2.30	
9.	Ambuja Cements Ltd	GBN	1.20	
10.	JK Lakshmi Cement	GBN	-	
11.	Heidelberg Cement	Jhansi	0.50	
12.	Birla Cement	Rae Bareli	2.00	
13.		Rae Bareli	1.30	
14.	Jaypee Cement	Prayagraj	0.60	
15.		Sonebhadra	0.73	
16.	Tikaria Cement (ACC)	Sultanpur	-	

UltraTech has two plants at Aligarh & Dadri in UP. Both are grinding units. Both Aligarh & Dadri Cement Works produce gray cement and their installed capacity is 1.3 MMTPA each.

Jaypee Cement is a big player in UP, as it owns five plants in the state, which is more in number than other players. Jaypee Group is the 3rd largest cement producer in India. The group produces special blend of Portland Pozzolana

Cement under the brand name 'Jaypee Cement'. Its cement division currently operates modern, computerized process control cement plants. Jaypee's plants are located in Sadva Khurd, Ayodhya Chunar, Sikandarabad& Dalla. The installed capacity of Chunar Cement Factory (CCF) is more than other Jaypee plants, which is 2.5 MMTPA. It is located at Mirzapur District. Total capacity of Jaypee Cement's Prayagraj plant is 0.60 MMTPA. Jaypee Ayodhya Grinding Operations (JAAGO) inFaizabad district has installed capacity of 1 MMTPA. Dalla Cement Factory (DCF) inSonebhadra district has total capacity of 0.5 MMTPA. Jaypee Sikandarabad CementGrinding Unit (JSCGU) in Sikandarabad district has an installed capacity of 1 MMTPA.

Presently, Kamdhenu has 1.5 MnT cement production capacity. The production capacity is expected to increase by 20% by the year-end. Kamdhenu owns one cement plant in Chandauli district.

ACC Limited's Tikaria Cement Works is located in Amethi district. This plant manufactures, exports and supplies a wide assortment produces, Fly-Ash based Portland Pozzolana Cement, Portland Slag Cement, Bulk Cement, Ready Mixed Concrete &Premium Cement. This plant's total capacity is 2.3 MMTPA.

Ambuja Cement has a plant in Dadri, which produces grey cement. Its installed capacity is 1.2 MMTPA.

Heidelberg Cement is a prominent player in the fields of cement. It has a plant in Jhansi district of UP. This plant is only 310 km far from the state capital, Lucknow. The installed capacity of this plant is 0.5 MMTPA. Heidelberg Cement has successfully completed the expansion of its clinker and cement grinding plants in Central India. The Company increased its capacity to 5.4 MMTPA through brown field expansion of its facilities in Central India in 2013. Jhansi unit's capacity has increased from 0.8 MMTPA to 2.7 MMTPA.

The Cement Division of Birla Corporation Ltd. manufactures varieties of cement like Ordinary Portland Cement (OPC), 43 & 53 grades, Portland Pozzolana Cement (PPC), Fly Ash based PPC, Low Alkali Portland Cement, Portland Slag Cement, Low Heat Cement and Sulphate Resistant Cement. Birla Cement has a plant located at Rae Bareliin Lucknow, with an installed capacity of 0.63 MMTPA.

- **Other States in Secondary Hinterland**

The below table shows existing cement plants in the three states, MP, Haryana and Rajasthan. MP houses more number of cement plants than Haryana and Rajasthan. Most of the cement plants in MP are situated in Satna. These plants would not provide any opportunity for the proposed waterway in river Yamuna.

Table 6.7 Cement Plants in Other States in the hinterland of Yamuna

Sr. No.	Cement Plant	Location	Installed Capacity (MMTPA)	State	Reasoning (No Opportunity)
17.	Shree Cement	Haryana	-	Haryana	Madhya Pradesh and Rajasthan have enough mines that avail raw materials required for production. Almost 80% of cement production is consumed by local districts of MP & Rajasthan. Kamdhenu Cement in Alwar, Rajasthan transports about 0.54 mnT cement p.a. by road to Varanasi. However, this company did not show willingness to use waterways. Shree Cement and Jaypee Cement both procure raw materials from Rewa itself and cement are mainly locally distributed, so they would not use waterways.
18.	Jaypee Rewa	Rewa	3	MP	
19.	Satna Cement Works (MP Birla Group)	Satna	2.2		
20.	Birla Gold (Maihar plant)	Satna	4.2		
21.	KJS Cement	Satna	2.25		
22.	Prism	Satna	5.6		
23.	Bhiilai Jaypee (Clinkerization)	Satna	1.2		
24.	Kamdhenu	Rajasthan	-	Rajasthan	
25.	Shree Cement	Khushkhera	-		
26.	J.K. Lakshmi, Jharli	Jhajjar	1.5	Haryana	
27.	Ultra Tech, Jhajjar	Jhajjar	1.6		

6.6.3 Automobile

Automobile industry occupies a prominent place in the economic growth of the country. In Fy 16, automobile industry contributed 7.1% to India's GDP and 49% of the nation's manufacturing GDP. Automobile sector is linked with not only economic growth, but also industrial development. Total automobile production volume grew at a CAGR of 4.43% during FY 12-17. The below table shows production share of different types of automobile in India;

Table 6.8 Production share of different types of vehicles in India

Type	%
Cars	75.90
LCV	20.00
HCV	3.70
Buses	0.40

Source: OICA, ACMA Annual Report, 2017

Passenger cars are manufactured in large number, compared to other types of four wheelers. Sale of passenger cars is highest among four wheeler vehicles. Two-wheelers are by far the most popular type of vehicle in India, with 80% share in Fy15-16. India became the largest two-wheeler market in the world, after selling 17.7million two-wheelers in 2016.

Table 6.9 Domestic Sale of Automobile in India

('000)

Category	2010	2011	2012	2013	2014	2015	2016	2017	2018
Passenger Vehicle	1,951	2,502	2,630	2,665	2,504	2,601	2,789	3,048	3,288
Commercial Vehicle	533	685	809	793	633	615	686	714	856
Three Wheeler	440	526	513	538	480	532	538	512	636
Total	2,924	3,712	3,953	3,997	3,616	3,748	4,013	4,274	4,780

Source: SIAM

Export in automobile has witnessed growth over last few years. Two wheelers dominate the export from India, followed by export of passenger cars.

Table 6.10 Export of Automobile from India

('000)

Category	2010	2011	2012	2013	2014	2015	2016	2017	2018
Passenger Vehicle	446	444	509	559	596	622	653	759	747
Commercial Vehicle	45	74	92	80	77	86	103	108	97
Three Wheeler	173	270	362	303	353	408	404	272	381
Total	664	788	963	943	1,027	1,116	1,161	1,139	1,225

Source: SIAM

Table 6.11 Domestic Sale & Export of Two Wheelers in India

('000)

	2010	2011	2012	2013	2014	2015	2016	2017	2018
Domestic Sale	9,371	11,769	13,409	13,797	14,807	16,005	16,456	17,590	20,193
Export	1,140	1,532	1,975	1,956	2,084	2,458	2,483	2,340	2,815
Total	10,511	13,301	15,384	15,754	16,891	18,462	18,939	19,930	23,008

Source: SIAM

There are three automobile clusters in India, NCR-Delhi Cluster in North, Mumbai-Pune Cluster in West and Bangalore- Chennai Cluster in South. NCR- Delhi Cluster includes Delhi, Gurgaon, Faridabad, Ghaziabad and Gautama Buddha Nagar. Mumbai-Pune cluster in West includes Mumbai, Pune, Nasik, Aurangabad and Thane. Bangalore- Chennai Cluster in South includes Chennai, Bangalore, Dharampuri, Vellore, Kanchipuram and Thiruvallore. Apart from these three prominent clusters, there are several manufacturing units in many other parts of India, but these three clusters are the main hubs for manufacturing in the automobile industry.

Among three clusters, as shown in the above map, only NCR Cluster is studied. Only this auto cluster falls in the catchment of river Yamuna. Other clusters are far from the proposed waterway in NW 110; hence would not provide any opportunity.

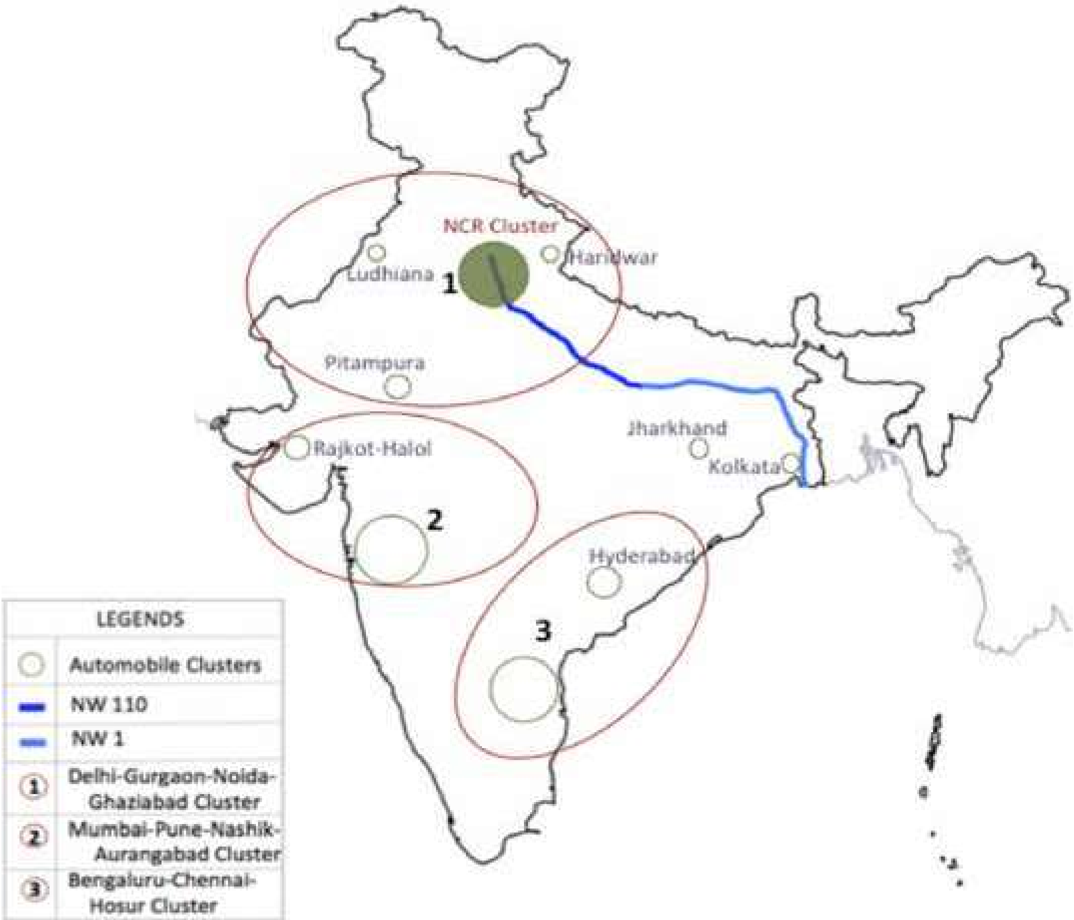


Fig. 6.8 Automobile Clusters in India

The below graph depicts vehicles registered in the hinterland of NW 110. The graph shows number of vehicles registered in those districts of UP, Delhi, Haryana & Rajasthan, which fall within the catchment area.

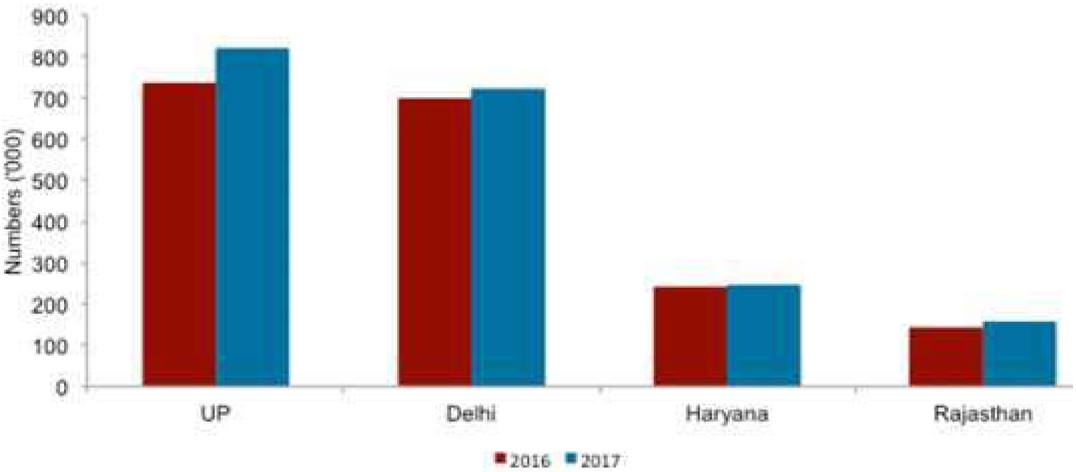


Fig. 6.9 Registered Vehicles in hinterland of NW 110

Source: Ministry of Road Transport and Highway, Pariwahan Sewa, GOI

- **NCR Auto Cluster**

NCR Cluster is located in the northern part of India and is spread across three states, Delhi, Haryana and Uttar Pradesh. In this cluster, cities like Delhi, Gurgaon, Faridabad, Ghaziabad and Gautama Buddha Nagar are prominent. All these cities fall in the hinterland of NW 110 in Yamuna.

NCR Cluster hosts production facilities of Maruti Suzuki, Honda, Hero Moto Corp, Yamaha and other established players in the automobile industry. The region also houses R&D and testing facilities at Rohtak and Manesar. Major factors for growth of the automobile sector in the NCR region are access to large domestic market, government's support and availability of land. Delhi and Haryana have an excellent road network, which facilitates faster transportation of goods from the point of production to the point of consumption.

Five states come under the hinterland of river Yamuna, Delhi, Uttar Pradesh, Haryana, Madhya Pradesh and small parts of Rajasthan. This section would undertake a detailed analysis of automobile plants in these states and evaluate the opportunity to shift automobile to the proposed waterway in river Yamuna. Suitable infrastructure could be proposed on river Yamuna to make it commercially attractive for automobile companies to shift transportation of their products from road or rail to waterways.

Automobile industry also includes auto components. NCR Cluster is a hub of auto component manufacturing plants, but this section would not study auto components. Auto components would be transported in containers. It would be included with other containerized commodities and could be moved through waterways. The table below depicts car sales data in the states that come under the hinterland of river Yamuna. UP dominates the sale of cars, followed by Delhi.

Table 6.12 State wise car sales data in the hinterland of NW 110

State/Union Territory	Fy 16(Nos.)	Fy 17(Nos.)
States in the hinterland of NW 110		
Uttar Pradesh	2,11,066	2,42,327
Delhi	1,83,541	2,00,797
Haryana	1,54,493	1,68,531
MP	n/a	98,590
Rajasthan	1,30,061	1,45,392
Total	6,79,161	8,55,637
States in the hinterland of NW 1		
Bihar	n/a	51,214
Jharkhand	n/a	45,888
West Bengal	n/a	95,878
Total	n/a	1,92,980

Source: Auto Punditz

The table below shows vehicles registered in the states that fall in the hinterland of NW 110 and NW 1. UP, Delhi and Haryana come under hinterland of NW 110, whereas Bihar, Jharkhand and West Bengal fall in the hinterland of NW 1. Bihar, Jharkhand and West Bengal are considered because automobiles are distributed in these states. Also, for transportation to Port for export, automobile could be shifted to NW 110 and then further to NW 1 to reach Haldia Port. The table shows statistics till Fy 15 due to unavailability of latest data.

Table 6.13 Motor Vehicles Registered(Nos.)

State/ Union Territory	Fy 06	Fy 07	Fy 08	Fy 09	Fy 10	Fy 11	Fy 12	Fy 13	Fy 14	Fy 15
States in the hinterland of NW 110										
U P	7,989	9,086	9,826	10,779	11,988	13,287	15,445	17,048	19,115	21,636
Delhi	4,487	5,492	5,899	6,302	6,747	7,228	7,350	7,785	8,293	8,851
Haryana	3,087	3,528	3,973	4,425	4,792	5,377	5,978	6,600	7,239	7,928
MP	4,609	5,047	5,523	6,011	6,591	7,356	8,144	8,760	9,722	11,141
Rajasthan	4,754	5,336	5,902	6,490	7,166	7,986	8,985	10,072	11,133	12,379
Total	24,926	28,489	31,123	34,007	37,284	41,234	45,902	50,625	55,502	61,935
States in the hinterland of NW 1										
Bihar	1,432	1,577	1,739	1,960	2,357	2,673	3,113	3,617	4,163	4,778
Jharkhand	1,505	1,686	1,850	2,038	2,767	3,113	3,158	3,417	1,719	2,066
West Bengal	2,872	3,198	2,762	3,044	2,747	3,261	3,861	6,111	6,745	7,403
Total	**5,809**	**6,461**	**6,351**	**7,042**	**7,871**	**9,047**	**10,132**	**13,145**	**12,627**	**14,247**

Source: Ministry of Statistics & Programme Implementation

The tables below show automobile companies, including four wheeler and two-wheeler manufacturers, which are located in the hinterland of river Yamuna. In Delhi, there is no automobile company, which manufactures vehicles. All the companies in Delhi manufacture auto components; hence these companies are not included in the table below.

Table 6.14 Four Wheeler Manufacturing Companies in the hinterland of NW 110

Company Name	Plant Location	Plant Area (Acres)	Production Capacity (lakh p.a.)	Distance from River Yamuna (Km)
Uttar Pradesh				
Honda	GBN	150	1.2	7
Tata Motors	Lucknow	600	2.3	166
New Holland Agriculture	Greater Noida	-	0.6	15
Haryana				
Maruti Suzuki	Gurgaon	-	7	33
Maruti Suzuki	Manesar	-	8	53
JCB	Faridabad	-	-	20
SAS Motors	Faridabad	-	-	55
Rajasthan				
Honda	Alwar	450	1.8	83
Ashok Leyland	Alwar	-	-	110
Madhya Pradesh				
Volvo Eicher	Dhar	-	0.5	691
Force Motors	Dhar	-	-	687

Table 6.15 Two wheeler Manufacturing Companies in the hinterland of NW 110

Company Name	Plant Location	Plant Area (Acres)	Production Capacity (lakh p.a.)	Distance from River Yamuna (Km)
Uttar Pradesh				
Yamaha	Surajpur	-	-	15
Scooters India	Lucknow	-	-	146
Haryana				
Honda	Manesar	52	16.5	53
Hero MotoCorp	Rewari	-	21	83
Hero MotoCorp	Gurgaon	-	21	39
Yamaha	Faridabad	-	-	22
Suzuki Motorcycle	Gurgaon	37	5.4	47
Harley-Davidson	Bawal		-	111
Rajasthan				
Honda	Alwar	450	16.4	83
Hero MotoCorp	Alwar	-	11	137

- **Uttar Pradesh**

Some major cities of Uttar Pradesh, like Greater Noida, Surajpur, Ghaziabad etc. are parts of NCR Cluster of automobile. The plants located in these cities are mostly manufacturers of auto components. These companies serve the automobile assembly units of major players like Maruti Udyog, Tata Motors etc., which are located in NCR Cluster.The demand for medium and heavy commercial vehicles (MHCVs) is growing rapidly in UP. According to data of SIAM (Society of Indian Automobile Manufacturers), UP recorded 54% and 88% growth in MHCVs in the second and third quarter of Fy 18, respectively. Some factors of growing demand of MHCVs are higher road construction, stricter rules against overloading and the replacement of vehicles. Tata Motors and Ashok Leyland are major players inMHCV segment in UP. The auto industries in UP have also benefited from the 165 km long newly constructed Yamuna Expressway Industrial Development Authority (YEIDA), which ensures planned development of areas along the route. The below chart shows vehicles registered in UP in 2017. The chart shows registered vehicles of those districts of UP, which fall in the hinterland of river Yamuna. It is evident thatPrayagraj and Kanpur Nagar have high number of registered vehicles.

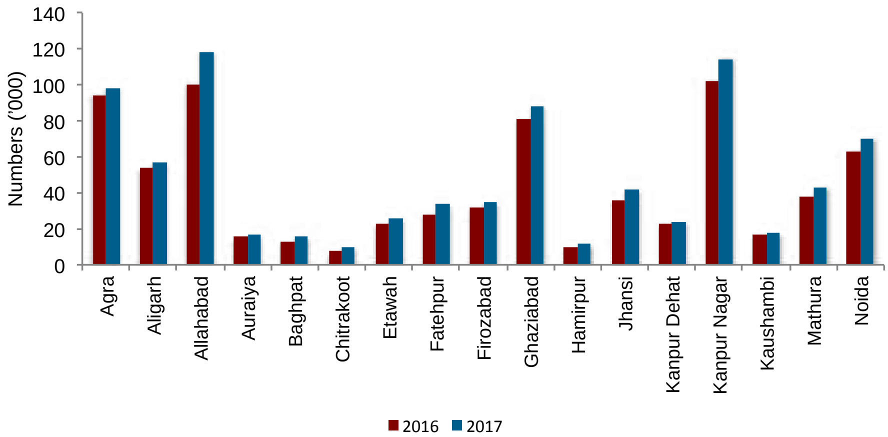


Fig. 6.10 Registered Vehicles in UP

Source: Ministry of Road Transport and Highway, Pariwahan Sewa, GOI

Plants of some major players are located in UP, which are discussed below.

- Honda Cars

This plant was established in 1997. This manufacturing facility is spread over 150 acres of land. Honda City, Civic, Accord and Jazz are some of the car models that are manufactured at this plant.

- TATA Motors

TATA established its plant in Lucknow in 1992. They design and manufacture a range of modern buses, which includes low floor, ultra-low floor, high deck & CNG buses. They also have an engineering research center in Lucknow. Apart from manufacturing, assembly work also takes place at this location. The facility is spread over600 acres of land in the Chinhut Industrial Area. The plant manufactures 640vehicles per day.

- New Holland Agriculture

NewHolland Agriculture began its operations in 1998 in India and it manufacturing plant is located in Greater Noida in UP. The plant has annual production capacity of 60,000 tractors. It is one of the most advanced tractor plant in India. It offers superior range of 35 HP to 90 HP tractors in India.

- India Yamaha Motor

IYM's (India Yamaha Motor Pvt. Ltd.) manufacturing facilities comprise of 3 State-of-the-art plants at Surajpur (Greater Noida, UP), Faridabad (Haryana) and Kanchipuram (Tamil Nadu). Among these, two plants, Surajpur (Greater Noida) and Faridabad fall in the hinterland of NW 110. The infrastructure at these plants supports production of two-wheelers and parts for the domestic and overseas markets.

- Scooters India

Scooter India plant is located at south-west of Lucknow. The company designs, develops, manufactures and markets a broad spectrum of conventional and non-conventional fuel driven 3-wheelers. Earlier the company used to manufacture two-wheelers, but since 1997, the company discontinued manufacturing two-wheelers and concentrated on three wheelers.

- **Delhi**

There is no automobile plant in Delhi. Delhi is a major consumption center for automobiles. The below chart shows vehicle registered in Delhi in 2017. The chart shows only those places of Delhi, which come under the hinterland of river Yamuna.

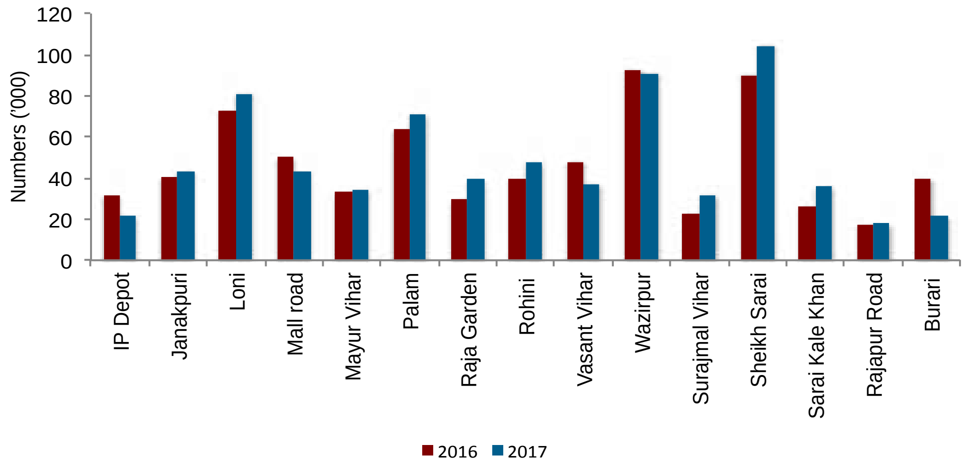


Fig. 6.11 Registered Vehicles in Delhi

Source: Ministry of Road Transport and Highway, Pariwahan Sewa, GOI

- **Other States in Secondary Hinterland**

Three states, Haryana, MP and Rajasthan come in the secondary hinterland of river Yamuna. Among these three states, Haryana plays a prominent role in Automobile because it covers a wide part of NCR Auto Cluster.

Haryana

The automobile industry is probably the biggest industry in Haryana, which ranks first in India in the production of passenger cars, motorcycles and tractors. The Gurgaon-Manesar-Bawal belt is a key auto component hub. NCR cluster follows the traditional pattern of auto clusters led by assemblers that serve as lead firms.
Haryana accounts for 50 percent of total small passenger cars and two-wheelers production in India. Market leader Maruti Suzuki is based in Gurgaon and Manesar in Haryana. Maruti's vital role in developing the components industry contributedto the gradual development of NCR cluster. The largest two-wheeler manufacturer in India, Hero Honda along with the other large two wheeler manufacturers,Yamahaand Escorts are also present in the state.The below table shows vehicles registered in some of the districts of Haryana, which fall in the hinterland of NW110.

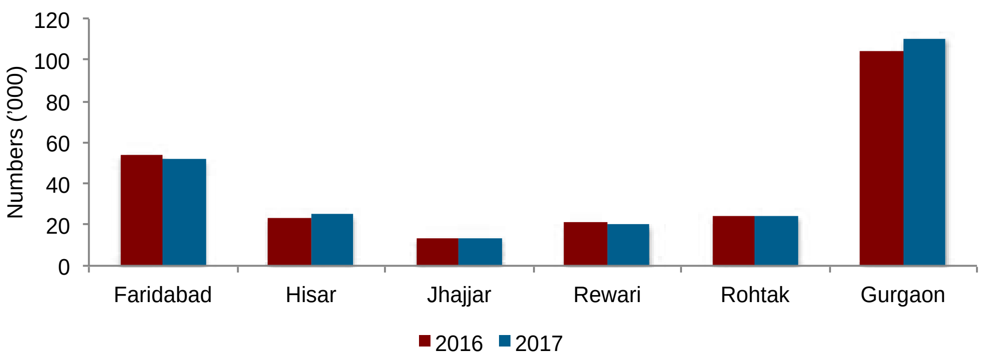


Fig. 6.12 Registered Vehicles in Haryana

Source: Ministry of Road Transport and Highway, Pariwahan Sewa, GOI

The major automobile players located in Haryana are discussed below.

- Maruti Suzuki

Maruti Suzuki is the lead automobile firm in NCR Cluster. Maruti Udyog Ltd. (MUL) started in 1982 as a joint venture firm between the Indian government and a Japanese automaker, Suzuki Motor Corporation. MUL set up its first plant in Gurgaon, as a 'greenfield' plant. It was the first modern assembly plant in India. Maruti's Gurgaon facility has three fully integrated manufacturing plants and is spread over 300 acres. It has production capacity of 7 lakhs units per annum. Manesar plant is spread over 600 acres and has a capacity of 8 lakh units a year. NCR auto cluster's development has been mainly driven by MUL. The NCR Cluster emerged rapidly as MUL grew, mainly through MUL's development of local suppliers.

- JCB

JCB India Limited is a leading manufacturer of earthmoving and construction equipment in India. JCB introduced Backhoe Loaders in India 35 years ago and has since expanded its product range to over 45 models in eight product categories. Apart from Backhoe Loaders, the company also manufactures Skid Steer Loaders, Telehandlers, Diesel Engines and Diesel Generators.

- Honda Motors

Honda is the world's largest manufacturer of two wheelers. Its plant in Manesar, Gurgaon was established in 1999. This plant is spread over 52 acres, including a covered area of about 100,000 sq. meters in Manesar. Its annual capacity is 1.65 million units.

- Hero MotoCorp

It is one of the leading two-wheeler manufacturers in the world. It has two manufacturing units in Haryana. One plant is located in Dharuhera town of Rewari district and the other is in Gurgaon.

- Yamaha

Yamaha's Haryana plant is located in Faridabad. The plant manufactures motorcycles, scooters and its parts for the domestic as well as overseas market. There is in-house facility for Machining, Welding processes as well as finishing processes of Electroplating and Painting till the assembly line.

- Suzuki Motorcycle

Suzuki Motorcycle's plant is located in Gurgaon. It has an annual capacity of 5,40,000 units per annum. The Gurgaon facility's total land area is 37 acres, out of which the present plant is constructed in an area of 10 acres of land. The remaining area is left for land development and future expansion.

- Harley Davidson

Harley Davidson has set up an assembly unit at Bawal, Haryana in 2011. This is the only assembly unit of the company in India.

Madhya Pradesh

- Eicher Motors

Eicher Motors manufactures commercial vehicles in the plant located in Pithampur of Dhar district in MP. The plant has an annual production capacity of 48,000 units. The state-of-the-art plant has access to top line manufacturing processes, including cab weld shop with robotic welding, CED paint shop, integrated testing facilities, 100% hot test facility for engines and a lean and scalable manufacturing set up.

- Force Motors

The Company is engaged in manufacturing light commercial vehicles and utility vehicles, and engines. Its product range includes Small Commercial Vehicles, Multi- Utility Vehicles (MUV), Light Commercial Vehicles (LCV), Sports Utility Vehicles (SUV) and Agricultural Tractors. Its personal vehicles include Force Gurkha and Force One. Its Commercial vehicles include Passenger Carrier, such as Trax GAMA,Trax Cruiser, Trax Toofan and Trax Cruiser, and Goods Carrier, such as Trump 40, Trump 40 Hi-Deck, Trax Delivery Van, Traveller Delivery Van and Trax Kargo-King.Its Agricultural Vehicles include Balwan and Orchard.

Rajasthan

- Honda

Honda's plant in Alwar, Rajasthan was set up in 2008. The plant is spread over an area of 450 acres. This plant produces Jazz, Amaze, City, BR-V and WR-V models.

- Ashok Leyland

It is the second largest manufacturer of commercial vehicles in India. The Alwar plant is established in 1982. It is an assembly plant for a wide range of vehicles with an emphasis on passenger chassis, including CNG buses. A globally benchmarked bus body building facility has also been set up on the premises.

- Hero Moto Corp

Hero Moto Corp's state-of-the-art factory is located in Neemrana of Alwar district in Rajasthan. It manufactures two-wheelers.

- **Opportunity to NW 110 from Automobile plants in the hinterland**

There are many major and non- major automobile plants in NCR Cluster and other states in the hinterland. This section discussed in detail the automobile plants in the states, which come under the hinterland of the proposed waterway NW 110. At present, vehicles manufactured in these plants are distributed in other parts of the country through roadway and railway. These automobile plants also export to other countries, using nearby ports. Mostly MbPT and Mundra Port are used for export.

After development of NW 110, automobile could be transported using the combination of NW 110 and NW 1. NW 1 is connected to Haldia Port; hence the automobile goods could be transported to Haldia Port for export through waterways. Automobile could be shifted to waterway for local distribution also. Automobile could be transported to the distribution centres or dealers, which are located on the bank of river Yamuna (NW 110) and river Ganga (NW 1).

Maruti Suzuki has already shown its willingness earlier to transport vehicles via inland waterways. With collaboration with IWAI, as a pilot project, Maruti had moved cars in barges along river Ganga from Varanasi to Haldia Port. By using waterway, Maruti intends to save logistics cost. After the development of waterways in river Yamuna, other automobile companies would also show interest to use waterway for vehicle transportation.

The coming years would witness growth in automobile consumption. Automobile industry is benefitted with consumption pattern of consumers. Rise in per capita GDP will lead to higher vehicle ownership in coming years. This will lead to high demand of automobile. Automobile plants could shift their vehicles, destined for different cities in the hinterland, to waterways.

Distribution centers of automobile in states, like UP, Delhi, Haryana, MP and Rajasthan could be connected through waterways. Shifting automobile transportation from railway and roadways to waterways would ease the congestion on the present mode of transportation. It would reduce logistics costs and would provide a smooth transportation. Other advantage of using waterway is cars and bikes could be moved in much larger volumes through waterways as compared to roadways. The capacity of a river vessel (car carrier) would be more than a typical road trailer. Hence, vessels on waterway could carry larger number of cars and bikes, as compared to roadways.

6.6.4 Iron & Steel

The existing iron & steel plants in India can be categorized in three groups; integrated iron & steel plants, located in Bhilai, Bokaro, Jamshedpur, Rourkela, Vishakhapatnam, Durgapur and Burnpur, Alloy Steel & Special steel plants located inBhadravati, Salem and Durgapur and Small steel plants. The main producers of iron & steel in India are SAIL, TISCO & RINL. The other major producers are ESSAR, ISPAT,Jindal Steel & Power Ltd. and JVSL. Other iron & steel plants in the country are mini plants. There are no main and other major plants in the catchment area of river Yamuna, except Jindal’s Hisar plant. The existing steel plants in the hinterland are mini plants. This section undertakes a detailed analysis of iron &steel plants located in the hinterland of NW 110 and evaluates shifting their cargo to waterways.Themap below depicts iron & steel plants located in the hinterland of river Yamuna and connectivity around these plants. The map also shows integrated steel plants in the region.

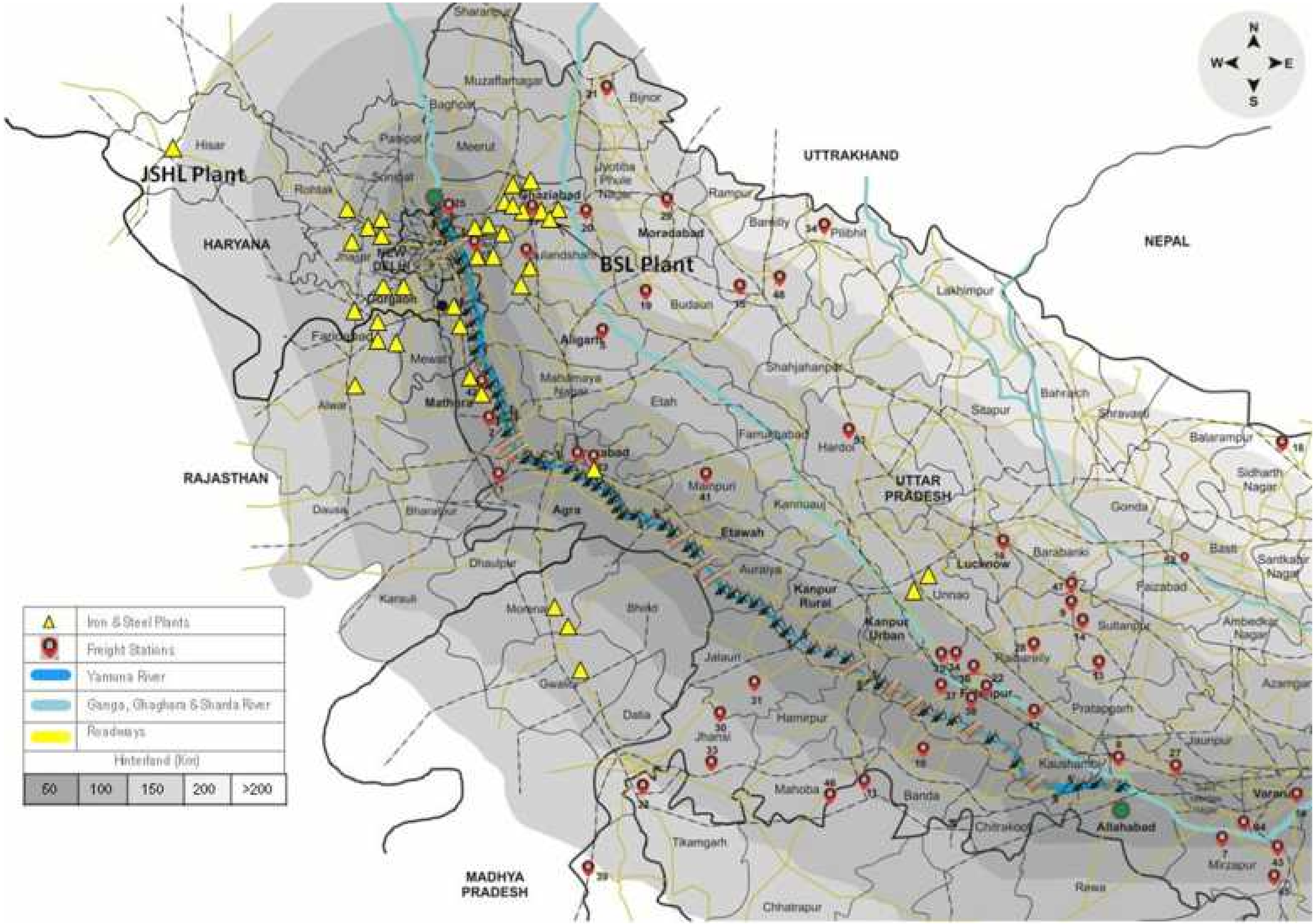


Fig. 6.13 Iron & Steel Plants in the hinterland

Uttar Pradesh

There exist mini plants of iron & steel in Uttar Pradesh. Majority of the plants are located in Ghaziabad, which holds an important place in industrial development of the state. The plants in Ghaziabad export their products to other countries. The table below depicts the major iron & steel companies located in Uttar Pradesh. Apart from these listed industries, there are some other plants in UP, which are not included for the study as they are located far from the hinterland.

Table 6.16 Availability of Minerals in the Hinterland of river Yamuna

Sr. No.	Company Name	Plant Location (District)	Production Capacity (MMTPA)	Distance from Yamuna (Km)
1.	Arya Iron & Steel Industries	Ghaziabad	N/A	15
2.	Bansal Wire Industries		0.14	18
3.	Mahadev Industries		N/A	3.3
4.	MS Steel (Gopal Group of Industries)		0.12	9
5.	Rama Steel Tubes		0.06	15
6.	Bhushan Steel & Strips		0.6	10
7.	Kathuria Rollmill Pvt. Ltd.		N/A	26
8.	Alka Forgings		N/A	24
9.	Ambica Steels (3 Units)		0.08	12
10.	K L Steels		0.12	26
11.	RP Alloys & Steel Forgings Pvt. Ltd.		N/A	25
12.	Shree Rathi Steel Ltd.		0.12	25
13.	CHW Forge (Unit 1)		0.04	25
14.	CHW Forge (Unit 2)	GBN		25.5
15.	Limieria Steel Industries Pvt. Ltd.		N/A	12
16.	AKG Steel Industries (2 Units)		N/A	11
17.	Kaizen Metal Forming (2 Units)		N/A	10
18.	Goodluck Group	GBN (1 unit)	0.2	29
19.		Bulandshahr(4 units)		34
20.	Mahavir Concast Ltd.	Bulandshahr	N/A	35
21.	Global Smelters	Unnao	0.5	108
22.	Rimjhim Ispat		N/A	80
23.	Ratan Industries	Agra	0.01	0.13
24.	Swastik Pipe Ltd.	Mathura	0.1	25
25.	Jindal Saw Ltd.		0.25	22

- Arya Iron & Steel Industries

This company manufactures forged components, casted components, tire moulds, tubular sewage poles etc. The company is equipped with state of art machining facilities.

- Bansal Wire Industries

Bansal Wire manufactures and exports different types of wires, strips and rods. It produces stainless steel wires & bars, stainless steel wire mesh, high & low carbon steel wires profile/shaped wires, cable armouring wires & strips and galvanized wires. The plant manufactures 10,000 tonnes of high & low carbon steel wires and 1,800 tonnes of stainless steel wires per month.

- Mahadev Industries

Mahadev Industries is located at Tronica City, Loni in Ghaziabad. It manufactures various types of tested steel wire ropes, strands & wire rope slings. The company exports its products to East Asia and South East Asian countries.

- MS Steel (Gopal Group of Industries)

Among steel plants of Gopal Group of Industries, MS Steel is located in the hinterland of river Yamuna. It is located in UPSIDC Industrial Area, Ghaziabad. The plant manufactures a wide range of products, like stainless steel bars, Forging Quality Ingots and Concast Billets etc. The company exports its products to many countries.

- Rama Steel Tubes

The company has a plant in Sahibabad in UP. Its range of products include ERW galvanized, black and scaffolding pipes and tubes, pre grooved pipes, swaged poles, Telecommunication transmission tower & station structure, hollow sections and different types of sheets. The company exports to countries, like UK, UAE, Sri Lanka, Ethiopia, Kenya, Uganda, Ghana, Kuwait, Republic of Congo, Yemen, Guyana, Germany, USA, South Africa, Zambia and Malta etc.

- Bhushan Steel & Strips

Bhushan Steel Ltd (BSL) is one of the prominent players in the Steel industry. Tata Steel Ltd. has acquired BSL in 2018. Its Ghaziabad plant is located in Sahibabad Industrial Area. It produces sheets for the automotive industry. Product range includes cold rolled steel coils, cold rolled steel sheets, colour coated coil, colour coated tiles, galvanized coils etc.

- Ambica Steels

There are three units of Ambica Steels in UP. Unit 1, which is Melting, Refining and Casting Division, is located in UPSIDC Industrial Area, Sahibabad. Unit 2 is located in Loni Industrial Area and has two divisions, Hot Rolling & Heat Treatment Division and Cold Finishing Division. These plants are fully integrated and equipped with all stainless steel manufacturing facilities. Ambica steel produces various types of steel bars, continuous cast billets and stainless steel ingots for various industrial applications. The company exports its products to Germany and Netherlands.

- Kathuria Rollmill Pvt. Ltd.

The company is located in Ghaziabad. It exports to countries like Bangladesh, Nepal, Afghanistan, Sri Lanka, UAE, Indonesia, Kenya, Zambia, Yemen, Ethiopia, Nigeria etc.

- Alka Forgings

Alka Forgings is one of the heaviest steel forging divisions in North India. They produce varieties of products, including hollow tubes, Hydro Turbine Shafts, Rectangular Blocks, Gears and steel shafts and Gear and Gear Rings. The company exports to countries like Australia, Germany, South Africa, and USA.

- K L Steels

The plant manufactures products, like channels and girders. The company also offers customized products of steel and alloy as per the requirement of the client.

- RP Alloys and Steel Forgings Pvt Ltd.

It produces Gears, Girth gears, Mill Heads, Reunions, Pinions, Pinions Shafts Assembly, Mill Cheeks and Turbine Casting.

- Shree Rathi Steel Ltd.

Shree Rathi's Ghaziabad plant is located in UPSIDC Industrial Area. The plant has a state of the art steel re-rolling mill with an installed capacity of 1,20,000 TPA. Shree Rathi also has another plant located in Bhiwadi, Alwar. This plant's installed capacity is also 1,20,000 TPA.

- CHW Forge

CHW Forge has two units in UP. Unit 1 is located in Maliwara, Ghaziabad and Unit 2 is located in Greater Noida (Phase II) in Gautam Budh Nagar district. CHW Forge manufactures a wide range of steel forging products, which are used in diverse industries. It exports its products to countries, like Oman, Saudi Arabia, Kuwait, Abu Dhabi, UAE, South Africa, Ukraine, Italy etc.

- Limieria Steel Industries Pvt. Ltd.

Limieria steel was set up in the Industrial Zone of Greater Noida. It manufactures metal boxes, metal cabinets and metal enclosures for many industries. The plant also manufactures and exports Railway Sheet Metal Component. It also makes switchgear components and electrical panels at large. They manufacture automotive parts and equipment for earth moving industry.

- AKG Steel Industries

AKG Steel has two plants in Noida. Unit I is located in Phase 3 and Unit II in Phase 2 of Noida. The company manufactures steel conduits pipes, cable trays, Meta conduit fittings, raceways etc. The company caters various industries, like Gas Companies, Oil field, Malls, Petrochemicals, Power Plants and Metro Railway etc.

- Kaizen Metal Forming

It manufactures Sheet Metal Stamping Parts, Tubular Parts, Welded sub-assemblies, Skin Panels for Automobiles, Farm equipment and various machines. The plant also designs, manufactures and supplies Steel Boxes and Cases.

- Goodluck Group

Goodluck Group's plant is at Sikandarabad industrial area in UP. The plant manufactures a wide range of galvanized sheets & coils, towers, hollow sections, CR coils CRCA and pipes & tubes. It also specializes in Telecommunication Structures, ERW Steel Tubes, ERW Steel Pipes, and Galvanized Black Steel Tubes. It exports products to UK, Singapore, South Africa, Oman, UAE, Australia, New Zealand, East and West Africa, Latin America, Trinidad, Ghana, Haiti, Madagascar, North America, Africa, Germany, France, Sweden, Belgium, Bolivia, Chile, Brazil, Ethiopia and Sri Lanka.

- Mahavir Concast Ltd.

The plant is located in Sikandrabad Industrial area of Bulandshahr district. It manufactures castings, ingots and forging ingots in various Indian and International grades.

- Global Smelters

The plant is located in USIDC Industrial Area of Unnao in UP. Global Smelters manufactures power transmission towers, sub-station structure, solar panel structures, telecommunication towers, monopole towers and FM/ TV towers.

- Rimjhim Ispat Ltd.

The plant is located in Industrial area of Akrampur in Unnao. It produces a wide range of steel sheets and tubular products, which are used in various industries including construction, automotive, container, appliance, industrial machinery, and oil & gas industries etc. The products include wire rods, bright bar, wires & fine wires, billet, HR Coils, CR coils, structures and TMT bars. The company exports its products to many companies across the globe, like UK, Germany, Italy, Korea, Malaysia, Thailand, Taiwan, Turkey, UAE, Vietnam, Egypt, Brazil and South Africa.

- Ratan Industries

Ratan Industries is situated in Agra. The plant manufactures machined parts, tractor parts, commercial vehicle and trailer parts, automotive parts, agricultural implement parts etc. with cast iron, SG iron, cast steel and alloys cast iron and cast steel. This plant supplies castings to a wide variety of industries, such as automobile, tractors, generators etc.

- Swastik Pipe Ltd.

Swastik Pipe Ltd. has two plants; one is in Kosi Kalan in Mathura district and another in Bahadurgarh, Jhajjar, and Haryana. Mathura plant's capacity is 0.1 MMTPA and Jhajjar plant's capacity is 0.22 MMTPA. It is one of the leading manufactures and exporter of high quality mild steel/carbon steel, ERW Black and Galvanized pipes & tubes. The plant export to countries, like USA, UK, UAE, Australia, Qatar, Oman, Ethiopia, Mauritius, Sri Lanka, Cyprus, Germany, Belgium, Kuwait etc.

- Jindal Saw Ltd.

Jindal Saw's plant is located in Kosi Kalan, Mathura. Its installed capacity is 0.25 MMTPA. Jindal Saw is manufacturer and supplier of Iron & Steel pipe products, SAW Pipes (Submerged Arc Welded Pipes) and spiral pipes. The company exports its products to different countries, especially Gulf countries.

Delhi

There is no iron & steel industries in Delhi. There are few component manufacturers, but their production volume is less and hence they would not provide any opportunity to the proposed waterway in river Yamuna. However, there are many companies in Delhi, which consume iron & steel. Inland waterway could be used for distribution of iron & steel to these companies.

Other States in Secondary Hinterland

Haryana and some parts of Madhya Pradesh and Rajasthan come in the secondary hinterland of river Yamuna. The below table shows iron & steel companies located in these three states, in the hinterland. Number of iron & steel plants in Haryana is more than MP and Rajasthan.

Table 6.17 Iron & Steel Companies in Haryana, MP & Rajasthan in the hinterland

Sr. No.	Company Name	Plant Location (District)	Production Capacity (MMTPA)	Distance from Yamuna (Km)
Haryana				
1.	Jindal Stainless Hisar Ltd. (JSHL)	Hisar	0.8	180
2.	Surya Roshni Ltd.	Jhajjar	0.34	37
3.	Allied Strips Ltd.		0.3	44
4.	Garg Inox		N/A	45
5.	Swastik Pipe Ltd.		0.22	39
6.	Ilasakaa Steel Ltd.		0.07	55
7.	Dee Piping Systems	Palwal	0.03	19
8.	Maruichi Kuma Steel Tube Pvt. Ltd.	Gurgaon	0.02	75
9.	Lakshmi Precision Screws Ltd.	Gurgaon	0.02	85
		Rohtak (3 Units)		38
10.	SKH Metals	Gurgaon (2 Units)	N/A	40
11.	Magnum MI Steel Pvt. Ltd.	Rewari	0.03	105
12.	GMT Industries Ltd.	Faridabad	N/A	18
Madhya Pradesh				
13.	Surya Roshni Ltd.	Gwalior	0.15	87
14.	Magnum Steels Ltd.		0.1	131
15.	Primegold-SAIL JVC Ltd.		0.1	132
Rajasthan				
16.	Abram Udyog Pvt. Ltd.	Alwar	N/A	112
17.	Kamdhenu Group		0.09	76
18.	Rathi Bars Ltd.		0.09	84
19.	Shree Rathi Steel Ltd.		0.12	85
20.	Uttam Strips Ltd.		0.23	76

Haryana

Iron & Steel plants in Haryana are located in Gurgaon, Jhajjar, Palwal, Faridabad, Rohtak and Hisar. Among all the plants located in Haryana, Jindal Stainless (Hisar) Ltd. is the biggest plant. The major steel plants located in Haryana are discussed below.

- Jindal Stainless (Hisar) Ltd.

This integrated stainless steel plant was established in 1975 at Hisar, Haryana as India's first stainless steel manufacturing unit. The plant has a capacity of 0.8 MMTPA. The plant is a major producer of Stainless Steel strips for razor blades and coin blanks for Indian and International mints. The product range includes Slabs & Blooms, Hot Rolled Coils, Strips, Plates, Coin Blanks, Precision Strips and Cold Rolled Coils.

- Surya Roshni Ltd.

Surya Roshni's Haryana plant is located at Bahadurgarh in Jhajjar district. The plant has a capacity of producing 2,25,000 MT of ERW pipes and 1,15,000 of CR sheets per annum. The plant manufactures steel pipe products for agriculture, infrastructure, oil & gas and construction sectors. Surya pipes are made from high quality tested HR coils from reputed steel producers like SAIL, ESSAR, JSW, TATA and Bhushan. The pipe plant is equipped with state-of-the-art machines, slitting lines, pipe mills, galvanizing units, finishing machines and failsafe, high pressure hydro testing machines. The plant also has sufficient handling facilities.

- Allied Strips Ltd.

It is one of the major producers of cold rolled steel products in North India. The plant is located at Bahadurgarh in Jhajjar. It has an installed capacity of 0.3 MMTPA. Steel produced by Allied Strips Ltd. is used in automobile, containers, precision tubes and electrical sectors. Clients of Allied strips include Maruti Suzuki, Tata, Ashok Leyland, Whirlpool, Samsung, etc.

- Garg Inox

Garg Inox manufactures and exports stainless steel & galvanized steel wires. Garg Inox has a production capacity of 0.06 MTPA from four production units in the country, out of which one plant is located at Bahadurgarh in Jhajjar. It manufactures stainless steel wires and bars, welding consumables etc. Their products are being exported to over 50 countries across the globe.

- Ilasakaa Steel Limited

The plant was established in 2008 at Bahadurgarh, Jhajjar, Haryana. It produces cold rolled steel products, tubes and pipes. It has production capacity of 0.07 MMTPA.

- Dee Piping Systems

It has two fabrication facilities in Palwal district of Haryana, with an installed capacity of more than 0.3 MMTPA. Their product range includes Shop Fabricated

Pipe Spools, Pipe Fittings, Induction Pipe Bends, etc. It provides end-to-end piping solutions for Power, Hydrocarbons, Marines/Offshore, Chemical, Fertilizers and other industries.

- Maruichi Kuma Steel Tube Pvt. Ltd.

It is a Japanese joint venture between M/s Maruichi Steel Tube Ltd., Japan and M/s Toyota Tsusho Corp Japan. The company's production unit is based in the automobile cluster of Manesar, Gurgaon. The plant manufactures stainless steel tubes and caters to the growing demands of the automobile industry in India. The plant has capacity of producing 24,000 metric tons of high frequency induction welded steel tubing annually. The pant imports coils from mills in Japan & Korea.

- Lakshmi Precision Screws Ltd.

The company has four plants in Haryana, 3 plants located in Rohtak and 1 plant in Manesar, Gurgaon. Total production capacity of all plants is 25,000 MT per annum. The company caters various sectors such as Wind Energy, Oil & Gas, Locomotives, Automobiles, Agriculture Equipment (Tractors), Machine Building etc. Manesar plant caters to automobile companies, like Hero Honda, Honda Motors Scooters India, Maruti Suzuki etc. The Company is one of the largest exporters of fasteners in India. Its products are exported to countries, like USA, Australia, Canada, Denmark, Dubai, France, Germany, Hong-Kong, Indonesia, Japan, Malaysia, Singapore, South Africa, Switzerland, Sweden etc.

- SKH Metals

SKH Metals is a Joint Venture between SKH and Maruti Suzuki India Ltd. SKH Metals currently has two facilities for Maruti Suzuki India Ltd., both are located on MSIL supplier Parks in Gurgaon and Manesar. It supplies critical components, such as Frame Front Suspensions, Arm Suspension, Metal Fuel Tanks, Axle Housings, Stamped and Welded Assemblies. Another venture of SKH is SKH Sheet Metals Components Pvt. Ltd (SKH SMC), which has three manufacturing facilities in India, out of which one unit is in Binola, Gurgaon. SKH SMC Binola manufactures Seat Structures, stamped and welded sheet metal components and stack pipes for automotive, off road and power generation sectors. SKH SMC exports exhaust parts to JCB, Hong Kong and Kohler Group, Italy.

- Magnum MI Steel Pvt. Ltd.

The plant is located at Bawal in Rewari district of Haryana. Its capacity is 0.03 MMTPA. It manufactures precision ERW, CDW and Stainless Steel tubes.

- GMT Industries Ltd.

The plant is located in Faridabad. It is a leading MS & SS ERW Tube Mill & Finishing Line Equipment manufacturer. The plant manufactures SS Tube Forming Mill, Slitting Line, ERW Tube Mills, Horizontal Strip Accumulator, Tube Draw Bench, Push Pointer, Strip Shear & Welder, Rolls, Tube Straightening Machine, Tube End Facer, Annealing Equipment, Tube Hydrotester, Pipe Bundling Machine, Pipe Threading Machine, Servo Cut to Length Line and Cold Saw. GMT Industries has a Joint Venture for manufacturing fully automatic Bundling machine and Recutting machines with OMP SRL, Italy.

Madhya Pradesh

In the hinterland of river Yamuna, there exist only three iron & steel plants in Madhya Pradesh.

- Surya Roshni Ltd.

Surya Roashni's MP plant is located at Malanpur in Gwalior. The plant has a capacity of producing 1,50,000 MT of ERW pipes per annum.

- Magnum Steels Ltd.

This steel plant is located at Banmore, Gwalior. The plant has capacity to produce more than 1,00,000 tonnes of output annually with 100% utilization capacity. The plant is equipped with six re-rolling mills of various sizes and 3 electric furnaces of 6 tonne each for melting purposes. The plant produces spring steel flats, Carbon & Alloy steel rounds, TMT bars, steel castings, DRI Sponge iron etc.

- Primegold-SAIL JVC Ltd.

This plant is a joint venture of Primegold & SAIL. This Steel Plant is located in Gwalior, MP. The plant has capacity to produce 1,00,000 tonnes of TMT. TMT produced in this plant is consumed in the states of MP, UP, Rajasthan, Haryana & Delhi.

Rajasthan

There are five iron & steel plants in Rajasthan, in the hinterland of river Yamuna.

- Abram Udyog Pvt. Ltd.

This plant is located in Matsya Industrial Area in Alwar, Rajasthan. Abram Udyog offers Pre-engineered steel buildings-PEB product portfolios globally, with applications in major market segments including heavy industry, infrastructure, high-rise buildings, warehouses, factories, oil and gas etc. The plant also manufactures structural steel products and hot rolled and welded steel structures for applications in various industries.

- Kamdhenu Group

The plant is located in RIICO Industrial Area in Bhiwadi, Rajasthan. The product range includes TMT Bars, Structural steel, PEB, etc. At present, Kamdhenu Group has more than 70 franchise units scattered across the Country.

- Rathi Bars Ltd.

The plant is located at RIICO Industrial Area, Khushkhera in Alwar. It has production capacity of 0.09 MMTPA. Rathi has introduced Rathi Shaktiman construction steel bars. These bars are produced with the mission to produce steel bars that are technologically superior, earthquake resistant, cost innovative and are the basis of strong and long lasting structures. The company mostly caters clients of north India.

- Uttam Strips Ltd.

Uttam Strips Ltd.'s plant is located at Bhiwadi in Rajasthan. It manufactures Cold Rolled and Precision Pipe Steel products. Its Cold Rolling division, which produces Cold Rolled Strips &Sheets has an annual capacity of 230,000 Tonnes. Its Precision ERW Tube Division has an annual capacity of 68,000 Tonnes. The company caters automobiles & white goods/domestic appliances & general engineering industries. It exports its products to major European countries, UK and USA.

- **Opportunity to NW 110 from Iron & Steel**

At present, most of the mini iron & steel plants located in the hinterland of river Yamuna procure steel from integrated plants, located in Jharkhand, West Bengal, Odisha, Chattisgarh etc. These plants use railways for transportation of steel from integrated plants to their own mini plants. Due to extensive use, railways are overburdened. Shifting cargo transportation to waterway for domestic transport would reduce burden on railways and would be relatively cheaper. Better connectivity of these steel plants to integrated plants, ports and steel markets is critical for the steel industry's competitive strength. Iron & steel plants located in the hinterland of river Yamuna could export their finished products through Haldia Port. These plants could use the proposed waterways in NW 110 and NW 1 to transport their products to Haldia Port. Imported iron & steel could be received at Haldia Port. After being unloaded at Haldia Dock Comp Bulk (HDCB), it could be further moved to Delhi using NW 1 and NW 110. This cargo could be distributed to industries in the hinterland by trucks. Major consumers of imported steel, especially steel coils are automobile industry and consumer durable industry. Multi-modal freight route, using national waterway and roadway could be very useful for distributing imported steel to industries, which are located in Delhi, NCR, UP and nearby states.

Inland Waterway could play vital role in connecting the production centre of iron & steel, i.e. integrated plants and the consumption centre, i.e. mini plants located in the hinterland of NW 110. Iron & steel, which is procured from different states for distribution in the hinterland, could be diverted to NW 110. Major players of Iron & Steel, like Tata Steel, Bhushan Steel, and Jindal Steel could use national waterway to distribute their products in Delhi or nearby cities. There are many companies in Delhi, Kanpur, Agra etc., which consume iron & steel. For instance, Bhushan Steel Plant, Khurda Road, Odisha sends consignment to Agra; Jindal Steel and Power Ltd. Angul, Odisha sends consignment to Chunar in Mirzapur; Rashtriya Ispat Nigam Limited (RINL), Vizag sends consignment to Faridabad, Delhi. NW 110, along with NW 1 would play a crucial role in bridging the gap between area of production and area of consumption.

6.6.5 Minerals and Mining

- **Delhi**

Delhi has limited resources of mineral and it lacks reserves of raw materials. Some raw materials such as stone, sand & bajra and China clays could be found in rare parts of Delhi.

- **Uttar Pradesh**

UP has limited mineral reserves in the state. It contributes less than 1% of the state's domestic production. Transportation of minerals due to the nature of cargo generates large possibility for river transportation for following reasons

- ✓ Minerals are produced in bulk quantity, providing sustainable volume for trade
- ✓ Minerals have to be taken to plants for processing. This generates assured origin and destination pairs constituting mines and industry
- ✓ Minerals are generally raw and dirty. Hence, transportation of minerals, passing by populated areas is restricted.

Absence of large mineral reserves and production in the state of Uttar Pradesh restricts possibility of river transportation of minerals on river Yamuna. Major minerals in UP are Limestone, Silica Sand, Diaspore, Magnesite & Coal. These deposits come from rock formation in Himalayan and Vindhyachal ranges. Following table describes the historic production of prominent minerals, namely Coal and Limestone in the state. The production of both the minerals has stagnated below 18 million tonnes annually in the last 6 years.

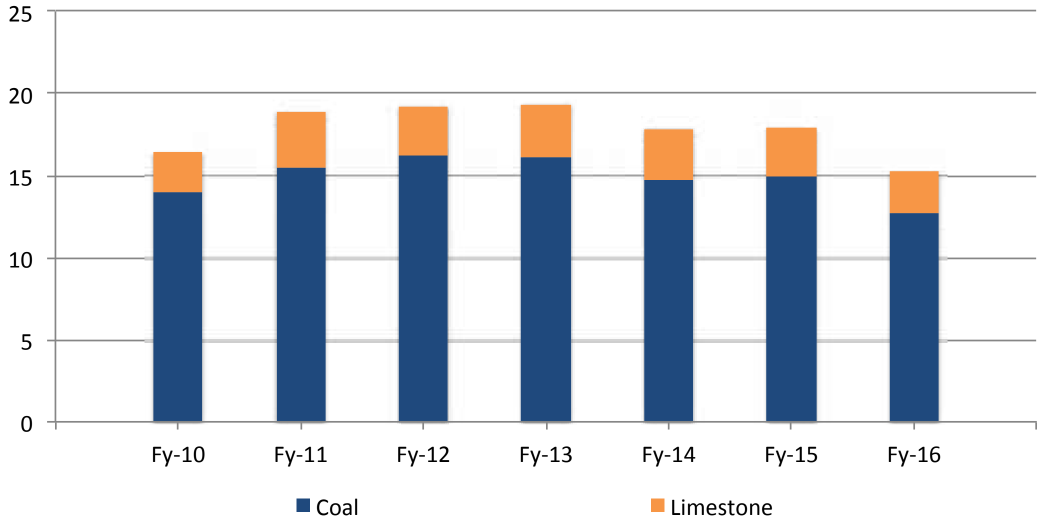


Fig. 6.14 Large Volume Minerals Produced in UP

Source: Indian Bureau of Mines, 2017

Uttar Pradesh also has other minerals. However, they are in low volume and the mines are located far away from river Yamuna. The production volume of these minerals has reduced over time. Following image shows historic production of other minerals in Uttar Pradesh.

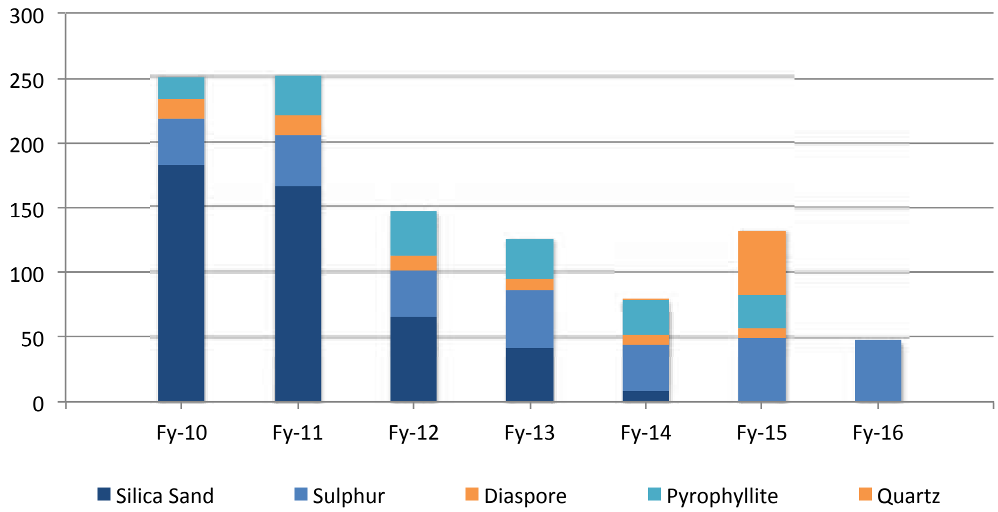


Fig. 6.15 Low Volume Minerals Produced in UP ('000 Tonnes)

Source: Indian Bureau of Mines, 2017

The table below depicts minerals and their reserves in Uttar Pradesh.

Table 6.18 Availability of Minerals in Uttar Pradesh

Sr. No.	Mineral	Location	Estimated Reserves (Mn T)	Distance from NW 110 (km)	Reasoning (No opportunity)
1.	Silica Sand	Prayagraj: Lalapur (Bara), Shankargarh	150	42	Silica sand from Prayagraj and Chitrakoot is mostly used in glass industry. Firozabad is hub of glass industries; hence a portion of silica sand production being transported to Firozabad, as silica sand is used in glass industry.
		Chitrakoot: Bargarh		100	
2.	Bauxite	Chitrakoot	9.4	100	Bauxite from Chitrakoot mines are used by Aluminium refinery located in Renukoot, which is more than 230 km away from Prayagraj. Due to long distance, it would not be viable to shift it to waterway.
3.	Ochre		0.005	19	Volume of Ochre is so less that it would not provide any opportunity for NW 110.
4.	Coal	Sonebhadra	800	200	Possibility may exist of transporting coal from Sonebhadra to Agra/Dadri region, if TPP/cement plants from that region procure coal from this region. However, the distance from Yamuna river is not in favour of coal transportation using waterway.
5.	Limestone		213.3		Limestone extracted from mines in Sonebhadra is used by nearby cement plants. Produced cement gets consumed locally. Thus, there is no opportunity for river Yamuna.

Sr. No.	Mineral	Location	Estimated Reserves (Mn T)	Distance from NW 110 (km)	Reasoning (No opportunity)
6.	Andalusite		14		These are minor minerals in UP, which mostly gets consumed by nearby industries. The production volume of these minerals is also very low. Sonebhadra is far from river Yamuna; hence long distance between mines and river is a major hurdle for shifting minerals to waterway. These minor minerals would not provide any opportunity for river Yamuna.
7.	Calcite		0.07		
8.	China Clay		17		
9.	Dolomite		15		
10.	Fire clay		2.7		
11.	Sillimanite		3.2		

Source: Directorate of Geology& Mining, UP

The state also has reserves of uranium, sandstone, pebbles, reh, salt punter, marang, sand and other minor minerals. The state Government has encouraged exploration and identification of new mineral deposits. However, Uttar Pradesh is unlikely to witness any large discovery of mineral reserves due to agrarian nature of soil.

Uttar Pradesh has an important share in minor minerals. These include non-plastic fireclay in Bansi and Makri- Khoh area of Mirzapur district, Uranium found in Lalitpur district, Barytes and Edalusite in Mirzapur and Sonebhadra.

Gold in Sonebhadra and diamond in Banda district of UP are newly discovered minerals of UP. TPP, Glass and ceramic units derive their Silica sand raw material from washing plants of Prayagraj and Chitrakoot district. Rock phosphate of Lalitpur district is used as a direct fertilizer in the state. About 8.4 million tones of metal grade Bauxite occur south of Manikpur in Chitrakoot district. Vindhyan sandstone occurs in Agra, Lalitpur, Chitrakoot, Prayagraj, Mirzapur, Varanasi and Sonebhadra districts. These are exploited by private parties and marketed as Slab stone, Millstone and Building stone. The mining department charges INR 30 per cubic metre as royalty from builders or contractors, who seek permission for digging soil for basement work within three months of obtaining the permission.

The Indian Cement sector is currently facing two challenges, i.e. (a) river sand mining ban in few states due to environmental issues and involvement of unorganised sector, and (b) pet coke ban issue, which is impacting the overall demand. Sand mining ban has obstructed the construction works in the state. Cement companies have faced a major roadblock when on November 17, 2017, Supreme Court ordered ban on usage of pet coke in UP, Rajasthan and Haryana, due to pollution in NCR region. After the ban on pet coke, cement companies have switched to imported coal, which is 25-35% expensive than pet coke. The ban has impacted the cement companies which used high volume of pet coke, like Shree Cement, JK Cement, JK Lakshmi Cement and Mangalam Cement.

UP government has allowed mining only to the mines license owners and is planning for e-tendering of new mining licences. Ban still continues on the major construction sites. However, partial removal has led to partial pick-up in the construction activities there.

Coal

The total coal production in India is estimated to be about 663 million tonnes in 2016-17. Chhattisgarh is the largest coal producing State, with a share of about 21.7%. Followed by Odisha with a share of 21.03%. Jharkhand (19.08%) is the 3rd largest producer followed by Madhya Pradesh (15.84%). Uttar Pradesh produces about 2.42% of the total coal produced in India amounting to a volume of about 15 million tonnes annually. All the thermal power plants of Uttar Pradesh are dependent on coal produced locally in Uttar Pradesh, Madhya Pradesh and Jharkhand. A share of coal is also imported to meet the demand.

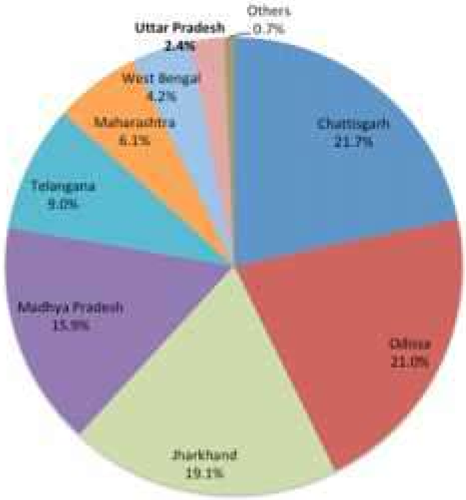


Fig. 6.16 Distribution of Coal production in Various States of India

Source: Indian Bureau of Mines, 2017

The demand for coal in UP is more than the supply of Coal. The state has to be dependent on the external sources to meet its Coal demand. Some of the major suppliers of Coal to Uttar Pradesh are Madhya Pradesh and mines located in Eastern Coal Fields. The cement plants are also dependent on imported coal using Gujarat Ports, apart from domestic coal.

Silica Sand

Among mineral resources of Uttar Pradesh, silica sand mines are located at Shankargarh and Lalapur in Bara tehsil in Prayagraj district and Bargarh in Chitrakoot district. As per Geology and Mining Department, Uttar Pradesh, silica sand reserves in Prayagraj&Chitrakoot in FY 16-17 is 150 mn tonnes and production in Prayagraj and Chitrakoot in the same year was 2.5 Lakh Tonnes. In the Trans-Yamuna region of Shankargarh in Prayagraj, there is large deposit of silica sand, which is of fine quality and one of the best in the country. There are around 12 mines in Shankargarh and 4 mines in Lalapur.

Fig. 6.17 Silica Sand Mines in Shankargarh & Lalapur (Prayagraj)

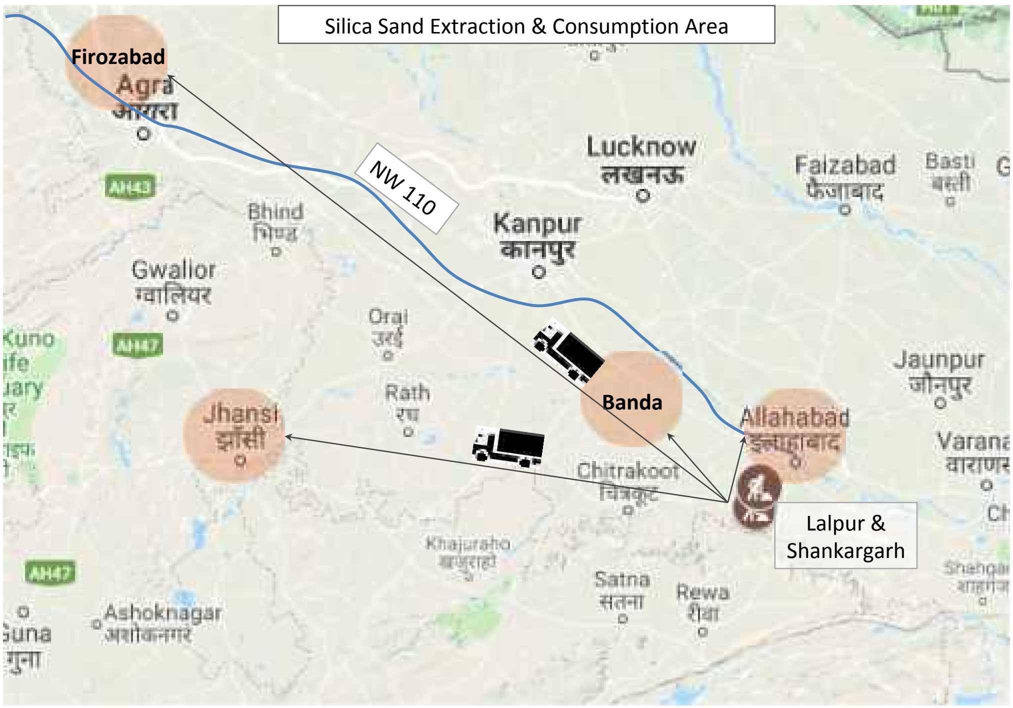


Fig. 6.18 Silica Sand Extraction & Consumption in hinterland of NW110

Silica sand from Prayagraj and Chitrakoot is sent to different factories in India after treatment. Silica sand is mostly used in Glass & Foundry Industry. Among the major clients of silica sand in India are ordnance factories, BHEL, rail factories, iron foundries, glass factories, sheet glass manufacturers, refractories and silicate industry.

Firozabad district, which is known as glass city of India, where traditional processes are still used for production of a wide variety of glass items is a major consumer of silica sand. As per Indian Bureau of Mines, about 70% of the total glass production in the Unorganised Sector in the country is contributed by Firozabad glass industry. During site visit, it was observed that silica sand from Lalapur is transported to Firozabad in trucks. Firozabad falls in the hinterland of NW 110; hence it is assumed that glass industries from Firozabad procure silica sand as raw material from Prayagraj and Chitrakoot. However, the volume of silica sand movement between mines and industries is so less that it is commercially not viable to shift to the proposed waterway in river Yamuna.

Table 6.19 O-D Pair of Silica Sand extracted from Prayagraj district

Location of Mines (Origin)	Designation	No. of trucks per Day (as on Dec. 2018)
Shankargarh	Prayagraj	15-20
	Banda	15-20
	Jhansi	15-20
Lalapur	Firozabad	5-6
	Sonebhadra	5-6
	Prayagraj	5-6

Stone Chips

Uttar Pradesh has many stone chips mines. Granite, dolostone, sandstone block etc. are sources of stone chips. Major locations of stone chip mines are Sonebhadra, Prayagraj, Mirzapur, Chitrakoot, Lalitpur, Jhansi, Mahoba etc. Some of the districts of Madhya Pradesh, which are closer to Uttar Pradesh's border have reserves of stone chips. These districts are Datia, Panna, Sagar, Tikamgarh etc. All the above mentioned districts of Madhya Pradesh& Uttar Pradesh come under Bundelkhand region. The image below shows stone mines located in Meja Tehsil and Mirzapur Division.

Fig. 6.19a Stone Chips Site at Meja Tehsil

Fig. 6.19b Stones Chips in Mirzapur Division

- **Terminal Site Identification for Stone Chips**

Prayagraj has a population of more than a million as per 2011 census, spreaded over 84 sq km. Naini bridge connecting it to the other banks of River Yamuna meets the city in the centre and divide it into 2 parts. Hence, the central part is most congested. All the vehicles entering city for whatever destination has to pass through it. Increasing redundant load on the internal roads of the city, moreover for the reasons, most of the construction takes outskirts of city. The city is expanding and the requirement for these trucks along with their cargo is on the outskirts of city than the internal roads of city. Providing 2 terminals on the outskirts of city would provide a better resolution than one. Figure shown below along with exiting road dedication and proposed route marking, explains the concept of transportation of stone chips from Meja regions to Eastern& Western side of Naini Bridge.

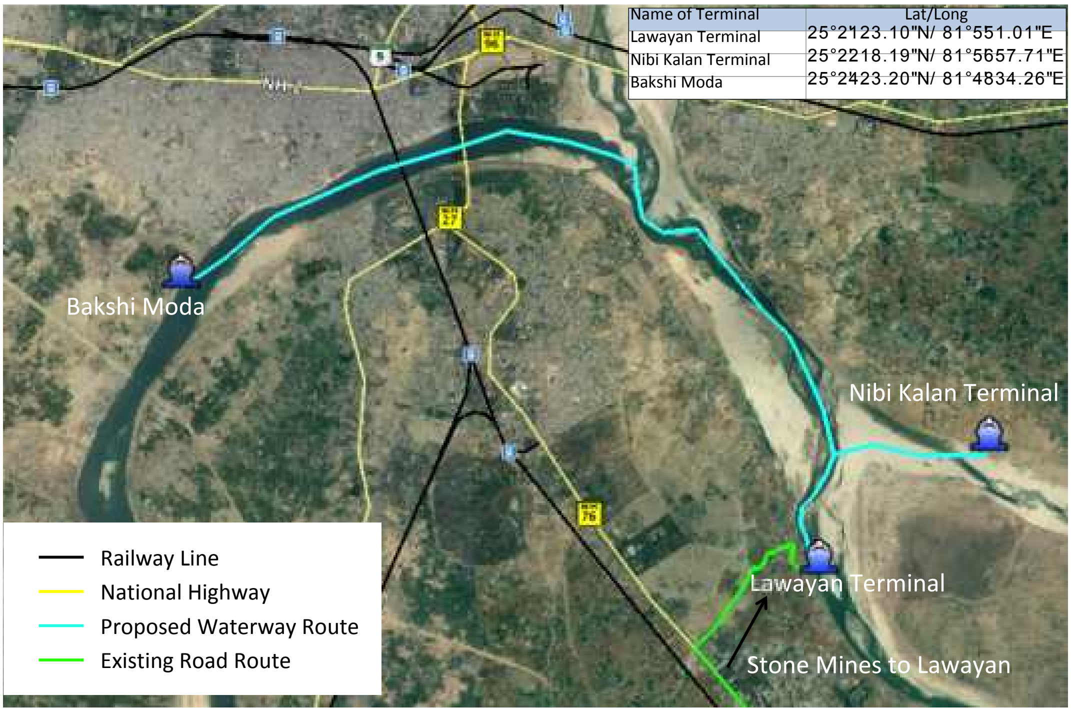


Fig. 6.20 Route Map of Stone Chips Movement from Mines to Prayagraj

A terminal named Nibi Kalan has been proposed on the other bank of River Ganga, opposite of proposed Lawayan Terminal by IWAI. This terminal would cater to the traffic going to the Prayagraj falling on the Eastern side of Naini Bridge along with other adjoining region

- A terminal named Bakshi Moda has been proposed on the Northern Bank of River Yamuna. This terminal would cater to the market located on the Western side of Naini bridge
- A single terminal would not be able to resolve the traffic problem of the city. Hence, 2 terminals would be idle in this case. A single terminal would force trucks to travel all the distance from one outskirt to other outskirts. This would defeat the purpose of decongestant the city, though decongestion of Naini bridge would be somewhat achieved.
- The Ro-Ro vessel is proposed to move in a merry go round service like a liner vessels. It would begin its journey by starting at Lawayan terminal go to Nibi Kalan Terminal and Reach Bakshi Moda Terminal followed by Lawayan terminal.
- At present, stone chips are transported from different stone crushing sites of Meja Tehsil as well as sites of Mirzapur to Prayagraj for construction purpose.

During site visit in September &December 2018, it was found that around 420 - 450 trucks of stone chips moves from Meja region, Mirzapur & Sonebhadra to Prayagraj on daily basis. This number will reduce in monsoon season. During the peak season, annual number of trucks from Meja Tehsil/Mirzapur to Prayagraj would be around 126,000 i.e. 420 trucks daily.

Stone chips, which mostly originated from mines in Meja tehsil in Prayagraj pass through Prayagraj city. Stone chips are either locally consumed in the city or moves ahead to nearby districts. At present, stone chips from stone crushers in Meja tehsil and other nearby mines are loaded in trucks for further transportation on roadways. These trucks take Kohadarghat Road, which further merges with NH 76 and move towards Prayagraj. However, these trucks cannot enter the city roads of Prayagraj during in day time. Heavy vehicles, including trucks are banned from entering internal city roads between 5 am- 11pm. Due to this restriction, these trucks wait on NH 76 till 11 pm. Long line of trucks block one way of NH 76 for several kms. Till the entry point of Old Yamuna Bridge and New Yamuna Bridge. One way road block due to waiting trucks is a major problem throughout the year. Only during Monsoon season, the number of trucks reduces. Once the no-entry opens for heavy vehicles after 11 pm,these trucks move further and pass through city road and reach its destination.

Uttar Pradesh also has many stone chips mines. Granite, dolostone, sandstone block etc. are sources of stone chips. Major locations where stone chips are found are Sonebhadra, Prayagraj, Mirzapur, Chitrakoot, Lalitpur, Jhansi, Mahoba etc. Some of the districts of Madhya Pradesh, which are closer to Uttar Pradesh's border also have reserves of stone chips. These districts are Datia, Panna, Sagar, Tikamgarh etc. All these districts of MP & Uttar Pradesh in this section come under Bundelkhand region.

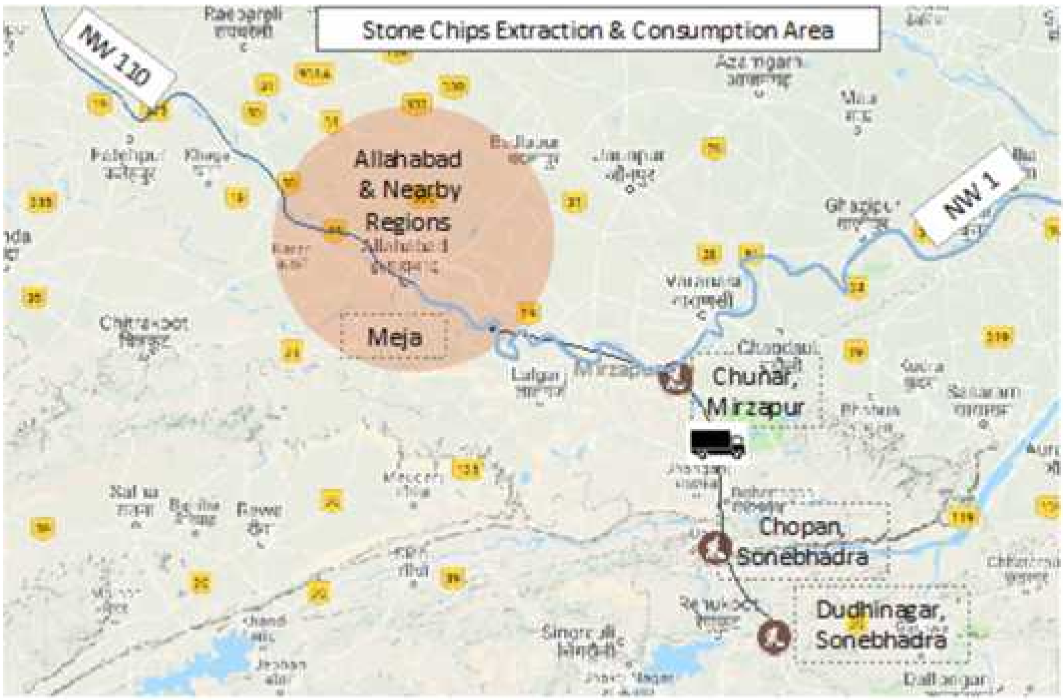


Fig. 6.21 Stone Chips Extraction & Consumption Prayagraj& nearby regions

6.6.6 Container

Container trade of any region is directly linked to the economy of that region. It is mostly derived from the purchasing power or disposable income available with the residents of that region. It has been observed that locations with high income group tend to consume more. Higher income people tend to buy more products of necessity and luxury. Containers are the most advanced and safe mode of transporting finished products from one location to another. Hence, there is correlation between the economic growth along with per capita income of the region and container trade in that region.

A comparison of GDP per capita of various countries of smaller size in Middle East has been made and with container trade per 100 persons. This has been done to illustrate the theory of a direct relation between container trade with economic prosperity of the individuals. The inference derived has been applied with respect to container transportation in river Yamuna.

All the statitics have been taken for the year 2014 for convenience of availability of Data and get a realistic picture during good times. The economy of oil dependent countries was doing well till the year 2014. Their economy and GDP have fallen drastically in the last 3 years due to fall in oil revenue. Economy has improved in India on the other hand. Following table describes the comparision between all the economies based on 2014 statistics.

Table 6.21 Relation between Economic Prosperity and Container Trade

Country	Population ('000)	Economic Category	Container Trade mn TEU	Trade (TEU / 100 Person)	GDP US$ Billion	GDP/ Capita US$
Bahrain	1,377	HI	0.4	28	34	24,582
Kuwait	3,892	HI	1.3	33	164	42,048
Oman	4,491	HI	1.3	29	82	18,214
KSA	31,540	HI	5.6	18	746	23,653
Iran	79,109	UMI	3.2	4	725	9,165
India	12,95,000	LMI	11.7	1	2,049	1,582
Total	16,48,224		35.9	2	4,687	2,843

Source: World Bank for Economic Matters, Other statistics from various sources (Statistics 2014)

India with GDP per capita of US$ 1600 at constant price in 2014 handled one container for every 100 People. The other countries with higher GDP per capita have higher container trade. The table above clearly states that countries with higher average per capita income trade higher number of containers. The container trade is very low compared to the large population and economy of India. The container trade has increased marginally with respect to the growth in economy.

The economic analysis undertaken in previous chapters has concluded that hinterland falling in the stretch of river Yamuna mostly falls in low-income group. The average annual per capita GDP of Uttar Pradesh, which is the largest hinterland falling in stretch of Yamuna is less than US$ 900. It is less than 50% of the national GDP per capita of India. Hence this is likely to generate lower container trade volumes for containerised cargo. New Delhi, on the other hand, is estimated to have a per capita GDP of US$ 4000.

Hence, the demand for container trade originated/destined from Delhi and NCR region would be relatively higher compared to other locations. Other states falling in the hinterland of river Yamuna have lower population residing on the bank of river Yamuna. Hence, their contribution would be negligible and could be ignored.

Table 6.22 Estimates for Containers generated for International Trade

State	Population Considered ('000)	GDP/Capita (INR)	TEU Per 100 Person	Container Volume (TEU)	Opportunity for IWT
Delhi	16,788	2,92,717	2.6	4,35,790	Yes
UP	1,99,812	54,000	0.5	9,56,853	Yes
Haryana	25,351	1,99,000	1.8	4,47,382	Yes
MP	13,287	59,000	0.5	69,520	No
Rajasthan	8,705	1,11,917	1.0	86,396	No
Total				**19,95,941**	

Delhi, Uttar Pradesh and Haryana fall in the immediate hinterland of Yamuna. The population of these 3 states have been considered to define hinterland for these states. The container transportation for international trade follows hub and spoke model on a larger scale. Hence, containers of whole Delhi and NCR region would be aggregated at one location for EXIM trade and not just locations lying in the immediate vicinity of river Yamuna.

The hinterland definition has been considered differently for Delhi, Uttar Pradesh and Haryana unlike for commodities, discussed in earlier sections. More than 90% of the containers in international trade get handled at JNPT or Mundra Port. International trade for containers from India could be divided into 4 main categories

- Trade to West including Europe, US, South America etc.
- Trade to African continent
- Trade to Middle East
- Trade to other Asian countries and South East Asia

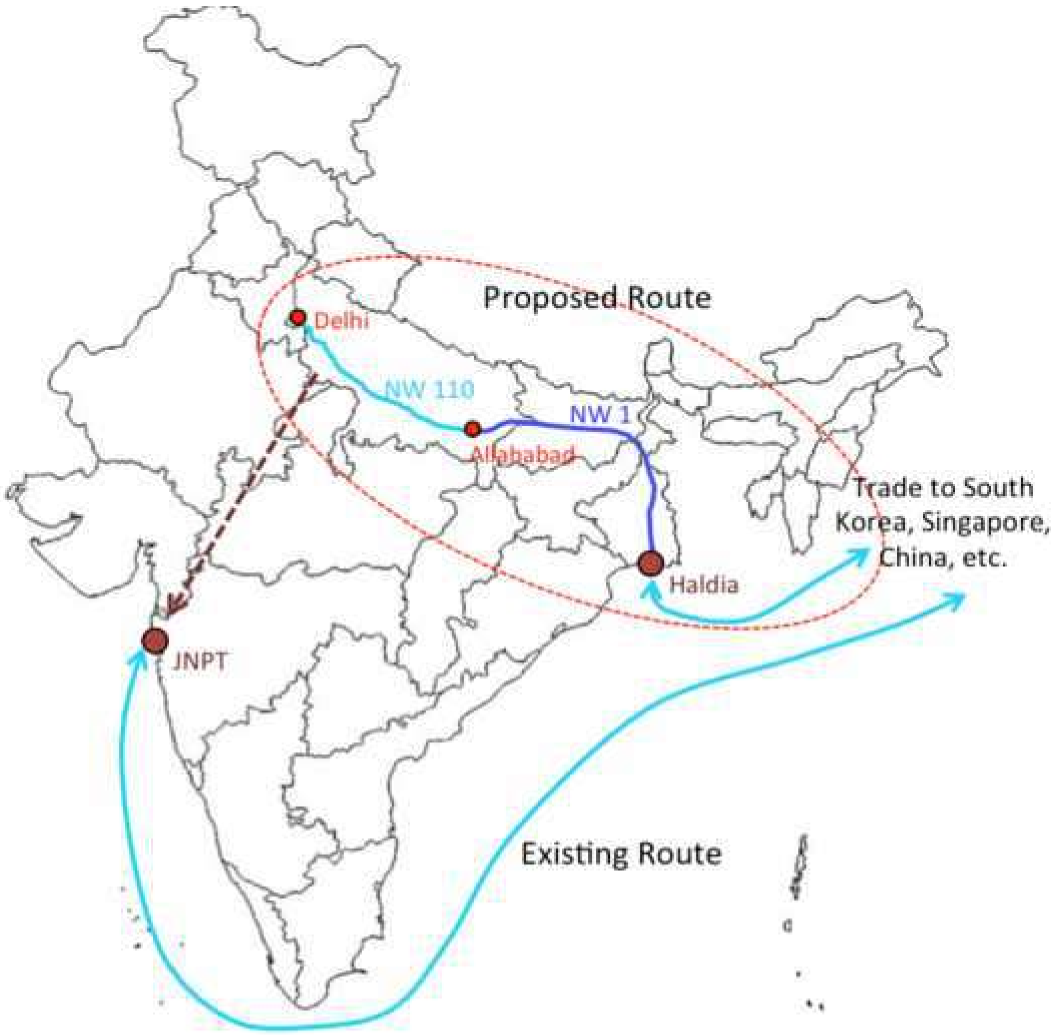


Fig. 6.22 Existing and proposed route of Container Movement

As shown in the figure above, use of JNPT or Mundra port for cargo originating in Yamuna hinterland leads to larger distance and time travelled. Following points broadly determine the trade pattern followed in this case

- Containers go to JNPT or Mundra travelling an Inland distance of about 1,500 kms
- The feeder vessel takes containers from West Coast of India to Colombo for transhipment
- The transhipped containers go directly to the final destination
- Some of the containers traded in mother vessels directly go to final destination in the East Asia

The long distance and time covered by taking containers to ports on the West Coast of India could be avoided by enabling waterways transportation of containers on river Yamuna. The proposed multimodal cargo terminal in Varanasi has provision for container trade, using Haldia Port. Development of river Yamuna enabling container transportation on the route could be able to divert containers using Western Ports for East Asia cargo.

6.6.7 Food Grains

Rice and Wheat are the major commodities transported between the nearby districts. Food Grains are procured in bulk from FCI and local mandis and get stored in State Warehouses for further distribution to PDS and small market places on daily basis as per requirement. Punjab and Haryana are the major sources of food grains for many states. Uttar Pradesh grows enough food grains to feed its population; however when the state has deficit of food grains and cannot fulfill the demand; it procures food grains from Punjab &Haryana. Following graph represents mode of transportation used by Punjab &Haryana for movement of food grains.

Table 6.23 Food Grain Transportation Mode preferred by Punjab & Haryana

Mode	Fy 15('000 Tonnes)	Fy 16('000 Tonnes)
Rail	29,105	22,081
Road	1,824	1,793
Total	**30,929**	**23,875**

Source: Food Corporation of India (FCI)

The map given below represents railway sidings locations owned by Food Corporation of India (FCI). FCI has only two rail sidings in Madhya Pradesh and only one in Rajasthan, whereas eleven in Uttar Pradesh.Tworailway sidings, located in Hapur & Harduaganj are not operational at present due to complete track renewal work. There are five FCI rail sidings in Punjab and four in Haryana. It is clearly visible from above map that two FCI rail sidings, located at Agra Cantt. and Chandari (Kanpur) are closer to Yamuna river. All FCI rail sidings have full rake facility.

Fig. 6.23 Locaton of FCI Rail Siding in the hinterland of Yamuna

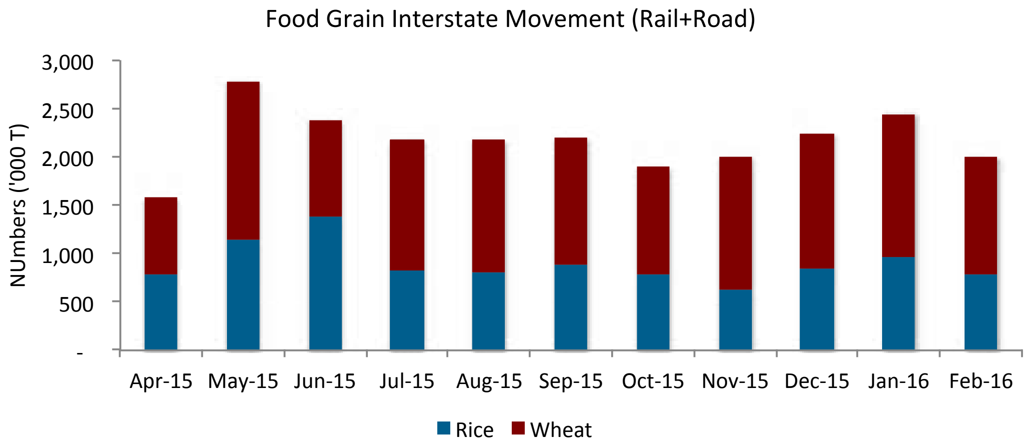


Fig. 6.24 Monthwise Food Grain Movement from Punjab & Haryana to other states

Above graph represents food grain transportation from Punjab & Haryana, which are highest food grain producing states in the country. It is clearly visible from the above graph that Rice & Wheat transportation was highest in the month of May. Lowest transportation took place in the month of April. Wheat transportation is relatively higher in every month compared to rice transportation.

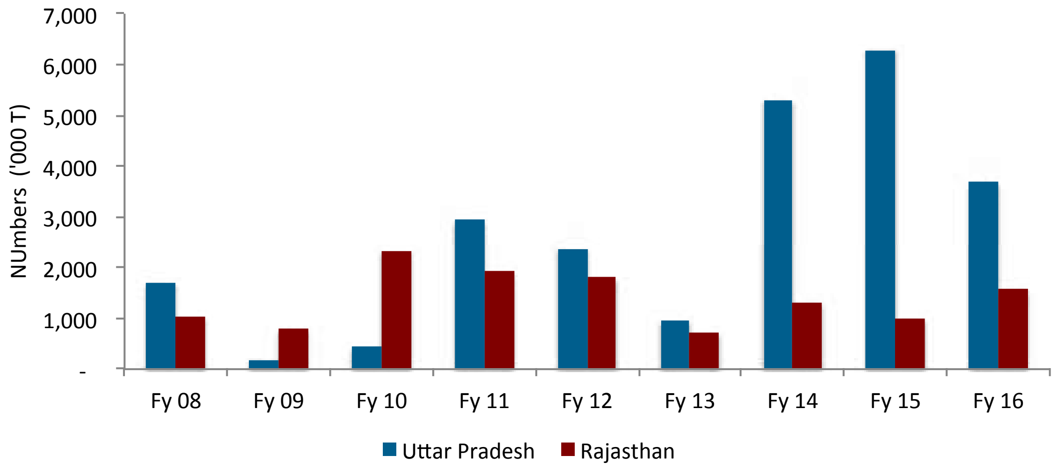


Fig. 6.25 Historic Food Grains received in UP & Rajasthan from Other States

Above graph represents historic food grain movement from other states of India to UP & Rajasthan. It is clearly visible that Uttar Pradesh procures highest volume of food grain compared to Rajasthan; hence, consultant would focus on deriving possibility of diverting this traffic on NW 110.

The figure below depicts food grains movement in UP within the hinterland of river Yamuna.

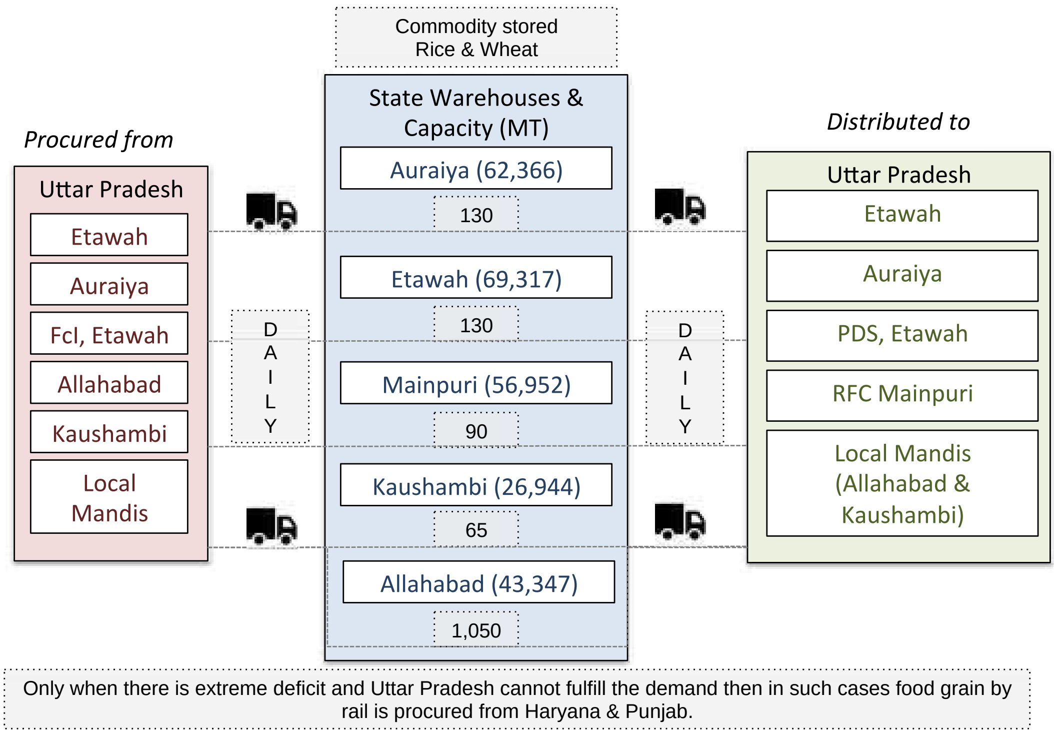


Fig. 6.26 Food Grain movement of UP in hinterland of Yamuna

Uttar Pradesh contributes to about 17% in the total food grains production in India. The state is leading producer of cereals. Pulses production is limited in the state. India is dependent on import of pulses to meet its domestic requirement. The below map shows division wise food grains production in Uttar Pradesh.

Fig. 6.27 Mapping of food grain production in UP

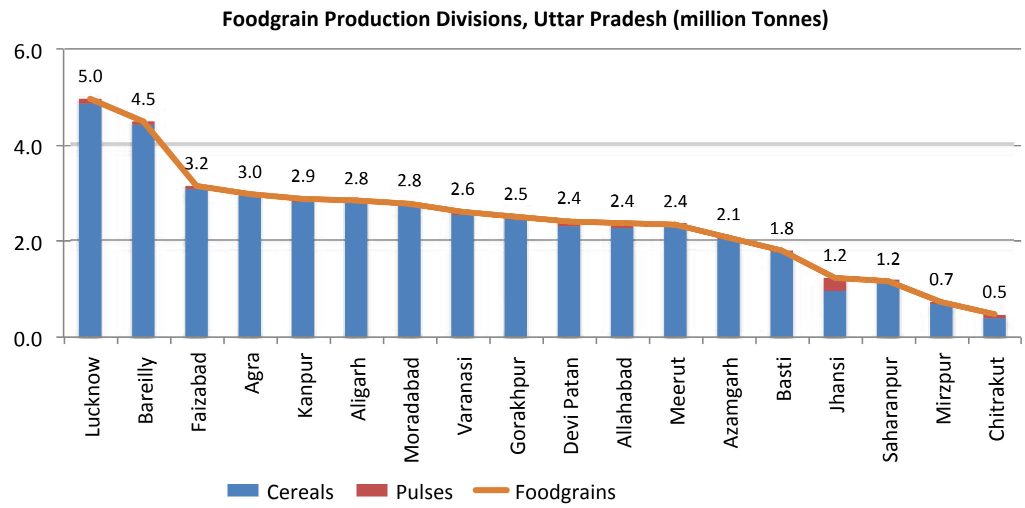


Fig. 6.28 Division wise production of foodgrains in UP

Cereals among food grains have the major share in local production in UP. Rice and Wheat are the predominant food crops produced in Uttar Pradesh. Following image shows cereal production in Uttar Pradesh.

The production of cereals, including Rice and Wheat, is totally scattered all over Uttar Pradesh. A large share of cereals is produced away from river Yamuna. Some of the prominent divisions producing cereals are located closer to Yamuna river. These divisions are Aligarh, Agra and Kanpur. Internal consumption of food grains in the aforementioned divisions restricts prospects of moving food grains using Yamuna river.

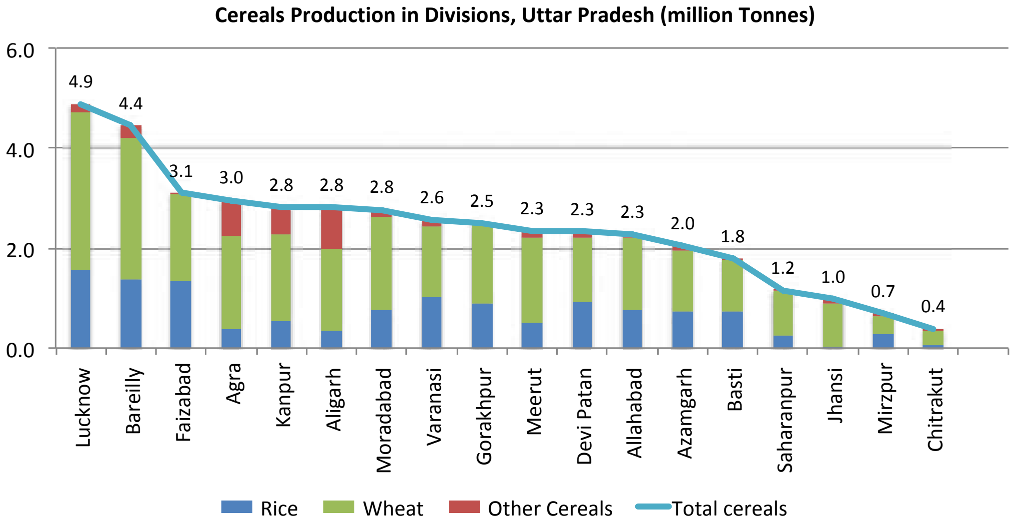


Fig. 6.29 Division wise production of Cereals in UP

The below graph depicts trends of planned & dispatched food grains by FCIs in UP.

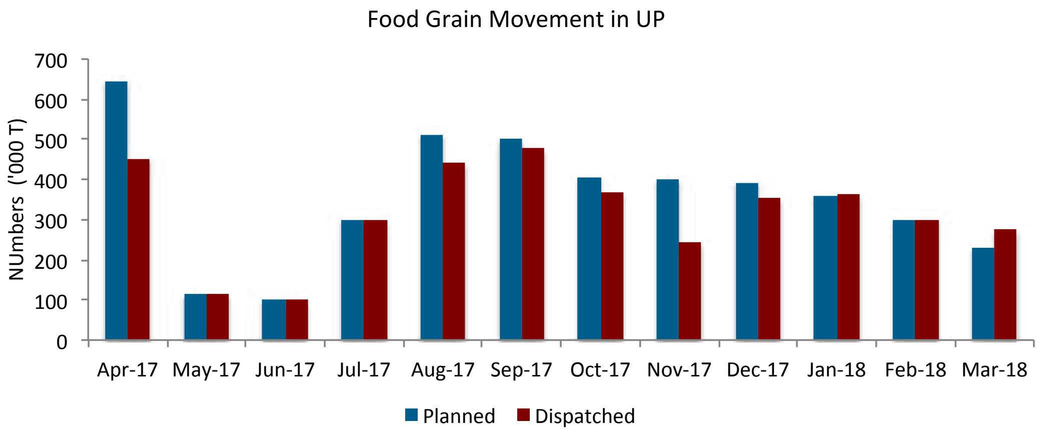


Fig. 6.30 Comparison of planned & dispatched food grains by FCIs in UP (Fy 18)

6.6.8 Sugar

Uttar Pradesh is the largest producer of sugar cane and sugar in India. High volume of sugarcane production is the reason of numerous sugar plants in the state. Sugar from UP gets distributed in Eastern India, especially Kolkata.Muzaffarnagar, Bareilly, Lucknow, Meerut, Moradabad and Saharanpur are the major Sugar producing districts in UP. Most of the sugar mills of the state are located between Shamli- Muzaffarnagar; hence it is called 'The Sugar Bowl of India'. Muzaffarnagar is far from NW 110 (129 km); however due to concentration of sugar mills in this district, it is considered for the study.Due to heavy transport charge with increasing distance, sugar industry cannot afford a long haulage of its raw material. Hence, the mills are generally located within 30 km radius from cane-fields.

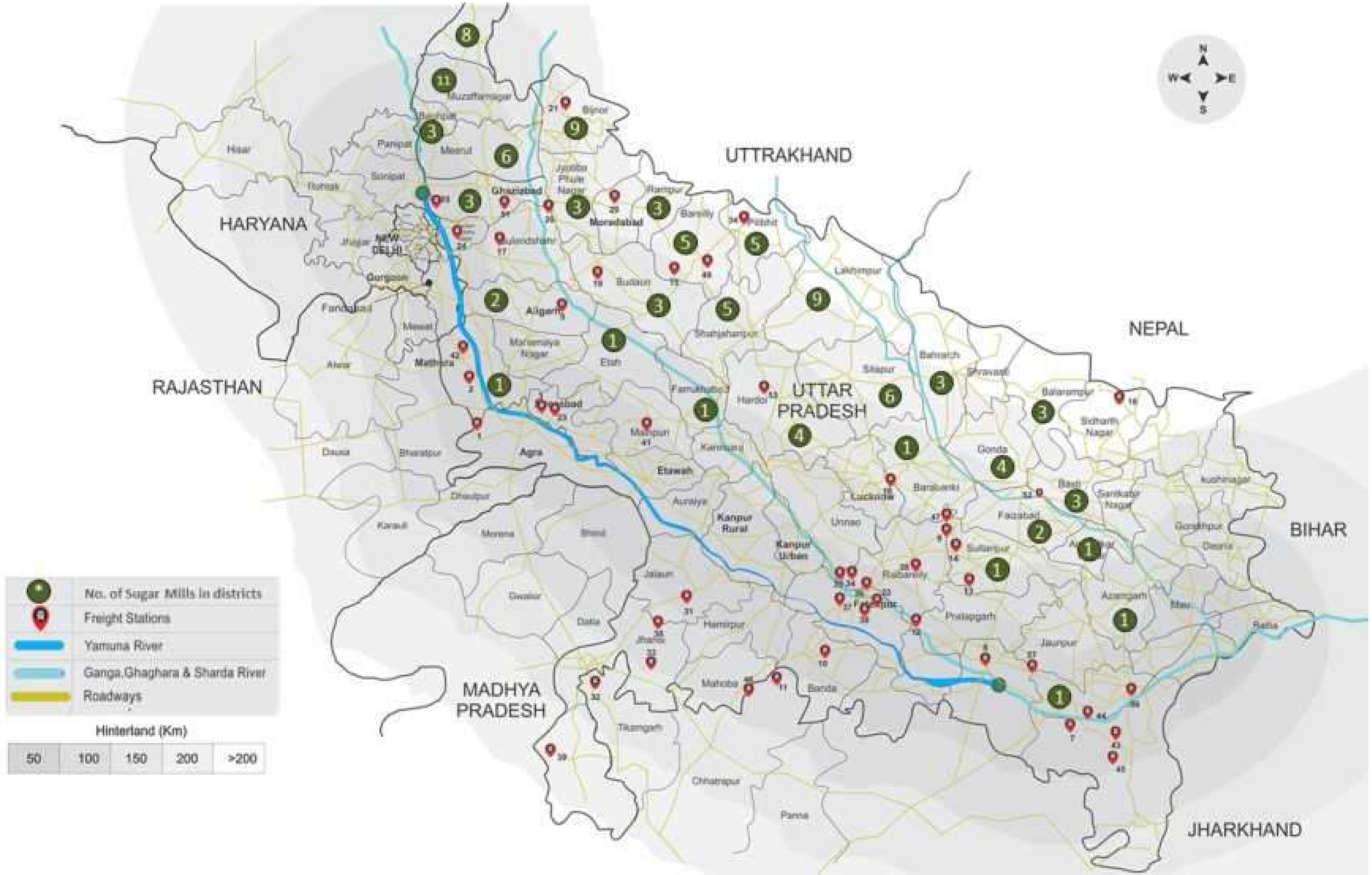


Fig. 6.31 Sugarcane Plants in the hinterland

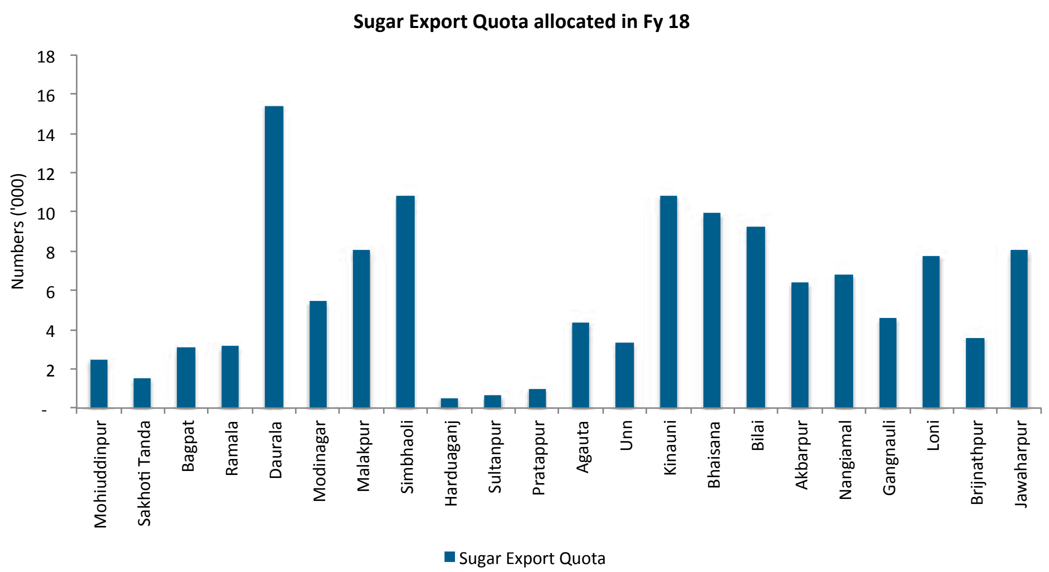


Fig. 6.32 Minimum Sugar Export Quota allocated in hinterland of Yamuna

Above graph represents places UP which are within 100 km from river Yamuna. These are allocated by Department of food & public distribution.

As per Uttar Pradesh Cooperative Sugar Factories Federation Ltd., total 24 sugar factories are functional in U.P in co-operative sector with total crushing capacity of 60,000 TCD. 12 co-operative sugar mills, which are located in the hinterland of river Yamuna are mentioned in the below table.

Table 6.24 Cooperative Sugar Mills in UP in the hinterland of Yamuna

Sr. No.	Location	District	Total Sugarcane Area (Ha.)	Capacity (TCD)	Sugar Produced Mn T	Reasoning
1.	Anoopshahar	Bulandshahar	58,500	2,500	0.06	Co-operative sugar mills which come in the hinterland of NW 110 are considered as opportunity for NW 110. After the development of NW 110, it is assumed that these mills would use inland waterway for the movement of their finished product, i.e. sugar.
2.	Bagpat	Bagpat	58,500	2,500	0.06	
3.	Morna	Muzaffarnagar	58,500	2,500	0.06	
4.	Ramala	Bagpat	64,350	2,750	0.06	
5.	Kaimganj	Farukhabad	29,250	1,250	0.03	
6.	Satha	Aligarh	29,250	1,250	0.03	
7.	Tilhar	Sahjahanpur	58,500	2,500	0.06	
8.	Powayan	Sahjahanpur	49,725	2,125	0.05	
9.	Sathiaon	Azamgarh	81,900	3,500	0.08	
10.	Sultanpur	Sultanpur	29,250	1,250	0.03	

There are many prominent private players in Sugar sector in Uttar Pradesh. Major sugar plants in the hinterland of NW 110 are depicted in the below table.

Table 6.25 Sugar Mills in UP in the hinterland of Yamuna

Sr. No.	Sugar Mill	Location	District	Crushing Capacity (TCD)	Sugar Production (Mn MT)
1.	Triveni Engineering & Industries Ltd.	Sabitgarh	Bulandshahar	7,000	0.16
		Milak Narayanpur	Rampur	6,000	0.14
		Khatauli	Muzaffarnagar	16,000	0.37
2.	Bajaj Hindustan Sugar Ltd.	Thanabhawan	Muzaffarnagar	7,000	0.16
3.	Dhampur Sugar Mills Ltd.	Mansurpur	Muzaffarnagar	8,000	0.19
4.	Upper Doab Sugar Mills Ltd.(Sir Shadi Lal Enterprises Ltd.)	Shamli	Muzaffarnagar	6,250	0.15
5.	Uttam Sugar Mills Ltd.	Khaikheri	Muzaffarnagar	4,500	0.11
6.	Balrampur Chini Mills Ltd.	Akbarpur	Ambedkar Nagar	76,500	1.79
7.	Modi Sugar Mills (Modi Industries Ltd.)	Modi Nagar	Ghaziabad	5,000	0.12
8.	SBEC Sugar Ltd. (Modi Industries Ltd.)	Baraut	Bagpat	8,000	0.19
9.	Simbholi Sugar Mills Ltd.	Simbholi	Ghaziabad	9,500	0.22
		Brijnathpur	Ghaziabad		
10.	Mawana Sugar works	Mawana	Meerut	29,500	0.69
		Nanglamal			
11.	Indian Potash Limited	Titawi	Muzaffarnagar	10,500	0.25
		Rohana Kalan	Muzaffarnagar	2,100	0.05
		Sakhoti Tanda	Meerut	2,100	0.05
12.	Shervani Sugar Syndicate Ltd.		Kanshiram Nagar	3,000	0.07
13.	DSCL Sugar	Hariawan	Hardoi	22500	0.53
		Loni			
		Rupapur			
14.	Kitply Industries Ltd. (Sugar Unit)	Rupapur	Hardoi	0.7	0.70
15.	Baghauli Sugar Ltd.	Baghauli	Hardoi	5000	0.12

Apart from the sugar plants mentioned in the above table, there are many small sugar mills in the state. Those plants, which are located far from the hinterland of river Yamuna, are not considered for the study. Small sugar plants in the hinterland with negligible capacity are also not included in the study, as they would not provide any opportunity to NW 110.

Details of some of the sugar plants, mentioned in the above table are below

- Triveni Engineering & Industries Ltd.
  Triveni is one of the large integrated sugar players in India with its 7 sugar mills Spread across the western, central and eastern part of the cane rich areas of Uttar Pradesh. Its Sabitgarh, Milak Narayanpur and Khatauli plants are located in the

hinterland of river Yamuna. Approximately 40% of the sugar produced by Triveni is refined sugar.

- Bajaj Hindustan Sugar Ltd.
  It has total 14 plants in UP. It has an aggregated sugarcane crushing capacity of 136,000 tonnes crushed per day (TCD), and alcohol distillation capacity of 800 kilo liters per day (KLD) across all 14 plants. Its mills located in Gangnauli, Thanabhavan and Budhana fall in the hinterland of river Yamuna.

- Dhampur Sugar Mills Ltd.
  It is one of the leading integrated sugarcane processing companies of the country. The company has 5 sugar plants in Asmoli, Dhampur, Mansurpur, Meerganj and Rajpura. Only Mansurpur falls in the hinterland of NW 110; hence it would be considered for traffic study. This plant has a crushing capacity of 8000 metric tonnes of cane per day.

- Upper Doab Sugar Mills Ltd.(Sir Shadi Lal Enterprises Ltd.)
  This sugar factory is owned by Sir Shadi Lal Enterprises Ltd. This mill is located at Shamli in Muzaffarnagar district. It has a cane crushing capacity of 6,250 TCD per day. The capacity utilization of the Plant for the last number of years has been more than 100%. Being a seasonal industry, the Sugar Factory works for about 180-200 days in a year.

- Uttam Sugar Mills Ltd.
  The Company has four sugar plants, out of which 3 plants are in Uttar Pradesh and 1 plant is in Uttarakhand. These plants have an aggregate sugarcane crushing capacity of 23,750 TCD. Khaikheri plant which is located in Muzaffarnagar has a cane crushing capacity of 4,500 TCD.

- Balrampur Chini Mills Ltd.
  It has total 10 plants in UP, out of which mills in Haidergarh and Akbarpur fall in the catchment area of NW 110. The Company possesses a cane crushing capacity of 76,500 tonnes per day.

- Modi Industries Ltd.
  Modi Industries has two sugar units in Uttar Pradesh, Modi Sugar Mills at Modi Nagar and SBEC Sugar Ltd. at Baraut. Modi Sugar Mills manufacturers white sugar and refined sugar. The mill has a crushing capacity of 5,000 TCD.

  SBEC Sugar plant produces 8,000 TCD of Plantation White Sugar; however it is designed for a daily production of 10,000 TCD. The annual production of the plant amounts to 1,40,000 tonne sugar.

  Both plants are located closer to river Yamuna. Modi Nagar plant is about 50 km away from the River, whereas SBEC Sugar located is at a distance of about 70 km from the river. Due to close proximity from the river, these plants could use the proposed waterway for the movement of their finished product.

- Simbholi Sugar Mills Ltd.
  Simbhaoli Sugar Mills have total three plants, two at Simbhaoli and Brijnathpur in western Uttar Pradesh and third plant at Chilwaria in eastern Uttar Pradesh. The total capacity of the three plants is 20,100 TCD. Cane crushing capacity of Simbhaoli is 9,500 TCD, Chilwaria 6,000 TCD and Brijnathpur is 4,000 TCD. As Chilwaria plant is located near to India Nepal border and is far away from river Yamuna; hence it would not provide any opportunity to NW 110. The other two plants, Simbhaoli and Brijnathpur might opt for inland waterway movement for transportation of their finished product, i.e. sugar.

- Shervani Sugar Syndicate Ltd.
  It is an associate company of Shervani Industrial Syndicate. This unit is located in Kanshiram Nagar district that produce white crystal sugar.

- DSCL Sugar
  DSCL Sugar has 4 sugar plants in Uttar Pradesh, out of which one plant is at Ajbapur in Lakhimpur Kheri district and 3 plants at Rupapur, Hariawan and Loni in Hardoi district. As Lakhimpur Kheri is far from the stretch of river Yamuna, hence this plant would not provide any opportunity to NW 110. Three plants at Hardoi come in the hinterland of NW 110; hence they might shift their cargo to the proposed waterway.

- Mawana Sugar Limited
  Mawana Sugar Ltd. has two plants in Meerut, at Mawna and Nanglamal. The combined installed capacity of these two plants is 29,500 TCD cane crush. Mawana Sugar Ltd. had a plant at Titawi, which was acquired by Indian Potash Limited in 2016.

- Indian Potash Limited (IPL)
  Indian Potash Ltd. had acquired 5 very old sugar factories from U.P. Government. It has also acquired Titwai sugar plant from Mawana Sugar Ltd. Out of IPL’s total 6 plants, three plants fall in the hinterland of NW 110. Titawi and Rohana Kalan plants are located in Muzaffarnagar district, whereas Sakhoti Tanda Sugar Unit is located in Meerut district.

Opportunity from Sugar Industry

Uttar Pradesh covers most of the hinterland of NW 110 and it is a leading sugar producer. Many sugar plants are located near river Yamuna. It is assumed that sugar mills, which are located far from the river but falls within the hinterland would also provide opportunity for the inland waterway for the movement of their finished products. Sugar mills could use proposed multipurpose terminals on NW 110 for loading and unloading of their finished products.

However, due to the seasonal nature of the industry, the state's sugar mills are idle for six to seven months a year, after cane crushing gets over. Hence, it is obvious that the sugar mills in the hinterland would use the inland waterway for a certain period of the year. They might not use NW 110 throughout the year for sugar movement.

6.6.9 Fertilizer Plants

Existing fertilizer plants in UP and Haryana are crucial as these plants would provide opportunity to river Yamuna. The below table depicts fertilizer production capacity and production of Fy 17 of these plants. Production of plants, like Chakradhar Chemicals, Swastik Pesticides & Chemicals and KRIBHCO Bio Fertilizer are not mentioned in the table, due to unavailability of data.

Table 6.26 Fertilizer Plants in the hinterland

'000 Tonnes

Sr. No.	Fertilizer Company	Plant Capacity p.a.	Production (Fy 17)
Uttar Pradesh			
1.	Asian Fertilisers, Gorakhpur	66	40
2.	Coromandel International, Raebareli	132	12
3.	Jubilant Agri. & Cons. Prod. Gajraula, Amroha	165	118
4.	Khaitan Chem. & Ferts. Malwan, Fatehpur	116	33
5.	Khaitan Chem. & Ferts. Goramachhia, Jhansi	132	62
6.	Madan Madhav Fert. & Chem., Fatehgarh	24	12
7.	V.K. Phosphates Bartara, Shahjhanpur	15	-
8.	KRIBHCO Shyam Ferts. Shahjahanpur	865	932
9.	IFFCO, Aonla 1 & II	2,000	2,102
10.	IFFCO, Phulpur 1 & II	1,698	1,624
11.	Indo Gulf Ferts., Jagdishpur	1,106	1,161
12.	TCL, Babrala	1,155	1,214
13.	Kanpur Ferts. & Cements Kanpur	723	723
14.	Chakradhar Chemicals, Muzaffarnagar	15,500	-
15.	Swastik Pesticides & Chemicals	-	-
16.	KRIBHCO Bio fertiliser (Varanasi Plant)	-	-
Haryana			
17.	Kisan Phosphate Gawar,Hisar	132	43
18.	NFL, Panipat	512	543

Source: Fertilizer Association of India, 2016-2017

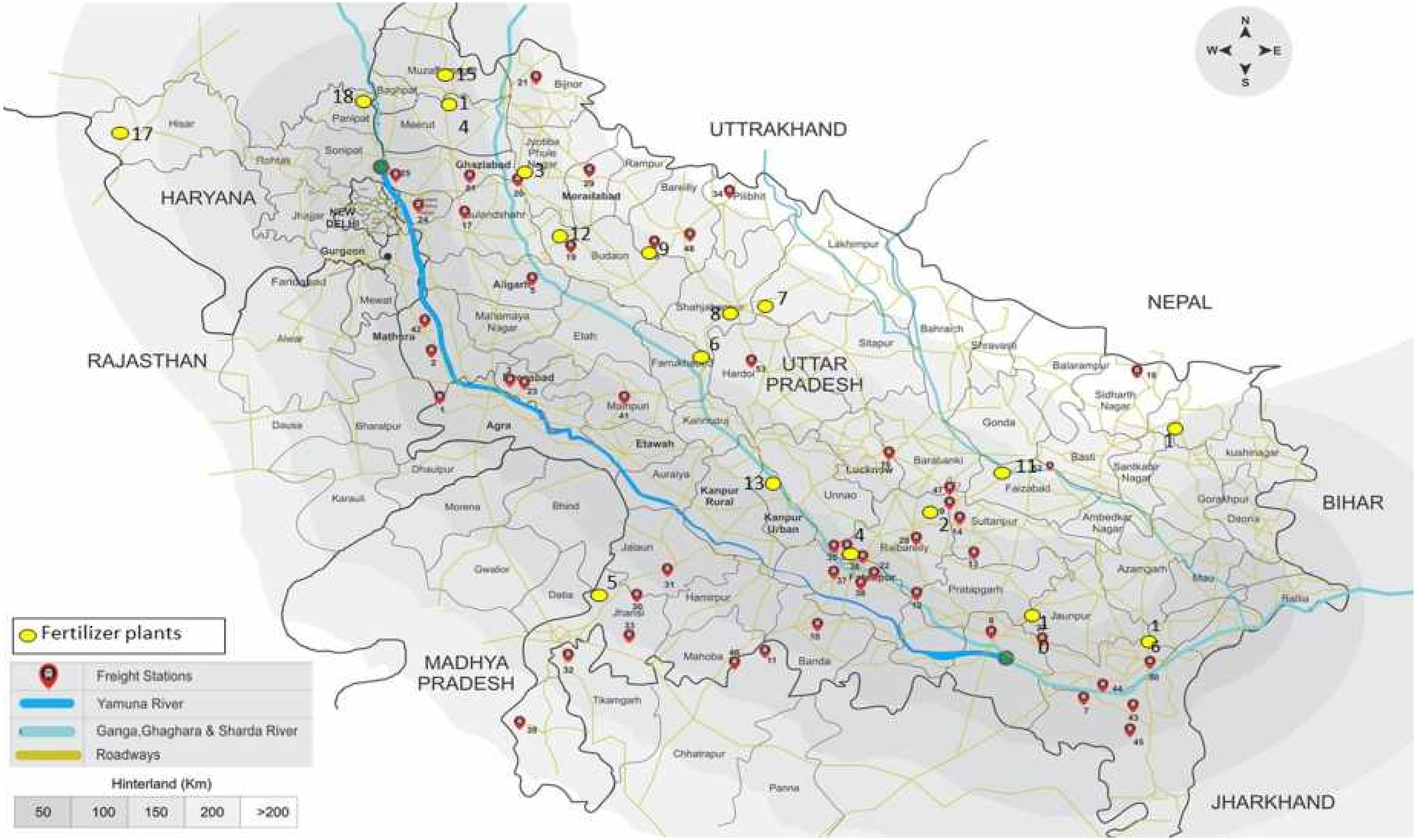


Fig. 6.33 Fertilizer Plants in the hinterland

UP is one of the largest fertilizer consuming states. The below graph shows historic fertilizer consumption in UP. It is evident from the chart that consumption of Urea is higher than other fertilizers in the state. In Fy 15, Urea's consumption has increased; however in Fy 16 and Fy 17, there is slight decline in Urea consumption.

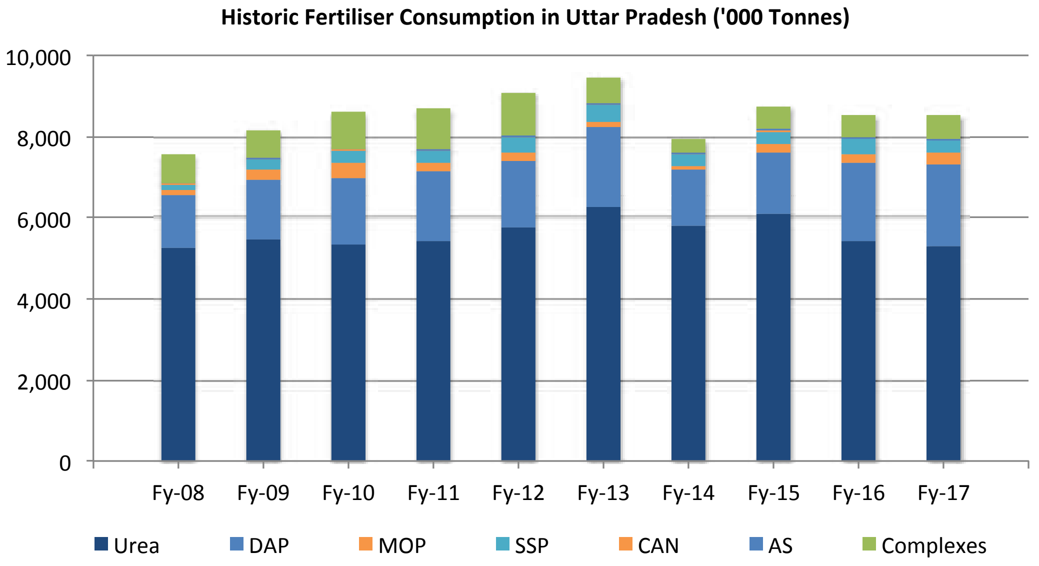


Fig. 6.34 Historic Consumption of Fertiliser in UP

Source: Fertilizer Association of India

Annual Fertiliser consumption in UP has varied between 8 million tonnes to 9 million tonnes. Urea has maximum share in the total consumption of Fertilisers in UP. It is supplied by existing fertiliser plants located in North India, including UP. A substantial share of Urea is imported from Oman and other countries. IFFCO is the largest producer and importer of fertilisers in India, including Urea. Following figure shows detailed capacity and production of fertilisers in North India.

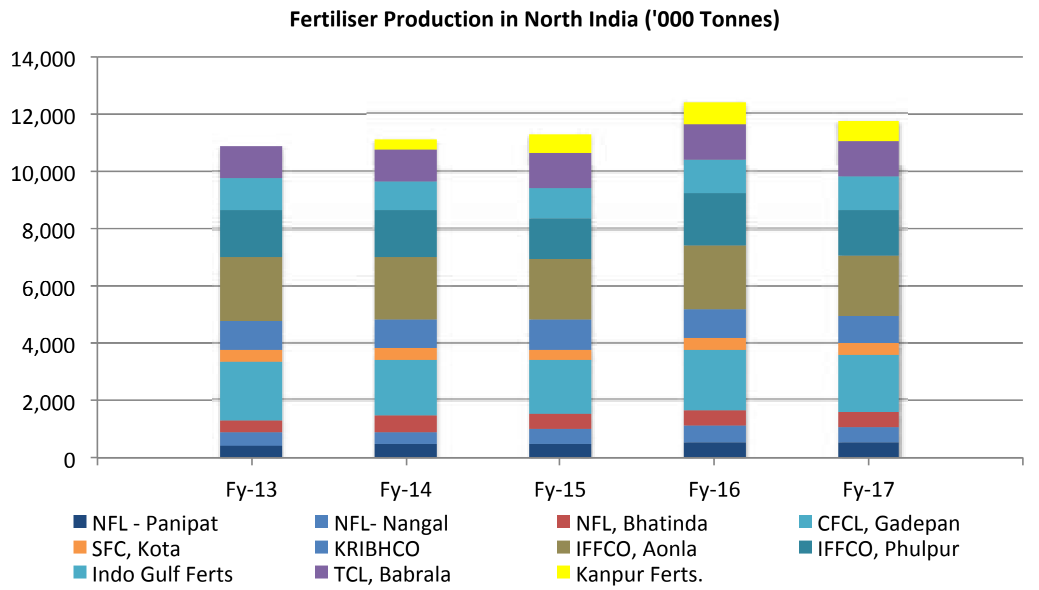


Fig. 6.35 Fertiliser Production in North India

Source: Fertilizer Association of India

Details of fertiliser distributed to various divisions of Uttar Pradesh are depicted in the following figure and map. It can be seen that fertiliser consumption is highest in Lucknow followed by Bareilly, Moradabad, Faridabad, etc. Most of the high fertiliser consuming divisions are located away from hinterland of river Yamuna.

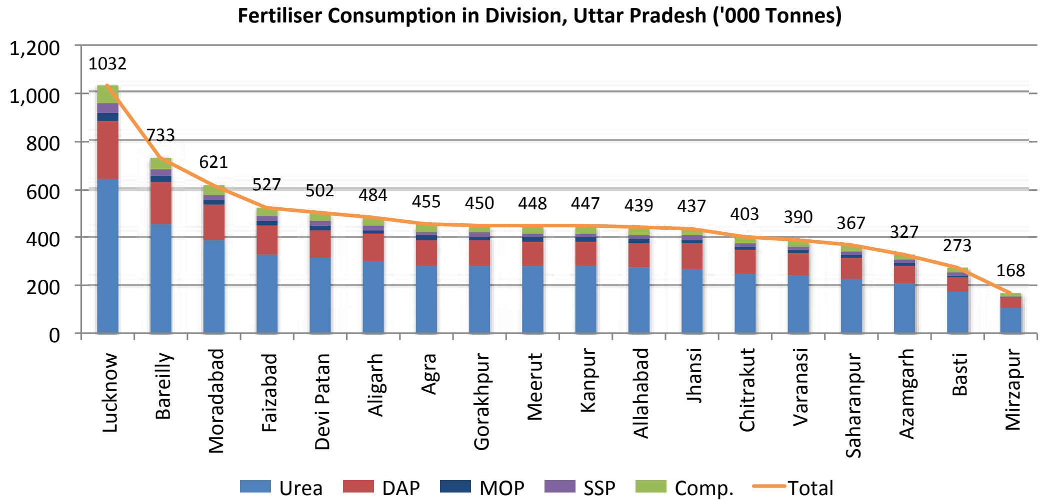


Fig. 6.36 Division wise consumption of Fertiliser in UP

Source: Fertiliser Association of India

Fig. 6.37 Mapping of division wise production of Fertiliser in UP

Source: Fertiliser Association of India

The below graph shows monthly consumption of fertiliser in UP in 2016-17.

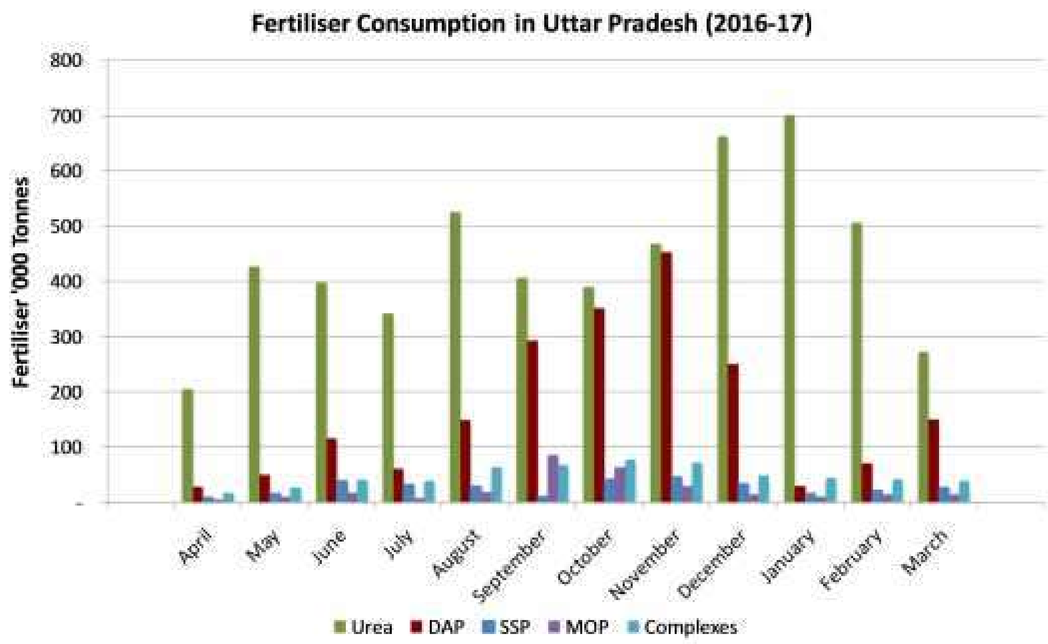


Fig. 6.38 Monthly consumption of Fertiliser in UP

Source: Fertiliser Association of India

Fig. 6.39 Mapping of Fertiliser production and Consumption in UP

Source: Fertiliser Association of India

The above image shows existing fertiliser plants in the hinterland of river Yamuna. Majority of the plants are located in UP.

6.6.10 Other Industrial Cargo in Primary hinterland

- **Delhi**

The manufacturing sector in Delhi has grown in recent years. The major manufacturing sectors are electronics, gems &jewellery, home textiles, leather industry, metal & minerals, pharmaceutical, plants & machinery and home consumable industry. The most profitable sectors in Delhi at present are construction, Retail, Power, Telecommunication, Health & Community Service, Real Estate and Aviation. Key industries located in Delhi are listed down in below table.

Table 6.27 Key Industries in Delhi

Sr. No.	Key Industries in Delhi	Opportunity	Reasoning
1.	Processed Food products	✗	Food products are containerized and may provide scope to river Yamuna. This possibility would be considered in evaluating container traffic for NW 110
2.	Construction and Real Estate	✗	All raw materials required for construction purpose would be according to projects. Delhi is a highly populated city and due to scarcity of land, major construction projects would come up rarely in the city.
3.	IT and ITeS	[illegible]	Service based industry; hence would not provide opportunity to the waterway.
4.	Tourism	✓	Some of the tourism activities near the waterfront of Delhi could be explored to boost water based tourism activity in Delhi.
5.	Logistics	[illegible]	Service based industry; hence it is irrelevant for the proposed waterway.

Delhi has few industrial areas, which are mostly located in Okhla, as shown in the table below. These industries are mostly agri based and processed food based. The produced commodities are not in bulk volume; hence they could be transported in containers. Industries in service sector are irrelevant for the proposed waterway.

Table 6.28 Industrial Opportunity from Delhi Region

No.	Name of Complex	No. of Sheds	Reasoning (No Opportunity)
1.	Okhla Industrial Complex Ph-I	232	Operation scale of these Industrial complexes in Delhi is micro and small scale. Some of the sectors are Cosmetic and Packaging, Mill sector, Textile, Wood& paper based plants, Engineering units etc. In these sectors, volume of production & transportation is fragmented and based on customers demand/need. It may not be a continuous process, thus limiting potential for generating consecutive large volume. Another factor is these commodities are container based and fragmented, which do not generate opportunity for waterway transportation.
2.	Okhla Industrial Complex Ph-II/I	112	
3.	Okhla Industrial Complex Ph-II/II	34	
4.	Okhla Industrial Complex Ph-II/III	59	
5.	Wazirpur Industrial Complex	103	
6.	Lawrance Road Industrial Complex	90	
7.	Jhilmil Tahirpur Industrial Complex	33	
8.	Rohtak Road Industrial Complex Ph-I	177	

Source: http://www.dsiidc.org/Industries

- **Uttar Pradesh**

Uttar Pradesh is emerging in industrial arena of the country. Agriculture is the main segment of the state's economy. Due to good availability of fertilizers, and increased use of irrigation, UP has become the largest producer of food grains in India. Uttar Pradesh’s textiles and sugar-refining industries provide employment to nearly one-third of the state's total workforce. Other growing industries in UP include vegetable oil, jute and cement. The below table shows key industries of UP and opportunity they would provide to the proposed waterway. Opportunity for the proposed waterway is justified with suitable reasoning. Service based industries would not provide any opportunity to NW 110. Some high value products, which are not produced in bulk, like handloom, textile, leather based industry etc. could be transported in the proposed waterway in containerised form.

Table 6.29 Key Industries in UP

Sr. No.	Key Industries	Opportunity	Reasoning
1.	IT	✗	IT is a service based industry; hence it would not provide any opportunity for water transportation in river Yamuna.
2.	Agriculture	✓	Agriculture products like rice & wheat are grown& stored in large volume in UP. At present, roadway and railway is used for transportation of these agro based cargo. This movement could be shifted to the proposed waterway. This possibility would be considered in projecting traffic for NW 110.
3.	Tourism	✓	Tourism sector has immense potential in UP, especially in Agra and Prayagraj(Sangam). At present, boating is used in some places. Once waterway is developed in river Yamuna, Tourism would provide opportunity to waterway.
4.	Mineral based industries	✓	There are around 10 Thermal power plants in UP. Coal for these plants, which is procured from neighboring states through railways, could be shifted to the proposed waterway. Also, finished products like iron and steel could be moved through waterways. This possibility would be evaluated in subsequent section
5.	Textiles	✗	Textiles are consumerable items that are bound by time & fast deliveries thus such industries prefer faster mode to meet deadlines and hence such commodities would not prefer waterway transportation.
6.	Food Processing	✓	Food products are containerized and maybe provide scope to NW 110. This is consumerable item that require quick movement.
7.	Leather based industries	✗	This type of industries does not provide scope for bulk cargo transportation due to lack of large volume, thereby limiting scope of cargo transportation through Yamuna river. Leather products just like textile look for faster and timely deliveries.
8.	Sports Goods	✗	These goods are not in bulk volume. Production of such commodities take place depending on market demand/sales and hence no fixed volume of production. These products are again consumerable items bound by time & quick deliveries.

Sr. No.	Key Industries	Opportunity	Reasoning
9.	Biotechnology	[illegible]	Biotechnology is a service based industry. It would not provide any opportunity for water transportation in river Yamuna.
10.	Handloom & handicrafts	[illegible]	These consumerable items are low in volume compared to other major commodities. Handloom producing units generally have small to medium scale operation limiting large scale production; hence no opportunity for NW 110.

Union Government has established some large factories in UP that manufacture heavy equipment, machinery, steel, telephone, electronics equipment and fertilizers. Some other noticeable Union Government projects are oil refinery at Mathura and the development of coalfields in Mirzapur. Uttar Pradesh has 15 industrial areas, 12 specialized parks, 3 growth centers, 4 industrial infrastructure development centers (IIDC). The State has 17 SEZ.

Uttar Pradesh has a considerable share in India's exports. UP achieved a growth rate of 21.6% in export in FY 13- Fy 14, which is the 2nd highest in the country. It has a significant share in export of handicraft, textile (handloom & power loom), carpets, apparels, leather & leather goods, leather footwear & saddler, food processing including processed meat, sugar, engineering & automobile hardware, sports goods, gems &jewellery. All major export items are exported to Latin American countries, CIS countries, ASEAN countries, UK, Europe, African countries, Japan, China, Middle East countries, Nepal and Bangladesh etc. The existing industrial regions of UP would not provide any opportunity for NW 110. The table below shows the type of industrial estates exist in the state along with reasoning for no opportunity.

Table 6.30 Opportunity from Existing Industrial Regions of UP

Sr. No.	Location	Industrial area	Area (sq.m.)	Reasoning (No Opportunity)
1.	Aligarh	C.D.F. Chherat	84,411	Production volume is not enough to transport on waterways.
2.	Auraiya	Dibiyapur	5,57,301	GAIL produces about 0.26 mnT p.a. plastic (High & Low density) but these plastic gets transported in fragmented section. Thus, they provide no opportunity for waterway transportation.
3.	Baghpat	I.A. IIDC Baghpat	21,102	Agro based and sugarcane production units, cottage based industry have their plants in this district.
4.	Banda	Bhuragarh	15,181	Agro based, Repair & maintenance, RMG based small scale units do not generate enough volume for waterway transportation.
5.	Bulandshahar	Sikandarabad	9,824	
6.	Etah	I.A. Etah	16,996	
7.		I.I.D.C. Etah	46,160	
8.	Fatehpur	Malwan	38,412	

Sr. No.	Location	Industrial area	Area (sq.m.)	Reasoning (No Opportunity)
9.	GB Nagar	E.P.I.P. Greater Noida	70,984	Micro & small scale industries include cotton, wood, chemical and medium-large scale industries include white goods manufacturing. These are containerized products and fragmented in nature.
10.		Surjapur Site 5 & B	12,506	
11.	Ghaziabad	Trans-Delhi Signature City	44,795	Paper, Chemical, Food, Cotton, Rubber transport equipment manufacturing etc. are not large scale units and thus provide no opportunity to Yamuna.
12.	Hamirpur	I.A. Sumerpur	3,20,137	Not feasible to move Non Obnoxious/Hazardous products on water.
13.	Jalaun	Orai 1 & 2	1,17,423	
14.	Kanpur Dehat	Growth Centre Jainpur	21,453	Industrial units are not on large scale and volume from these industries is not large to start.
15.	Manipuri	Bhogaon	61,108	This district is not well known for industries. There are very few small scale industries, which would not provide any opportunity to waterway.
16.	Mathura	IIDC Kosi Kotwan	6,380	Apart from IOCL refinery, there does not exists other large scale units. Majority of the units are service and maintenance based, thus providing no opportunity for Yamuna river.
17.		Kosi Kalan	25,110	
18.		Kosi Kotwan, I&II	14,02,273	
19.		Mathura Site-B	24,885	

Source: UPSIDC

Though UP has abundance of manpower, it faces many issues cited below. Some of the manufacturing units are managed by family members, therefore investments into the business is comparatively lower.

- Illiterate and poor work force
- Lack of new designing as per market trend
- Lack of market intelligence and techniques
- Lack of brand building and networking
- Un-organised sector and un-economic scale of operations
- Use of old and obsolete manufacturing process reduces the quality of products
- Lack of knowledge on packaging
- Lack of active association
- Issues faced in transporting Bamboo from North East takes time due to conversion in rail track, which is still not complete
- Breakage of raw material in transportation

Electronic Manufacturing

Noida and Greater Noida is the hub for semiconductor manufacturing industry. Many industries have their R&D centers in this region.

Table 6.31 Electrical Machinery Cluster in the hinterland of Yamuna

Sr. No.	Companies	Location	Distance from Yamuna (Km)	Reasoning
1.	ABB India	Faridabad	11	Electrical Machineries and appliances are mixture of heavy& light weight components. Generally, these products get transported in container form. The plants are located nearriverYamuna.Hence, these commodities could be moved in containers using the proposed waterway and are considered in container traffic.
2.	Mitsubishi Electric India	New Delhi, Gurgaon	6; 59	
3.	Havells India Ltd	Noida	2	
4.	BHEL	New Delhi	10	
5.	Crompton Greaves	Gurgaon	34	
6.	Siemens	New Delhi, Gurgaon	31	
7.	Bosch	Gurgaon	56	
8.	Philips	Gurgaon	27	
9.	Yaskawa India	Gurgaon	36	
10.	Godrej	Gurgaon	39	
11.	BCH Electric	Faridabad	21	

Textile

UP is the 5th state in terms of silk production and number of handlooms in the country. It has 58 spinning mills and 74 textile mills. UP is the 3rd highest fabric producing state. About 90% of India's carpets are produced in UP and exported to different countries. Agra, Etawah, Fatehpur Sikri, Ghaziabad, Hathras are some of the locations that fall into the hinterland of Yamuna.

Bhadohi is the largest exporter of carpet, which is 82 km away from Prayagraj and lies on Ganga River. This place is also known as carpet city of India. As river Ganga (NW 1) is already operational, potential from this place to NW 110 is not possible. Another silk cluster is present in Varanasi district that produces about 90% of silk sarees in UP; however this district is also located near NW 1; hence would not provide opportunity for NW 110. UP have 58 spinning mills, 74 non SSI textile mills. It has about 3 lac handloom weavers and 4 lac power looms. Consumer base of 200 million people make UP attractive destination for investment. During Fy16 and Fy 17, UP exported more number of carpet durries.

Leather

Noida and Faridabad are two leather producing locations that are closer to Yamuna River. The table below depicts leather producing centers located in the hinterland of river Yamuna.

Table 6.32 Leather Production Centers in the hinterland of Yamuna

Sr. No.	Production Center	Distance from NW 110 (km)	Reasoning (No Opportunity)
1.	Saharanpur	49	All the production centers are more than 50 km away from Yamuna. Leather is a containerized item and bound for timely delivery. Production & distribution of such items are based on market demand; volume of products differs with every demand. Low volume and uncertainty of regular distribution makes it an unviable product for waterway transportation.
2.	Ambala	80	
3.	Delhi	0	
4.	Noida	0	
5.	Gurgaon	42	
6.	Faridabad	0	
7.	Kanpur	82	

Other Industries

Apart from the industries discussed above, there are also some other industries, which are shown in the below table. These industries would not provide any opportunity to the proposed waterway in river Yamuna.

Table 6.33 Other industries in the hinterland of Yamuna

Sr. No.	Companies	Location	Product	Distance from NW110 (km)	Opportunity
1.	GAIL	Auraiya	Liquefied Petroleum Gas	25	[illegible]
2.	IOCL Refinery	Mathura	Oil Refinery	1	
3.	BHEL	Jhansi	Power Transformers	13	
		Jagadishpur	Insulators	24	

Source: District Profile

GAIL has already started implementing Jagadishpur (UP)- Haldia pipeline project; it would go via Phulpur near Prayagraj to Haldia and then to Dhamra. Central Government has accepted this proposal. Thus, it is very unlikely that GAIL would be shifting its cargo to waterways.IOCL refinery at Mathura distributes cargo via rail tankers to Nepal, Jaipur, Haridwar and Loni. Kanpur, Banaras & Aligarh are local distribution regions, Freight station has close proximity to the Plant IOCL already has pipeline connectivity from Kanpur to Haldia and now they have started pipeline construction from Tundla (Mathura) to Gwria (Kanpur) to have full fleged connectivity up to Haldia. Hence, it restricts any opportunity for NW 110.

BHEL, Jagdishpur plant heavily uses roadway for timely delivery of consignment. They use various types of trucks, ranging from mini truck to heavy goods truck to flatbed trailer etc. depending upon type of consignment. Their distribution regions are Maharashtra, Uttarakhand, MP, Andhra Pradesh, Tamil Nadu, Karnataka, UP (Jhansi) and New Delhi. BHEL supplies cargo as per project demand.

Thus, there is no guarantee of fixed supply quantity. Hence, no opportunity exists for IWT movement.

6.6.11 Other Industrial Cargo in Secondary Hinterland

- **Haryana**

The state boundary of Haryana is around 50 kms from river Yamuna. The below table shows type of industries in the state and the opportunity they would provide to NW 110.

Table 6.34 Key Industries in Haryana

Sr. No.	Key Industries in Haryana	Opportunity	Reasoning
1.	Automotive	✓	Haryana is a large automotive hub. It is among top states, which produce passenger cars. There would be requirement of larger vessels for transporting large automotive such as car carrier. This possible diversion on NW 110 would be discussed in subsequent section
2.	Agro Based	[illegible]	When UP is under deficiency of agro based products, it procures agro products from Haryana. But there is no regular supply of such products to UP, so there is not much potential for the proposed waterway.
3.	IT	[illegible]	Service based industry; hence would not provide any opportunity for the waterway.
4.	Textile	[illegible]	Textiles are consumerable items that are bound by time & fast deliveries thus such industries prefer faster mode to meet deadlines and hence such commodities would not prefer waterway transportation.
5.	Oil Refining	[illegible]	Mostly transportation of such products is done via pipeline and by rail for quick transportation. Some of the industries are planning to develop pipeline hence they would not shift to NW 110
6.	Biotechnology & Petrochemical	[illegible]	

Source: IBEF

Table 6.35 Industrial Cluster in Haryana

Name of Cluster	Location	Total Units (No.)	Reasoning
Gurgaon Readymade Garments	Gurgaon	1,310	RMG commodities are containerised items and distribution depends on demand in the market.
Manesar Leather & Products	Manesar	205	Leather products are of high value and containerized products. These are bound for timely delivery, thus won't provide opportunity for waterways.
Gurgaon Auto Parts	Gurgaon	350	Auto parts assembly and related units products come in containerized category. They could be moved in containers, using the waterway on river Yamuna.

- **Madhya Pradesh**

Madhya Pradesh is a leading producer of many industrial products, namely Cement, automobile, agricultural equipment and other heavy machinery, food processing and textile. Gwalior is one of the industrial clusters in MP, having manufacturing units of Sandstone, Transformer and allied, Confectionary etc. There also exist thermal power plants in the state, coal used in the plants are procured from nearby mines.

River Yamuna does not hold any cargo opportunity for water transportation from Madhya Pradesh because raw material required in all manufacturing plants like Cement, TPP, textile, etc. are easily available in the state.

- **Rajasthan**

There are many industries in entire Rajasthan state, but only two industries exist in the hinterland of river Yamuna, which would not provide any opportunity for the proposed waterway, as shown in the table below

Table 6.36 Industrial Cluster in Rajasthan in the hinterland of Yamuna

District	Company	Type	Distance from Yamuna (Km)	Reasoning (No Opportunity)
Alwar	Jay ShreeKripa	Cement	150	Paras Steel's finished product gets transported in UP, but the volume depends on demand and distance between Yamuna. Both these industries did not show their willingness to use the proposed waterway for moving their cargo; hence they would not provide any opportunity to the waterway.
	Paras Steel	Steel	74	

Source: District Profile

6.7 Market Survey Passenger Transportation

There exist inter and intra district passenger movement on river Yamuna. Both inter and intra district movements are considered for the study because there is a need for developing an alternate mode of transportation here.

For intra district movement, New Delhi and Prayagraj are only considered. In New Delhi, water taxi could be developed for passengers. In New Delhi, there is huge traffic on Wazirabad Bridge. To reduce the congestion on present mode of transportation, there is a need to develop an alternate mode of transportation to cross river Yamuna. Prayagraj's Sangam attracts large number of people, especially during Maha Kumbh. To handle such large traffic, there would be requirement for intra district river movement in Prayagraj.

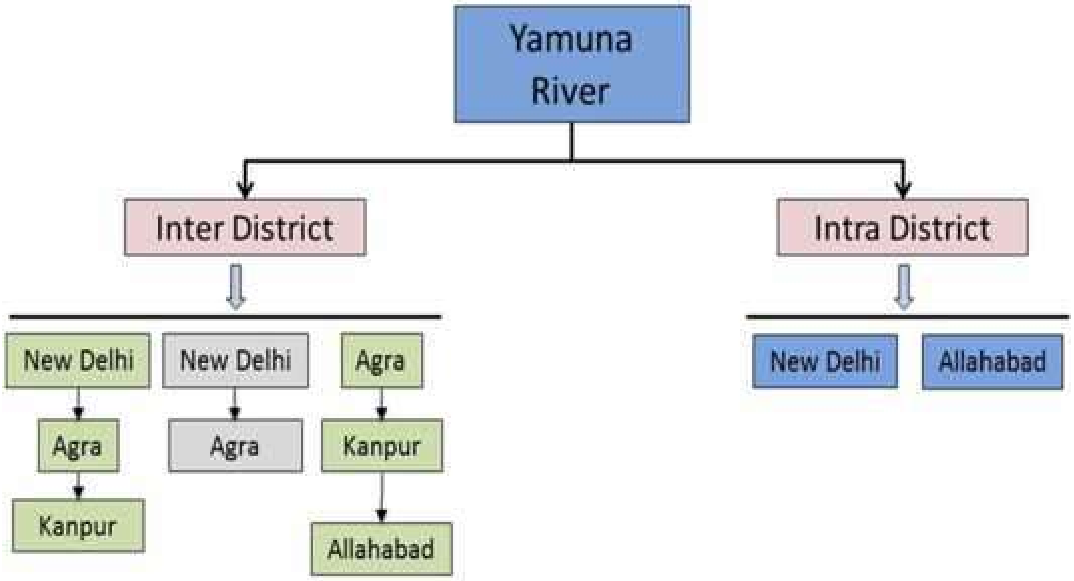


Fig. 6.40 Prospects of Passenger Transportation on River Yamuna (NW 110)

For inter district movement on Yamuna River, some routes are identified, New Delhi to Vrindavan, New Delhi to Agra and Vrindavan to Agra to Prayagraj. These long-distance travels on the river Yamuna should be considered as luxury ride for tourists. This will give waterway movement experience to the tourist visiting Vrindavan, Mathura, Agra&Prayagraj.

The passenger tourist transportation on Yamuna could be evaluated for inter district movement of passengers and intra-district movement of passengers. All the 5 important districts with high population are located in the hinterland of Yamuna. This section analyses prospects of passenger transportation on river Yamuna.

Several districts of UP have long route bus service to Delhi. National Capital Region (NCR) is large industrial region. There are several trains and buses, connecting local districts of Uttar Pradesh with Delhi. Prospect of starting passenger cruise would be explored between New Delhi and other districts of Uttar Pradesh.

Passenger transportation has evolved over a period of time. The 3 fundamentals for passenger transportation are time, cost and reliability. Faster modes of transportation have developed in last 2 to 3 decades. The infrastructures such as rail and roadways have improved. This has led to increasing average speed of a vehicle. Waterway on the other hand is a slower mode of transportation. Moreover, majority of population is stationed away from waterways. The rivers of North India have a wider base, sometimes with runs into kilometre with large floodplains. Most of the rivers are prone to flooding during monsoon. These factors and uncertainties have led to development of civilisation away from river.

6.7.1 Inter District

Route survey was undertaken on the bus depots of major cities in the hinterland of River Yamuna. The detailed route survey is explained as below:

6.7.1.1 Route Survey – Kanpur

Survey has been conducted in Kanpur to identify route for proposed waterway. The below table shows various routes, which originate from Kanpur Bus Depot. The table depicts type of vehicles, which are considered for survey. Routes, which fall in the catchment area of river Yamuna and have along the river movement, are only considered for intra district proposed waterway movement. There is no potential for waterway movement in those routes, which fall far from the hinterland.

Table 6.37 Route Identification for proposed IWT, originating from Kanpur

Sr. No.	Type of Service	Route (O-via-D)	Destination	Considerable for Proposed IWT
1.	Bus	Mandhna	Shivali	✗
2.	Bus	Lucknow, Ayodhya	Gorakhpur	✗
3.	Volvo/Scania/Janrath	Lucknow, Ayodhya	Gorakhpur	✗
4.	Bus	Daulatpur, Pukhraya, Orai	Jhansi	✗
5.	Volvo/Scania/Janrath	Daulatpur, Pukhraya, Orai	Jhansi	✗
6.	Bus	Daulatpur, Pukhraya, Orai	Raniyaa	✗
7.	Bus	Unnao, Nawabganj	Lucknow	✗
8.	Jan Rath/Volvo	Unnao, Nawabganj	Lucknow AC	✗
9.	Scania/Volvo	Unnao, Nawabganj	Varanasi	✓
10.	Bus	Auraiya	Mathura	✓
11.	Bus	Auraiya, Etawah	Agra	✓
12.	Bus	Noida, Yamuna Expressway	Delhi	✓
13.	Bus	Kannauj	Indergarh	✗
14.	Scania/Volvo	Auraiya	Etawah*	✓
15.	Bus	Auraiya	Etawah	✓
16.	Bus	Etah	Aligarh	✗
17.	Bus	Lucknow, Gorakhpur	Patna	✗
18.	Bus	Lucknow, Ayodhya	Basti	✗
19.	Volvo/Scania/Janrath	Sikhohabad via G.T.Road	Firozabad*	✓
20.	Volvo/Scania/Janrath	Lucknow	Ayodhya	✗
21.	Janrath	Takia	Raibareily	✗
22.	Bus	Takia	Raibareily	✗
23.	Bus	Lucknow	Barabanki	✗
24.	Volvo/Scania/Janrath	Lucknow	Barabanki	✗
25.	Bus	Etah, Aligarh	Anand Vihar	✗
26.	Bus	Etah, Aligarh	Mainpuri	✗
27.	Bus	Etah, Aligarh	Bighapur	✗
28.	Bus	Etah, Aligarh	Magarwara	✗
29.	Bus	Etah, Aligarh	Ayodhya	✗
30.	Bus	Etah, Aligarh	Firozabad	✓

Sr. No.	Type of Service	Route (O-via-D)	Destination	Considerable for Proposed IWT
31.	Bus	Kannauj	Saurikh	✗
32.	Bus	Sarsaul	Bhindki	✗
33.	Bus	Rasoolabad	Mannava	✗
34.	Bus	Rania	Pukhraya	✓
35.	Bus	Ramaipur	Jahanabad	✗
36.	Bus	Akbarpur	Derapur	✗
37.	Bus		Fatehpur	✗
38.	Volvo/Scania/Janrath		Fatehpur	✗
39.	Volvo/Scania/Janrath		Banda	✗
40.	Bus		Banda	✗

The below table shows details of bus service at Kanpur Bus Depot. Only nine destinations, which are considered for proposed waterway, as shown in the table below. Kanpur to Etawah is the busiest route, as number of trips to/ from Etawah is more than other routes.

Table 6.38 Bus Service at Kanpur Bus Depot

Sr. No.	Destination	No. of Vehicles	Trips/Bus	No. of Trips	Type of Service
1.	Varanasi	5	3	15	Scania/Volvo
2.	Mathura	5	2	10	Bus
3.	Agra	3	3	9	Bus
4.	Delhi	6	3	18	Bus
5.	Etawah*	12	4	48	Scania/Volvo
6.	Etawah	16	3	48	Bus
7.	Firozabad*	10	3	30	Volvo/Scania/Janrath
8.	Firozabad	7	3	21	Bus
9.	Pukhraya	2	3	6	Bus

Note: *AC Buses like Scania, Volvo, Janrath, etc.

Based on the survey, volume count of passenger movement at Kanpur bus depot is done. Passenger movement is more in peak hours (morning and evening during office hours) when mostly working class and students travel. Passenger movement is more in working days than non- working days when offices, school and universities are closed.

Table 6.39 Volume Count of Passenger Movement at Kanpur Bus depot

Sr. No.	Destination	Working Days		Non-Working Days
		Peak Hrs.	Moderate Hrs.	Moderate Hrs.
1.	Varanasi	500	350	307
2.	Mathura	650	250	218
3.	Agra	390	210	176
4.	Delhi	780	420	405
5.	Etawah*	660	825	805
6.	Etawah	1500	600	532
7.	Firozabad*	360	180	167
8.	Firozabad	910	350	307
9.	Pukhraya	260	200	176

Note: *AC Buses like Scania, Volvo, Janrath, etc.

6.7.1.2 Route Survey – Agra

Table 6.40 Route Identification for proposed IWT, originating from Agra

Sr. No.	Origin	Via	Destinations	Considered for IWT
1.	Edgah	Mathura, Faridabad, Kosi, Palwal	Delhi	✓
2.		Bharatpur, Mahua, Beelaji, Dausa	Jaipur	✗
3.		Saiyyan, Dholpur, Morena	Gwalior	✗
4.		Fatehabad, Bah, Arnata, Khudimod	Bhind	✗
5.		Jaipur, Kanpur, Lucknow	Sonauli	✗
6.		Etawah, Auraiya, Kanpur, Lucknow, Bahraich	Rupedia	✗
7.		Firozabad, Mainpuri, Bewar	Faurrakhabad	✗
8.	Fort	Etawah, Firozabad	Lucknow	✗
9.		Lucknow,Kanpur, Etawah	Sanauli	✗
10.		-	Haridwar	✗
11.		Farah	Mathura	✓
12.		Mainpuri	Agra	✓
13.		Tundla	Firozabad	✓
14.		-	Meerut	✗
15.		Pilbhit, Haldwani, Bareily	Tanakpur	✗
16.		-	Aligarh	✗
17.		Palwal, Kosi, Faridabad	Delhi	✓
18.		Palwal, Mathura, Kosi	Gurgaon	✓
19.		-	Bareily	✗
20.		-	Etawah	✓
21.		-	Gorakhpur	✗
22.		Yamuna Expressway, Pari Chowk	Noida	✓
23.		Bharatpur, Mahua, Balaji	Jaipur	✗
24.	Foundary Nagar	Tundla, Jhalesar	Firozabad	✗
25.		Fatehabad, Arnata, Bah	Bah	✓
26.		Dhauki, Fatehabad, Arnata	Pinhat	✓
27.		Farah	Mathura	✓
28.		Saiyyan	Kheragarh	✓
29.		Samsabad	Samsabad-Kheragarh	✓
30.		Atmadpur	Tundla Rly Stn	✓

Note: '*' AC Buses like Scania, Volvo, Janrath, etc.

Table 6.41 Bus Service at Bus Depots of Agra

Sr. No	Origin	Destination	No. of Vehicles	No. of Trips	Purpose
1.	Edgah	Delhi	30	1	Tourist Purpose
2.	Fort	Mathura	10	2	Office
3.		Agra	15	2	Student and Labour
4.		Firozabad	15	3	Tourist Purpose
5.		Central Delhi	15	1	Tourist Purpose
6.		Gurgaon	8	1	Tourist Purpose
7.		Etawah	15	2	Tourist Purpose
8.		Noida	10	1	Tourist Purpose
9.	Foundary Nagar	Bah	20	3	Student and Office
10.		Pinhat	20	2-3	Tourist Purpose
11.		Mathura	10	3-4	Tourist Purpose
12.		Kheragarh	15	3-4	Tourist Purpose
13.		Samsabad-Kheragarh	10	3	Tourist Purpose
14.		Tundla Rly Stn	20	3	Tourist Purpose

Table 6.42 Volume Count of Passenger Movement at Bus depots of Agra

Sr. No	Bus Service	Destination	Tariff (INR/Passenger)	Daily Traffic (No.)
1.	Edgah	Delhi	227	1,350
2.	Fort	Mathura	69	1,000
3.		Agra	76	1,500
4.		Firozabad	56	2,025
5.		Delhi	227	675
6.		Gurgaon	185	360
7.		Etawah	136	900
8.		Noida		500
9.	Foundary Nagar	Firozabad	56	4,500
10.		Bah	75	3,000
11.		Pinhat	58	2,400
12.		Mathura	76	2,000
13.		Kheragarh	40	3,000
14.		Samsabad-Kheragarh	25	1,500
15.		Tundla Rly Stn	35	3,000

6.7.1.3 Route Survey – Mathura

Based on the survey in Mathura, routes are identified for proposed waterway. The below table shows various routes, which originate from Mathura Bus Depot. Routes, which come in the hinterland of river Yamuna and have along the river movement, are only considered for proposed waterway movement. Routes, which are far from the hinterland, are not considered for waterway movement.

Table 6.43 Route Identification for proposed IWT, originating from Mathura

Sr. No.	Destination	Districts	Considerable for Proposed IWT
1.	Delhi	Delhi	✓
2.	Sonauli	Maharajganj	✗
3.	Haridwar	Haridwar	✗
4.	Gorakhpur	Gorakhpur	✗
5.	Banaras	Varanasi	✓
6.	Lucknow	Lucknow	✗
7.	Tanakpur	Champawat	✗
8.	Bareilly	Bareilly	✗
9.	Noida	Gautam Buddha Nagar	✓
10.	Firozabad	Firozabad	✓
11.	Vrindavan	Mathura	✓
12.	Govardhan	Mathura	✓
13.	Barsana	Mathura	✓
14.	Kosi	Mathura	✓
15.	Unnao Depot	Unnao	✓
16.	Fatehpur	Fatehpur	✓
17.	Azadnagar		✗
18.	Keshavbagh		✗
19.	Awadh		✗
20.	Jhansi	Jhansi	✗
21.	Dholpur depot	Dholpur	✗
22.	Rath depot	Hamirpur	✗
23.	Ma depot		✗
24.	Banda depot	Banda	✓
25.	Mau depot	Mau	✗
26.	Badiga depot		✗
27.	Etawah	Etawah	✓
28.	Taz depot		✗
29.	Fort		✗
30.	Foundary Nagar	Agra	✓
31.	Edgah	Agra	✓
32.	Hathras	Hathras	✓
33.	Kasganj	Kasganj	✗
34.	Aligarh	Aligarh	✗
35.	Shahjahanpur	Shahjahanpur	✗
36.	Rohil Khand	Bareilly	✗
37.	Bulandshahar	Bulandshahar	✗
38.	Haridwar	Haridwar	✗
39.	Bareilly	Bareilly	✗
40.	Aligarh	Aligarh	✗
41.	Bajna	Mathura	✓
42.	Moradabad	Moradabad	✗

The below table shows details of bus service at Mathura Bus Depot. Only 15 destinations, which are considered for proposed waterway, as shown in the table below. Mathura to Govardhan is the busiest route, as number of trips to/ from Govardhan is more than other routes.

Table 6.44 Bus Service at Mathura Bus Depot

Sr. No.	Origin	Owned/Hired	Destination	No. of Vehicles	No. of Trips
1.	Mathura (New)	Owned	Delhi	21	1
2.			Banaras	1	1
3.			Noida	2	1
4.			Firozabad	28	2
5.			Vrindavan	8	8
6.			Govardhan	30	5
7.			Barsana	15	5
8.			Kosi	15	5
9.		Hired	Fatehpur	1	1
10.			Banda depot	1	1
11.			Etawah	3	1
12.			Foundary Nagar	10	2
13.			Edgah	2	2
14.			Hathras	1	1
15.	Mathura (Old)	Owned	Bajna	15	2

Tourists are the major contributor in traffic at Mathura. Being a religious place of Hindus, Mathura attracts large number of tourists from all over the country. Mathura is also favourite among International tourists, as it is popular as the birthplace of Lord Krishna.

Table 6.45 Traffic at Mathura Bus Depot

Sr. No.	Bus Service	Destination	Travel Purpose	Daily Traffic (No.)
1.	Mathura (New)	Delhi	Tourist/ Work	420
2.		Banaras	Tourist	60
3.		Noida		40
4.		Firozabad		1,120
5.		Vrindavan		1,600
6.		Govardhan		3,750
7.		Barsana		1,500
8.		Kosi		2,250
9.		Fatehpur	Villagers/ Relatives	25
10.		Banda depot		30
11.		Etawah		150
12.		Foundary Nagar		700
13.		Edgah		140
14.		Hathras		50
15.	Mathura (Old)	Bajna	Tourist	1,800

6.7.1.4 Route Survey – Prayagraj

Based on the survey in Prayagraj, routes are identified for proposed waterway. The below table shows various routes, which originate from Prayagraj Bus Depot. Routes, which come in the hinterland of river Yamuna and have along the river movement, are only considered for proposed waterway movement. Routes, which are far from the hinterland, are not considered for waterway movement. There are 14 routes to/from Prayagraj which are considered for proposed waterway.

Table 6.46 Route Identification for proposed IWT, originating from Prayagraj

Sr. No.	Origin	Destinations	To be considered for IWT
1.	Civil Lines	Lucknow	✗
2.		Bansi	✗
3.		Bahraich	✗
4.		Delhi Via Kanpur	✓
5.		Gorakhpur	✗
6.		Varanasi	✓
7.		Pratapgarh	✓
8.		Kunda	✓
9.		Sultanpur	✗
10.		Goi Ganj Bhadohi	✗
11.		Akbarpur	✗
12.		Badlapur	✓
13.		Kanpur, Agra, Mathura	✓
14.		Haldwani, Agra	✗
15.		Jhansi Via Kanpur	✓
16.		Tanda Via Pratap	✗
17.		Mau / Azamgarh	✗
18.		Gonda	✗
19.	Civil Lines (Cab Tavera)	Shahganj	✓
20.		Jalalpur	✗
21.		Malipur	✗
22.		Lucknow	✗
23.	Bai Ka Bagh	Karwi	✗
24.		Banda	✓
25.		Rewa	✓
26.		Seedhi	✗
27.		Mirzapur	✗
28.		Rubartsganj	✗
29.	Leader Road	Rajapur	✗
30.		Muratganj	✗
31.		Maujanpur	✗
32.	Zero Road Bus Depots	Banda	✓

Sr. No.	Origin	Destinations	To be considered for IWT
33.		Mahoba	✗
34.		Sagar	✗
35.		Mirzapur	✗
36.		Obra	✗
37.		Shakti Nagar	✗
38.		Hanuman	✗
39.		Seedhi	✗
40.		Koraw Nagar Mijan	✗
41.		Kurki	✗
42.		Rewa	✓
43.		Amarkautak	✗
44.		Seedthi	✗
45.		Banda	✓
46.		Renukot	✗
47.		Rabarstganj	✗
48.		Chakghaut	✓

Table 6.47 Bus Service at Bus Depots of Prayagraj

Sr. No.	Origin	Destination	No. of Vehicles	No. of Trips	Purpose
1.	Civil Lines	Delhi Via Kanpur	5	1	Company Tour
2.		Varanasi	30	1	Govt., Office, Local
3.		Pratapgarh	25	2	Local, Medical Student
4.		Kunda	10	3	Pvt. Job, Teacher, Student
5.		Badlapur	15	2	Student medical
6.		Kanpur, Agra, Mathura	8	1	Govt. job, Private office
7.		Jhansi Via Kanpur	2	1	Company work
8.	Civil Lines (Cab Tavera)	Shahganj	12	2	Student, Medical, Pvt Job
9.	Bai ka Bagh	Banda	15	1	Govt. job, Student, Medical
10.		Rewa	15	1	Govt. job, Student, Medical
11.	Zero Road Bus Depot	Banda	40	1	
12.		Rewa	8	1	Personal work, Govt. job, student
13.		Banda	6	1	Govt. job, student
14.		Chakghaut	4	1	Student; Govt. job

Table 6.48 Traffic at Bus Depots of Prayagraj

Sr. No.	Bus Service	Destination	Daily Traffic
1.	Civil Lines	Delhi Via Kanpur	125
2.		Varanasi	900

Sr. No.	Bus Service	Destination	Daily Traffic
3.		Pratapgarh	2,500
4.		Kunda	1,500
5.		Badlapur	900
6.		Kanpur, Agra, Mathura	360
7.		Jhansi Via Kanpur	60
8.	Civil Lines (Cab Tavera)	Shahganj	1,200
9.	Bai ka Bagh	Banda	600
10.		Rewa	600
11.	Zero Road Bus Depot	Banda	2,200
12.		Rewa	440
13.		Banda	330
14.		Chakghaut	100

There are some cities located on the banks of River Yamuna. The distance of waterways is at least 1 km away from the city. Hence, any person willing to use waterways has to first travel a few kilometres in the city to reach at the water terminal site. The waterway has speed restriction. The efficient and economical speed of water transport is about 10 knots to 12 knots. This speed is less as compared to the average speed logged by Railways and roadways. The development of Yamuna Expressway along with 6 lane National highways has further reduced transportation time in the hinterland of Yamuna. Hence, it would not be possible to develop water transportation for passengers due to the above-mentioned reasons. The passengers would find water transport time-consuming. The regular office going peoples, students and such travels would be avoided. Hence, passenger transportation for the local travel has been discarded in cities of River Yamuna, except two cities namely Delhi and Prayagraj (Sangam).

6.7.2 Intra District Passenger Tourism

- **Water Taxi – Delhi**

DIMTS and DTC together operate about 5,000 numbers of buses for Delhi. Due to increased population and demand, there is requirement for about 10,000 numbers of buses. The procurement for additional buses is taking time because of scarcity of space required for parking of additional buses. It is expected that additional 135 acres of land is required for parking. DTC's daily carrying capacity is about 30 lakhs, which is more than passenger carrying capacity of Delhi Metro. Despite this there is a growing demand to cater more passengers. If water taxi could be started on Yamuna, it could ease the burden of both DTC and DIMTS. People would also have another mode of transportation open for their daily commute. Developing water taxi as a daily commute option would be feasible.

Fig. 6.41 Proposed water taxi route

Fig. 6.42 Proposed Jagatpur Terminal

Fig. 6.43 Proposed Soniya Vihar Terminal

Fig. 6.44 Proposed Tronica City Terminal

Fig. 6.45 Signature Bridge near Soniya Vihar

Table 6.49 Details of Water Taxi operated in other countries

Location	Population (million)	Tourists (million) p.a	Speed (knots)	Passenger Capacity	Travel Time (minutes)	Distance between two furthest points (Km)
Boston	6.4	22.5	10	17-21	12	4
Victoria	0.08	3.5	7	12	21	5
Istanbul	13.9	11.6	10	10	4 mnts to 2hrs.	34
Sydney	4.6	10.5	20-25	Oct-20	30	24
Hong Kong	7	42	3	300	15	1
Seattle	0.635	8.8	26	172	Oct-20	15

Above table represents water taxi movement in various countries. Specifications provided in above table are intended for general information only. Vessel specifications and other details may vary subject to geographical and other conditions.

- **Sangam - Prayagraj**

The most famous place in Prayagraj is Triveni Sangam. This is the point, where three holy rivers, Ganga, Yamuna and Saraswati merge. Both the rivers, Ganga and Yamuna are associated with mythology and are considered sacred rivers in India. Hence, the confluence point of these rivers has high religious importance. Triveni Sangam is a sacred place for Hindus. It attracts large number of devotees every day from all over the country. It is the site of Kumbh Mela every twelve years, Ardh Kumbh every six years and Magh Mela every year. Maha Kumbh Mela occurs after 144 years. Maha Kumbh is the largest religious gathering of the world. During Kumbh Mela, devotees take holy dip in Triveni Sangam. Each day is auspicious for bathing. However, some dates have special significance and are considered most auspicious. During these special days, Prayagraj witnesses a huge surge of devotees.

Triveni Sangam is associated with Hindu mythology. It is believed that Lord Brahma had performed the Prakrista Yagna here; hence Prayagraj was previously known as Prayag. It is also believed that Lord Vishnu was carrying a kumbh (pot) of amrit (nectar) and four drops of nectar spilled. They fell at the four Tirthas, namely Prayag, Haridwar, Nasik and Ujjain. This event is commemorated every three years by the Kumbh Mela, held at each tirtha in turn. The Sangam is called Tirtharaj, the ‘King of Tirthas’. Devotees believe that water of Triveni has healing power and a holy bath here would make one free from the karmic cycle of birth and rebirth.

It is easy to distinguish Yamuna and Ganga at the Sangam, as both the rivers maintain their identity and colour when they merge. While Yamuna is deep, calm and greenish in colour, Ganga is shallow, forceful and yellow in colour. Saraswati remains hidden, but devotees believe that she flows underwater. Saraswati is a mythical river, supposed to have dried up long back. During the monsoon, when the rivers are in full force, the confluence is seen clearly. Due to the force, it is difficult to take a dip at the confluence. While Ganga is only 4-6 feet deep, Yamuna is 40-60 feet deep in non-rainy season. After merging at the Sangam, both the rivers continue their journey to Bay of Bengal.

A boat ride takes around 10 minutes from the bank takes to Triveni Sangam. Tourists can take holy dip and perform puja. Pandits take people across the river in boats, which serve as a makeshift platform, where one can perform pujas. Puja is usually conducted in the waters. The boat ride is very scenic. One can see many sea gulls, flying around. The boat ride to the spot where puja is performed is expensive, as pandits and boat owners manipulate the price and over charge visitors. People need to bargain with boatmen for the price of boat ride. Boat ride is available from different ghats of Prayagraj to Triveni Sangam. Following table depicts boat ride tariff from other ghats to Triveni Sangam.

Table 6.50 Boat ride tariff from other ghats to Sangam

Name of ghats	Rates- both ways (INR)
Balua Ghat	53
Gau Ghat	44
Imly Ghat	42
Minto Park	42
Mankameshwar	42
Saraswati Ghat	42
Quila Ghat	40
Arail Ghat	32
Mela Ghat	32

Name of ghats	Rates- both ways (INR)
Someshwar Ghat	26
Ganga & Yamuna	26
Shankh Beni Ghat	26
Ram Ghat	24
Raj Ghat	24

Source: Uttar Pradesh Tourism

The Boat ride tariff, as shown in the above table, is fixed. It is issued by Prayagraj Administration. If a boat is hired for a group, then the price would be calculated by multiplying number of person with tariff of each person. On total sum, there would be discount of 25%. For example, if a boat is hired for 10 people from Balua ghat, total rate would be INR 397.50, instead of INR 530.

- **Prayagraj Fort**

This old fort is located on the bank of Yamuna River, near Triveni Sangam. Mughal emperor, Akbar built this fort. The fort's design, construction and craftsmanship are magnificent. This fort has three galleries flanked by high towers. The East India Company used the fort as its garrison. The British did some renovation in the fort. At present, the fort is used by Indian Army and only a limited area is open to visitors. Entry is restricted in inner parts of the fort. Visitors are allowed to see the Ashoka Pillar, Saraswati Koop, which is believed to be the source of the Saraswati River and Jodhabai Palace. Ashoka pillar is made of polished sandstone in 232 B.C. and is 10.6 meters high. The fort also houses the famous Patalpuri temple and Akshay Vat or immortal Banyan tree. The temple and tree are mentioned in many ancient scriptures.

- **Hanuman Temple**

This ancient temple is located near Prayagraj Fort and very close to Triveni ghat. In this temple, one can see and worship a big idol of Lord Hanuman in lying or resting posture. The deity is called Bade Hanuman ji. A myth is associated with the temple. According to the myth, when the British were renovating Prayagraj Fort, the fort wall was coming in the way of the temple. With every effort to remove the deity of Hanuman, the size of the deity grew bigger. The commanding officer of the fort got a dream not to disturb the temple, and he did so and left the temple in its original form.

- **Shivkoti Mahadev Temple**

Shivkoti Mahadev Temple is located on the bank of river Yamuna, near Triveni Sangam. This temple is also known as Someshwar Mahadev Temple. The temple also acts as a resting place for the devotees, who seek spiritual experience and would like to sit near the temple. Devotees go to the temple after the holy dip in Triveni Sangam to seek blessings of Lord Shiva.

Apart from above mentioned tourist places near Triveni Sangam, there are other places to visit in Prayagraj. The city is known for beautiful architecture from Nawab and British era. Some of the popular places in Prayagraj are All Saints Cathedral, Alfred Park, Prayagraj High Court, Ashok Pillar, Anand Bhawan, Swaraj Bhawan and Prayagraj Planetarium.

- **Upcoming Development Around Triveni Sangam**

Prayagraj is a major religious center and attracts large number of pilgrims and foreign tourists annually. As per site of Uttar Pradesh Tourism, 7,83,15,500 Indians and 3,50,000 foreigners visited Kumbh, 2013 (between January 2013 to March 2013). It is expected that around 12 lakh pilgrims would be visiting Sangam every day during Kumbh, 2019. Keeping Kumbh of 2019 in mind, the government has planned some upcoming developments around Triveni Sangam.

A large Tent City would be developed for Kumbh, 2019. A massive area of over 800 acres would be developed for stay of pilgrims and other tourists. This Tent city or 'city of tents' would be bigger than the previous Kumbh of 2013. It would comprise of thousands of tents, roads, streets and other facilities. The Tent City would also have tents of 13 prominent Akharas and saints, who come from all parts of the country. The Mela area, along with a maze of roads, streets and tents would be accessed by Google Map during Kumbh, 2019. This would be very useful for pilgrims and tourists to find their way in the vast Mela area.

The Kumbh Mela Authority has planned to set up 120 parking slots on 1,193 hectare land, around the Mela area. These parking slots would accommodate over 6 lakh vehicles, expected on the main days of Kumbh. In Kumbh, 2019, there would be a huge parking area, which would be 2.5 times bigger than the parking area during Kumbh Mela, 2013. Around 125 cranes would be deployed at the parking slots to clean routes or to lift small or heavy vehicles during any emergency. There is a plan to develop a ropeway facility over Yamuna near Sangam, before Ardh Kumbh. Two sites, Boat Club and near Saraswati Ghat, have been suggested for the proposed facility. River Traffic Control System (RTCS) will be extended to Prayagraj before Kumbh 2019. RTC controls the navigation of steamers and ships on waterway. For Kumbh 2019, Authority of Prayagraj division of North Central Railway (NCR) has taken up several development projects at Prayagraj Junction and its surrounding areas. The development works include a new platform, installation of CCTV cameras, a green belt, large size retiring rooms etc.

6.7.3 Other States

6.7.3.1 Tourism in Haryana

There are many places in Haryana, which attract tourists from all over the country. Some of the famous places are Sultanpur National Park Bird Sanctuary, Sohna Lake, Heritage Transport Museum, Vintage Camera Museum, Sonipat, Kingdom of dreams etc. Sultanpur is the habitat of almost 250 species of birds, among which some are local residents, while others migrate from far-off lands like Siberia, Afghanistan and Europe. Sohna Lake is renowned for its sand littered with gold, hence it got its name, Sohna (Gold). Sonipat is famous for being the legendary Suvarnaprastha Village of Mahabharata, one of the five villages that were demanded by the Pandavas in return for handing over Hastinapur to Kauravas.

Some monuments provide a glimpse of bygone Mughal era. These places include Farrukhnagar Fort, Sheesha Mahal, Qutub Khan's Tomb and Mughal Bridge. Apart from these tourist sites, there are places for recreational activities, like paramotoring, parasailing, paintball, water park, golf club, Damdama lake boating, Epicenter and many resorts.

6.7.3.2 Tourism in Rajasthan

Tourist places located in Karauli, Dausa and Alwar are more than 100 km away from river Yamuna, hence they are not considered to determine potential tourist traffic for NW 110. Only two districts, which fall within the radius of 100 km are Bharatpur and Dholpur. All the tourist locations have better road and rail connectivity and are far away from river Yamuna.

In Bharatpur district, there are tourist places, like bird sanctuary, wildlife sanctuaries, historic forts etc. Some of the famous places are Keoladev National Park and Bharatpur Bird Sanctuary, Bharatpur Palace and Museum, Ganga Mandir, Lohagarh Fort, Deeg, Band Baretha wildlife reserve and Kaman. Keoladev National Park is the most famous tourist destination. In FY -17, nearly 1,47,250 numbers of tourists visited this park. Among them, walk-in tourists contributed more to the total number of people visited. In Dholpur district, the major attractions are City Palace, Nihal Tower, Van Vihar Sanctuary and Ramsagar wildlife sanctuary.

6.7.3.3 Tourism in Madhya Pradesh

Madhya Pradesh has many national parks, heritage sites, forts & palaces, religious monuments etc. Madhya Pradesh has dense forest covers, which houses many famous national parks, like Kanha, Bandhavgarh, Shivpuri, Panna, Pench etc. Tourists visit these national parks to see tigers, bisons, deer and other wild animals.

There are three sites in MP, which are declared World Heritage Sites by UNESCO; these sites are the Khajuraho Group of Monuments, Buddhist Monuments at Sanchi and the Rock Shelters of Bhimbetka.

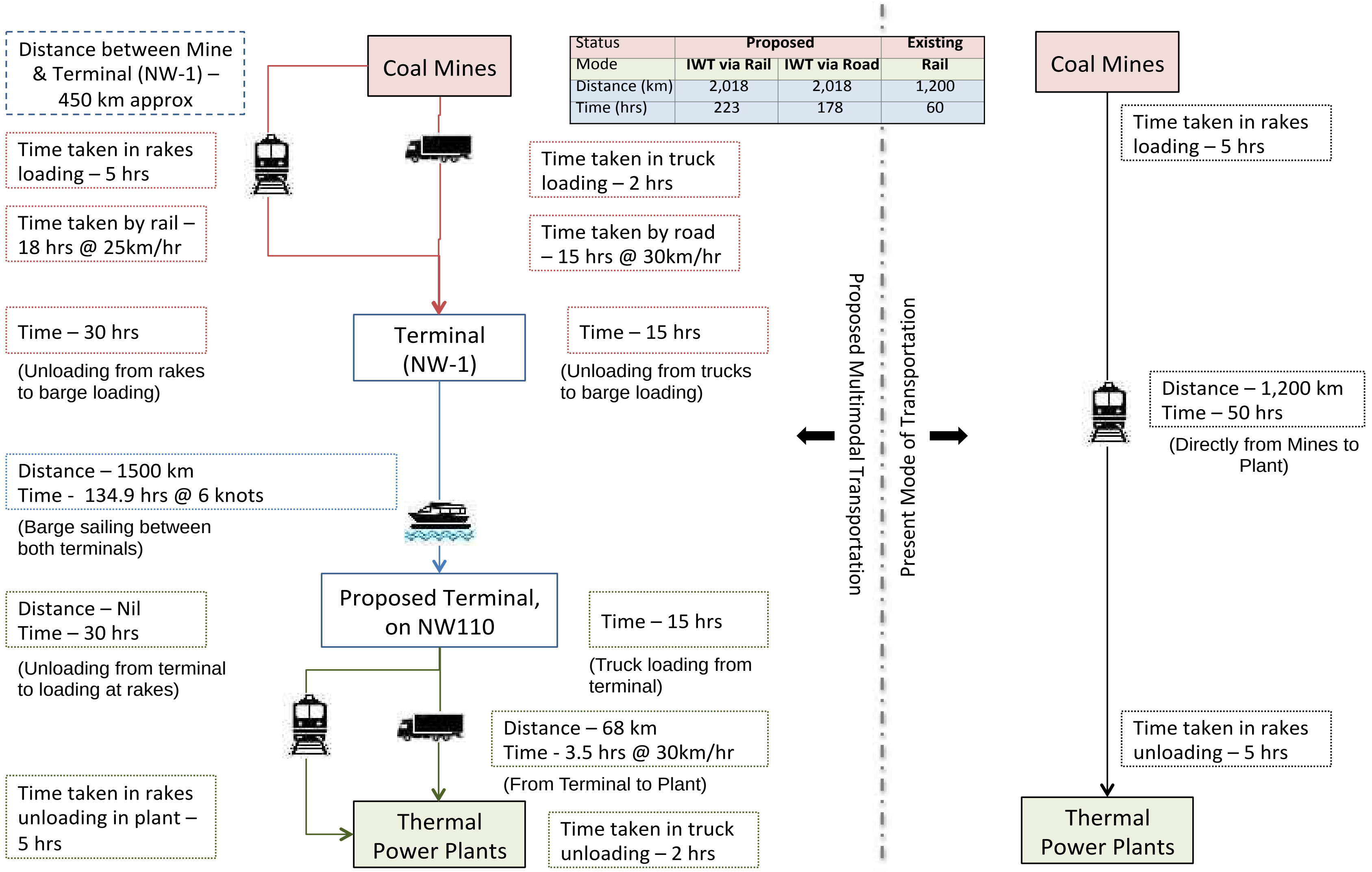
6.8 Cargo Terminal Locations

Efforts have been made to select location of terminals that requires minimum investment for development. The operational cost of transporting cargo on River has been planned to be optimum. The overall unit transportation cost has to be proposed to be shifted from road and rail to the proposed waterways is also minimal.Two separate types of terminal have been identified for cargo transportation. Mineral related bulk materials that are classified as dirty cargo due to their nature has to be handled on separate terminals. Such cargo mostly constitutes coal and fly ash. Other categories of minerals extracted in Uttar Pradesh are lower in volume and it was found to be difficult to shift them to the waterways.Multipurpose terminals have been proposed wherever there is a possibility of handling multiple commodities. These commodities are mostly categorised as clean cargo. They have to be handled carefully and away from dirty cargo to avoid any type of contamination. Commodities such as foodgrains, fertiliser and other break bulk cargo such as iron and steel, automobiles, etc could be handled at these terminals. The terminal locations have been described in the map below. These terminals have been identified based on the market survey and analysis of the needs of local economy and population.

Fig. 6.46 Cargo Terminal Mapping on Yamuna River

6.8.1 Coal

All thermal based plant within 200 km of Yamuna (NW 110) hinterland has been considered for traffic estimation and projection. The capacity and coal consumption of respective TPP is entirely based on database of Central Electricity Authority (CEA), National Thermal Power Corporation (NTPC) and Coal India Mine.



Status	Proposed		Existing
Mode	IWT via Rail	IWT via Road	Rail
Distance (km)	2,018	2,018	1,200
Time (hrs)	223	178	60

Fig. 6.47 Time-Distance Comparision of Coal Movement

6.8.1.1 Assumptions

In the following table, percentage share of domestic & imported coal are described with respect to all thermal power plants along with capacity and coal consumption. All power plants considered for cargo projection use domestic coal only, except NTPC Dadri, Feroz Gandhi Unchahar & Rosa TPP.

Table 6.51 Assumptions for Traffic Projection of Coal

Name of Plants	Capacity (MW)	Coal ('000 T)	Coal Mines	Procurement Locations & Quantity (%Share)*					Opportunity for Yamuna	No Opportunity
				N.K.F	NCL	BCCL / ECL	Other	Import		
NTPC Dadri	1,820	8,128	Piparwar Mines				90%	10%	100%	0%
Badarpur	705	2,706	ECL			100%			100%	0%
Harduaganj	665	2,981	BCCL & ECL			100%			100%	0%
Jawaharpur (P)	1,320	5,630	CCL / NCL / SECL		40%		20%		60%	40%
NTPC Tanda	440	2,498	North Karnpura	100%					100%	0%
Unchahar TPP	1,050	5,005	North Karnpura	90%				10%	100%	0%
Parichha TPP	1140	4,859	BCCL / ECL			100%			100%	0%
Panki Thermal	210	917	BCCL / ECL			100%			100%	0%
Rosa Thermal	1,200	5,211	Ashoka Coal Mines					20%	20%	80%
Meja STPP (P)	1320	5,630	NCL		100%				100%	0%
Bara TPP (Prayagraj)	1,980	8,445	NCL		100%				100%	0%

Source : CEA,NTPC,Coal India,

Following table indicates the amount of domestic as well as imported coal procured for different thermal power plant. The origin-destination pair for coal-based power plant has been analysed, taking into account volume of domestic coal from different coal mines and imported coal.

Table 6.52 Opportunity identifcation and volumes of coal

('000 T)

Name of Plants	Capacity (MW)	Coal ('000 Tonnes)	Coal Mines	Procurement Locations & Quantity (%Share)*					Opportunity for Yamuna	No Opportunity
				N.K.F	NCL	BCCL/ECL	Other	Import		
NTPC Dadri	1,820	8,128	Piparwar Mines	-	-	-	7,315	813	8,128	-
Badarpur TPP	705	2,706	ECL	-	-	2,706	-	-	2,706	-
Harduaganj	665	2,981	BCCL & ECL	-	-	2,981	-	-	2,981	-
Jawaharpur TPP (P)	1,320	5,630	CCL / NCL / SECL	-	2,252	-	1,126	-	3,378	2,252
NTPC Tanda	440	2,498	North Karnpura	2,498	-	-	-	-	2,498	-
Feroz Gandhi Unchahar	1,050	5,005	North Karnpura	4,505	-	-	-	501	5,005	-
Parichha TPP	1140	4,859	BCCL / ECL	-	-	4,859	-	-	4,859	-
Panki Thermal	210	917	BCCL / ECL	-	-	917	-	-	917	-
Rosa Thermal	1,200	5,211	Ashoka Coal Mines	-	-	-	-	1,042	1,042	4,169
Meja TPS (P)	1320	5,630	NCL	-	5,630	-	-	-	5,630	-
Bara TPP (Prayagraj)	1,980	8,445	NCL	-	8,445	-	-	-	8,445	-

Source : CEA,NTPC,Coal India

All the assumptions are made for three scenarios, i.e. optimistic, realistic and pessimistic. Fy 17 has been taken as base year for all the cargo related projection. It is assumed that all the power plants would grow at rate of 8% for first 5 years till Fy 22, then 5% for next 5 years by Fy 27 irrespective of all different scenarios. In optimistic scenario after Fy 27, gradual increment of 6% in shift has been taken in account. Similarly, in realistic & pessimistic scenarios, it has been taken as 4% and 2% respectively. Cargo is proposed to be shifted from present mode of transportation using railways to waterways. The ultimate capacity of the power plants has been kept based on the existing capacity as well as incorporation of expansion. The volume of coal proposed for waterways has been derived taking a nominal % share of existing volume. The volume of shift would increase in proportion to the acceptability of water transport and development of NW 110. The power plants would shift up to a certain % of their cargo to waterways, even after complete development of River Yamuna, due to uncertainty and seasonality of water in the river system. Hence, most appropriate % shift has been taken for different power plants and existing volume of coal required by them.

Thecoal shift has been assumed as such that the ultimate share of waterway should reach about 40% of total coal transportation in optimistic scenario, 35% of total coal transportation in realistic scenario and 28% of total coal transportation in pessimistic scenario. Here, the existing volume of coal remains same due to non-availability of future expansion plan of power plant. The value of these shares has been taken based on qualitative view from consultant. There was an effort to contact power plants and take inputs on the share of cargo distribution using railways and waterways. They said that waterways would not be fully reliable. Hence, they would share only a certain % of total transportation if it fully developed and deemed to be cost effective/reliable compared to their present mode of transportation.

Table 6.53 Gradual Annual Shift of Coal Traffic from Indian Railways to NW-110

Name of Plants	Terminal	Fy 17 Traffic ('000 T)	Optimistic Scenario					Realistic Scenario					Pessimistic Scenario				
			5 Yr	10 Yr	15 Yr	20 Yr	30 Yr	5 Yr	10 Yr	15 Yr	20 Yr	30 Yr	5 Yr	10 Yr	15 Yr	20 Yr	30 Yr
NTPC Dadri	1	813	8%	5%	4%	4%	4%	8%	5%	4%	3%	3%	8%	5%	2%	2%	2%
Badarpur TPP		271	8%	5%	4%	4%	4%	8%	5%	4%	3%	3%	8%	5%	2%	2%	2%
Harduaganj	2	298	8%	5%	4%	4%	4%	8%	5%	4%	3%	3%	8%	5%	2%	2%	2%
Jawaharpur TPP*		338	8%	5%	4%	4%	4%	8%	5%	4%	3%	3%	8%	5%	2%	2%	2%
NTPC Tanda	3	250	8%	5%	4%	4%	4%	8%	5%	4%	3%	3%	8%	5%	2%	2%	2%
Unchahar		501	8%	5%	4%	4%	4%	8%	5%	4%	3%	3%	8%	5%	2%	2%	2%
Parichha TPP	4	486	8%	5%	4%	4%	4%	8%	5%	4%	3%	3%	8%	5%	2%	2%	2%
Panki Thermal		92	8%	5%	4%	4%	4%	8%	5%	4%	3%	3%	8%	5%	2%	2%	2%
Rosa Thermal		104	8%	5%	4%	4%	4%	8%	5%	4%	3%	3%	8%	5%	2%	2%	2%
Meja STPP*	5	563	8%	5%	4%	4%	4%	8%	5%	4%	3%	3%	8%	5%	2%	2%	2%
Bara TPP		844	8%	5%	4%	4%	4%	8%	5%	4%	3%	3%	8%	5%	2%	2%	2%

Source : CEA,NTPC,Coal India
'*' denotes proposed thermal power plant

6.8.1.2 Traffic Projections

Optimistic Scenario

It is estimated that 10% of total coal requirement of each TPP mentioned in the above table would be diverted to waterway, since the time waterway would be operational. Following table shows the traffic projection for coal till Fy 47, based on above mentioned assumptions in optimistic scenario.

Table 6.54 Volume of Coal inOptimistic Scenario('000 T)

Cargo Terminal	Locations	Company	Origin	Destination	Existing Volume	Fy 17	Fy 22	Fy 27	Fy 37	Fy 47
1	Madanpur Khadar(Delhi)	NTPC Dadri	Piparwar Mines	Dadri	8,128	813	1,194	1,524	2,256	3,340
		Badarpur TPP	ECL	Badarpur	2,706	271	398	507	751	1,112
2	Samogar Mustkil (Agra)	Harduaganj	BCCL	Harduaganj, Aligarh	2,981	298	438	559	827	1,225
		Jawaharpur TPS	NCL	Prayagraj	5,630	338	496	633	938	1,388
3	Kaushambhi (Mahewa Khachhar)	NTPC Tanda	Northern Karnpur Coal Fields	Tanda	2,498	250	367	468	693	1,026
		Feroz Gandhi Unchahar	Northern Karnpur Coal Fields	Unchahar	5,005	501	735	939	1,389	2,057
4	Dilauliya Kachhar (Kanpur Dehat)	Parichha TPS	ECL	Parichha, Jhansi	4,859	486	714	911	1,349	1,997
		Panki Thermal	ECL	Panki	917	92	135	172	255	377
		Rosa TPP	Haldia	Rosa	5,211	104	153	195	289	428
5	Prayagraj (Naini Bridge)	Meja TPS	NCL	Prayagraj	5,630	563	827	1,056	1,563	2,313
		Bara TPS	NCL	Prayagraj	8,445	844	1,241	1,584	2,344	3,470

Source : CEA,NTPC,Coal India

Realistic Scenario

Similarly, in case of realistic scenario, 10% of total coal consumption is assumed to be diverted to waterway since the time waterway would become operational. Following table shows cargo projection for coal in realistic scenario.

Table 6.55 Volume of Coal inRealistic Scenario('000 T)

Cargo Terminal	Locations	Company	Origin	Destination	Existing Volume	Fy 17	Fy 22	Fy 27	Fy 37	Fy 47
1	Madanpur Khadar (Delhi)	NTPC Dadri	Piparwar Mines / Haldia (Imported)	Dadri	8,128	813	1,194	1,524	2,150	2,889
		Badarpur TPP	ECL	Badarpur	2,706	271	398	507	716	962
2	Samogar Mustkil (Agra)	Harduaganj	BCCL	Harduaganj, Aligarh	2,981	298	438	559	788	1,060
		Jawaharpur TPS	NCL	Prayagraj	5,630	338	496	633	893	1,201
3	Kaushambhi (Mahewa Khachhar)	NTPC Tanda	Northern Karnpur Coal Fields	Tanda	2,498	250	367	468	661	888
		Unchahar TPP	Northern Karnpur Coal Fields	Unchahar	5,005	501	735	939	1,324	1,779
4	Kanpur Dehat (Daulatpur)	Parichha TPP	ECL	Parichha, Jhansi	4,859	486	714	911	1,285	1,727
		Panki Thermal	ECL	Panki	917	92	135	172	243	326
		Rosa TPP	Haldia	Rosa	5,211	104	153	195	276	370
5	Prayagraj (Naini Bridge)	Meja TPS	NCL	Prayagraj	5,630	563	827	1,056	1,489	2,001
		Bara TPS	NCL	Prayagraj	8,445	844	1,241	1,584	2,234	3,002

Source : CEA,NTPC,Coal India

- **Pessimistic**

Following table shows coal traffic projection till Fy 47 in pessimistic scenario.

Table 6.56 Volume of Coal inPessimistic Scenario('000 T)

Cargo Terminal	Locations	Company	Origin	Destination	Existing Volume	Fy 17	Fy 22	Fy 27	Fy 37	Fy 47
1	Madanpur Khadar(Delhi)	NTPC Dadri	Piparwar Mines / Haldia (Imported)	Dadri	8,128	813	1,194	1,524	1,858	2,265
		Badarpur TPP	Badarpur	Badarpur	2,706	271	398	507	619	754
2	Samogar Mustkil (Agra)	Harduaganj	BCCL	Harduaganj, Aligarh	2,981	298	438	559	681	831
		Jawaharpur TPS	NCL	Prayagraj	5,630	338	496	633	772	941
3	Kaushambhi (Mahewa Khachhar)	NTPC Tanda	Northern Karnpur Coal Fields	Tanda	2,498	250	367	468	571	696
		Feroz Gandhi Unchahar	Northern Karnpur Coal Fields	Unchahar	5,005	501	735	939	1,144	1,395
4	Dilauliya Kachhar (Kanpur Dehat)	Parichha Thermal	ECL	Parichha, Jhansi	4,859	486	714	911	1,111	1,354
		Panki Thermal	ECL	Panki	917	92	135	172	210	256
		Rosa TPP	Haldia	Rosa	5,211	104	153	195	238	290
5	Prayagraj (Naini Bridge)	Meja TPS	NCL	Prayagraj	5,630	563	827	1,056	1,287	1,569
		Bara TPS	NCL	Prayagraj	8,445	844	1,241	1,584	1,930	2,353

Source : CEA,NTPC,Coal India

6.8.2 Fly ash

At present Thermal Power Plant has started using Indian coal of lower grade with higher ash content of the order of 30-45%, whereas imported coalhas low ash content of the order of 10-15%. Therefore, large quantity of ash is generated, which not only requires large area of land for its disposal, but also a reason of worry for environment. Central Electricity Authority tracks fly ash generation and utilization in these power plants.

6.8.2.1 Assumption

In the hinterland of river Yamuna, all the power plants either transport ash to some cement plants or dump it in ash pond. All the assumptions are estimated for three scenarios, i.e. optimistic, realistic and pessimistic. Fy 17 has been taken as base year for all the cargo related projection. For assumption, those power plants are also considered which have higher Fly ash generation than ash utilisation.

It is assumed that in Fy 17, 45% of unutilized fly ash would be shifted to waterway in Optimistic Scenario, 35% in realistic scenario and 25% in pessimistic scenario. It is assumed that IWT movement on NW 110 for all fly ash utilization in power plants would grow at rate of 10% for first 5 year till Fy 22, then 8% for next 5 years by Fy 27, 2% for next 5 years by Fy 32, 1% for rest of the years till Fy 47 in Optimistic scenario. In realistic scenario, it is assumed that gradual increasement of 8% shift would be 8% for first 5 year till Fy 22, then 5% for next 5 years by Fy 27, 2% for next 5 years by Fy 32, 1% for rest of the years till Fy 47.In pessimistic scenario, it is assumed that growth rate would be 5% for first 5 year till Fy 22, then 4% for next 5 years by Fy 27, 1% for rest of the years till Fy 47. The value of these shares has been taken based on qualitative view from consultant. For Fly Ash traffic projection, it is taken into consideration that dumped and unutilized Fly Ash would be exported to Singapore and Bangladesh, using Haldia Port. This unutilized fly ash movement from power plants to the port would be fully shifted (100%) to waterway. Following table only consider those power plants which have higher Fly ash generation than ash utilisation.

Table 6.57 Volume of Fly Ash Generation &Utilisation ('000 T)

Terminals	Locations	Company	Origin	Destination	Capacity (MW)	Ash Generation	Ash Utilisation	Ash left
2	Samogar Mustkil (Agra)	Jawaharpur TPS	Jawaharpur	Singapore	1,320	1,423	672	751
3	Kaushambhi (Mahewa Khachhar)	NTPC Tanda	Tanda	Singapore	440	1,037	570	467
		Unchahar	Unchahar	Singapore	1,050	1,925	1,361	564
4	Dilauliya Kachhar (Kanpur Dehat)	Parichha TPS	Parichha	Singapore	1,140	2,042	1,111	931
		Rosa TPS	Rosa	Singapore	1,200	1,344	601	743
5	Prayagraj (Naini Bridge)	Meja TPS	Prayagraj	Singapore	1,320	1,358	590	768
		Bara TPS	Prayagraj	Singapore	1,980	1,773	910	863

Source: CEA,NTPC,Coal India, By Primary Research

Table 6.58 Share of Unutilised Fly Ash shift to Waterways

Commodity	Optimistic	Realistic	Pessimistic
Fly Ash left Share	45%	35%	25%

6.8.2.2 Traffic Projections

- **Optimistic**

Following table indicates Fly ash traffic projection in Optimistic scenario. It is assumed that movement of fly ash in the proposed waterway would start with 20%of unutilised fly ash. By Fy 27, 100% fly ash would be transported by waterway and would remain constant afterwards.

Table 6.59 Fly Ash Traffic Projection in Optimistic Scenario('000 T)

Terminals	Locations	Company	Origin	Destination	Fy 17	Fy 22	Fy 27	Fy 37	Fy 47
2	Samogar Mustkil(Agra)	Jawaharpur TPS	Jawaharpur	Singapore	338	544	751	751	751
3	Kaushambhi (Mahewa Khachhar)	NTPC Tanda	Tanda	Singapore	210	338	467	467	467
		Feroz Gandhi Unchahar	Unchahar	Singapore	254	409	564	564	564
4	Dilauliya Kachhar (Kanpur Dehat)	Parichha Thermal	Parichha, Jhansi	Singapore	419	675	931	931	931
		Rosa TPP	Rosa	Singapore	334	538	743	743	743
5	Prayagraj (Naini Bridge)	Meja TPS	Prayagraj	Singapore	346	557	768	768	768
		Bara TPS	Prayagraj	Singapore	388	625	863	863	863

Source : CEA,NTPC,Coal India

- **Realistic**

Following table indicates fly ash traffic projection in Realistic scenario. It is assumed that movement of fly ash in proposed waterway will start with 15% of unutilised fly ash. From Fy 32, 100% fly ash would be transported by waterway and would remain constant afterwards.

Table 6.60 Fly Ash Traffic Projection in Realistic Scenario('000 T)

Terminals	Locations	Company	Origin	Destination	Fy 17	Fy 22	Fy 27	Fy 37	Fy 47
2	Samogar Mustkil (Agra)	Jawaharpur TPP	Jawaharpur	Singapore	263	386	493	572	632
3	Kaushambhi (Mahewa Khachhar)	NTPC Tanda	Tanda	Singapore	163	240	307	356	393
		Unchahar	Unchahar	Singapore	197	290	370	430	474
4	Dilauliya Kachhar (Kanpur Dehat)	Parichha TPP	Parichha, Jhansi	Singapore	326	479	611	709	783
		Rosa TPP	Rosa	Singapore	260	382	488	566	625
5	Prayagraj (Naini Bridge)	Meja TPS	Prayagraj	Singapore	269	395	504	585	646
		Bara TPS	Prayagraj	Singapore	302	444	566	657	726

Source : CEA,NTPC,Coal India

- **Pessimistic**

Following table indicates fly ash traffic projection in Pessimistic scenario. It is assumed that Traffic of fly ash will start with 10% of unutilised fly ash. From Fy 37, 100% fly ash would be transported by waterway and would remain constant afterwards.

Table 6.61 Fly Ash Traffic Projection in Pessimistic Scenario

('000 T)

Terminal	Locations	Company	Origin	Destination	Fy 17	Fy 22	Fy 27	Fy 37	Fy 47
2	Samogar Mustkil (Agra)	Jawaharpur TPP	Jawaharpur	Singapore	188	240	292	322	356
3	Kaushambhi(Mahewa Khachhar)	NTPC Tanda	Tanda	Singapore	117	149	181	200	221
		Unchahar	Unchahar	Singapore	141	180	219	242	267
4	Dilauliya Kachhar (Kanpur Dehat)	Parichha TPP	Parichha	Singapore	233	297	361	399	441
		Rosa TPP	Rosa	Singapore	186	237	288	319	352
5	Prayagraj (Naini Bridge)	Meja TPS	Prayagraj	Singapore	192	245	298	329	364
		Bara TPS	Prayagraj	Singapore	216	275	335	370	409

Source : CEA,NTPC,Coal India

6.8.3 Fertiliser

As per Fertiliser Association of India, IFFCO Phulpur produces around 1.6 Mn tonnes of fertiliser. It distributes its production in the surrounding areas. Following table shows the detailed share for growth of waterway transport.

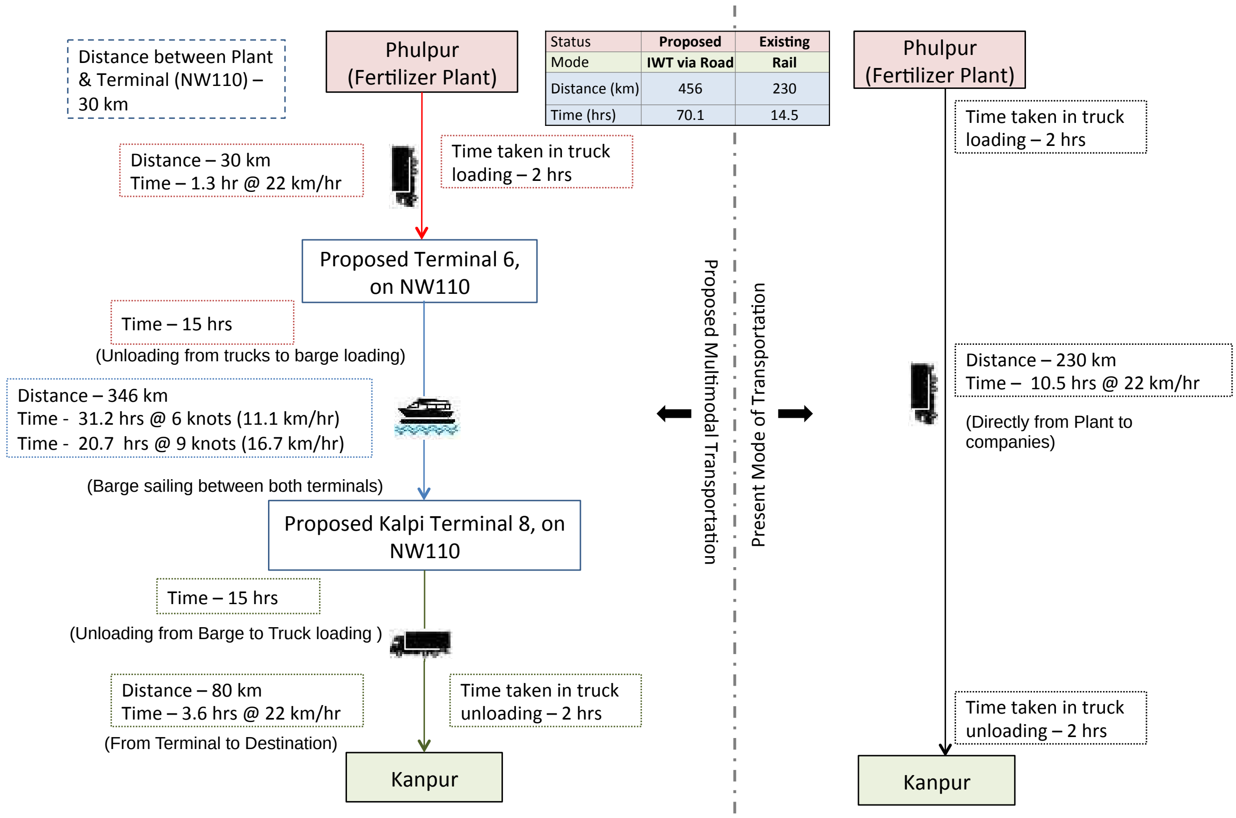


Fig. 6.48 Time-Distance Comparision of Fertilizer Movement

6.8.3.1 Assumption

For fertilizer projection, it is considered that IFFCO Phulpur's production distribution in surrounding region would be partially shifted to waterway. All the assumptions are made for three scenarios, i.e. optimistic, realistic and pessimistic. Fy 17 has been taken as base year for all the cargo related projection.

It is assumed that share of fertiliser for waterway transport would increase from 25% to 40% by Fy 47 in Optimistic scenario. The share would not exceed more than 40%. In realistic scenario, this share would be from 20% to 35%, whereas in pessimistic scenario, it would be 15% to 25%. As per interaction with IFFCO, at present the plant is using railway and roadway for distribution.

As railway movement is subsidized for fertilizer and waterways would not be fully reliable due to water depth and navigability issues throughout the year. Hence, they would share only a certain % of total transportation, if it fully developed and deemed to be cost effective/reliable compared to their present mode of transportation.

Table 6.62 Assumption for Fertiliser Traffic

Scenarios	Fy 17	Fy 22	Fy 27	Fy 37	Fy 47
Optimistic	25%	30%	35%	40%	40%
Realistic	20%	25%	30%	35%	35%
Pessimistic	15%	20%	20%	25%	25%

6.8.3.2 Traffic Projections

Following table shows the fertiliser traffic projection in all different scenarios as optimistic, realistic & pessimistic from Fy 17 to Fy 47.

Table 6.63 Fertiliser Traffic Projection for different scenarios

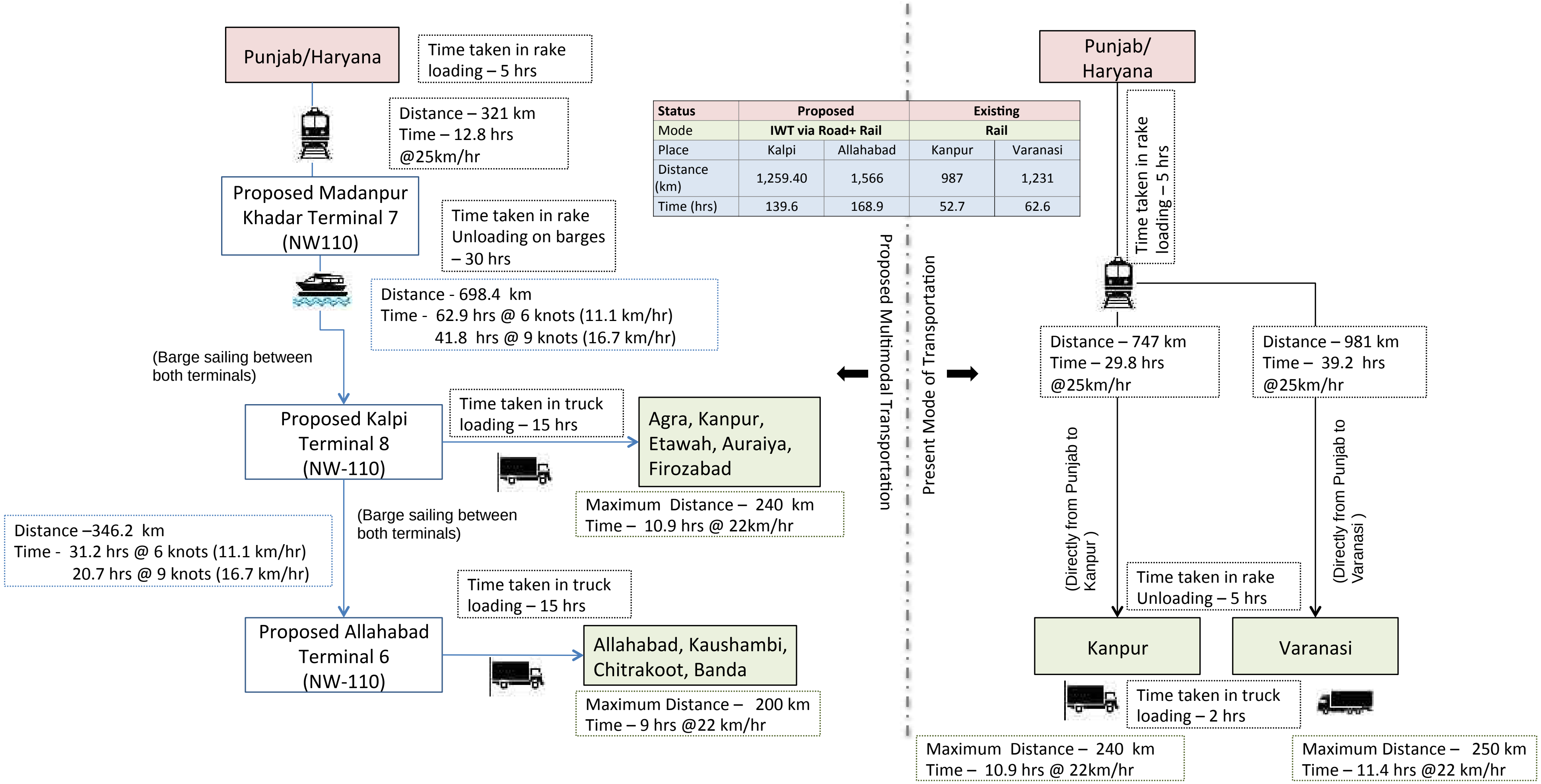
Route	Origin		Destination		Existing Volume	Scenarios ('000 T)	Fy 17	Fy 22	Fy 27	Fy 37	Fy 47
	From	Terminal	Terminal	To							
Prayagraj to Kanpur	IFFCO, Phulpur	6. Jamuna Bridge, Prayagraj	8.Daulatpur, Kanpur	Kanpur, Agra, Etawah, etc.	1,624	Optimistic	406	487	568	650	650
						Realistic	325	406	487	568	568
						Pessimistic	244	325	325	406	406

6.8.4 Food Grains

Uttar Pradesh procures food grains from states, like Punjab and Haryana when its own production of food grains cannot meet market demand. Food grains from northern states get transported to Uttar Pradesh by railway. Food Grain Corporation has its own rail siding in every state.

A portion of this food grain movement could be shifted to the proposed waterway on river Yamuna. Food grains originating from Punjab/Haryana would be loaded at Madanpur Khadar and gets unloaded at Daulatpur&Prayagraj for distribution in the hinterland.

Following chart shows the time-distance matrix and comparison between proposed IWT route and existing mode of transportation i.e. railways.



Status	Proposed		Existing	
Mode	IWT via Road+ Rail		Rail	
Place	Kalpi	Allahabad	Kanpur	Varanasi
Distance (km)	1,259.40	1,566	987	1,231
Time (hrs)	139.6	168.9	52.7	62.6

Fig. 6.49 Time-Distance Comparision of Food Grains Movement

6.8.4.1 Assumption

For food grains traffic projection, the consultant has considered that food grains movement from Punjab and Haryana to Uttar Pradesh would be partially shifted to the proposed waterway.

Food grains originating from FCIs in Punjab/Haryana, i.e. 3.7 mnTwould be loaded at Madanpur Khadar and gets unloaded at Daulatpur&Prayagraj for distribution in the hinterland. It is assumed that 60% of loaded food grains at MadanpurKhadar would be unloaded at Daulatpur and 40% would be unloaded at Prayagraj.

All the assumptions are estimated for three scenarios, i.e. optimistic, realistic and pessimistic. Fy 17 has been taken as base year for all the cargo related projection. It is assumed that IWT movement of food grains from FCI would grow at rate of 8% for first 5 year till Fy 22, then 5% for next 10 years till Fy 32, 5% for next 5 years by Fy 37, 3% for rest of the years till Fy 47 in Optimistic scenario.

In optimistic scenario, the IWT movement growth would not increase more than 30%.

In realistic scenario, it is assumed that growth rate would be 8% for first 5 year till Fy 22, then 5% for next 5 years by Fy 27, 3% for next 10 years by Fy 37, 2% for rest of the years till Fy 47.

In pessimistic scenario, it is assumed that growth rate would be 8% for first 5 year till Fy 22, then 4% for next 5 years by Fy 27, 2% for next 10 years by Fy 37 and 1% for rest of the years till Fy 47. The value of these shares has been taken based on qualitative view from consultant.

As per interaction with FCI managers, shifting of food grains from present mode of transportation, i.e. railway to waterway would depend on subsidy provided by government for using IWT. Without subsidy, the movement through waterway would not be commercially viable. Hence, the consultant has assumed that only 10% of total transportation would be shifted to waterway, if it is fully developed and deemed to be cost effective/reliable compared to their present mode of transportation.

Table 6.64 Annual Increment in % Share ofAssumption for Projected Food Grains Traffic

Scenarios	Fy 17	Fy 22	Fy 27	Fy 37
Optimistic	8%	5%	5%	3%
Realistic	8%	5%	3%	2%
Pessimistic	8%	4%	2%	1%

6.8.4.2 Traffic Projection

Table 6.65 Food Grains Traffic Projection in different Scenario for Terminal 7

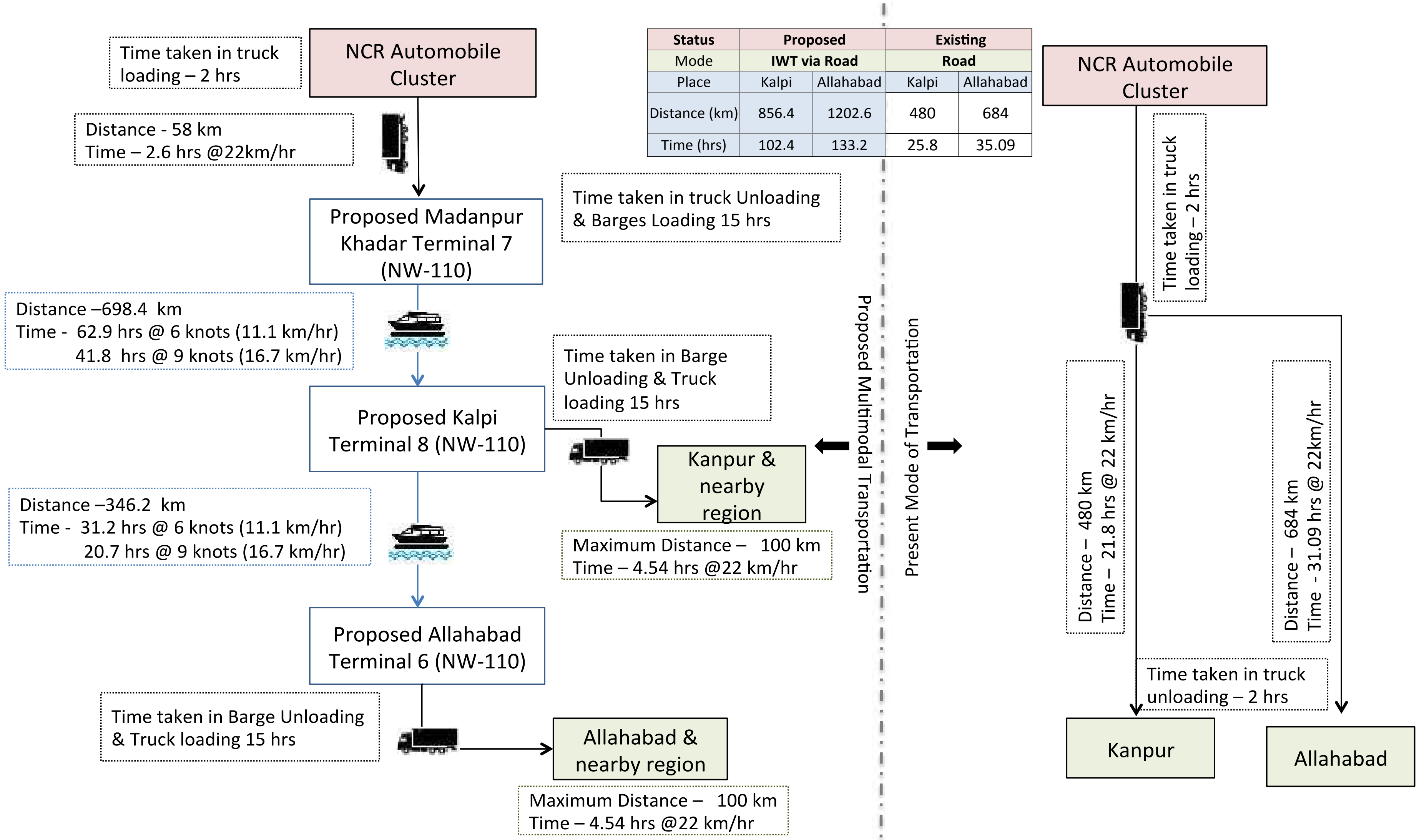
000 Tonnes

Route	Origin		Destination		Scenarios ('000 T)	Fy 17	Fy 22	Fy 27	Fy 37	Fy 47
	From	Terminal	Terminal	To						
Delhi to Kanpur	Punjab & Haryana	7. Madanpur Khadar	8. Daulatpur, Kanpur	Kanpur, Agra, Etawah, etc.	Optimistic	227	324	413	661	888
					Realistic	227	324	406	540	658
					Pessimistic	227	321	383	462	510
Delhi to Prayagraj via Kanpur	Punjab &Haryana	7. Madanpur Khadar	6. Jamuna Bridge, Prayagraj	Prayagraj	Optimistic	151	216	276	440	592
					Realistic	151	216	270	360	439
					Pessimistic	151	214	255	308	340

6.8.5 Automobile

NCR cluster is known as automobile hub. It is proposed that automobiles in car carrier would be transported using NW 110 in UP for distribution. At present, vehicles manufactured in NCR plants are distributed in other parts of the country through roadway or railway. These automobile plants also export to other countries, using nearby ports.

Mostly Mumbai Port and Mundra Port are used for export. Following chart shows the time-distance matrix and comparison between proposed IWT route and existing mode of transportation i.e. railways.



Status	Proposed		Existing	
Mode	IWT via Road		Road	
Place	Kalpi	Allahabad	Kalpi	Allahabad
Distance (km)	856.4	1202.6	480	684
Time (hrs)	102.4	133.2	25.8	35.09

Fig. 6.50 Time-Distance Comparision of Automobiles Movement

6.8.5.1 Assumption

For automobile projection, automobile production in NCR Cluster is considered, which could be distributed in Daulatpur and Prayagraj using waterway. It is assumed that automobile from NCR cluster would get loaded in car carriers at MadanpurKhadar terminal and would further get distributed in Daulatpur and Prayagraj. During road survey, it was observed that around 31,680 automobile loaded trucks moved from NCR towards Uttar Pradesh. It is also assumed that 1 automobile truck has capacity of 10 PCU. The consultant has assumed that only 20% of this road transportation would be shifted to waterway in the three different scenarios, considering IWAI would maintain navigability and water depth throughout the year in river Yamuna and subsidize the difference in logistics cost. All the assumptions are estimated for three scenarios, i.e. optimistic, realistic and pessimistic. Fy 17 has been taken as base year for all the cargo related projection. It is assumed that growth rate would be 5% for first 10 years till Fy 27, irrespective of all different scenarios. After Fy 27, growth rate would be 4% for rest of years till Fy 47 in optimistic scenario. In realistic scenario, growth rate of 3% has been taken in account after Fy 27 for rest of the years. In pessimistic scenario, it is assumed that growth rate after FY 27would be 2% for rest of the years. The value of these shares has been taken based on qualitative view from consultant.

Table 6.66 Assumption for Proposed Automobile Projection

Total Number of Automobile Trucks	31,680	Annually
1 Automobile Truck	10	PCU
% Share to Waterway	20%	-

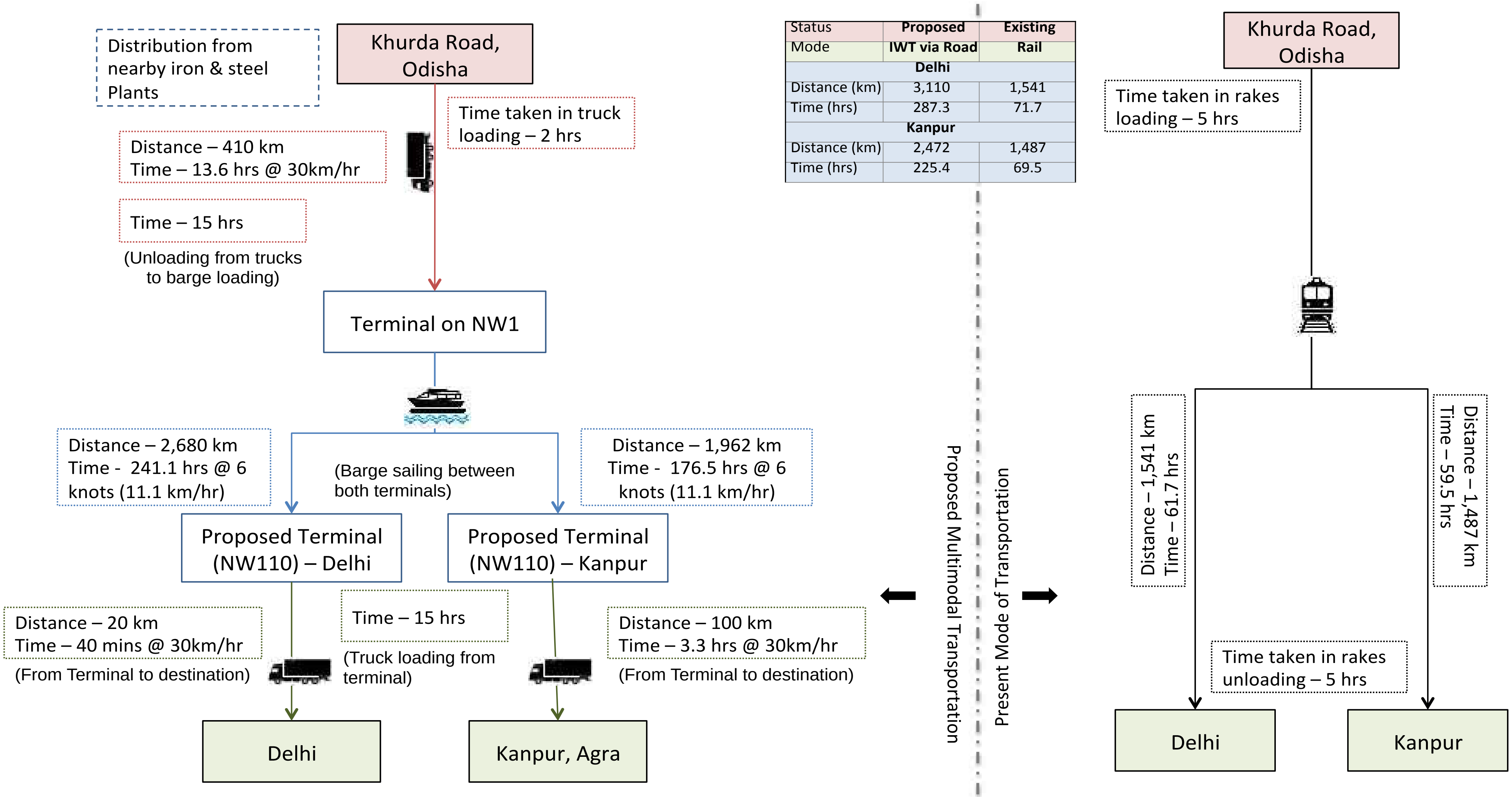
6.8.5.2 Traffic Projection

Table 6.67 Automobiles Traffic Projection in different scenarios

Route	Origin		Destination		Scenarios ('000 T)	Units (PCU)	Fy 17	Fy 22	Fy 27	Fy 37	Fy 47
	From	Terminal	Terminal	To							
Delhi to Kanpur &Prayagraj	NCR Cluster	7.Madanpur Khadar	8.Daulatpur & 6.Jamuna bridge	Prayagraj, Kanpur, Agra, Etawah, etc.	Optimistic	Annual ('000)	63	81	103	153	226
						Daily	176	225	287	424	628
					Realistic	Annual ('000)	63	81	103	139	186
						Daily	176	225	287	385	518
					Pessimistic	Annual ('000)	63	81	103	126	153
						Daily	176	225	287	349	426

6.8.6 Iron & Steel

Following terminals would be handling Iron & Steel procured from Odisha/Haldia and distributes further to the nearby Plants and industries located in Kanpur and Agra. Bhushan Steel, JSW and Global Smelters are the major user of Iron & Steel in the hinterland. It is planned that Iron & Steel from these plants would be transported toShahibganj terminal on NW1, loaded on barge and moved till proposed terminals at Kanpur and Delhi using NW1 and NW110.



Status	Proposed	Existing
Mode	IWT via Road	Rail
Delhi		
Distance (km)	3,110	1,541
Time (hrs)	287.3	71.7
Kanpur		
Distance (km)	2,472	1,487
Time (hrs)	225.4	69.5

Fig. 6.51 Time-Distance Comparision of Iron & Steel Movement

6.8.6.1 Assumption

All the assumptions for three scenarios, i.e. optimistic, realistic and pessimistic are estimated in the respective tables. Fy 17 has been taken as base year for all the cargo related projection. It is assumed that 30% of 1.9 mn T (i.e. 5,70,000 tonnes) requirement fromBhushan, Global Smelters and JSW plant in the region would be shifted to the waterway. In Fy 17, it is assumed that 30% of 5,70,000 tonnes (i.e. 1,71,000 tonnes) would be shifted to NW 110.It is assumed that share of iron & steel for waterway transport would increase from 30% in Fy 17 to 60% by Fy 47 in Optimistic scenario. The share would not exceed more than 60%. In realistic scenario, this share would be from 30% to 50%, whereas in pessimistic scenario, it would be 30% to 40%.

Table 6.68 Assumption for Iron & Steel Projection

Scenarios	Fy 17	Fy 22	Fy 27	Fy 37	Fy 47
Optimistic	30%	30%	40%	45%	60%
Realistic	30%	30%	35%	45%	50%
Pessimistic	30%	30%	35%	35%	40%

Base Assumption & Estimation

- Iron & Steel Market Share in Hinterland – 1.9 MnT
- % Movement (Kolkata, U.P Route to Delhi) – 30%
- Estimated Volume:570 ('000 T)
- % Share for Waterway Movement in Fy 17 – 30%
- Estimated Volume for Waterway Traffic in Fy 17 – 171 ('000 Tonnes)

6.8.6.2 Traffic Projections

Table 6.69 Iron & Steel Traffic Projection under different Scenario

('000 T)

Route	Origin		Destination		Scenarios	Fy	Fy	Fy	Fy	Fy
	From	Terminal	Terminal	To	('000 T)	17	22	27	37	47
Haldia to Delhi	Import	Haldia	7.Madanpur Khadar	Delhi	Optimistic	171	171	228	257	342
					Realistic	171	171	200	257	285
					Pessimistic	171	171	200	200	228
Haldia to Kanpur	Khurda Road, Orissa	Haldia	8.Daulatpur, Kanpur Dehat	Kanpur& Agra	Optimistic	73	73	98	110	147
					Realistic	73	73	85	110	122
					Pessimistic	73	73	85	85	98

6.8.7 Container

Presently, the containers are traded internationally using Sea ports of Gujarat and Maharashtra. Container traffic of Delhi and Uttar Pradesh are moved by roadways to these ports, get loaded into mother vessels and further transported to final destinations i.e. Singapore, China, South Korea, etc. A share of the above described container movement could be diverted on NW110 i.e. loaded in feeder vessel from terminal proposed in Delhi and moved till Haldia/Kolkata Port using NW110 and NW1. Further from Kolkata port using mother vessel containers could be transported to the final destination. Assumptions for the container traffic proposed on NW110 are listed below along with 30 years projections.

Mode	Export	Singapore	South Korea	China
IWT (NW 110 & NW 1) + Sea Route	Distance (km)	5,730	10,834	10,245
	Time (hrs)	335	488	470
Existing Rail + Sea route	Distance (km)	6,100	11,235	10,584
	Time (hrs)	190	344	325

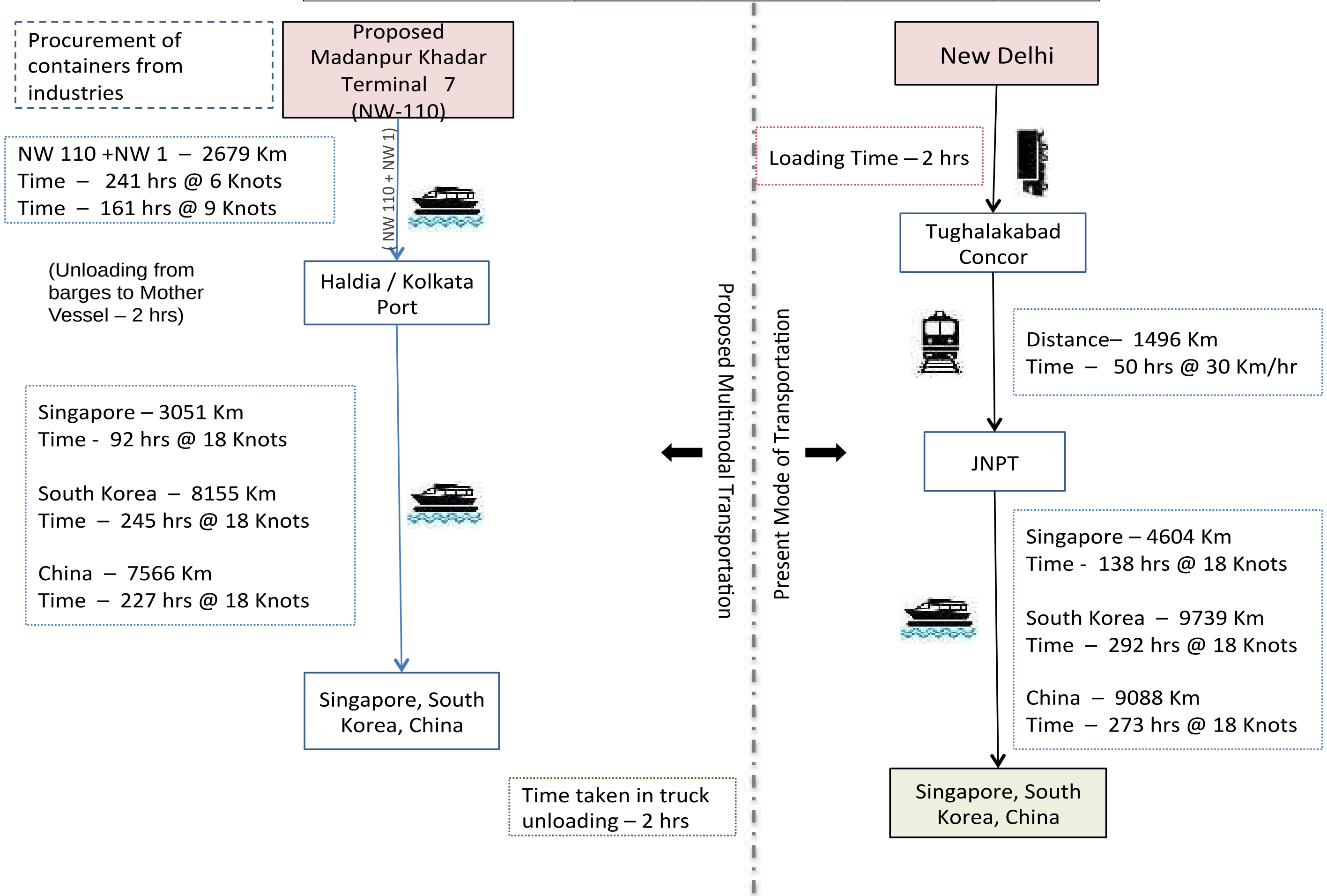


Fig. 6.52 Time distance matrix for Container Movement

6.8.7.1 Assumptions

For projection of container, the consultant assumes that IWAI would maintain depth of the river throughout the year for seamless movement of vessels. IWAI would have to subsidize the difference in logistics cost between present mode of transportation and IWT route. The value of these shares has been taken based on qualitative view from consultant. There was an effort to contact power plants and take inputs on the share of cargo distribution using railways and waterways. They said that waterways would not be fully reliable. Hence, they would share only a % of total transportation if it fully developed and deemed to be cost effective/reliable compared to their present mode of transportation.

Table 6.70 Volume projections for International Container Trade using Yamuna

State	Container	Trade	Market Share	Volume	Volume
	Volume (TEU)	East Asia ('000)	Yamuna (TEU)	Yamuna (TEU)	Western Ports (TEU)
Delhi	4,35,790	1,30,737	40%	52,295	3,83,495
UP	9,56,853	2,87,056	55%	1,57,881	7,98,972
Haryana	4,47,382	1,34,215	30%	40,265	4,07,117
MP	69,520	20,856	0%	-	69,520
Rajasthan	86,396	25,919	0%	-	86,396
Total	**19,95,941**	**5,98,782**		**2,50,441**	**17,45,500**

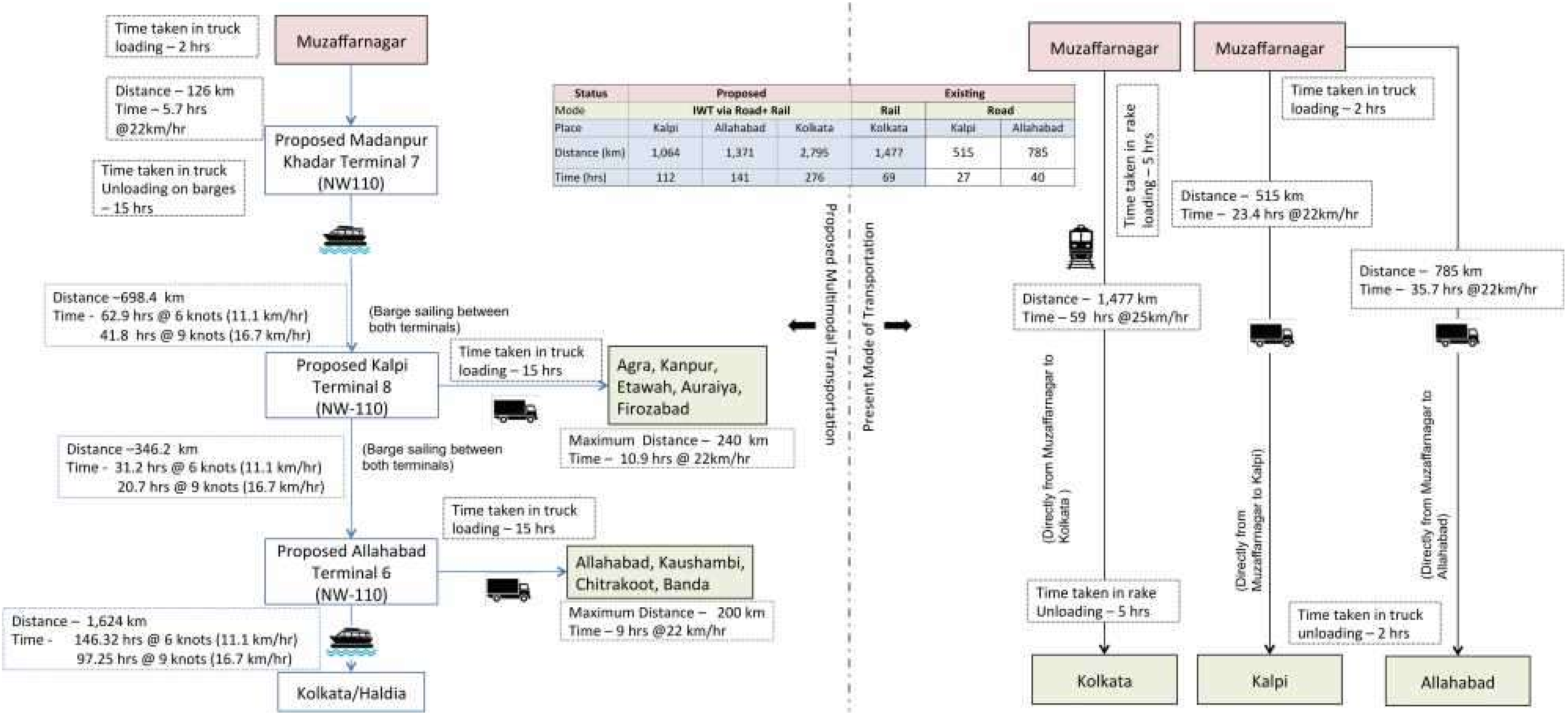
6.8.7.2 Traffic Projections

Table 6.71 Container Projections at Delhi MMLP (TEU)

Terminal	Origin	Destination	Scenarios	Fy-17	Fy-22	Fy-27	Fy-32	Fy-37	Fy-47
7	Madanpur Khadar, Delhi	EXIM (via KPT)	Optimistic	2,50,441	3,51,260	4,70,068	5,99,942	7,09,006	9,52,850
			Realistic	2,50,441	3,51,260	4,70,068	5,71,912	6,56,538	8,40,430
			Pessimistic	2,50,441	3,51,260	4,70,068	5,44,941	5,84,082	6,45,195

6.8.8 Sugar

For sugar traffic projection, the consultant has considered movement of sugar from Muzafarnagar/ Shamli to other districts of Uttar Pradesh. Sugar produced in Muzafarnagar and Shamli is consumed in other districts of the state as well as other parts of the country. It is assumed that 10% of sugar produced in Muzafarnagar and Shamli would be shifted to the proposed waterway in river Yamuna via proposed Madanpur Khadar terminal near Okhla. It would further get distributed in Daulatpur and Prayagraj.



Status	Proposed			Existing		
Mode	IWT via Road+ Rail			Rail	Road	
Place	Kalpi	Allahabad	Kolkata	Kolkata	Kalpi	Allahabad
Distance (km)	1,064	1,371	2,795	1,477	515	785
Time (hrs)	112	141	276	69	27	40

Fig. 6.53 Time Distance Matrix for Sugar Movement

6.8.8.1 Assumptions

Sugar projection is based on sugar movement from sugar mills in the hinterland to the nearby region. Sugar mills from Muzzafarnagar and Shamli would be loaded at MadanpurKhadar and would be unloaded at Daulatpur, Prayagraj and Patna/Haldia (using NW 110 & NW 1). It is assumed that 30% of loaded sugar at MadanpurKhadar would be unloaded at Daulatpur and 20% would be unloaded at Prayagraj and rest 50% would be unloaded at Patna/ Haldia.

All the assumptions for three scenarios, i.e. optimistic, realistic and pessimistic are estimated in the respective tables. Fy 17 has been taken as base year for all the cargo related projection. It is assumed that IWT movement of sugar would grow at rate of 8% for first 5 year till Fy 22,irrespective of all different scenarios. In Optimistic scenario, after Fy 22, growth rate would be 6% for next 5 year till Fy27, then 4% for next 10 years by Fy 37 and 2% for next 10 years by Fy 47.In Realistic scenario, after Fy 22, growth rate would be 5% for next 5 year till Fy 27, then 2% for next 10 years by Fy 37 and 1% for next 10 years by Fy 47. In Pessimistic scenario, after Fy 22, growth rate would be 3% for next 5 year till Fy 27, then 1% for rest of the years till Fy 47.

Below table depicts the assumed growth rate for Sugar traffic projection.

Table 6.72 Assumption for Sugar Traffic Projection

Growth Rate	Fy 17	Fy 22	Fy 27	Fy 37
Optimistic	8%	6%	4%	2%
Realistics	8%	5%	2%	1%
Pessimistics	8%	3%	1%	1%

6.8.8.2 Traffic Projections

Table 6.73 Overall Traffic Projection for Sugar Movement in Nw 110

Mn Tonnes

Locations	Origin	Destination	Fy 17	Fy 22	Fy 27	Fy 37	Fy 47
7.Madanpur Khadar	Madanpur Khadar	Daulatpur / Prayagraj/ Haldia	0.3	0.6	0.8	1.2	1.5

***Table 6.74 Sugar Traffic Projection under different Scenario*'000 Tonnes**

Route	Origin		Destination		Scenarios ('000 T)	Fy 17	Fy 22	Fy 27	Fy 37	Fy 47
	From	Terminal	Terminal	To						
Delhi to Kanpur	Muzaffarnagar& Shamli	7.Madanpur Khadar	8. Daulatpur, Kanpur	Kanpur, Agra, Etawah, etc.	Optimistic	77	111	145	211	257
					Realistic	77	110	136	164	181
					Pessimistic	77	107	122	135	149

Route	Origin		Destination		Scenarios ('000 T)	Fy 17	Fy 22	Fy 27	Fy 37	Fy 47
	From	Terminal	Terminal	To						
Delhi to Prayagraj via Kanpur	Muzaffarnagar & Shamli	7.Madanpur Khadar	6. Jamuna Bridge, Prayagraj	Prayagraj	Optimistic	51	74	97	141	171
					Realistic	51	73	91	109	121
					Pessimistic	51	72	81	90	99
Delhi to Haldia via Kanpur &Prayagraj	Muzaffarnagar & Shamli	7.Madanpur Khadar	Haldia	West Bengal	Optimistic	128	185	242	352	428
					Realistic	128	183	227	273	302
					Pessimistic	128	179	203	225	248

6.8.9 Stone Chips

6.8.9.1 Assumptions

As per the site visit, around 420-450 trucks are moving to Prayagraj city on daily basis. It is assumed that number of operational days for waterway would be 300 days. In realistic cases; it is assumed that maximum 45% of existing road traffic of stone chips would be shifted to waterways by Fy 47. For both the routes, traffic has been distributed in ratio of 70:30 (Ratio of Lawayan to Nibi Kalan&Lawayan to Bakshi Moda).

Table 6.75 Assumption for % Share of Trucks Movement

Scenarios	Fy 17	Fy 22	Fy 27	Fy 37	Fy 47
Optimistic	30%	30%	40%	50%	55%
Realistic	30%	30%	35%	40%	45%
Pessimistic	30%	30%	30%	35%	40%

6.8.9.2 Stone Chips Traffic Projection

Trucks of stone chips from Meja, Mirzapur & Sonebhadra mines would be loaded at Lawayan terminal to bypass the congested Naini Bridge to reach Prayagraj city and nearby districts. These trucks of stone chips would evacuate at proposed terminal at Nibi Kalan. The utilisation of Ro Ro terminals at Lawayan as well as Nibi Kalan &Bakshi Moda will reduce the city traffic of Prayagraj to some extent. It will fasten the transportation process. Below table indicates the traffic projection of Stone Chips movement on both the routes mentioned above.

Table 6.76 Stone Chips Annual Traffic Projection in different scenarios

('000 Trucks)

Route	Origin		Destination		Scenario	Fy 17	Fy 22	Fy 27	Fy 37	Fy 47
	Location	Proposed Terminals	Location	Proposed Terminal						
Meja, Mirzapur, Sonebhadra to Prayagraj& Nearby Regions	Meja, Mirzapur, Sonebhadra	Lawayan	North Prayagraj	Nibi Kalan	Optimistic	26.5	26.5	35.3	44.1	48.5
					Realistic	26.5	26.5	30.9	35.3	39.7
					Pessimistic	26.5	26.5	26.5	30.9	35.3
			North Eastern Prayagraj	Bakshi Moda	Optimistic	11.3	11.3	15.1	18.9	20.8
					Realistic	11.3	11.3	13.2	15.1	17.0
					Pessimistic	11.3	11.3	11.3	13.2	15.1
Total Potential Traffic										
Meja, Mirzapur, Sonebhadra to Prayagraj& Nearby Regions	Meja, Mirzapur, Sonebhadra	Lawayan	Prayagraj	Nibi Kalan & Bakshi Moda	Optimistic	37.8	37.8	50.4	63.0	69.3
					Realistic	37.8	37.8	44.1	50.4	56.7
					Pessimistic	37.8	37.8	37.8	44.1	50.4

6.8.10 Total Cargo Traffic for Overall Stretch of NW110& NW 1

The table below shows the commodity wise consolidated cargo traffic to be handled on river Yamuna.

Table 6.77 Overall Dirty Cargo Traffic on NW110 in realistic scenario

Sr. No.	Commodity	Units	Existing Requirement	Fy 17	Fy 22	Fy 27	Fy 37	Fy 47
1.	Coal	'000 T	52,010	4,559	6,698	8,549	12,058	16,205
2.	Fly Ash	'000 T	5,087 (Current availability)	1,780	2,616	3,339	3,874	4,280

Table 6.78 Overall Clean Cargo Traffic on NW110 in realistic scenario

Sr. No.	Commodity	Units	Fy 17	Fy 22	Fy 27	Fy 37	Fy 47
1.	Fertilizer	'000 T	325	406	487	568	568
2.	Food Grains	'000 T	378	540	676	900	1,097
3.	Automobile	'000 T	63	81	103	139	186

Sr. No.	Commodity	Units	Fy 17	Fy 22	Fy 27	Fy 37	Fy 47
4.	Iron & Steel	'000 T	244	244	285	367	407
5.	Container	TEU	250,441	351,260	470,068	656,538	840,430
6.	Sugar	'000 T	256	366	454	546	604
7.	Stone Chips, Silica Sand etc.	'000 Trucks	11.3	11.3	13.2	15.1	17

6.9 Cargo Traffic on development of NW 110 only

This section deals with traffic projection based on Cargo movement on NW 110 only.

6.9.1 Coal& Fly Ash

There is no traffic for coal and fly ash transportation on development of NW 110 only. The source station for coal is situated near the bank of NW 1 whereas destination of fly ash is Singapore/Bangladesh via NW 1.

6.9.2 Fertiliser

Following table shows the route for transportation of fertiliser in NW 110 (River Yamuna) only

Table 6.79 Fertiliser Traffic for NW110 only

Route	Origin		Destination		Existing Volume	Scenarios ('000 T)	Fy 17	Fy 22	Fy 27	Fy 37	Fy 47
	From	Terminal	Terminal	To							
Prayagraj to Kanpur	IFFCO, Phulpur	6. Jamuna Bridge, Prayagraj	8. Daulatpur, Kanpur	Kanpur, Agra, Etawah, etc.	1,624	Optimistic	406	487	568	650	650
						Realistic	325	406	487	568	568
						Pessimistic	244	325	325	406	406

6.9.3 Food Grains

Below table indicates food grains transportation in NW 110 (River Yamuna) only.

Table 6.80 Food Grains Traffic Projection for NW110 only

Route	Origin		Destination		Scenarios ('000 T)	Fy 17	Fy 22	Fy 27	Fy 37	Fy 47
	From	Terminal	Terminal	To						
Delhi to Kanpur	Punjab & Haryana	7. Madanpur Khadar	8. Daulatpur, Kanpur	Kanpur, Agra, Etawah, etc.	Optimistic	227	324	413	661	888
					Realistic	227	324	406	540	658
					Pessimistic	227	321	383	462	510
Delhi to Prayagraj via Kanpur	Punjab & Haryana	7. Madanpur Khadar	6. Jamuna Bridge, Prayagraj	Prayagraj	Optimistic	151	216	276	440	592
					Realistic	151	216	270	360	439
					Pessimistic	151	214	255	308	340

6.9.4 Automobiles

Table 6.81 Automobiles Traffic Projection for movement on NW110 only

Route	Origin		Destination		Scenarios ('000 T)	Units (PCU)	Fy 17	Fy 22	Fy 27	Fy 37	Fy 47
	From	Terminal	Terminal	To							
Delhi to Kanpur &Prayagraj	NCR Cluster	7. Madanpur Khadar	8.Daulatpur& 6.Jamuna bridge	Prayagraj, Kanpur, Agra, Etawah, etc.	Optimistic	Annual ('000)	63	81	103	153	226
						Daily	176	225	287	424	628
					Realistic	Annual ('000)	63	81	103	139	186
						Daily	176	225	287	385	518
					Pessimistic	Annual ('000)	63	81	103	126	153
						Daily	176	225	287	349	426

6.9.5 Sugar

Table 6.82 Sugar Traffic Projection for movement on NW110 only

Route	Origin		Destination		Scenarios ('000 T)	Fy 17	Fy 22	Fy 27	Fy 37	Fy 47
	From	Terminal	Terminal	To						
Delhi to Kanpur	Muzaffarnagar & Shamli	7. Madanpur Khadar	8. Daulatpur, Kanpur	Kanpur, Agra, Etawah, etc.	Optimistic	77	111	145	211	257
					Realistic	77	110	136	164	181
					Pessimistic	77	107	122	135	149

Route	Origin		Destination		Scenarios ('000 T)	Fy 17	Fy 22	Fy 27	Fy 37	Fy 47
	From	Terminal	Terminal	To						
Delhi to Prayagraj via Kanpur	Muzaffarnagar & Shamli	7. Madanpur Khadar	6. Jamuna Bridge, Prayagraj	Prayagraj	Optimistic	51	74	97	141	171
					Realistic	51	73	91	109	121
					Pessimistic	51	72	81	90	99

6.9.6 Stone Chips

There is no traffic proposed for stone chips movement which would move on NW 110 only. Cargo Traffic Projection for movement in NW 110 & NW 1 both (Except Individual waterway Traffic)

6.10 Cargo Traffic Projection for Movement in NW 110 & NW 1 Both

6.10.1 Coal Traffic Projection

Table 6.83 Coal Traffic Projection for movement on NW110 & NW 1 both in Optimistic Scenario

'000 T

Cargo Terminal	Locations	Company	Origin	Destination	Existing Volume	Fy 17	Fy 22	Fy 27	Fy 37	Fy 47
1	Madanpur Khadar (Delhi)	NTPC Dadri	Piparwar Mines	Dadri	8,128	813	1,194	1,524	2,256	3,340
		Badarpur TPP	ECL	Badarpur	2,706	271	398	507	751	1,112
2	Samogar Mustkil (Agra)	Harduaganj	BCCL	Harduaganj, Aligarh	2,981	298	438	559	827	1,225
		Jawaharpur TPS	NCL	Prayagraj	5,630	338	496	633	938	1,388
3	Kaushambhi(Mahewa Khachhar)	NTPC Tanda	N.K.C.F	Tanda	2,498	250	367	468	693	1,026
		Feroz Gandhi Unchahar	N.K.C.F	Unchahar	5,005	501	735	939	1,389	2,057
4	Dilauliya Kachhar (Kanpur Dehat)	Parichha TPS	ECL	Parichha, Jhansi	4,859	486	714	911	1,349	1,997
		Panki Thermal	ECL	Panki	917	92	135	172	255	377
		Rosa TPP	Haldia	Rosa	5,211	104	153	195	289	428
5	Prayagraj (Naini Bridge)	Meja TPS	NCL	Prayagraj	5,630	563	827	1,056	1,563	2,313
		Bara TPS	NCL	Prayagraj	8,445	844	1,241	1,584	2,344	3,470

Table 6.84 Coal Traffic Projection for movement on NW110 & NW 1 both in Realistic Scenario

'000 T

Cargo Terminals	Locations	Company	Origin	Destination	Existing Volume	Fy 17	Fy 22	Fy 27	Fy 37	Fy 47
1	Madanpur Khadar (Delhi)	NTPC Dadri	Piparwar Mines	Dadri	8,128	813	1,194	1,524	2,150	2,889
		Badarpur TPP	ECL	Badarpur	2,706	271	398	507	716	962
2	Samogar Mustkil (Agra)	Harduaganj	BCCL	Harduaganj, Aligarh	2,981	298	438	559	788	1,060
		Jawaharpur TPS	NCL	Prayagraj	5,630	338	496	633	893	1,201
3	Kaushambhi (Mahewa Khachhar)	NTPC Tanda	N.K.C.F	Tanda	2,498	250	367	468	661	888
		Unchahar TPP	N.K.C.F	Unchahar	5,005	501	735	939	1,324	1,779
4	Dilauliya Kachhar (Kanpur Dehat)	Parichha TPP	ECL	Parichha, Jhansi	4,859	486	714	911	1,285	1,727
		Panki Thermal	ECL	Panki	917	92	135	172	243	326
		Rosa TPP	Haldia	Rosa	5,211	104	153	195	276	370
5	Prayagraj (Naini Bridge)	Meja TPS	NCL	Prayagraj	5,630	563	827	1,056	1,489	2,001
		Bara TPS	NCL	Prayagraj	8,445	844	1,241	1,584	2,234	3,002

Table 6.85 Coal Traffic Projection for movement on NW110 & NW 1 both in Pessimistic Scenario

'000 T

Cargo Terminal	Locations	Company	Origin	Destination	Existing Volume	Fy 17	Fy 22	Fy 27	Fy 37	Fy 47
1	Madanpur Khadar (Delhi)	NTPC Dadri	Piparwar Mines	Dadri	8,128	813	1,194	1,524	1,858	2,265
		Badarpur TPP	Badarpur	Badarpur	2,706	271	398	507	619	754
2	Samogar Mustkil(Agra)	Harduaganj	BCCL	Harduaganj, Aligarh	2,981	298	438	559	681	831
		Jawaharpur TPS	NCL	Prayagraj	5,630	338	496	633	772	941
3	Kaushambhi (Mahewa Khachhar)	NTPC Tanda	N.K.C.F	Tanda	2,498	250	367	468	571	696
		Unchahar TPP	N.K.C.F	Unchahar	5,005	501	735	939	1,144	1,395
4	Dilauliya Kachhar (Kanpur Dehat)	Parichha Thermal	ECL	Parichha, Jhansi	4,859	486	714	911	1,111	1,354
		Panki Thermal	ECL	Panki	917	92	135	172	210	256
		Rosa TPP	Haldia	Rosa	5,211	104	153	195	238	290
5	Prayagraj (Naini Bridge)	Meja TPS	NCL	Prayagraj	5,630	563	827	1,056	1,287	1,569
		Bara TPS	NCL	Prayagraj	8,445	844	1,241	1,584	1,930	2,353

6.10.2 Fly Ash Traffic Projection

Table 6.86 Fly Ash Traffic Projection for movement on NW110 & NW 1 both in Optimistic Scenario

'000 T

Terminals	Locations	Company	Origin	Destination	Fy 17	Fy 22	Fy 27	Fy 37	Fy 47
2	Samogar Mustkil (Agra)	Jawaharpur TPS	Jawaharpur	Singapore	338	544	751	751	751
3	Kaushambhi (Mahewa Khachhar)	NTPC Tanda	Tanda	Singapore	210	338	467	467	467
		Feroz Gandhi TPS	Unchahar	Singapore	254	409	564	564	564
4	Dilauliya Kachhar (Kanpur Dehat)	Parichha TPS	Parichha, Jhansi	Singapore	419	675	931	931	931
		Rosa TPP	Rosa	Singapore	334	538	743	743	743
5	Prayagraj (Naini Bridge)	Meja TPS	Prayagraj	Singapore	346	557	768	768	768
		Bara TPS	Prayagraj	Singapore	388	625	863	863	863

Table 6.87 Fly Ash Traffic Projection for movement on NW110 & NW 1 both in Realistic Scenario

'000 T

Terminals	Locations	Company	Origin	Destination	Fy 17	Fy 22	Fy 27	Fy 37	Fy 47
2	Samogar Mustkil (Agra)	Jawaharpur TPP	Jawaharpur	Singapore	263	386	493	572	632
3	Kaushambhi (Mahewa Khachhar)	NTPC Tanda	Tanda	Singapore	163	240	307	356	393
		Feroz Gandhi TPS	Unchahar	Singapore	197	290	370	430	474
4	Dilauliya Kachhar (Kanpur Dehat)	Parichha TPP	Parichha, Jhansi	Singapore	326	479	611	709	783
		Rosa TPP	Rosa	Singapore	260	382	488	566	625
5	Prayagraj (Naini Bridge)	Meja TPS	Prayagraj	Singapore	269	395	504	585	646
		Bara TPS	Prayagraj	Singapore	302	444	566	657	726

Table 6.88 Fly Ash Traffic Projection for movement on NW110 & NW 1 both in Pessimistic Scenario

'000 T

Terminal	Locations	Company	Origin	Destination	Fy 17	Fy 22	Fy 27	Fy 37	Fy 47
2	Samogar Mustkil (Agra)	Jawaharpur TPP	Jawaharpur	Singapore	188	240	292	322	356
3	Kaushambhi (Mahewa Khachhar)	NTPC Tanda	Tanda	Singapore	117	149	181	200	221
		Unchahar	Unchahar	Singapore	141	180	219	242	267
4	Dilauliya Kachhar (Kanpur Dehat)	Parichha TPP	Parichha	Singapore	233	297	361	399	441
		Rosa TPP	Rosa	Singapore	186	237	288	319	352
5	Prayagraj (Naini Bridge)	Meja TPS	Prayagraj	Singapore	192	245	298	329	364
		Bara TPS	Prayagraj	Singapore	216	275	335	370	409

6.10.3 Fertiliser

There is no traffic for fertiliser transportation on both the NW 110 & NW 1. Fertiliser has been proposed to transport only on NW 110 (Terminal 6 to Terminal 8.

6.10.4 Iron & Steel Traffic Projection

Table 6.89 Iron & Steel Traffic for movement in NW110 & NW 1 both

'000 T

Route	Origin		Destination		Scenarios ('000 T)	Fy 17	Fy 22	Fy 27	Fy 37	Fy 47
	From	Terminal	Terminal	To						
Haldia to Delhi	Import	Haldia	7.Madanpur Khadar	Delhi	Optimistic	171	171	228	257	342
					Realistic	171	171	200	257	285
					Pessimistic	171	171	200	200	228
Haldia to Kanpur	Khurda Road, Odisha	Haldia	8.Daulatpur, Kanpur	Kanpur & Agra	Optimistic	73	73	98	110	147
					Realistic	73	73	85	110	122
					Pessimistic	73	73	85	85	98

6.10.5 Container Cargo

Table 6.90 Container Traffic for movement in NW110 & NW 1 both (TEU)

Origin	Destination	Scenarios	Fy-17	Fy-22	Fy-27	Fy-32	Fy-37	Fy-47
7. Madanpur Khadar, Delhi	EXIM (via KPT)	Optimistic	2,50,441	3,51,260	4,70,068	5,99,942	7,09,006	9,52,850
		Realistic	2,50,441	3,51,260	4,70,068	5,71,912	6,56,538	8,40,430
		Pessimistic	2,50,441	3,51,260	4,70,068	5,44,941	5,84,082	6,45,195

6.10.6 Sugar

Table 6.91 Sugar Traffic for movement in NW110 & NW 1 both

'000 T

Route	Origin		Destination		Scenarios ('000 T)	Fy 17	Fy 22	Fy 27	Fy 37	Fy 47
	From	Terminal	Terminal	To						
Delhi to Haldia via Kanpur&Prayagraj	Muzaffarnagar & Shamli	7.Madanpur Khadar	Haldia	W.B	Optimistic	128	185	242	352	428
					Realistic	128	183	227	273	302
					Pessimistic	128	179	203	225	248

6.10.7 Stone Chips

Table 6.92 Stone Chips Annual Traffic Projection in in NW110 & NW 1 both

('000 Trucks)

Route	Origin Location	Origin Proposed Terminals	Destination Location	Destination Proposed Terminal	Scenario	Fy 17	Fy 22	Fy 27	Fy 37	Fy 47
Meja, Mirzapur, Sonebhadra to Prayagraj &Nearby Regions	Meja, Mirzapur Sonebhadra	Lawayan	North Prayagraj	Nibi Kalan	Optimistic	26.5	26.5	35.3	44.1	48.5
					Realistic	26.5	26.5	30.9	35.3	39.7
					Pessimistic	26.5	26.5	26.5	30.9	35.3
			North Eastern Prayagraj	Bakshi Moda	Optimistic	11.3	11.3	15.1	18.9	20.8
					Realistic	11.3	11.3	13.2	15.1	17.0
					Pessimistic	11.3	11.3	11.3	13.2	15.1
Total Potential Traffic										
Meja, Mirzapur, Sonebhadra to Prayagraj &Nearby Regions	Meja, Mirzapur, Sonebhadra	Lawayan	Prayagraj	Nibi Kalan & Bakshi Moda	Optimistic	37.8	37.8	50.4	63.0	69.3
					Realistic	37.8	37.8	44.1	50.4	56.7
					Pessimistic	37.8	37.8	37.8	44.1	50.4

6.11 Passenger Traffic – Inter District

Delhi – Agra, Prayagraj – Agra and Mathura – Delhi are the 3 routes considered for inter district movement of passengers. These are the busiest route with all-time heavy congestion. Congested traffic movement on existing route demands development of alternate mode of transportation. Following are the list of assumptions taken for generating the traffic on NW110.

6.11.1 Assumptions

The tourists of existing visit to various tourism locations will also use River cruise and ferry service out of novelty to see and explore River Yamuna. Hence, a modest share of less than 2% has been assumed to shift on to waterways in a realistic case.

Table 6.93 Assumption for Passenger/Tourist traffic

Routes	Assumption	Source
Delhi - Agra	2% of Agra Tourism (Fy 17)	UP Tourism, Govt. UP
Prayagraj - Agra	15% of Daily local bus movement	Local Traffic Survey
Mathura/Vrindavan-Delhi	1.5% of Mathura & Vrindavan Tourism (Fy 17)	UP Tourism, Govt. UP

Table 6.94 Percentage Share Passenger/Tourist traffic in various scenarios

Routes - Share Scenario	Optimistic	Realistic	Pessimistic
Delhi – Agra	3%	2%	1%
Prayagraj-Agra	20%	15%	10%
Mathura/Vrindavan-Delhi	2%	1.5%	1%

6.11.2 Traffic Projections

Table 6.95 Inter – District Passenger Traffic under various Scenarios

Route	Origin Terminal	Destination Terminal	Units	Fy 17	Fy 22	Fy 27	Fy 37	Fy 47
Optimistic Scenario								
Delhi - Agra	9 Madanpur, Khadar	10. Agra	Annual ('000)	308	357	394	436	481
			Daily	844	978	1,080	1,193	1,318
Agra - Prayagraj	10. Agra	6. Sujawan Ghat	Annual ('000)	72	80	84	93	102
			Daily	198	219	230	254	280
Delhi - Mathura	9 Madanpur, Khadar	11. Vrindavan	Annual ('000)	422	489	540	596	659
			Daily	1,156	1,340	1,479	1,634	1,805
Realistic Scenario								
Delhi - Agra	9 Madanpur, Khadar	10. Agra	Annual ('000)	205	238	263	290	321
			Daily	563	652	720	796	879
Agra - Prayagraj	10. Agra	6. Sujawan Ghat	Annual ('000)	54	60	63	69	77
			Daily	149	164	172	190	210
Delhi - Mathura	9Madanpur, Khadar	11. Vrindavan	Annual ('000)	316	367	405	447	494
			Daily	867	1,005	1,109	1,226	1,354
Pessimistic Scenario								
Delhi - Agra	9. Madanpur, Khadar	10. Agra	Annual ('000)	103	119	131	145	160
			Daily	281	326	360	398	439
Agra - Prayagraj	10. Agra	6. Sujawan Ghat	Annual ('000)	36	40	42	46	51
			Daily	99	109	115	127	140
Delhi - Mathura	9. Madanpur, Khadar	11. Vrindavan	Annual ('000)	211	245	270	298	329
			Daily	578	670	740	817	903

6.12 Passenger Traffic – Intra District

New Delhi and Prayagraj are considered for intra district movement. Terminals at these locations would be catering mostly tourism traffic i.e. people visiting various location on the bank of Yamuna river.

6.12.1 Prayagraj - Sangam

Proposed terminals at Sangam would be handling large number of pilgrims, tourists who visit Sangam throughout the year. The traffic would increase dramatically near Sangam during Kumbh festival. Proposed 4 ghats at Sangam would handle this traffic in future. Traffic projections for proposed ghats at Sangam along with assumptions are as follows.

Fig. 6.54 Proposed Terminals near Sangam

6.12.1.1 Assumptions

Table 6.96 Assumption for Traffic Calculation

Projection Segment	Source	Rationale
Projection of Prayagraj Tourism Traffic	UP Tourism, Govt. of UP	Tourism Traffic of Prayagraj would increase y-o-y by 2% in FY17 to FY21 and thereafter by 1% till FY 47
Traffic projections for proposed terminals	% Share of Projected Prayagraj Tourism Traffic	Kumbh Period - 5% Optimistic 3% Realistic, 2% Pessimistic. Non-Kumbh Period - 20% Optimistic 15% Realistic, 10% Pessimistic
Ghat wise Traffic	Traffic projections for proposed terminals	13a - 35%, 13b - 20%, 13c - 20%, 13d - 25%

6.12.1.2 Traffic Projections

- **Optimistic Scenario**

Table 6.97 Tourists Traffic (Kumbh& Non Kumbh) in Optimistic Scenario

Terminals	Origin	Units	Fy 17	Fy 22	Fy 27	Fy 37	Fy 47
13	Prayagraj (Kumbh Period)	Monthly('000)	550	607	638	705	779
		Daily	18,333	20,241	21,274	23,500	25,958
	Prayagraj (Non Kumbh Period)	Monthly('000)	143	158	166	183	202
		Daily	4,767	5,263	5,531	6,110	6,749

Table 6.98 Ghat wise Traffic in Optimistic Scenario (Kumbh Months)

Origin	Destination	Units	Fy 17	Fy 22	Fy 27	Fy 37	Fy 47
Sujawan Ghat	Sangam	Monthly('000)	193	213	223	247	273
		Daily	6,417	7,085	7,446	8,225	9,085
Hanuman Ghat	Sangam	Monthly('000)	110	121	128	141	156
		Daily	3,667	4,048	4,255	4,700	5,192
Saraswati Ghat	Sangam	Monthly('000)	110	121	128	141	156
		Daily	3,667	4,048	4,255	4,700	5,192
Boat Club	Sangam	Monthly('000)	138	152	160	176	195
		Daily	4,583	5,060	5,319	5,875	6,490

Table 6.99 Ghat wise Traffic (Non Kumbh Months) in Optimistic Scenario

Origin	Destination	Units	Fy 17	Fy 22	Fy 27	Fy 37	Fy 47
Sujawan Ghat	Sangam	Monthly('000)	50	55	58	64	71
		Daily	1,668	1,842	1,936	2,138	2,362
Hanuman Ghat	Sangam	Monthly('000)	29	32	33	37	40
		Daily	953	1,053	1,106	1,222	1,350
Saraswati Ghat	Sangam	Monthly('000)	29	32	33	37	40
		Daily	953	1,053	1,106	1,222	1,350
Boat Club	Sangam	Monthly('000)	36	39	41	46	51
		Daily	1,192	1,316	1,383	1,527	1,687

- **Realistic Scenario**

Table 6.100 Tourists Traffic (Kumbh& Non Kumbh) in Realistic Scenario

Terminal	Origin	Units	Fy 17	Fy 22	Fy 27	Fy 37	Fy 47
13	Prayagraj (Kumbh Period)	Monthly('000)	330	364	383	423	467
		Daily	11,000	12,145	12,764	14,100	15,575
	Prayagraj (Non Kumbh Period)	Monthly('000)	107	118	124	137	152
		Daily	3,575	3,947	4,148	4,582	5,062

Table 6.101 Ghat wise Traffic in Realistic Scenario (Kumbh Months)

Origin	Destination	Units	Fy 17	Fy 22	Fy 27	Fy 37	Fy 47
Sujawan Ghat	Sangam	Monthly('000)	116	128	134	148	164
		Daily	3,850	4,251	4,468	4,935	5,451
Hanuman Ghat	Sangam	Monthly('000)	66	73	77	85	93
		Daily	2,200	2,429	2,553	2,820	3,115
Saraswati Ghat	Sangam	Monthly('000)	66	73	77	85	93
		Daily	2,200	2,429	2,553	2,820	3,115
Boat Club	Sangam	Monthly('000)	83	91	96	106	117
		Daily	2,750	3,036	3,191	3,525	3,894

Table 6.102 Ghat wise Traffic in Realistic Scenario (Non Kumbh Months)

Origin	Units	Fy 17	Fy 22	Fy 27	Fy 37	Fy 47
Sujawan Ghat	Monthly('000)	38	41	44	48	53
	Daily	1,251	1,381	1,452	1,604	1,772
Hanuman Ghat	Monthly('000)	21	24	25	27	30
	Daily	715	789	830	916	1,012
Saraswati Ghat	Monthly('000)	21	24	25	27	30
	Daily	715	789	830	916	1,012
Boat Club	Monthly('000)	27	30	31	34	38
	Daily	894	987	1,037	1,146	1,265

- **Pessimistic Scenario**

Table 6.103 Tourists Traffic (Kumbh& Non Kumbh) in Pessimistic Scenario

Terminals	Origin	Units	Fy 17	Fy 22	Fy 27	Fy 37	Fy 47
13	Prayagraj (Kumbh Period)	Monthly('000)	220	243	255	282	311
		Daily	7,333	8,097	8,510	9,400	10,383
	Prayagraj (Non Kumbh Period)	Monthly('000)	72	79	83	92	101
		Daily	2,383	2,631	2,766	3,055	3,375

Table 6.104 Ghat wise Traffic in Pessimistic Scenario (Kumbh Months)

Origin	Destination	Units	Fy 17	Fy 22	Fy 27	Fy 37	Fy 47
Sujawan Ghat	Sangam	Monthly('000)	77	85	89	99	109
		Daily	2,567	2,834	2,978	3,290	3,634
Hanuman Ghat	Sangam	Monthly('000)	44	49	51	56	62
		Daily	1,467	1,619	1,702	1,880	2,077
Saraswati Ghat	Sangam	Monthly('000)	44	49	51	56	62
		Daily	1,467	1,619	1,702	1,880	2,077
Boat Club	Sangam	Monthly('000)	55	61	64	70	78
		Daily	1,833	2,024	2,127	2,350	2,596

Table 6.105 Ghat wise Traffic in Pessimistic Scenario (Non Kumbh Months)

Origin	Destination	Units	Fy 17	Fy 22	Fy 27	Fy 37	Fy 47
Sujawan Ghat	Sangam	Monthly('000)	25	28	29	32	35
		Daily	834	921	968	1,069	1,181
Hanuman Ghat	Sangam	Monthly('000)	14	16	17	18	20
		Daily	477	526	553	611	675
Saraswati Ghat	Sangam	Monthly('000)	14	16	17	18	20
		Daily	477	526	553	611	675
Boat Club	Sangam	Monthly('000)	18	20	21	23	25
		Daily	596	658	691	764	844

6.12.2 Delhi – Water Taxi

In Delhi, water taxi is proposed in three locations, Tronica city, Sonia Vihar and Jagatpur. These three places are located on the bank of river Yamuna. Areas near the river are sparsely populated and are mostly covered in thick vegetation. Residents of Tronica city, Sonia Vihar and Jagatpur live far from the river.

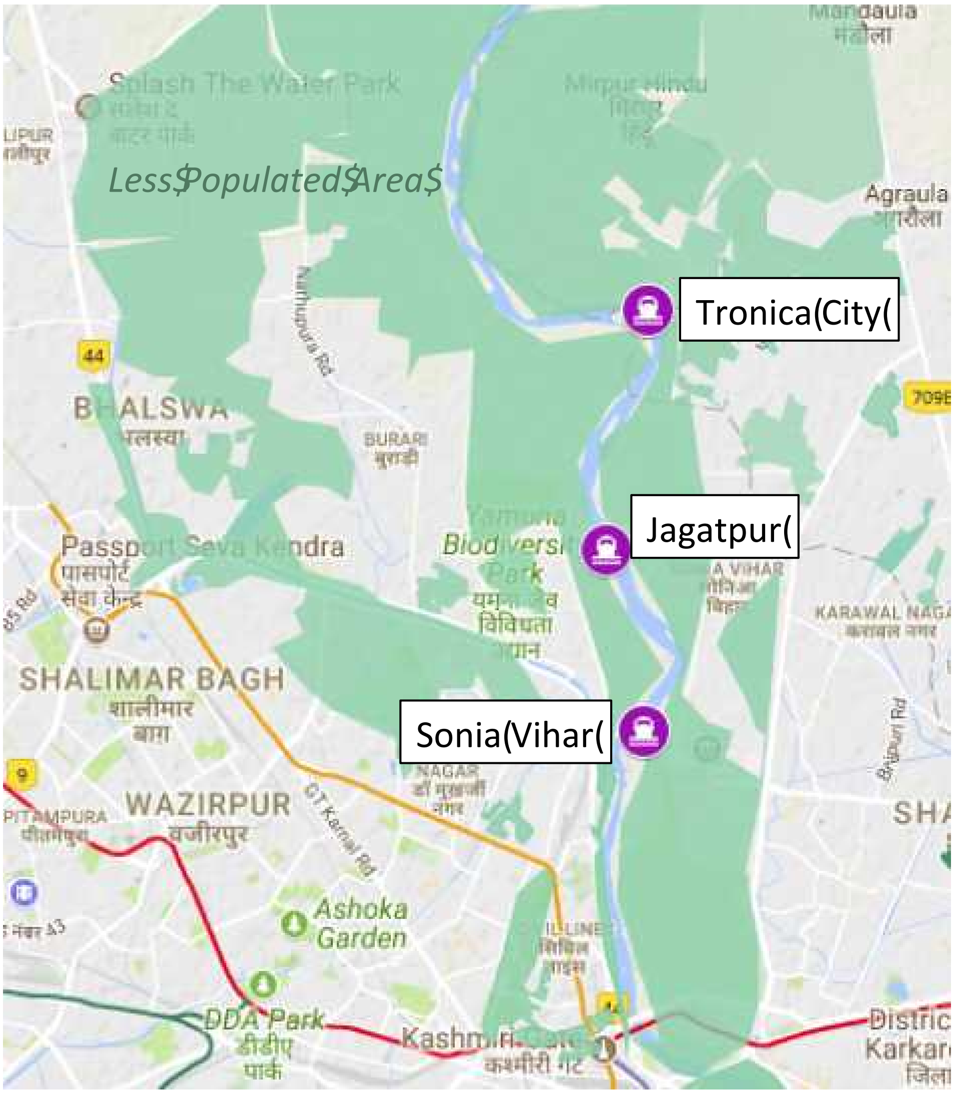


Fig. 6.55 Proposed Terminals in Delhi for Water Taxi

These places are self-sufficient and people do not cross the river for their daily needs. Even after the development of water taxi in these three places, it is very unlikely that people would use the waterway for day-to-day necessities. Also, the bridge near Sonia Vihar and Jagatpur is getting widened. The work of widening is in progress. This bridge would pose threat to the proposed water taxi. With this development, people of the region would prefer the bridge for crossing the river. Due to congestion at Wazirabad Bridge, waterway can be ideal mode of passenger transportation from one side to another side i.e. across the river. Considering the present scenario, it is assumed that passenger traffic in the proposed water taxi would be less.

6.12.2.1 Assumptions

Table 6.106 Assumptions for Calculation of Traffic for water taxi

Projection Segment	Source	Rationale
Traffic generation for Water Taxi	Current Population of nearby villages	Share of Population under different scenarios - 25% Optimistic, 20% Realistic, 15% Optimistic
Traffic growth	Traffic generation for Water Taxi	Traffic generated for water taxi would increase y-o-y by 2% in FY17 to FY21 and thereafter by 1% till FY 47

6.12.2.2 Traffic Projections

Table 6.107 Passenger Traffic in different Scenarios

Terminal	Origin	Destination	Scenarios	Units	Fy 17	Fy 22	Fy 27	Fy 37	Fy 47
12	Jagatpur	Tronica City via Sonia Vihar	Optimistic	Annual('000)	160	177	186	206	227
				Daily	440	485	510	564	622
			Realistic	Annual('000)	128	142	149	165	182
				Daily	352	388	408	451	498
			Pessimistic	Annual('000)	96	106	112	123	136
				Daily	264	291	306	338	373

6.13 Logistics Cost Analysis

The possibility of shippers shifting their mode of transportation from Road or Rail to waterways would be influenced by per ton landed cost of commodity to their plant or consumer. Majority of the commodities identified to be transported using waterways are bulk in nature with large volumes moving by Indian Railways. Hence, it is essential to undertake cost comparison between existing mode of transportation using railways and likely cost of transportation using proposed IWT. The costs associated with transporting cargo using railways is known due to declaration of tariffs, time of transportation, loading/unloading costs, etc. However, waterway on River Yamuna is proposed and River Ganga is not fully commercialized yet. Hence, reasonable assumptions related to various infrastructure availability and costs associated with using those infrastructures have been made. Following are the broad assumptions undertaken during logistics cost analysis to compare the cost of transporting Cargo using Railways (in present case) to cost of transporting Cargo using Waterways (once they are developed).

- It has been assumed that the waterways would be developed by the Government (IWAI) to bring parity between water transportation and railway transportation. The cost associated with development of navigation on waterways and maintaining its depth round the year would be borne by the Government (IWAI). The cost of developing and maintaining navigation depth should not be transferred to the Cargo Owner or Vessel Operator. No tariff would be charged for using fairway developed by IWAI.
- IWAI would ascertain availability of water round the year in the river with maintenance of certain uniform water depth.
- The existing bridges on the River Yamuna and River Ganga would be modified to facilitate seamless movement of Inland Water vessels without any hindrance and delay.
- IWAI would facilitate connectivity with Road and Rail to the terminal. These rail and road from terminal should be connected to the existing nearest transportation grid.
- The below table shows the broad commercial assumptions related to Cargo handling cost (tariffs) at terminal, Stackyard, etc. These assumptions and tariff have been constant for all cases (unless specified due to specific nature of cargo). These tariffs have been also considered during financial analysis as prospective revenue for the developer and operator of the terminals of River Yamuna.

Table 6.108 Commercial Cost Assumption for all Coal Terminals (INR/Tonne)

Commercial Assumptions	Tariff	Unit
Material Handling Cost at Mines / Source		
Loading of Rakes at Mine	60	INR/Tonne
Material Handling Cost at Initial Terminal		
Discharge of Rakes at Terminal	20	INR/Tonne
Storage Charges at Terminal	50	INR/Tonne
Stackyard Handling Charges	60	INR/Tonne
IWAI Tariff at Terminal	180	INR/Tonne
Loading Cost of Barges	20	INR/Tonne
Material Handling Cost at Destination Terminal		
Unloading of Barge at Terminal	20	INR/Tonne
Storage Charges at Terminal	50	INR/Tonne
Stackyard Handling Charges	60	INR/Tonne
Loading of Rakes at Terminal	60	INR/Tonne
IWAI Tariff at Terminal	180	INR/Tonne
Material Handling Cost at Final Destination		
Discharge of Rakes at Plant	20	INR/Tonne

Logistics cost comparison is undertaken only for cargo and not for passenger movement. Logistics cost comparison is necessary for cargo movement, as users would prefer economically cheaper mode. Whereas, there is no requirement of logistic cost comparison for passenger movement. Passenger traffic proposed on River Yamuna constitutes mostly tourists. Tourists are considered as passenger traffic on NW 110 and they would use inland waterway as a recreational activity. Cost is irrelevant to tourists, as they would opt to travel using NW 110 for leisure and fun. If distance and cost is compared between existing mode (roadway/railway) and IWT for tourism purpose, cost of IWT would be higher. Despite the longer distance and higher cost, tourists would use inland waterway on NW 110. Considering these reasons, logistics cost comparison for tourists/passengers is not done.

6.13.1 Vessel Design

The design of vessels and their operational parameters influence logistics cost associated with cargo transportation on river. The unit transportation cost inputs generated from the operational cost of vessels plays a pivoting role in deciding end to end logistics cost. Class III & IV have been considered to be suitable for NW 110. IWAI's designed vessels could also be deployed on NW 110. The decision of vessels selection vests with the vessel's operator or cargo owner. IWAI would have no role to play. IWAI might build and deploy few vessels as pilot project to establish technical viability and showcase them to the users. The logistics cost analysis has been undertaken using both categories of vessels as mentioned above.

Two types of vessels are considered for Logistics Cost Analysis for NW 110; vessels, which are currently available in market and IWAI's designed vessels. First category contains vessels presently operating in Indian waters/seacoasts. Some of the vessels falling in class I and Class II have been extrapolated as they have been discontinued for decades. Class IV vessels are not readily available in India and hence, taken from international references. Following table describes broad assumptions behind vessel design.

Table 6.109 Proposed Vessel Design based on Market Standards

Class	Size (m)		Loaded	Capacity	Consumption	Speed
	Length	Breadth	Draft (m)	(DWT)	Ltr/Hr	(Knots)
I	32	5	1.0	100	50	6-7
II	45	8	1.2	300	90	6-7
III	58	9	1.5	500	110	6-7
IV	70	12	1.8	1,000	122	6-7
V	70	12	1.8	1,000	122	6-7
VI	86	14	2.5	2,000	177	6-7
VII	86	14	2.9	4,000	250	6-7

Second category consists of IWAI's specially designed vessels customized to Indian Rivers. IWAI had commissioned a European Consultant for designing cost effective vessels to be deployed in inland waterways of India. Following table describes the principal particulars of all the vessels designed by IWAI.

Table 6.110 IWAI designed Vessels Specifications

Type of Vessel	L (m)	B (m)	Depth (m)	Draught (m)	Power (Kw)	DWT
Bulk Carrier B1	110	12.0	3.7	2.8	1,000	2,500
Bulk Carrier B2	110	12.0	4.3	2.8	1,000	2,500
Bulk Carrier B3	92	12.0	3.7	2.8	1,000	2,100
Car Carrier	90	14.5	3.1	1.8	1,000	840
Container CO2	110	12.0	4.3	2.6	1,000	2,100
Container CO1	110	12.0	3.7	2.5	1,000	2,100
Dumb Barge	42	8.0	2.8	2.5	1,000	580
Ro-Ro	70	15.0	2.8	1.7	1,000	750
Liquid Bulk T1	110	12.0	3.7	2.8	1,000	2,400
Liquid Bulk T2	110	12.0	3.7	2.8	1,000	2,400

Source: IWAI

These designed vessels do not fit in any existing vessel class defined by IWAI. Hence, they are considered as specific types of vessels, i.e. Vessel 1 (1,300 DWT), Vessel 2 (1800 DWT) & Vessel 3 (2,500 DWT).

The below section describes the logistic cost comparison of existing class of vessels and IWAI's designed vessels.

Table 6.111 IWAI Bulk 1 Vessel considered for Comparison

Vessel Type	Water Depth (m)	Draught (m)	L (m)	B (m)	Power (Kw)	Speed (Knots)	DWT
Vessel I	2.0	1.5	110	12	1,000	4.5	1,300
Vessel II	2.5	2.0	110	12	1,000	4.5	1,800
Vessel III	3.5	2.8	110	12	1,000	6.5	2,500

Source: IWAI

6.13.2 Distance Matrix Origin – Destination (Cargo)

The below table depicts Origin-Destination of all the targeted commodities, which would be transported using NW 110. As shown in the table, cargo movement from Origin to Destination would be done using multi-modal. First and last mile delivery would be done by railway/roadway. Inland waterway transportation would be done using NW 1 (River Ganga) and NW 110 (River Yamuna). Origin of Coal is coal mines from where the identified thermal power plants procure coal.

Table 6.112 Summarised OD Pairs for all Proposed Cargo Terminals

Terminal No.	Commodity	Origin	Destination	IWT Route (Km)				Railway Route (Km)	Roadway (Km)
				Origin to Terminal	Barge Sailing (NW110+ NW1)	Terminal to Destination (Proposed Rail)	Total (Km)		
1	Coal	Piparwar Mines	NTPC, Dadri	257	1,651	38	1,946	1,141	1,125
		Haldia (Imported)	NTPC, Dadri	-	2,671	38	2,709	1,476	1,547
		ECL	Badarpur	246	1,861	11	2,118	1,276	1,248
2	Coal	BCCL	Harduaganj	310	1,727	74	2,111	1,091	870
		NCL	Jawaharpur	196	1,137	149	1,481	784	706
3	Coal	Northern Karanpura Coal Fields	NTPC, Tanda	515	909	230	1,654	584	504
			Unchahar TPS	515	909	76	1,499	621	543
4	Coal	ECL	Parichha	246	1,160	132	1,538	1,035	984
			Panki	246	1,160	68	1,475	850	790
		Haldia	Rosa	-	1,970	234	2,204	1,187	1,251
5	Coal	NCL	Meja TPS	196	220	42	458	258	195
			Bara TPS	196	220	39	455	321	224
6	Food Grains	Punjab / Haryana(Ludhiana FCI is considered)	Prayagraj	331	1,045	200	1,576	1,231	1,014
	Sugar	Muzaffarnagar/Shamli	Prayagraj	126	1,045	200	1,371	-	785
	Automobiles	NCR Cluster	Prayagraj	58	1,045	100	1,203	-	684
7	Iron & Steel	Haldia	Delhi	-	2,669	25	2,694	1,541	1,565
	Sugar	Muzaffarnagar/Shamli	Kolkata/Haldia	126	2,669	-	2,795	1,477	1,572
	Container	UP & Delhi	EXIM (Singapore)	-	2,679	3,051 (Coastal)	5,730	1,496 (Rail) + 4,604 (Coastal) = 6,100	
8	Fertilizer	IFFCO, Phulpur	Kanpur	30	346	80	456	233	230
	Iron & Steel	Khurda Road , Odisha	Kanpur/Agra	410	1,970	150	2,530	1,487	1,441
	Food Grains	Punjab / Haryana(Ludhiana FCI is considered)	Daulatpur	331	698	240	1,269	987	815
	Sugar	Muzaffarnagar/Shamli	Daulatpur	126	698	240	1,064	-	515
	Automobiles	NCR Cluster	Kanpur	58	698	100	856	-	480

6.13.3 Terminal 1-Dadri Power Plant

6.13.3.1Origin –Destination Movement – Mapping

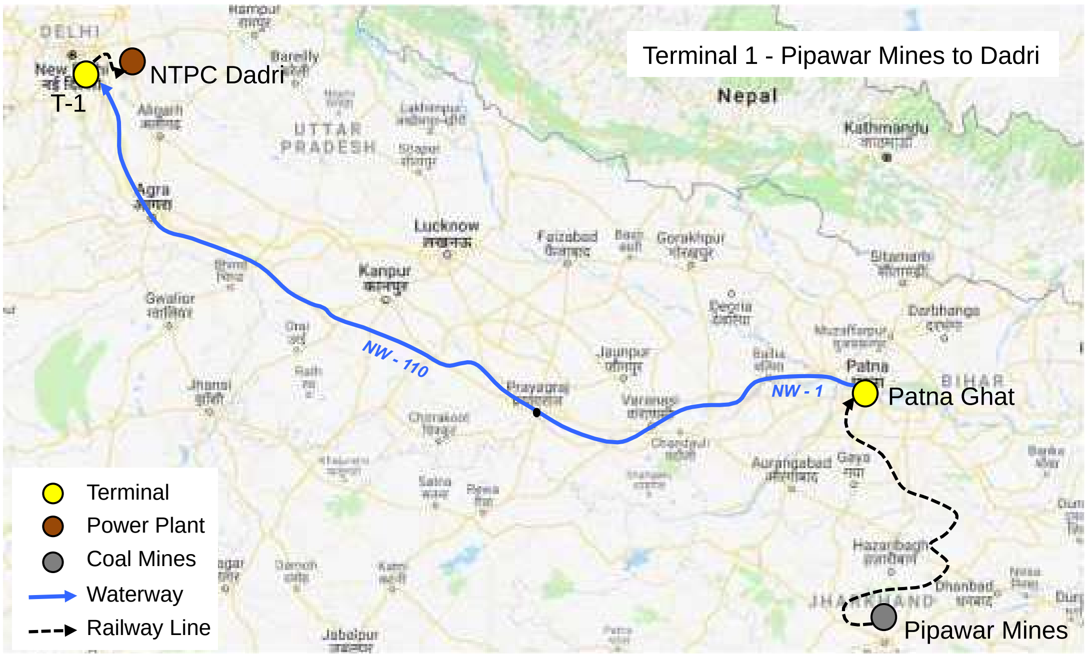


Fig. 6.56 Origin Destination Movement on River Yamuna (NW 110)

6.13.3.2Logistic Cost Comparison - Standard Vessels

- **Logistics Cost Comparison – INR per Ton-Km**

Dadri TPP procures coal from Piparwar Mines of central coalfields. It is assumed that this plant is only 10% dependent on imported coal. Following graph represent per ton coal transportation cost under each type of vessels using waterway (NW 1+ NW110) for two cases i.e. one way ballast & No ballastper ton km cost depicted in figure below is for waterway transportation alone.

First & last mile cost of transportation has not been factored in the calculation shown in figure. Domestic/imported coal movement for TPP in Uttar Pradesh would originate from Sahibganj.

The unit cost of transportation reduces with increase in sizes of barge and class waterways. Loaded speed & Ballast speed has been considered 6 knots & 9 knotsrespectively for all class of waterway.

IWAI intends to develop NW 110 for handling class III & class IV size of vessels. Following table describes end-to-end total logistic cost comparison of present & proposed mode of transportation.

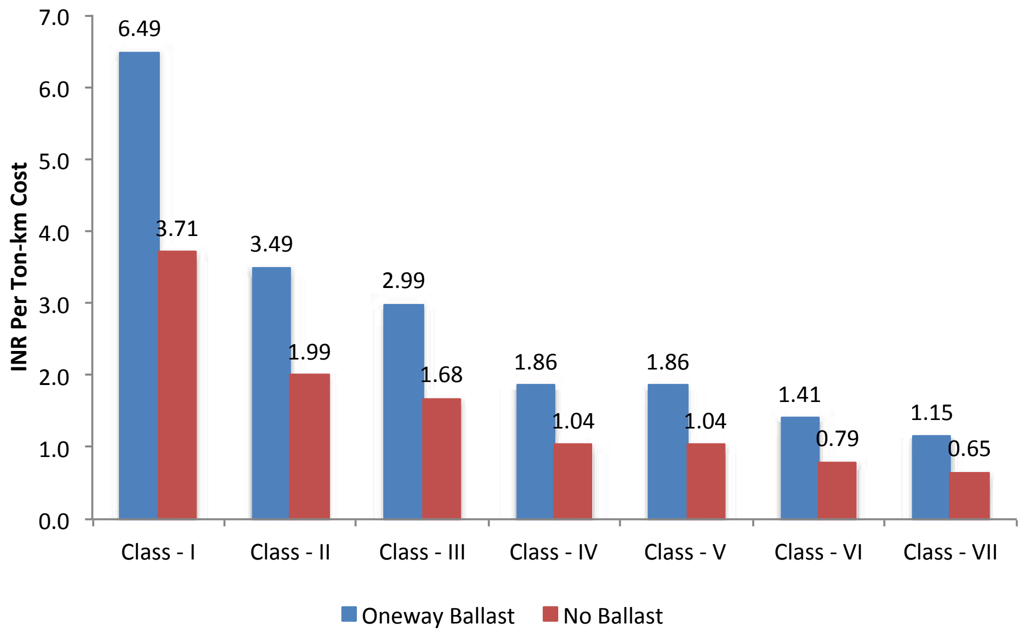


Fig. 6.57 Dadri TPP Per ton/km cost for waterway

- **Cumulative Logistics Cost Comparison – INR Per Ton**

The following table shows Cumulative Logistics Cost Comparison for Dadri Power Plant for Class III, IV and VI.

Table 6.113 Dadrilogistics cost for different classes- OneWay Ballast

Particulars	ClassIII	Class IV	Class VI	Railway Cost
Barge DWT	500	1000	2000	
Cost of Coal Loading at Mine	60.0	60.0	60.0	60.0
Coal Loading + Railway Tariff (Mine -Patna Ghat Terminal)	411.1	411.1	411.1	
Cost of Unloading Rake at Patna Ghat Terminal	60.0	60.0	60.0	
Stacking Cost at Patna Ghat Terminal	110.0	110.0	110.0	
Cost at Patna Ghat Terminal	200.0	200.0	200.0	
Lock Operation Cost - Assuming	-	-	-	
Feeder Barge - Sailing Cost	4,868.6	3,027.8	2,291.1	
Charges for Jetty (Dadri)	200.0	200.0	200.0	
Storage & Material Handling	110.0	110.0	110.0	
Cost of Coal Loading Rake at Dadri	60.0	60.0	60.0	
Railway Tariff at Dadri + Coal Unloading	205.6	205.6	205.6	1,607.6
Coal Unloading at Dadri	60.0	60.0	60.0	60.0
Total Cost	**6,345**	**4,505**	**3,768**	**1,728**

Logistics Cost Comparison for Dadri Power Plant is done for Class III, IV and VI waterways in the following charts.

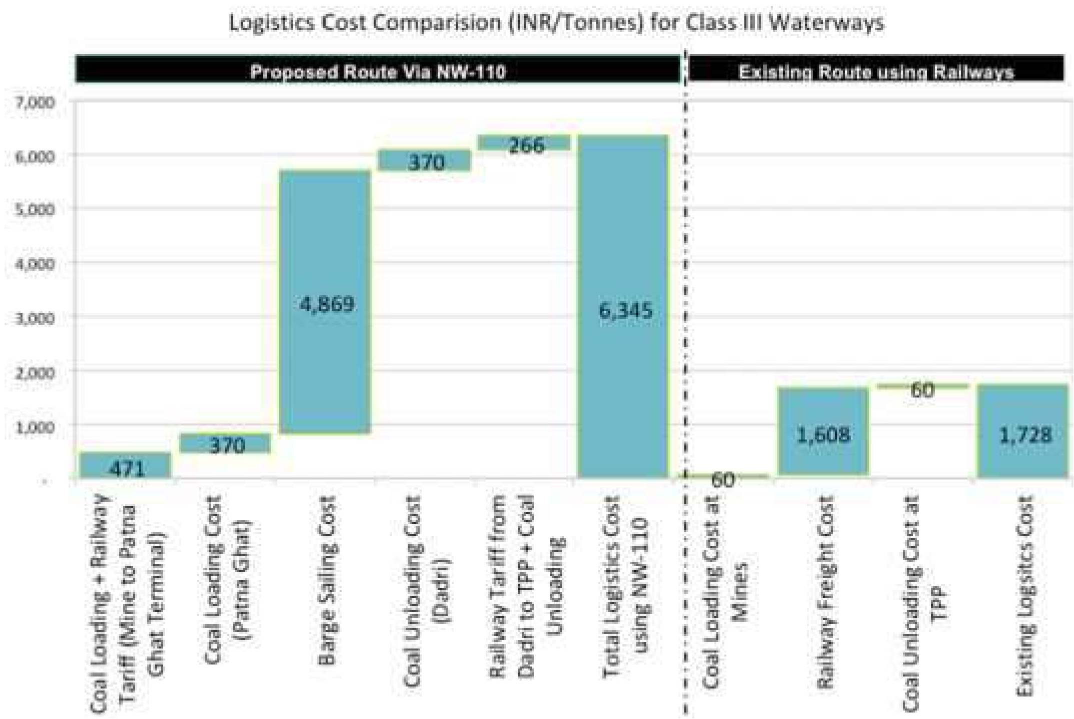


Fig. 6.58 Dadri Logistics cost comparison b/w Road, Rail & IWT for Class III

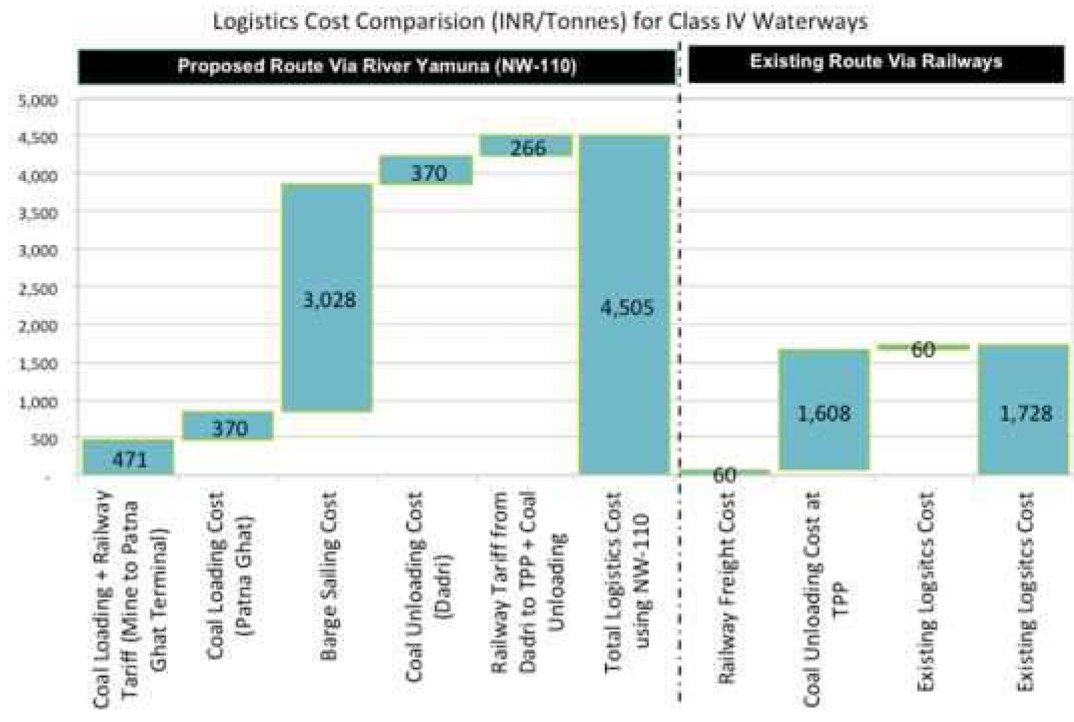


Fig. 6.59 Dadri Logistics cost comparison `b/w Road, Rail & IWT for Class IV

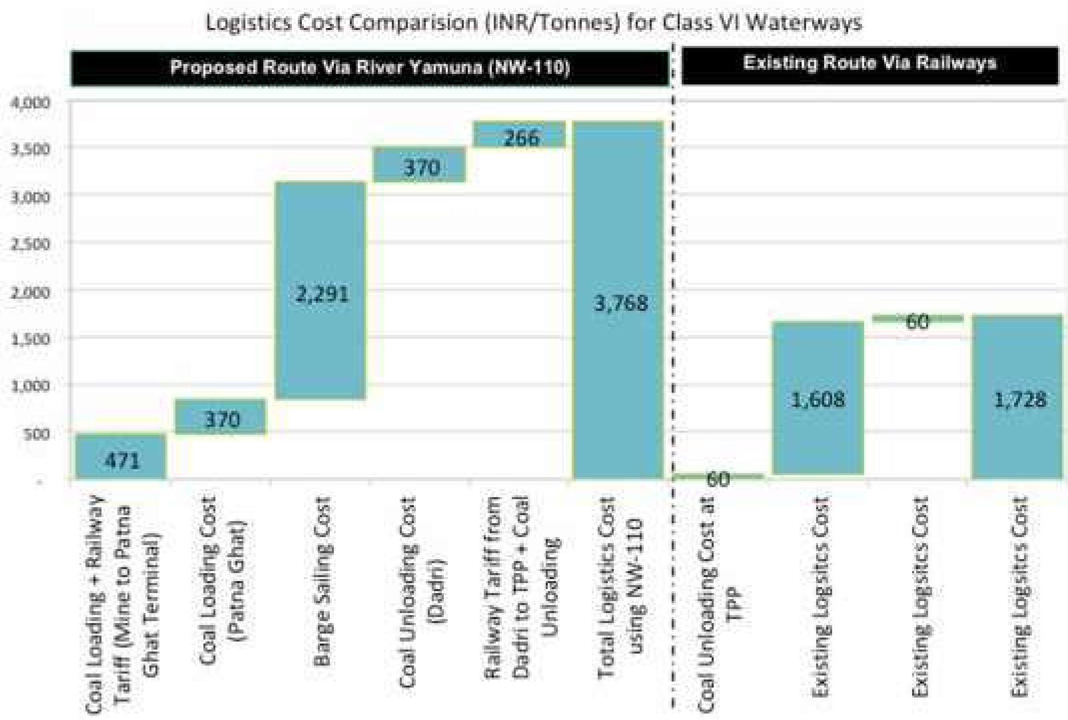


Fig. 6.60 Dadri Logistics cost comparison b/w Road, Rail & IWT for Class VI

6.13.3.3Logistic Cost Comparison - IWAI Designed Vessels

- **Logistics Cost Comparison– INR Per Ton-Km**

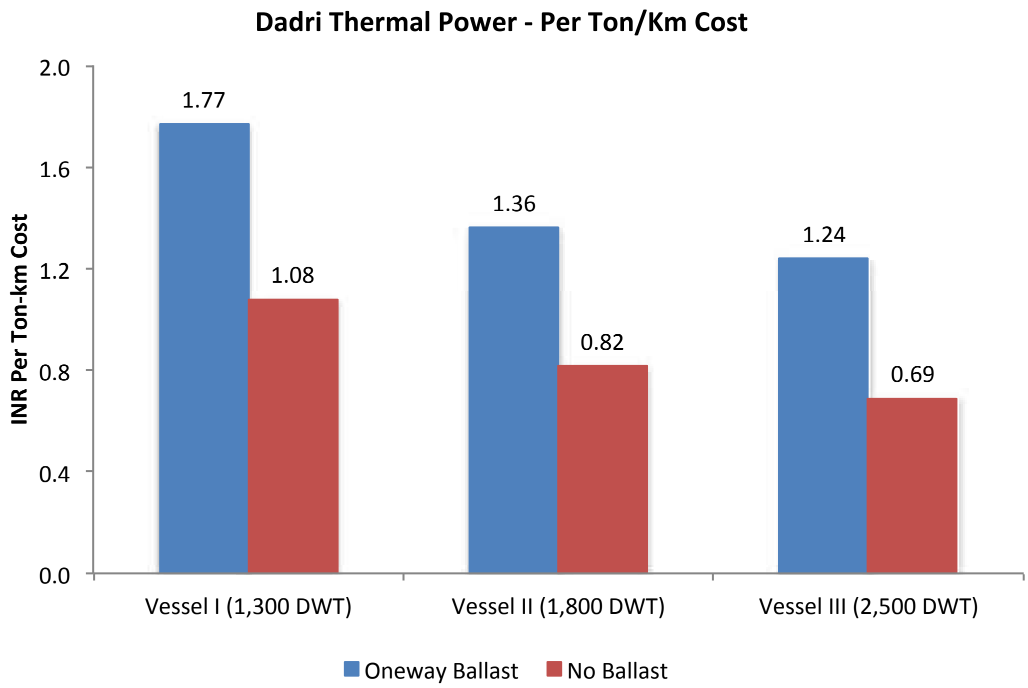


Fig. 6.61 Dadri TPP Per ton/km logistic cost using IWAI's vessels

- **Cumulative Logistics Cost Comparison– INR Per Ton**

The following table shows Cumulative Logistics Cost Comparison for Dadri Power Plant, for IWAI's special designed vessels, i.e. Vessel I (1,300 DWT), II (1,800 DWT) and III (2,500 DWT).

Table 6.114 Dadri Logistic Cost for different class - One Way Ballast

Particulars	Vessel I	Vessel II	Vessel III	Railway Cost
Barge DWT	1,300	1,800	2,500	n/a
Cost of Coal Loading at Mine	60	60	60	60
Coal Loading + Railway Tariff (Mine to Patna Ghat Terminal)	411	411	411	1,608
Cost of Unloading Rake at Patna Ghat Terminal	60	60	60	
Stacking Cost at Patna Ghat Terminal	110	110	110	
Cost at Patna Ghat Terminal	200	200	200	
Lock Operation Cost - Assuming	-	-	-	
Feeder Barge - Sailing Cost	2,885	2,220	2,022	
Charges for Jetty (Dadri)	200	200	200	
Storage & Material Handling	110	110	110	
Cost of Coal Loading Rake at Dadri	60	60	60	
Railway Tariff at Dadri + Coal Unloading	206	206	206	
Coal Unloading at Dadri	60	60	60	60
Total Cost	4,362	3,696	3,498	**1,728**

Logistics Cost Comparison for Dadri Power Plant is done for IWAI's special Class of vessels, i.e. Vessel I, II and III in the following charts.

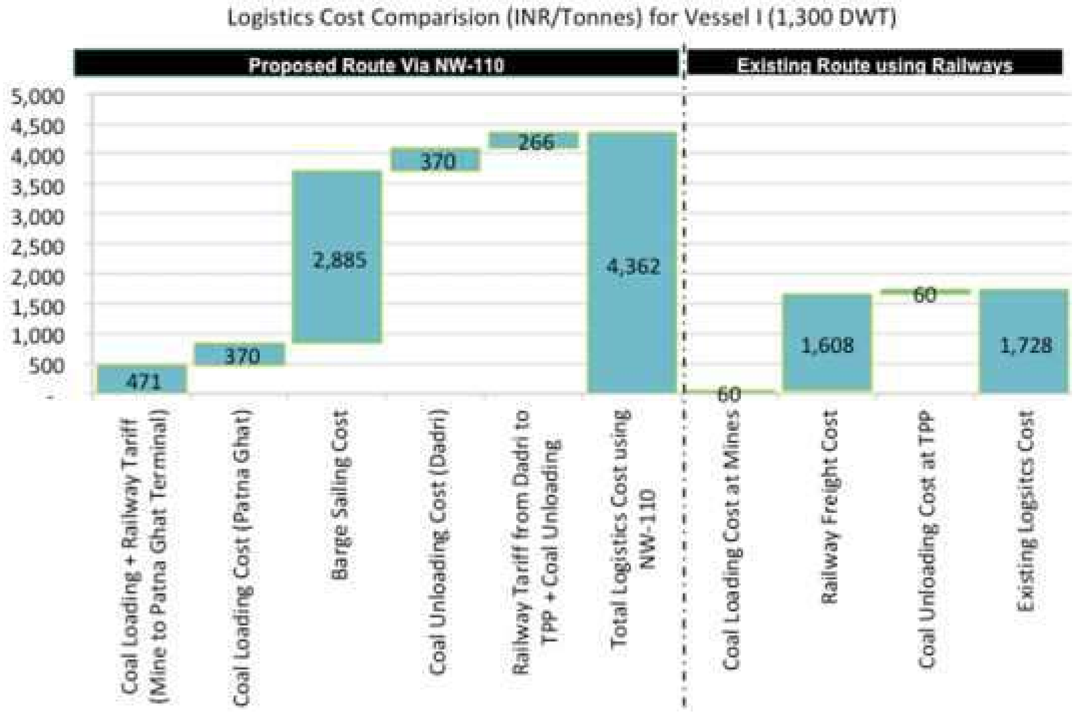


Fig. 6.62 Logistic Cost Comparison for IWAI Vessel I for Dadri TPP

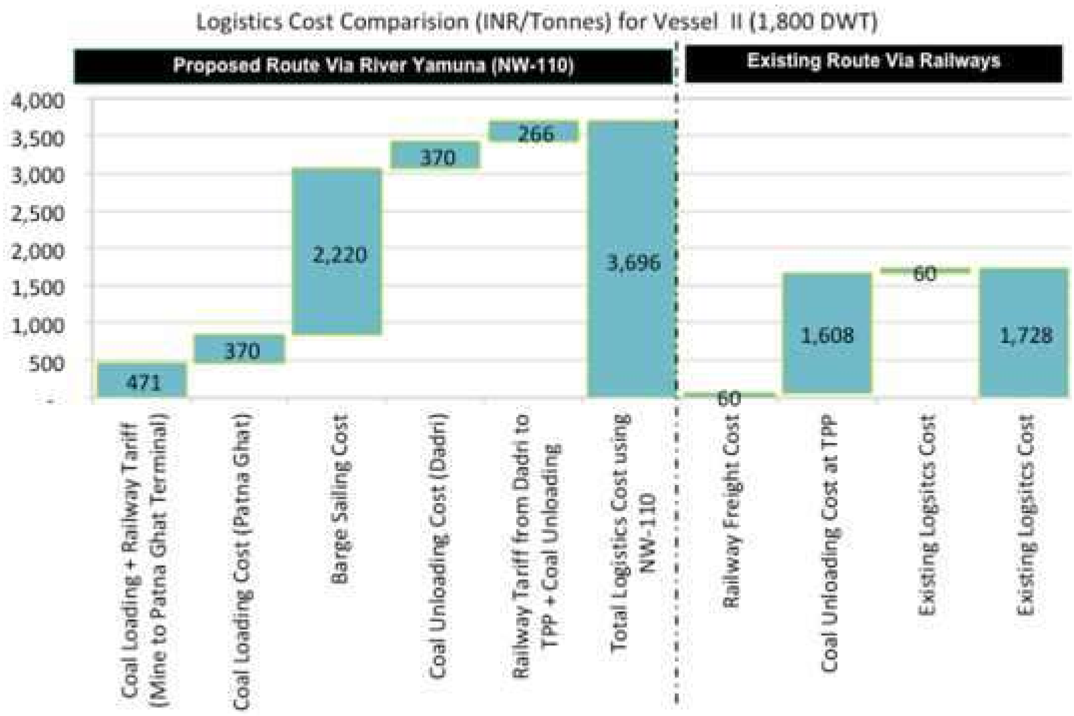


Fig. 6.63 Logistic Cost Comparison for IWAI Vessel II for Dadri TPP

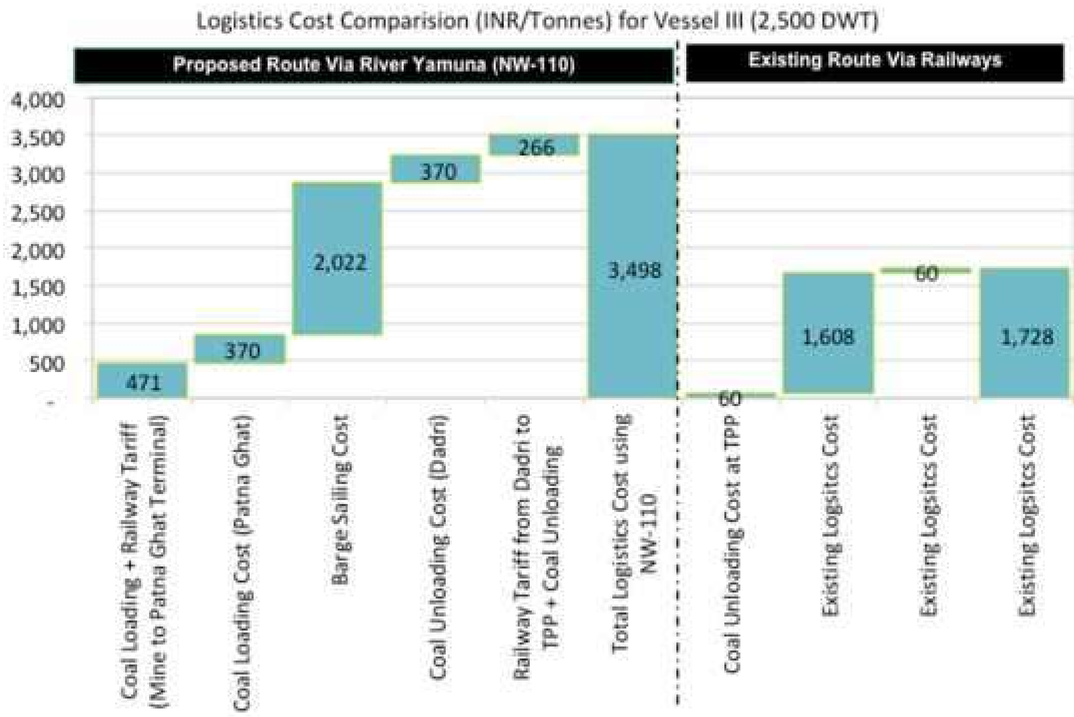


Fig. 6.64 Logistic Cost Comparison for IWAI Vessel III for Dadri TPP

6.13.4 Terminal 1 - Badarpur Power Plant

6.13.4.1Origin –Destination Movement - Mapping

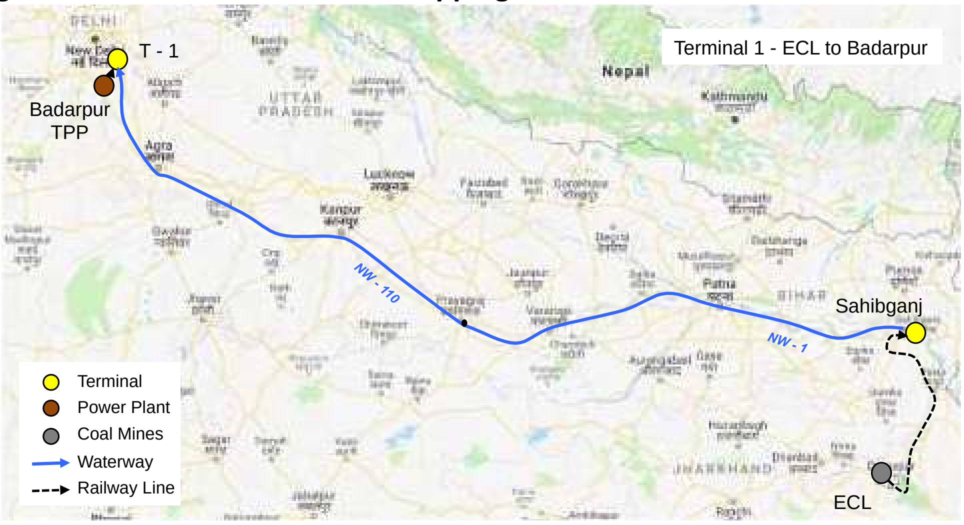


Fig. 6.65 Origin Destination Movement on River Yamuna (NW 110) for Badarpur TPP

6.13.4.2 Logistic Cost Comparison - Standard Vessels

Logistics Cost Comparison – INR per Ton-Km

Badarpur plant procures coal from ECL. Following graph represent per ton coal transportation cost under each type of vessels using waterway (NW 1+ NW110) for two cases i.e. one way ballast & No ballast per ton km cost depicted in figure below is for waterway transportation alone. First & last mile cost of transportation has not been factored in the calculation shown in figure. Domestic/imported coal movement for TPP in Uttar Pradesh would originate from Sahibganj. The unit cost of transportation reduces with increase in sizes of barge and class waterways. Loaded speed & Ballast speed has been considered 6 knots & 9 knots respectively for all class of waterway.

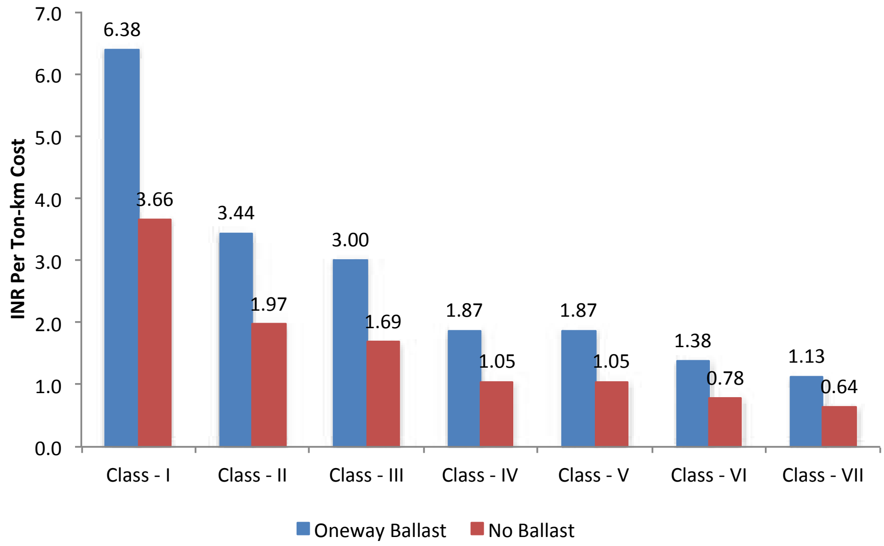


Fig. 6.66 Badarpur TPP Per ton/km cost for waterway

- **Cumulative Logistics Cost – INR Per Ton**

The following table shows Cumulative Logistics Cost Comparison for Badarpur Power Plant for Class III, IV and VI.

Table 6.115 Badarpur logistics cost for different classes- One Way Ballast

	Class - III	Class - IV	Class - VI	Railway Cost
Barge DWT	500	1000	2000	
Cost of Coal Loading at Mine	60.0	60.0	60.0	60.0
Coal Unloading + Railway Tariff (Mine to Sahibganj Terminal)	378.0	378.0	378.0	
Cost of Unloading Rake at Sahibganj Terminal	60.0	60.0	60.0	
Stacking Cost at Sahibganj Terminal	110.0	110.0	110.0	
Cost at Sahibganj Terminal	200.0	200.0	200.0	
Lock Operation Cost - Assuming	-	-	-	
Feeder Barge - Sailing Cost	5,525.3	3,439.6	2,533.9	
Charges for Jetty (Badapur)	200.0	200.0	200.0	
Storage & Material Handling	110.0	110.0	110.0	
Cost of Coal Loading Rake at Badarpur	60.0	60.0	60.0	
Railway Tariff at Badarpur	205.6	205.6	205.6	1,736.2
Coal Unloading at Badarpur	60.0	60.0	60.0	60.0
Total Cost	**6,969**	**4,883**	**3,978**	**1,856**

Logistics Cost Comparison for Badarpur Power Plant is done for Class III, IV and VI waterways in the following charts.

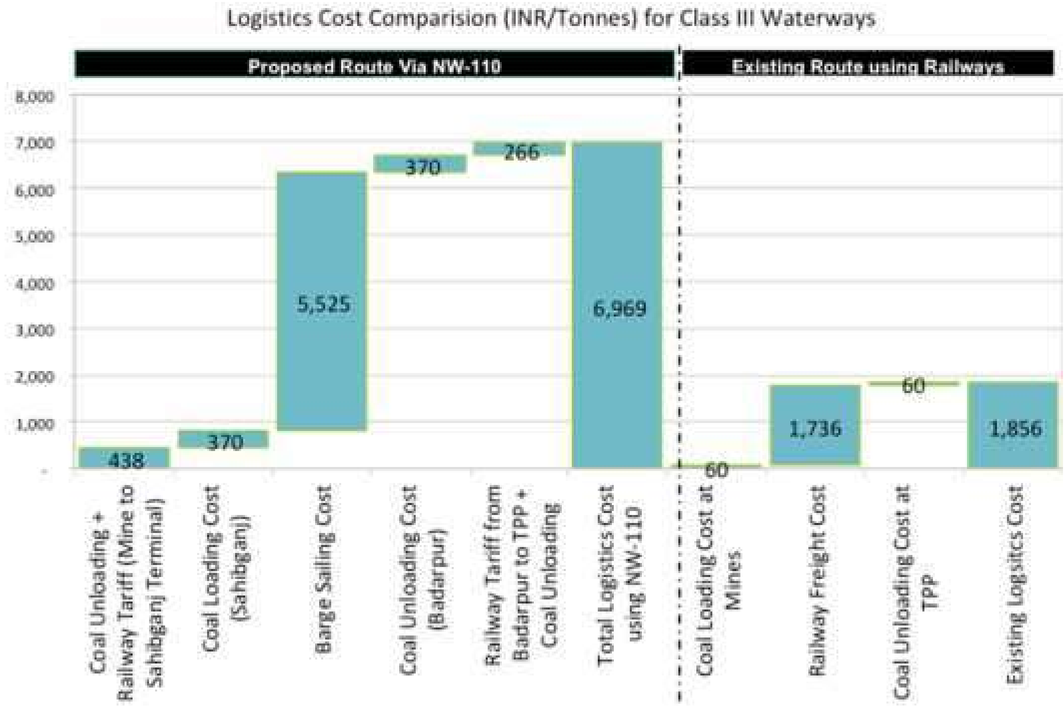


Fig. 6.67 Badarpur Logistics comparison b/w Road, Rail & IWT for Class III

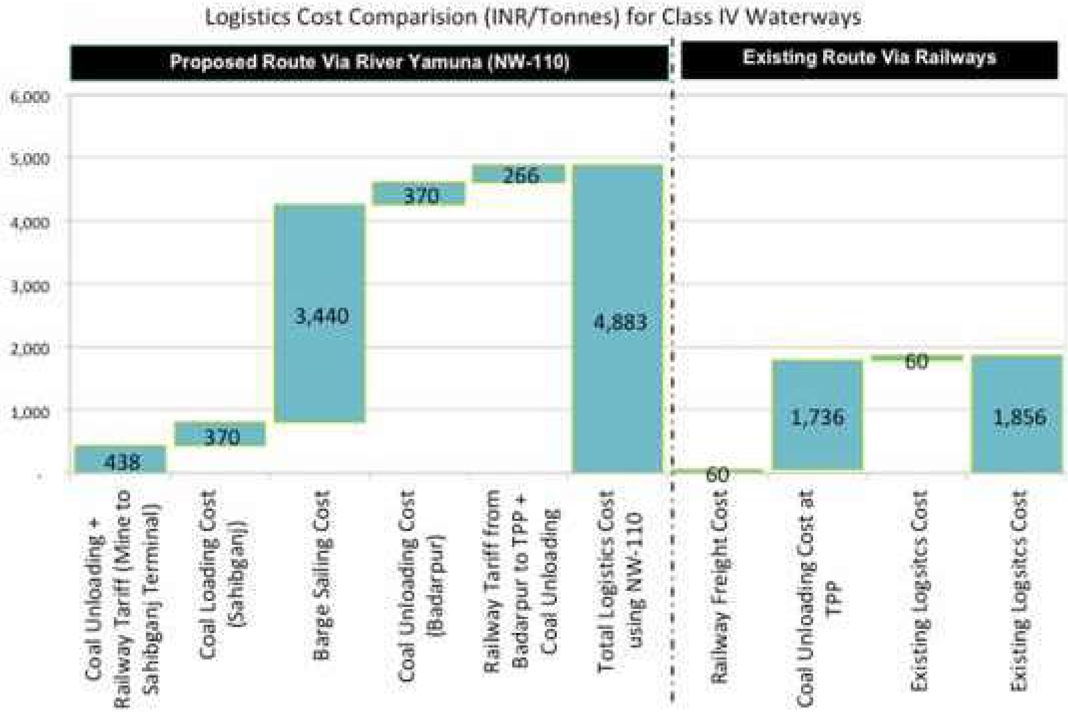


Fig. 6.68 Badarpur Logistics comparison b/w Road, Rail & IWT for Class IV

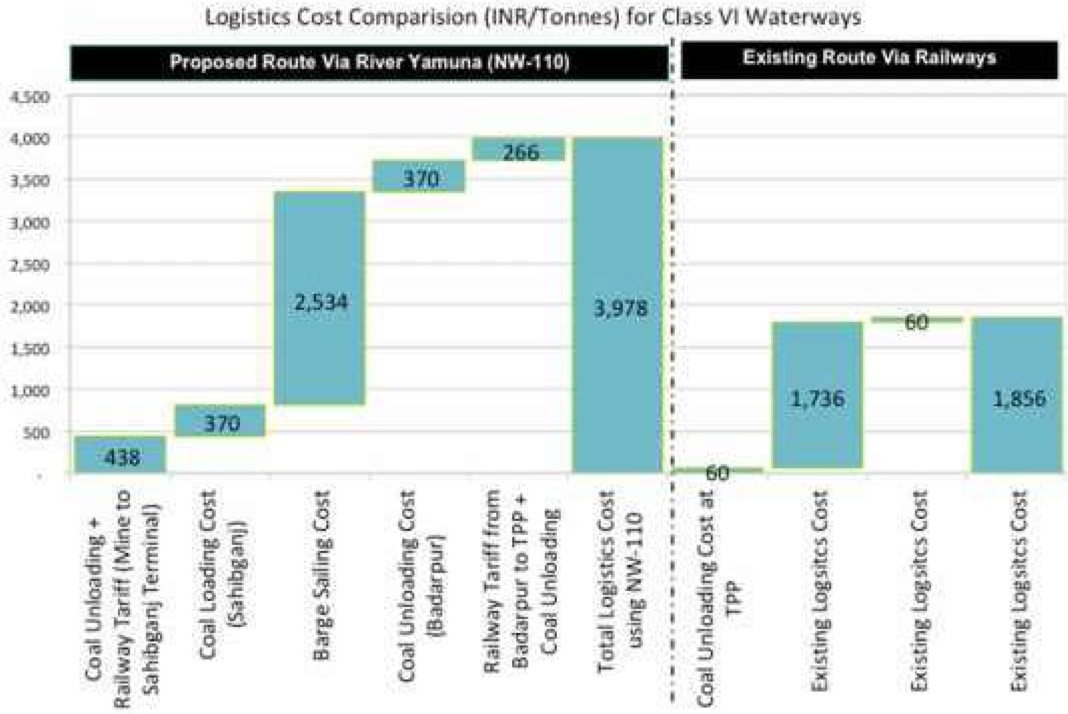


Fig. 6.69 Badarpur Logistics comparison b/w Road, Rail & IWT for Class VI

6.13.4.3Logistic Cost Comparison - IWAI Designed Vessels

- **Logistics Cost Comparison– INR Per Ton-Km**

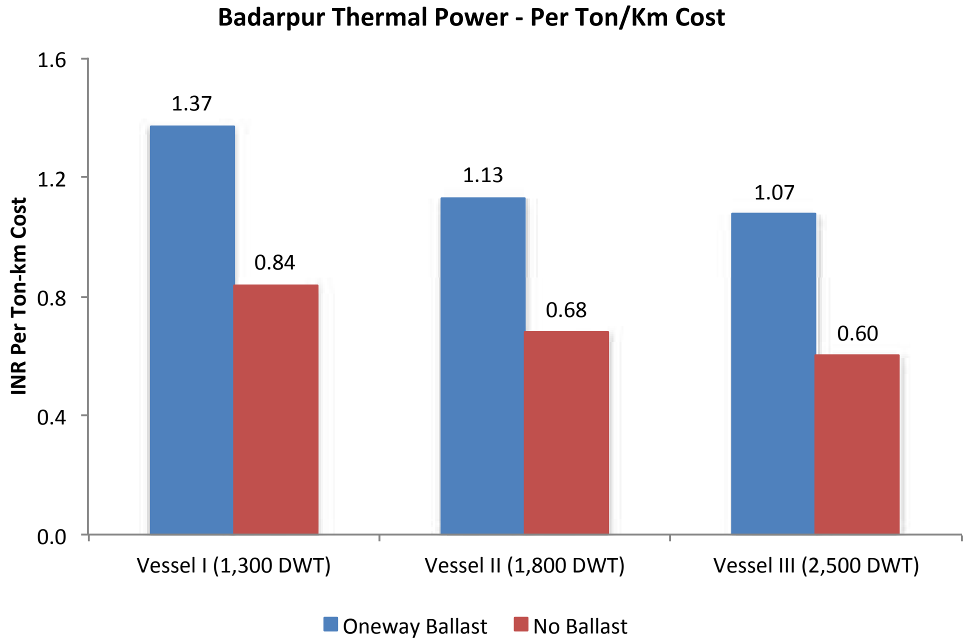


Fig. 6.70 Badarpur TPP Per ton/km cost for IWAI's Vessels

- **Cumulative Logistics Cost Comparison – INR Per Ton**

The following table shows Cumulative Logistics Cost Comparison for Badarpur Power Plant, for IWAI's special designed vessels, i.e. Vessel I (1,300 DWT), II (1,800 DWT) and III (2,500 DWT).

Table 6.116 Badarpur logistics cost for different classes- One Way Ballast

Particulars	Vessel I	Vessel II	Vessel III	Railway Cost
Barge DWT	1300	1800	2500	n/a
Cost of Coal Loading at Mine	60	60	60	60
Coal Unloading + Railway Tariff (Mine to Sahibganj Terminal)	378	378	378	
Cost of Unloading Rake at Sahibganj Terminal	60	60	60	
Stacking Cost at Sahibganj Terminal	110	110	110	
Cost at Sahibganj Terminal	200	200	200	
Lock Operation Cost - Assuming	0	0	0	
Feeder Barge - Sailing Cost	2525	2082	1976	
Charges for Jetty (Badapur)	200	200	200	
Storage & Material Handling	110	110	110	
Cost of Coal Loading Rake at Badarpur	60	60	60	
Railway Tariff at Badarpur	206	206	206	1,736
Coal Unloading at Badarpur	60	60	60	60
Total Cost	**3969**	**3526**	**3420**	**1,856**

Logistics Cost Comparison for Badarpur Power Plant is done for IWAI's special Class of vessels, i.e. Vessel I, II and III in the following charts.

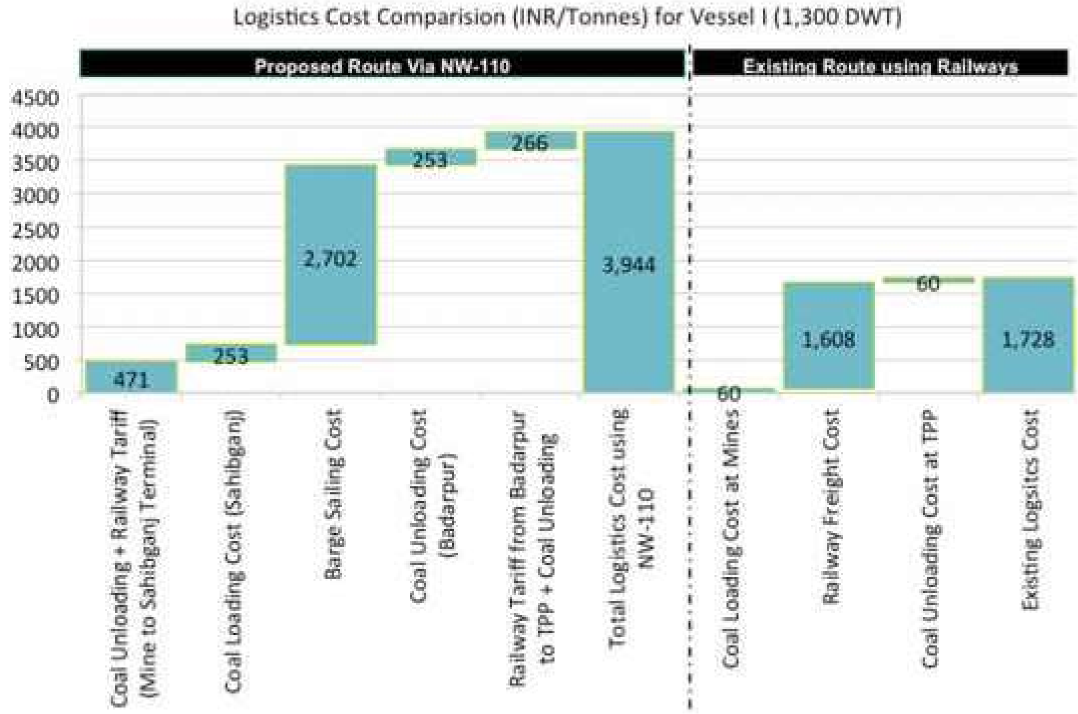


Fig. 6.71 Badarpur Logistic Cost Comparison b/w IWAI Vessel I & Existing Route

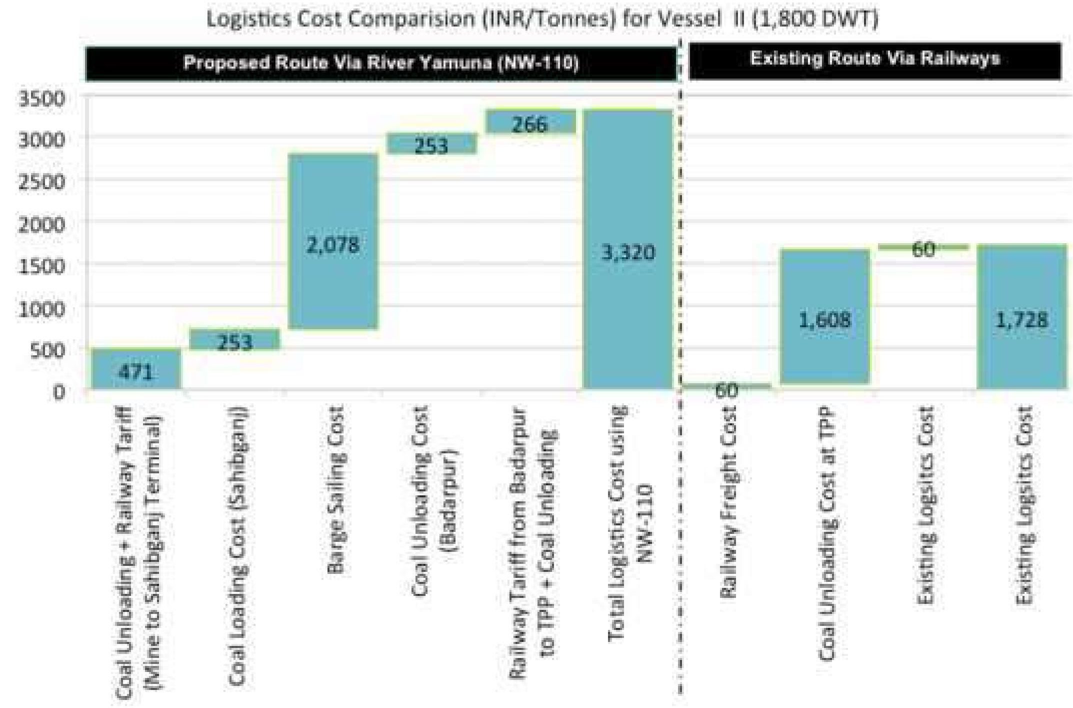


Fig. 6.72 Badarpur Logistic Cost Comparison b/w IWAI Vessel II & Existing Route

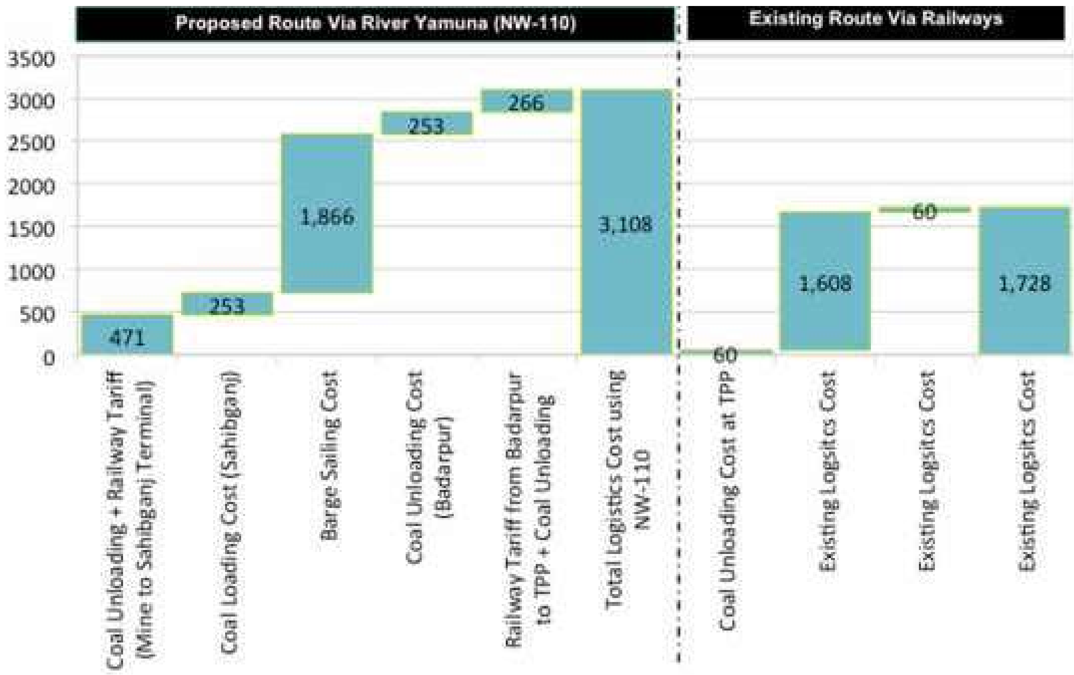


Fig. 6.73 Badarpur Logistic Cost Comparison b/w IWAI Vessel III & Existing Route

6.13.5 Terminal 2 - Harduaganj Power Plant

6.13.5.1Origin –Destination Movement – Mapping

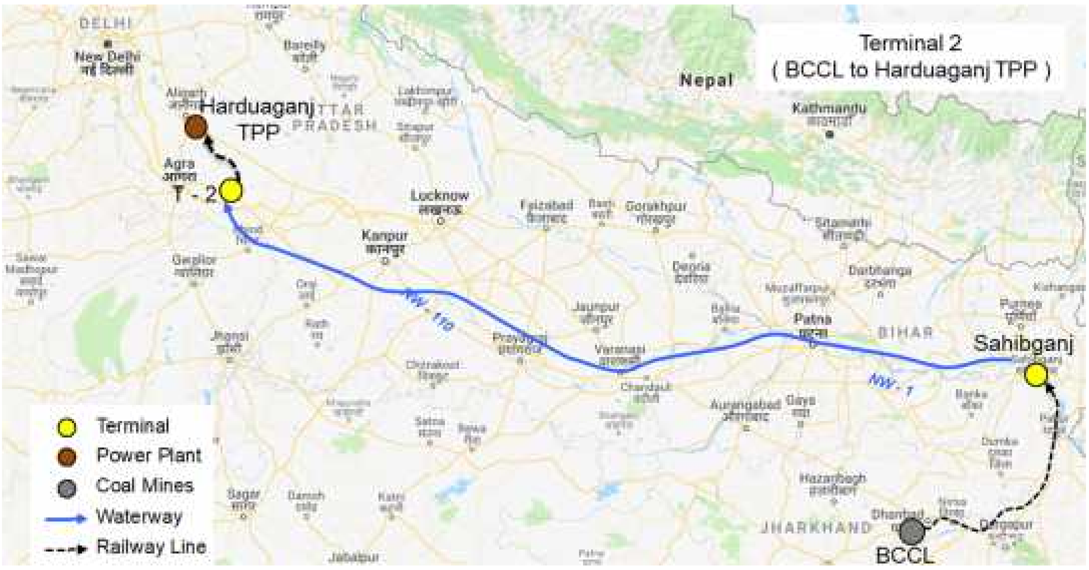


Fig. 6.74 Origin Destination Movement on River Yamuna (NW 110)

6.13.5.2Logistic Cost Comparison - Standard Vessels

Logistics Cost Comparison – INR per Ton-Km

Harduaganjplant procures coal from BCCL & ECL Mines. Following graph represent per ton coal transportation cost under each type of vessels using waterway (NW 1+ NW110) for two cases i.e. one way ballast & No ballast. Per ton km cost depicted in figure below is for waterway transportation alone. First & last mile cost of transportation has not been factored in the calculation shown in figure. Domestic/imported coal movement for TPP in Uttar Pradesh would originate from Sahibganj. The unit cost of transportation reduces with increase in sizes of barge and class waterways. Loaded speed & Ballast speed has been considered 6 knots& 9 knots respectively for all class of waterway.

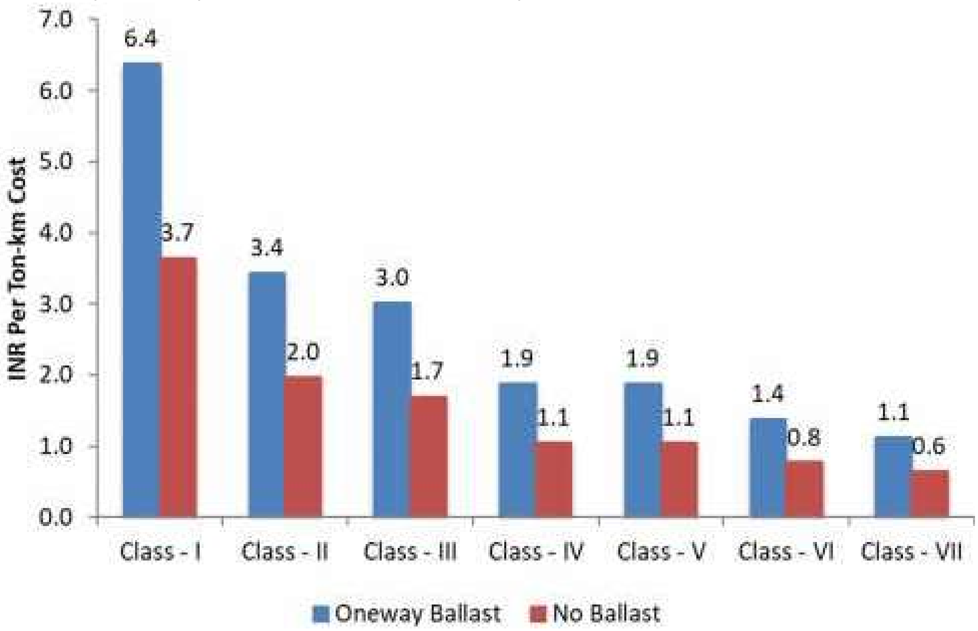


Fig. 6.75 Harduaganj TPP Per ton/km cost for waterway

- **Cumulative Logistics Cost – INR Per Ton**

The following table shows Cumulative Logistics Cost Comparison for Harduaganj Power Plant for Class III, IV and VI.

Table 6.117 Harduaganj logistics cost for different classes- One Way Ballast

Particulars	Class - III	Class - IV	Class - VI	Railway Cost
Barge DWT	500	1000	2000	
Cost of Coal Loading at Mine	60.0	60.0	60.0	60.0
Coal Loading + Railway Tariff (Mine to Sahibganj Terminal)	474.6	474.6	474.6	
Cost of Unloading Rake at Sahibganj Terminal	60.0	60.0	60.0	
Stacking Cost at Sahibganj Terminal	110.0	110.0	110.0	
Cost at Sahibganj Terminal	200.0	200.0	200.0	
Lock Operation Cost - Assuming	-	-	-	
Feeder Barge - Sailing Cost	4,655.1	2,899.7	2,133.1	
Charges for Jetty (Harduaganj)	200.0	200.0	200.0	
Storage & Material Handling	110.0	110.0	110.0	
Cost of Coal Loading Rake at Harduaganj	60.0	60.0	60.0	
Railway Tariff at Harduaganj + Coal Unloading	205.6	205.6	205.6	1,478.4
Coal Unloading at Harduaganj	60.0	60.0	60.0	60.0
Total Cost	**6,195**	**4,440**	**3,673**	**1,598**

Logistics Cost Comparison for Harduaganj Power Plant is done for Class III, IV and VI waterways in the following charts.

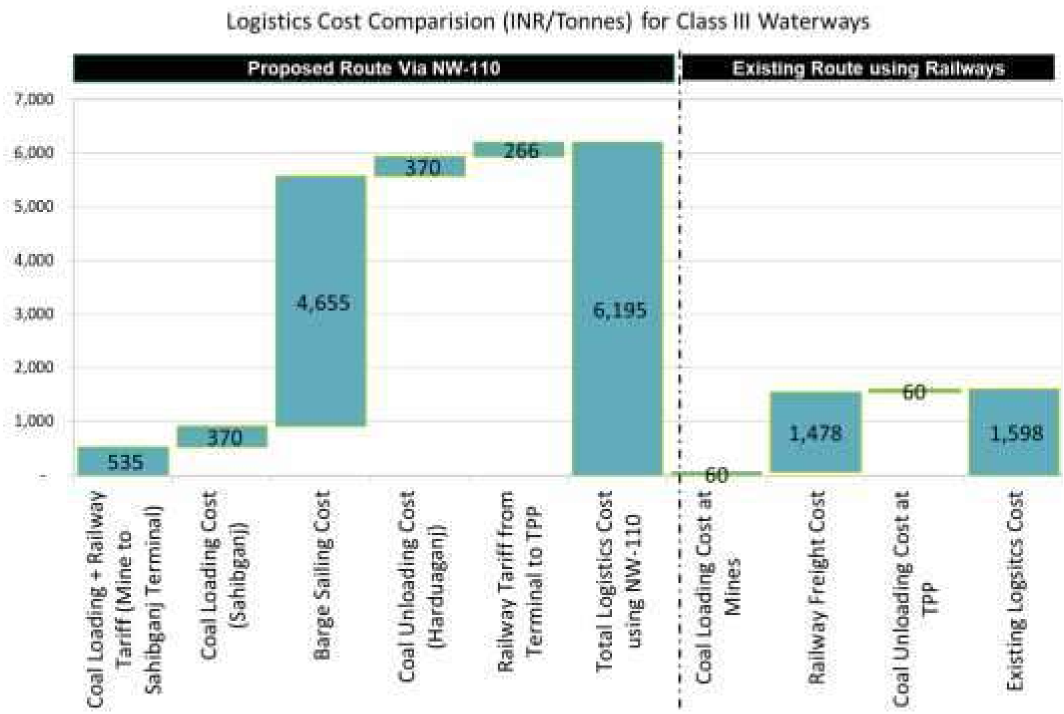


Fig. 6.76 Harduaganj Logistics cost comparison b/w Road, Rail & IWT for Class III

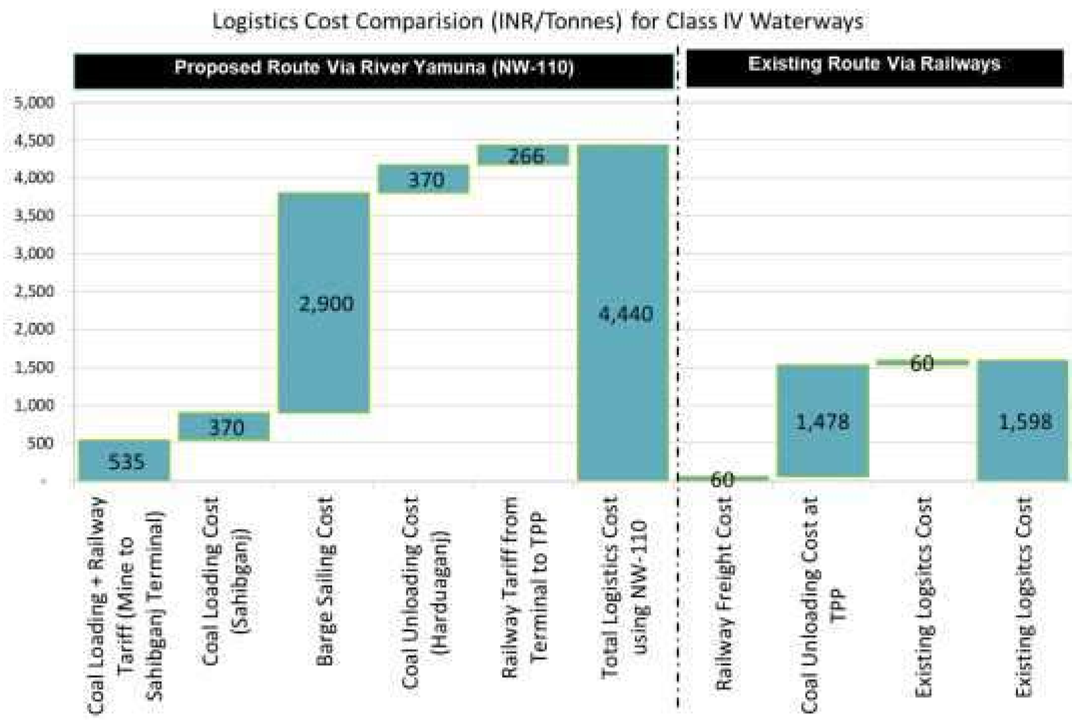


Fig. 6.77 Harduaganj Logistics cost comparison b/w Road, Rail & IWT for Class IV

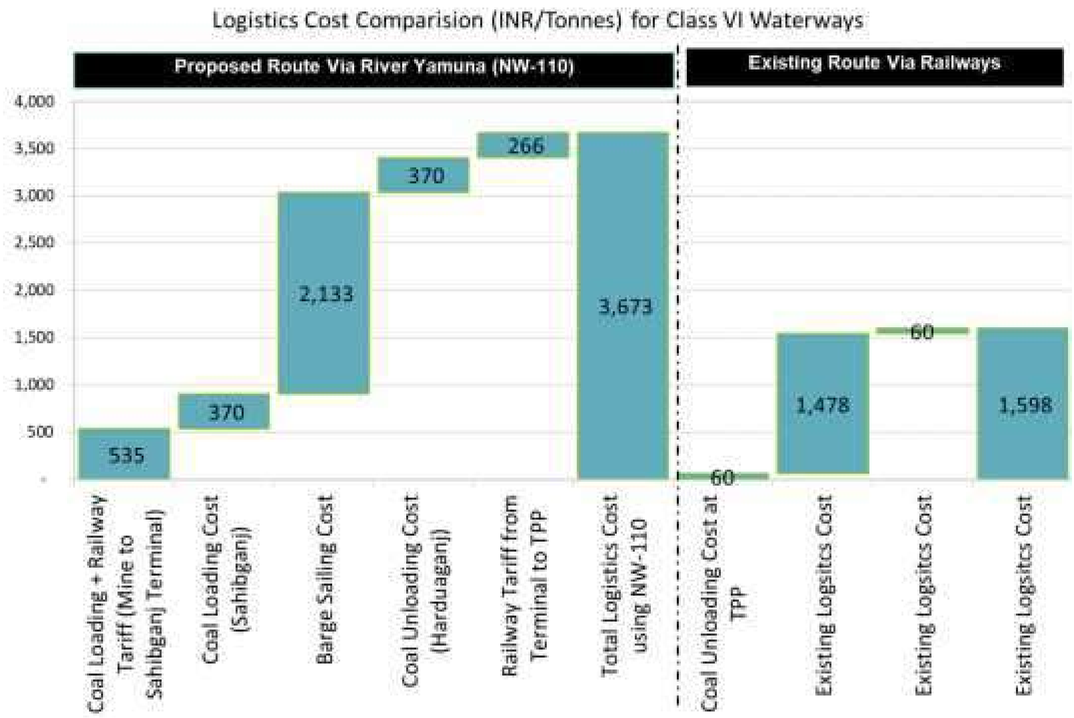


Fig. 6.78 Harduaganj Logistics cost comparison b/w Road, Rail & IWT for Class VI

6.13.5.3Logistic Cost Comparison - IWAI Designed Vessels

- **Logistics Cost Comparison– INR Per Ton-Km**

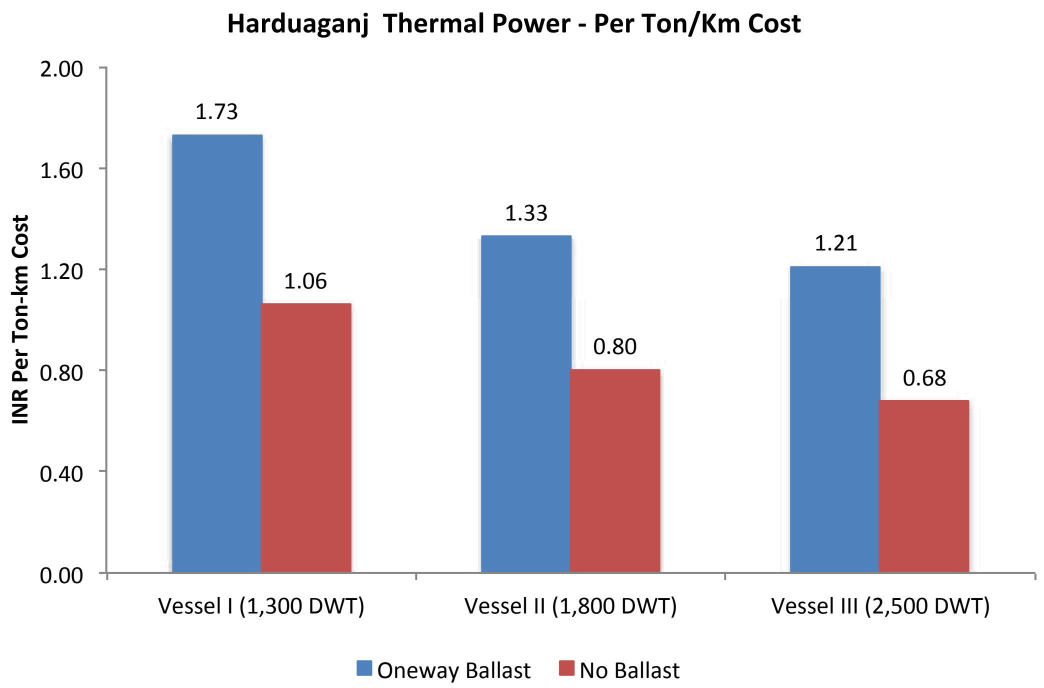


Fig. 6.79 Harduaganj TPP Per ton/km cost for IWAI's Vessels

- **Cumulative Logistics Cost Comparison – INR Per Ton**

The following table shows Cumulative Logistics Cost Comparison for Harduaganj Power Plant, for IWAI's special designed vessels, i.e. Vessel I (1,300 DWT), II (1,800 DWT) and III (2,500 DWT).

Table 6.118 Harduaganj logistics cost for different classes- One Way Ballast

Particulars	Vessel I	Vessel II	Vessel III	Railway Cost
Barge DWT	1300	1800	2500	n/a
Cost of Coal Loading at Mine	60	60	60	60
Coal Loading + Railway Tariff (Mine to Sahibganj Terminal)	475	475	475	
Cost of Unloading Rake at Sahibganj Terminal	60	60	60	
Stacking Cost at Sahibganj Terminal	110	110	110	
Cost at Sahibganj Terminal	200	200	200	
Lock Operation Cost - Assuming	-	-	-	
Feeder Barge - Sailing Cost	2,948	2,263	2,064	
Charges for Jetty (Harduaganj)	200	200	200	
Storage & Material Handling	110	110	110	
Cost of Coal Loading Rake at Harduaganj	60	60	60	
Railway Tariff at Harduaganj + Coal Unloading	206	206	206	1478
Coal Unloading at Harduaganj	60	60	60	60
Total Cost	**4,488**	**3,803**	**3,604**	**1598**

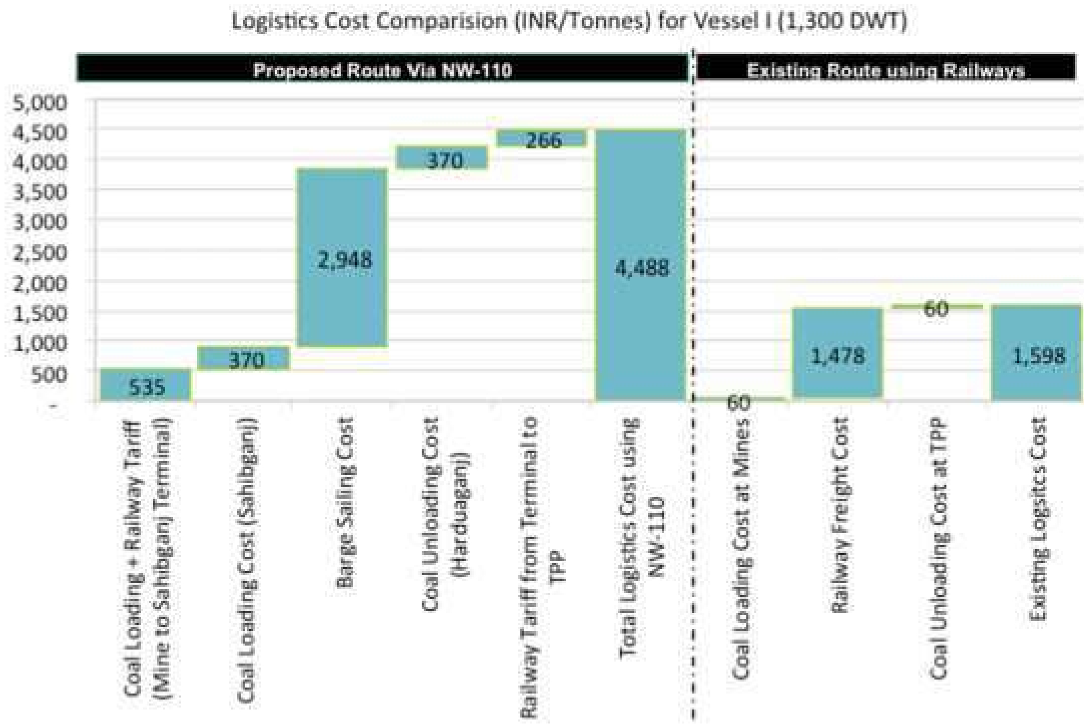


Fig. 6.80 Harduaganj Logistic Cost Comparison b/w IWAI Vessel I& Existing Route

Logistics Cost Comparison for Harduaganj Power Plant is done for IWAI's special Class of vessels, i.e. Vessel I, II and III in the following charts.

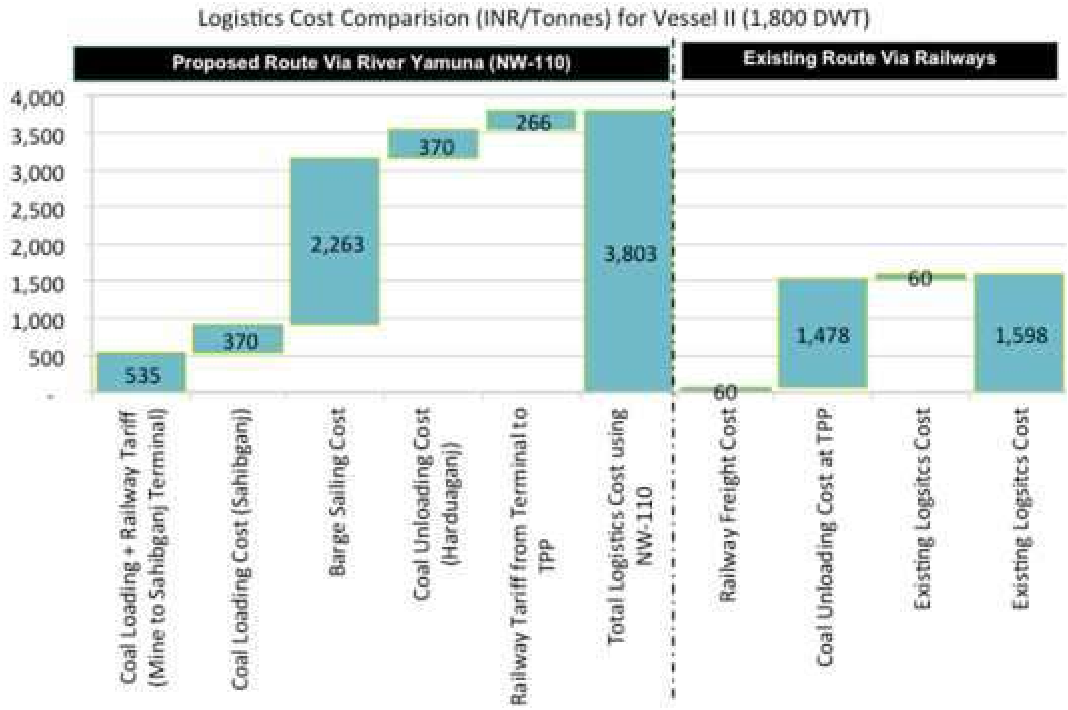


Fig. 6.81 Harduaganj Logistic Cost Comparison b/w IWAI Vessel II & Existing Route

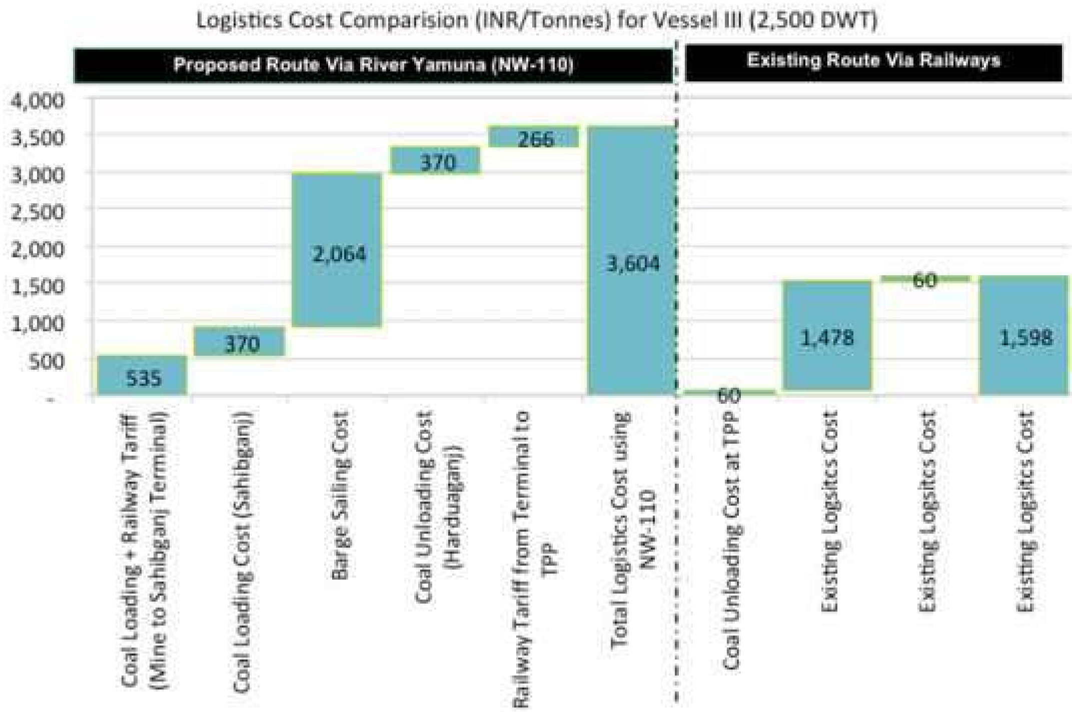


Fig. 6.82 Harduaganj Logistic Cost Comparison b/w IWAI Vessel III & Existing Route

6.13.6 Terminal 2 - Jawaharpur Power Plant

6.13.6.1Origin –Destination Movement – Mapping

Fig. 6.83 Origin Destination Movement on River Yamuna (NW 110)

6.13.6.2Logistic Cost Comparison - Standard Vessels

- **Logistics Cost Comparison – INR Per Ton-Km**

Jawaharpur plant procures domestic coal from either BCCL & ECL Mines. Following graph represent per ton coal transportation cost under each type of vessels using waterway (NW 1+ NW110) for two cases i.e. one way ballast & No ballast. Per ton km cost depicted in figure below is for waterway transportation alone. First & last mile cost of transportation has not been factored in the calculation shown in figure. Domestic/imported coal movement for TPP in Uttar Pradesh would originate from Sahibganj. The unit cost of transportation reduces with increase in sizes of barge and class waterways. Loaded speed & Ballast speed has been considered 6 knots & 9 knots respectively for all class of waterway.

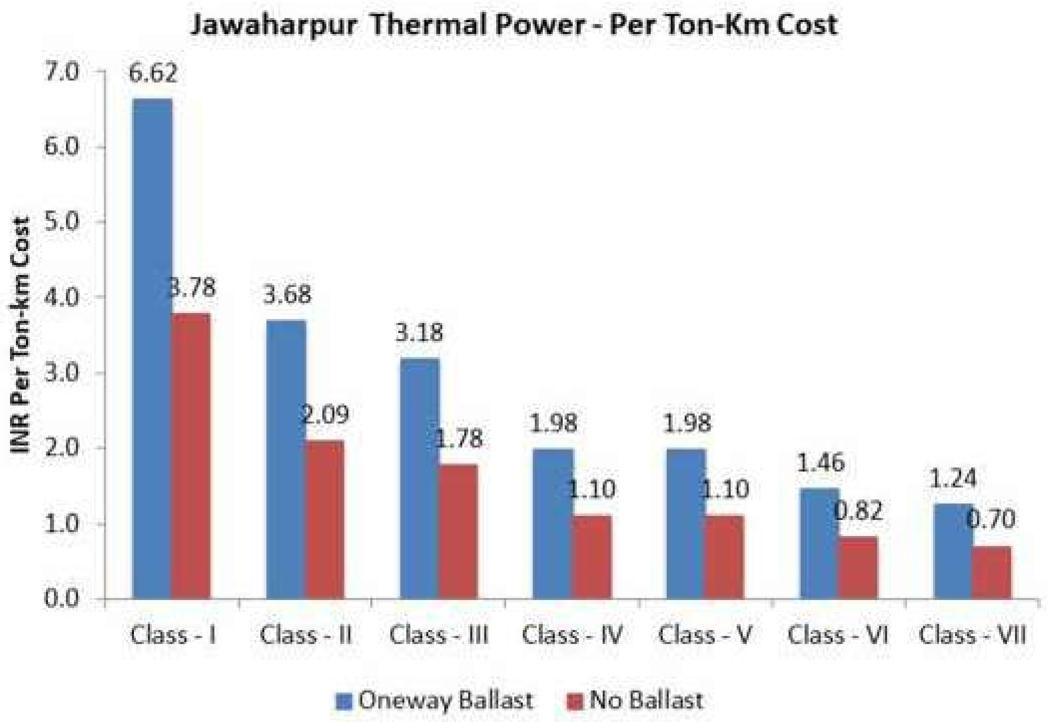


Fig. 6.84 Jawaharpur TPP Per ton/km cost for waterway

- **Cumulative Logistics Cost Comparison – INR Per Ton**

The following table shows Cumulative Logistics Cost Comparison for Jawaharpur Power Plant for Class III, IV and VI.

Table 6.119 Jawaharpur logistics cost for different classes- One Way Ballast

Particulars	Class - III	Class - IV	Class - VI	Railway Cost
Barge DWT	500	1000	2000	
Cost of Coal Loading at Mine	60.0	60.0	60.0	60.0
Coal Loading + Railway Tariff (Mine to Varanasi Terminal)	314.2	314.2	314.2	
Cost of Unloading Rake at Varanasi Terminal	60.0	60.0	60.0	
Stacking Cost at Varanasi Terminal	110.0	110.0	110.0	
Cost at Varanasi Terminal	200.0	200.0	200.0	
Lock Operation Cost - Assuming	-	-	-	
Feeder Barge - Sailing Cost	3,025.8	1,886.6	1,384.8	
Charges for Jetty	200.0	200.0	200.0	
Storage & Material Handling	110.0	110.0	110.0	
Cost of Coal Loading Rake at Jawaharpur	60.0	60.0	60.0	
Railway Tariff at Jawaharpur + Coal Unloading	205.6	205.6	205.6	1,093.7
Coal Unloading at Jawaharpur	60.0	60.0	60.0	60.0
Total Cost	**4,406**	**3,266**	**2,765**	**1,214**

Logistics Cost Comparison for Jawaharpur Power Plant is done for Class III, IV and VI waterways in the following charts.

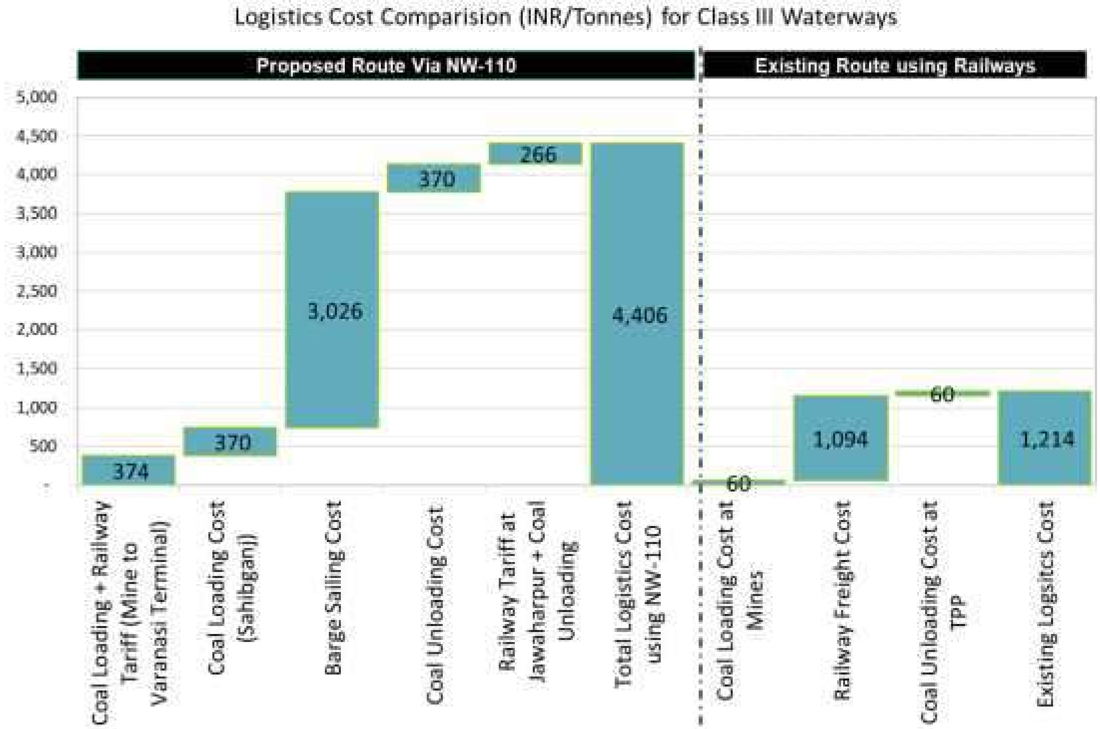


Fig. 6.85 Jawaharpur Logistics cost comparison b/w Road, Rail & IWT for Class III

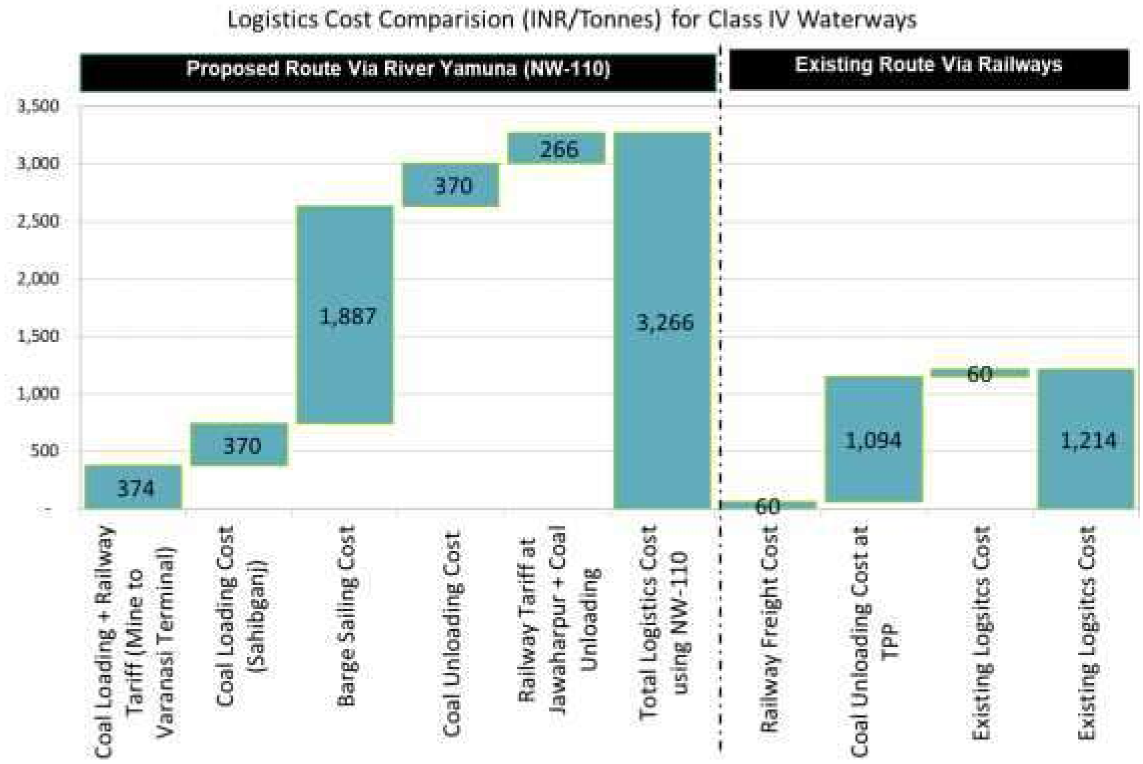


Fig. 6.86 Jawaharpur Logistics cost comparison b/w Road, Rail & IWT for Class IV

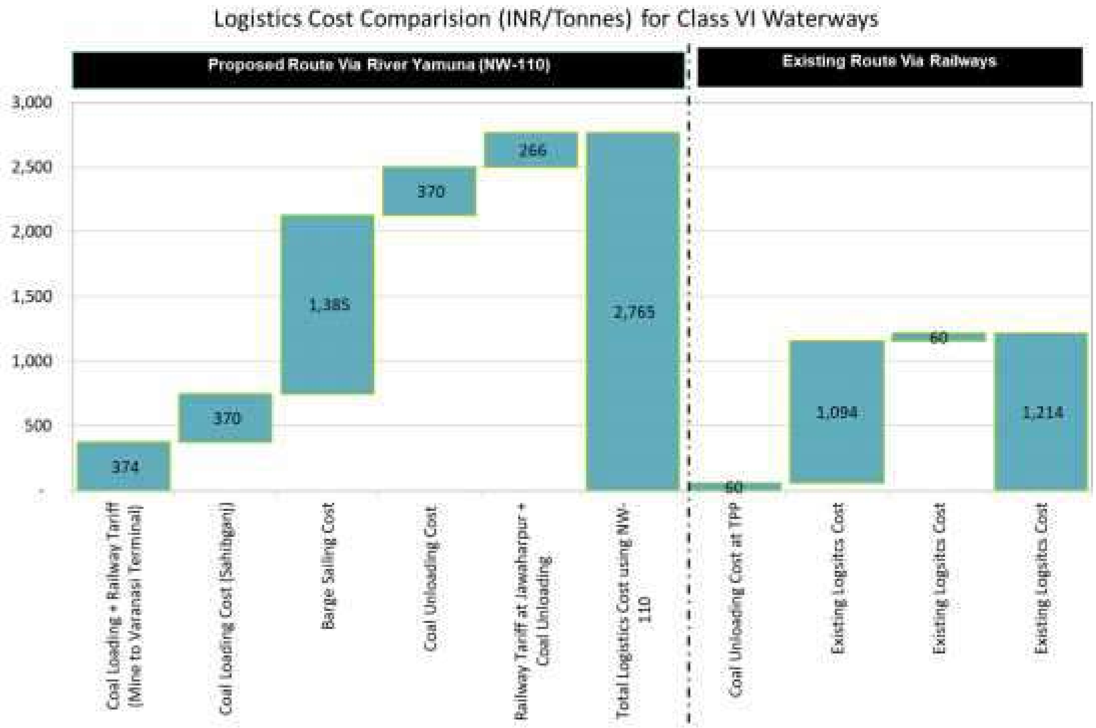


Fig. 6.87 Jawaharpur Logistics cost comparison b/w Road, Rail & IWT for Class VI

6.13.6.3 Logistic Cost Comparison - IWAI Designed Vessels

- **Logistics Cost Comparison– INR Per Ton-Km**

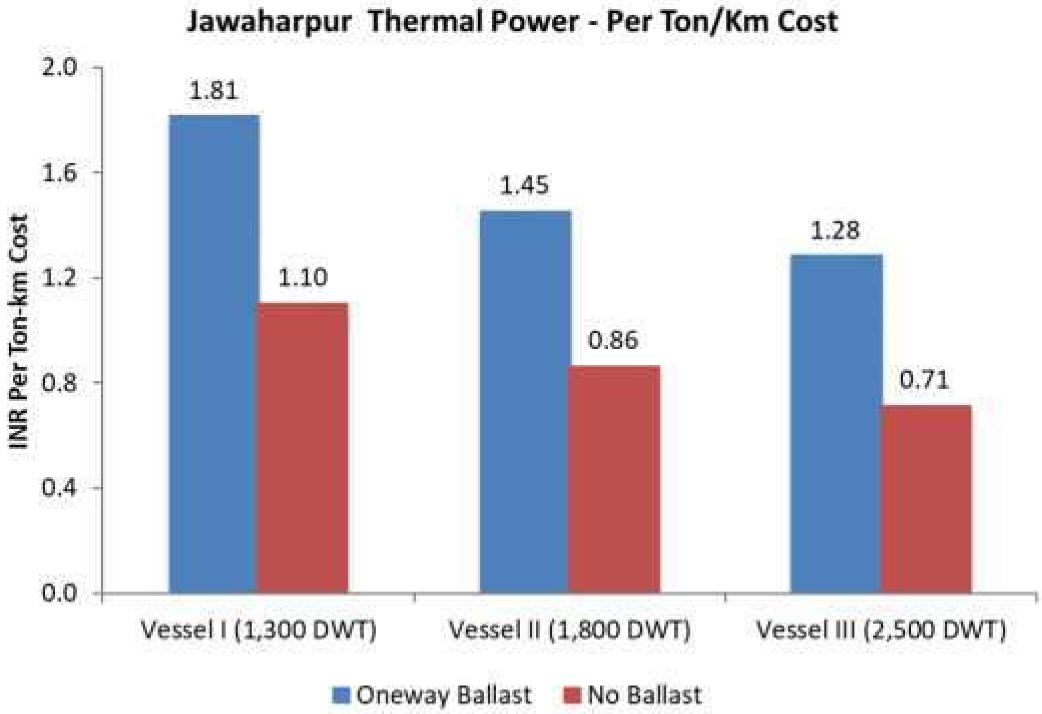


Fig. 6.88 Jawaharpur TPP Per ton/km cost for IWAI's Vessels

- **Cumulative Logistics Cost Comparison – INR Per Ton**

The following table shows Cumulative Logistics Cost Comparison for Jawaharpur Power Plant, for IWAI's special designed vessels, i.e. Vessel I (1,300 DWT), II (1,800 DWT) and III (2,500 DWT).

Table 6.120 Jawaharpur logistics cost for different classes- One Way Ballast

Particulars	Vessel I	Vessel II	Vessel III	Railway Cost
Barge DWT	1,300	1,800	2,500	n/a
Cost of Coal Loading at Mine	60.0	60.0	60.0	60
Coal Loading + Railway Tariff (Mine to Varanasi Terminal)	314.2	314.2	314.2	
Cost of Unloading Rake at Varanasi Terminal	60.0	60.0	60.0	
Stacking Cost at Varanasi Terminal	110.0	110.0	110.0	
Cost at Varanasi Terminal	200.0	200.0	200.0	
Lock Operation Cost - Assuming				
Feeder Barge - Sailing Cost	1,724.9	1,380.5	1,220.3	
Charges for Jetty	200.0	200.0	200.0	
Storage & Material Handling	110.0	110.0	110.0	
Cost of Coal Loading Rake at Jawaharpur	60.0	60.0	60.0	
Railway Tariff at Jawaharpur + Coal Unloading	205.6	205.6	205.6	1,094
Coal Unloading at Jawaharpur	60.0	60.0	60.0	60
Total Cost	**3,105**	**2,760**	**2,600**	**1,214**

Logistics Cost Comparison for Jawaharpur Power Plant is done for IWAI's special Class of vessels, i.e. Vessel I, II and III in the following charts.

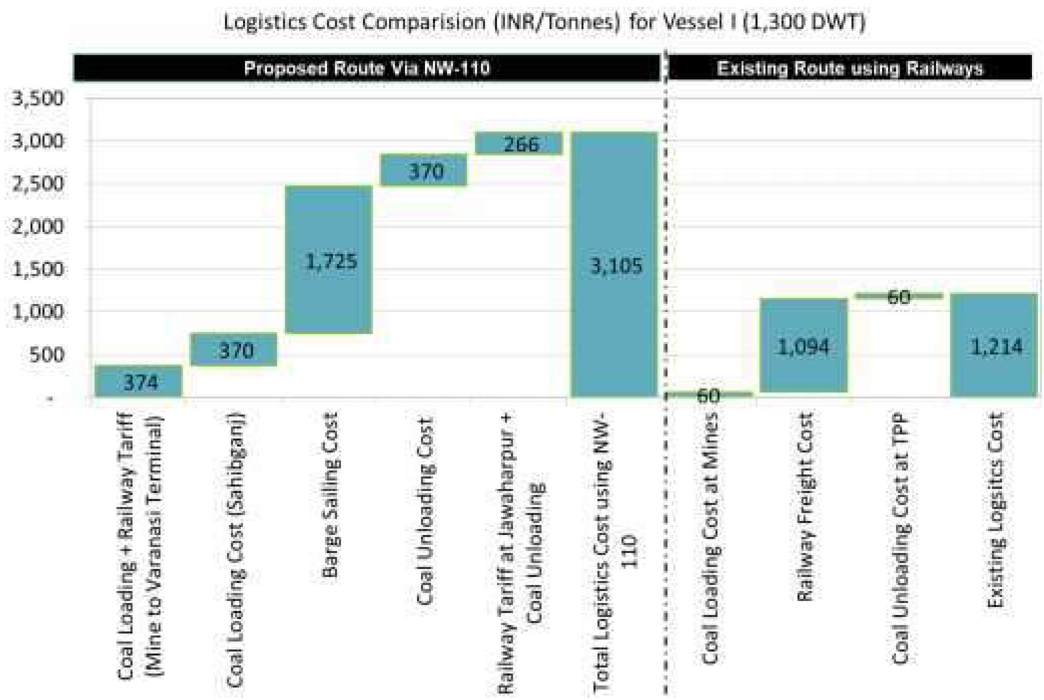


Fig. 6.89 Jawaharpur Logistic Cost Comparison b/w IWAI Vessel I & Existing Route

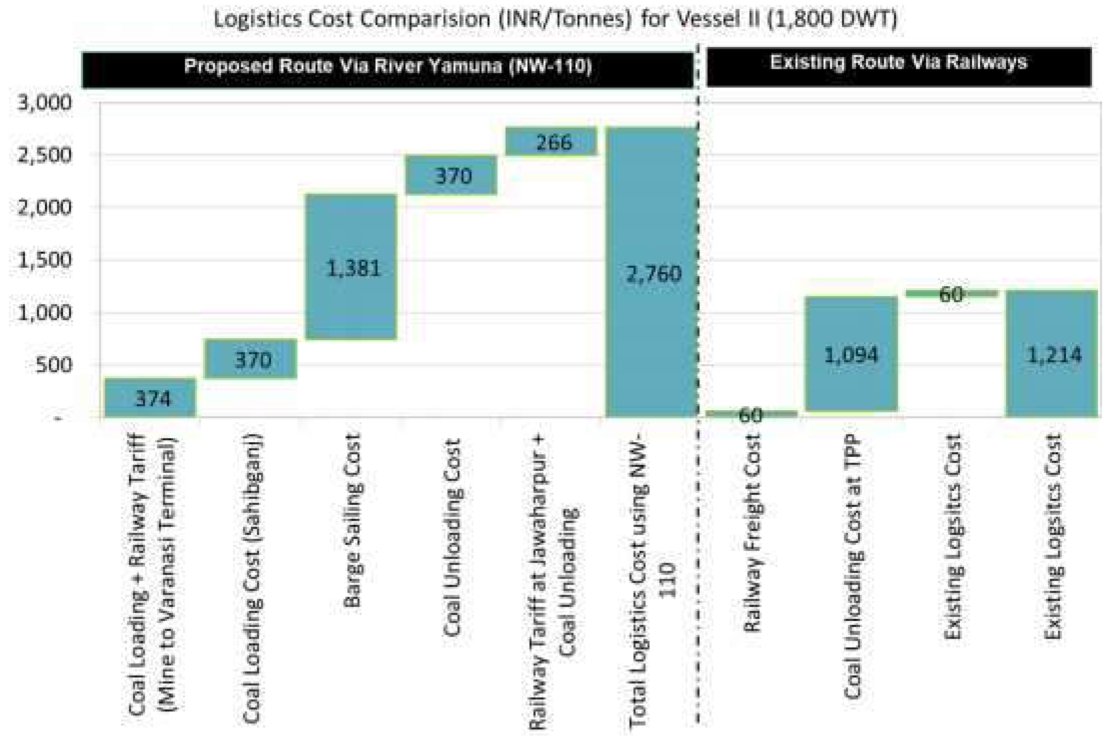


Fig. 6.90 Jawaharpur Logistic Cost Comparison b/w IWAI Vessel II & Existing Route

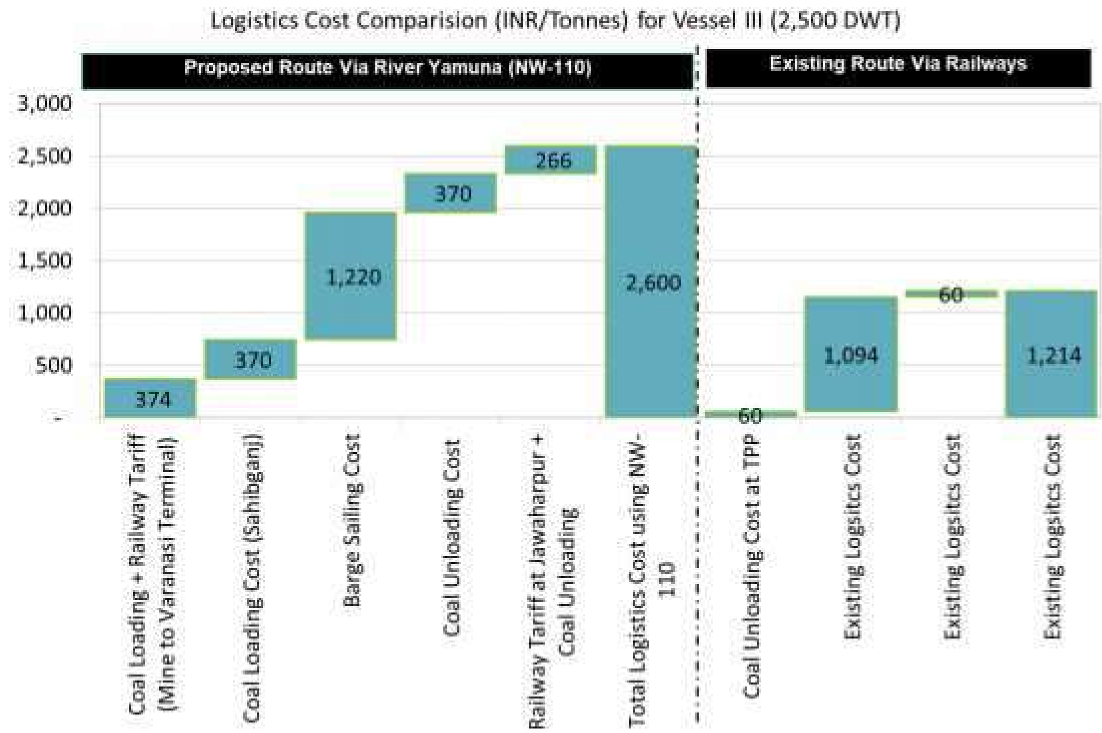


Fig. 6.91Jawaharpur Logistic Cost Comparison b/w IWAI Vessel III & Existing Route

6.13.7 Terminal 3 - Tanda Power Plant

6.13.7.1Origin –Destination Movement – Mapping

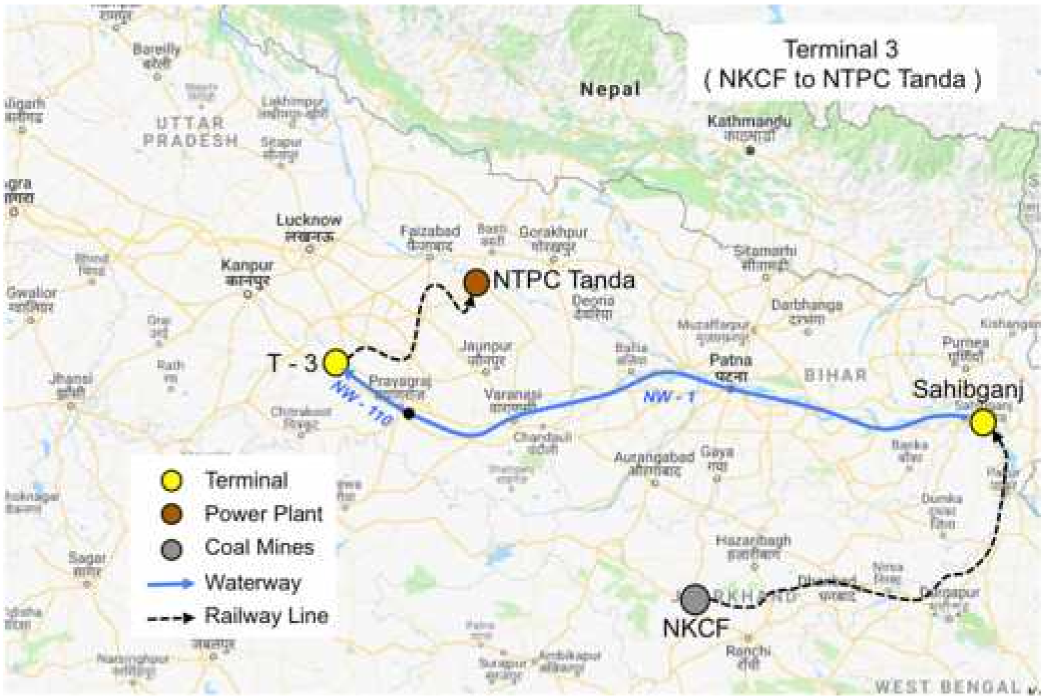


Fig. 6.92 Origin Destination Movement on River Yamuna (NW 110)

6.13.7.2 Logistic Cost Comparison - Standard Vessels

- **Logistics Cost Comparison – INR Per Ton-Km**

Tanda TPP which has installed capacity of 440 mw, requires 2,498 thousand tons of coal annually to generate power. It procures coal from North Karanpura Coal Fields.

Following graph represent per ton coal transportation cost under each type of vessels using waterway (NW 1+ NW110) for two cases i.e. one way ballast & No ballast. Per ton km cost depicted in figure below is for waterway transportation alone. First & last mile cost of transportation has not been factored in the calculation shown in figure. Domestic/imported coal movement for TPP in Uttar Pradesh would originate from Sahibganj. The unit cost of transportation reduces with increase in sizes of barge and class waterways. Loaded speed & Ballast speed has been considered 6 knots & 9 knots respectively for all class of waterway.

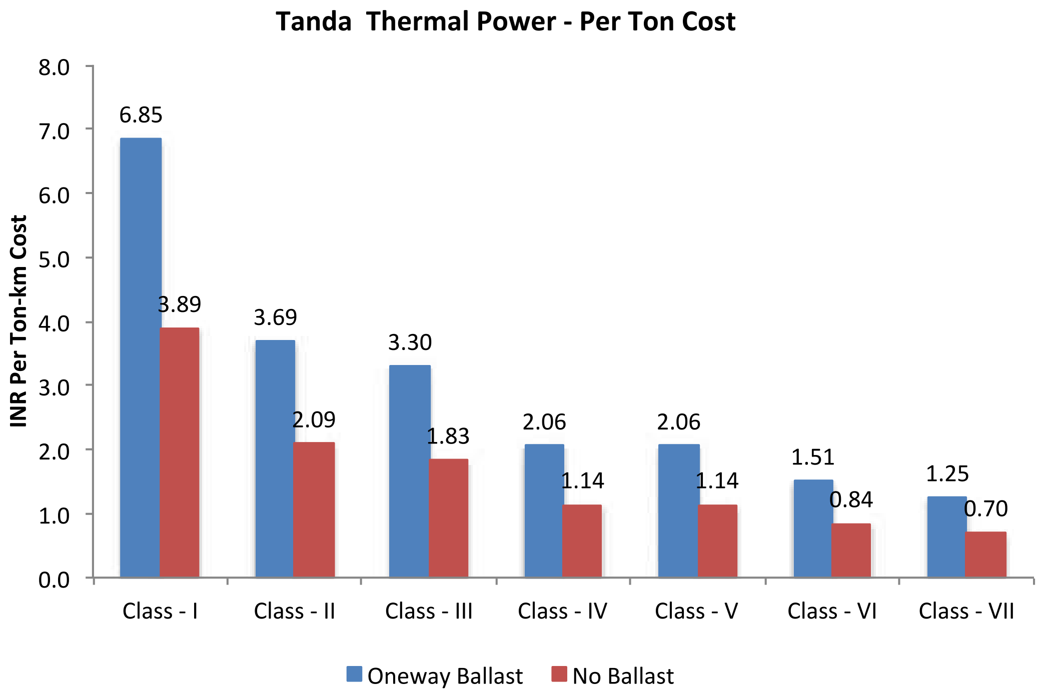


Fig. 6.93 Tanda TPP Per ton/km cost for waterway

- **Cumulative Logistics Cost Comparison – INR Per Ton**

The following table shows Cumulative Logistics Cost Comparison for Tanda Power Plant for Class III, IV and VI.

Table 6.121 Tanda logistics cost for different classes- One Way Ballast

Particulars	Class - III	Class - IV	Class - VI	Railway Cost
Barge DWT	500	1000	2000	
Cost of Coal Loading at Mine	60.0	60.0	60.0	60.0
Railway Tariff (Mine to Sahibganj Terminal)	768.6	768.6	768.6	
Cost of Unloading Rake at Sahibganj Terminal	60.0	60.0	60.0	
Stacking Cost at Sahibganj Terminal	110.0	110.0	110.0	
Cost at Sahebganj Terminal	200.0	200.0	200.0	
Lock Operation Cost - Assuming	-	-	-	
Feeder Barge - Sailing Cost	2,994.2	1,867.6	1,369.6	
Charges for Jetty (Mahewa Kachhar)	200.0	200.0	200.0	
Storage & Material Handling	110.0	110.0	110.0	
Cost of Coal Loading Rake at Tanda	60.0	60.0	60.0	
Railway Tariff at Mahewa Kachhar	378.0	378.0	378.0	834.3
Coal Unloading at Mahewa Kachhar	60.0	60.0	60.0	60.0
Total Cost	**5,001**	**3,874**	**3,376**	**954**

Logistics Cost Comparison for Tanda Power Plant is done for Class III, IV and VI waterways in the following charts.

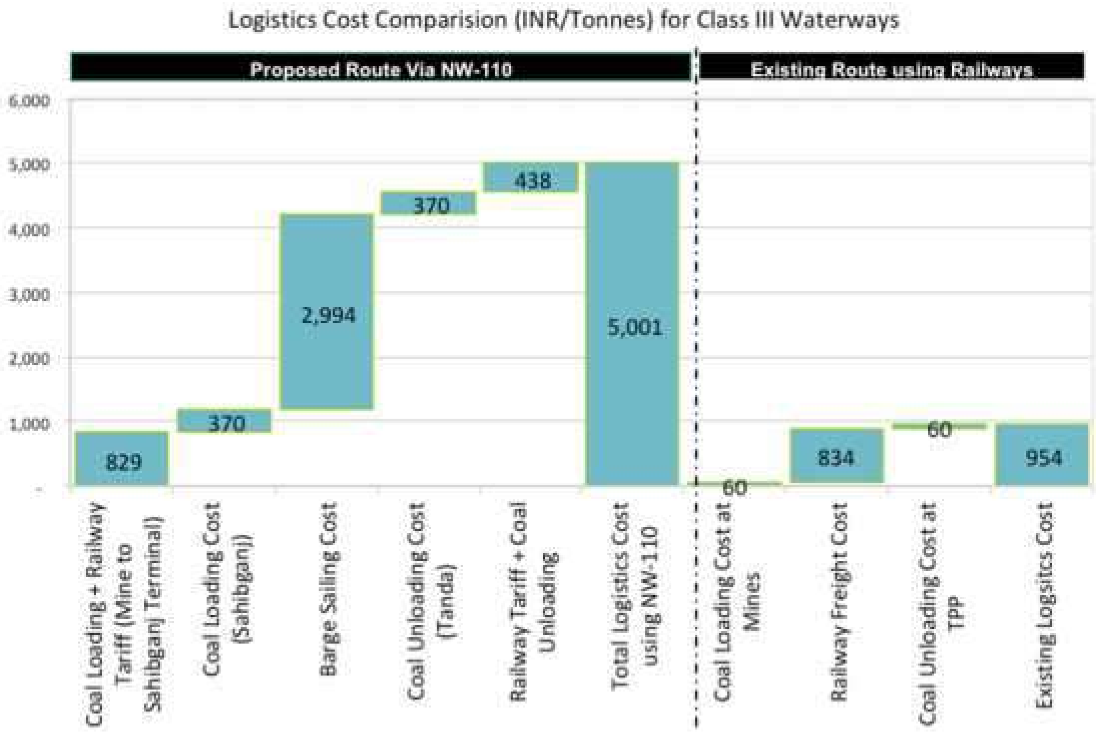


Fig. 6.94Tanda Logistics cost comparison b/w Road, Rail & IWT for Class III

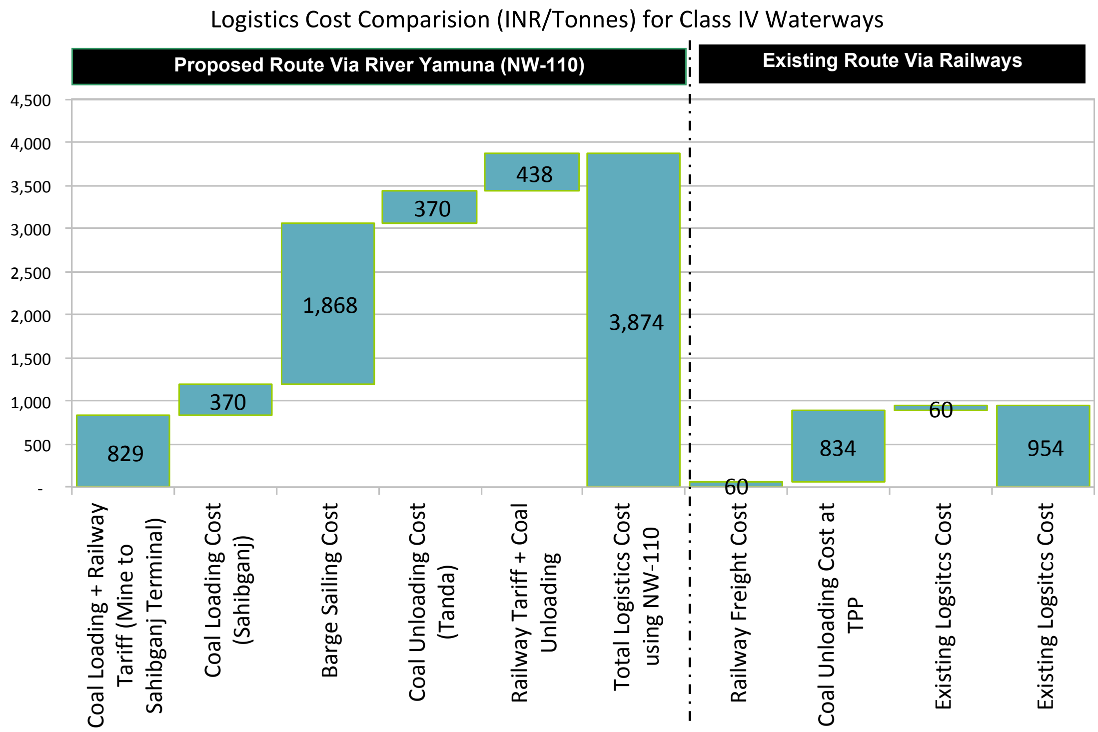


Fig. 6.95 Tanda Logistics cost comparison b/w Road, Rail & IWT for Class IV

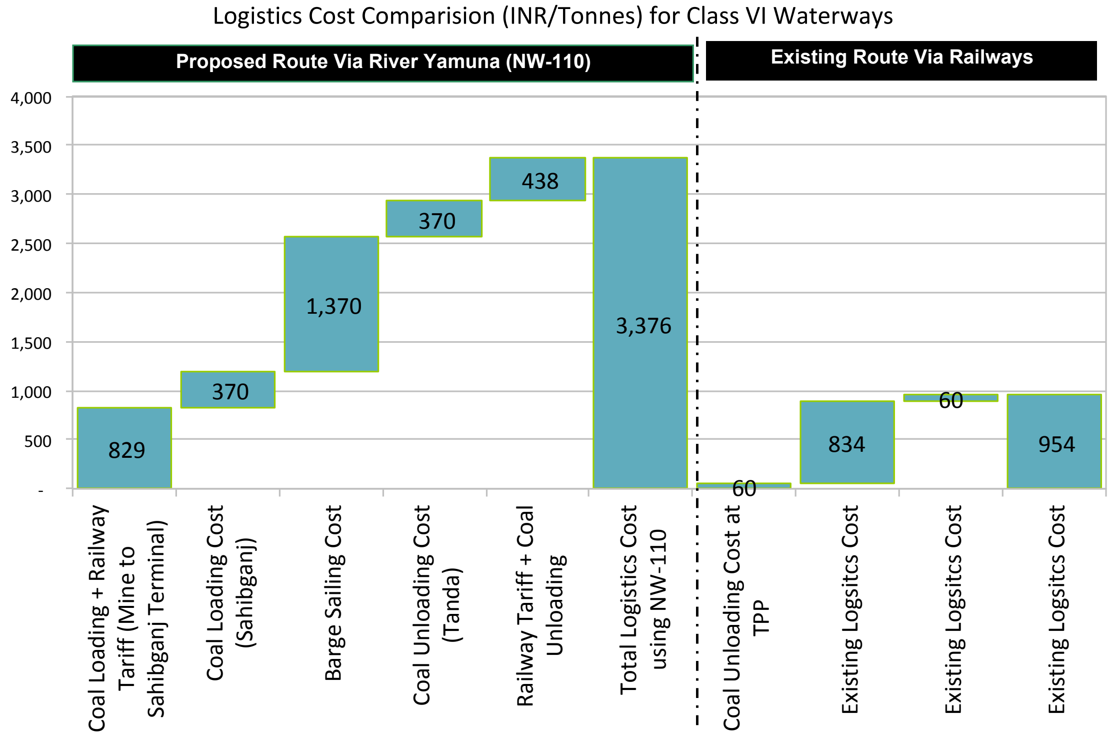


Fig. 6.96 Tanda Logistics cost comparison b/w Road, Rail & IWT for Class VI

6.13.7.3 Logistic Cost Comparison - IWAI Designed Vessels

- **Logistics Cost Comparison– INR Per Ton-Km**

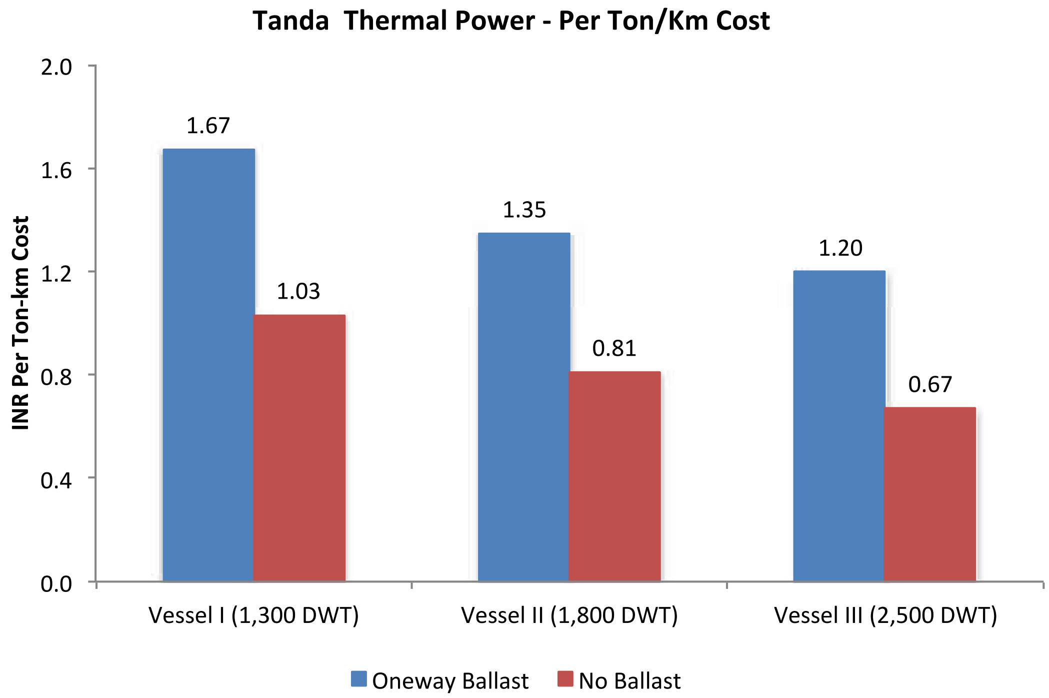


Fig. 6.97 Tanda TPP Per ton/km cost for IWAI's Vessels

- **Cumulative Logistics Cost Comparison – INR Per Ton**

The following table shows Cumulative Logistics Cost Comparison for Tanda Power Plant, for IWAI's special designed vessels, i.e. Vessel I (1,300 DWT), II (1,800 DWT) and III (2,500 DWT).

Table 6.122 Tanda logistics cost for different classes- One Way Ballast

Particulars	Vessel I	Vessel II	Vessel III	Railway Cost
Barge DWT	1,300	1,800	2,500	n/a
Cost of Coal Loading at Mine	60	60	60	60
Railway Tariff (Mine to Sahibganj Terminal)	769	769	769	
Cost of Unloading Rake at Sahibganj Terminal	60	60	60	
Stacking Cost at Sahibganj Terminal	110	110	110	
Cost at Sahebganj Terminal	200	200	200	
Lock Operation Cost - Assuming	-	-	-	
Feeder Barge - Sailing Cost	1,517	1,222	1,087	
Charges for Jetty (Mahewa Kachhar)	200	200	200	
Storage & Material Handling	110	110	110	
Cost of Coal Loading Rake at Tanda	60	60	60	
Railway Tariff at Mahewa Kachhar	378	378	378	834
Coal Unloading at Mahewa Kachhar	60	60	60	60
Total Cost	**3,523**	**3,228**	**3,093**	**954**

Logistics Cost Comparison for Tanda Power Plant is done for IWAI's special Class of vessels, i.e. Vessel I, II and III in the following charts.

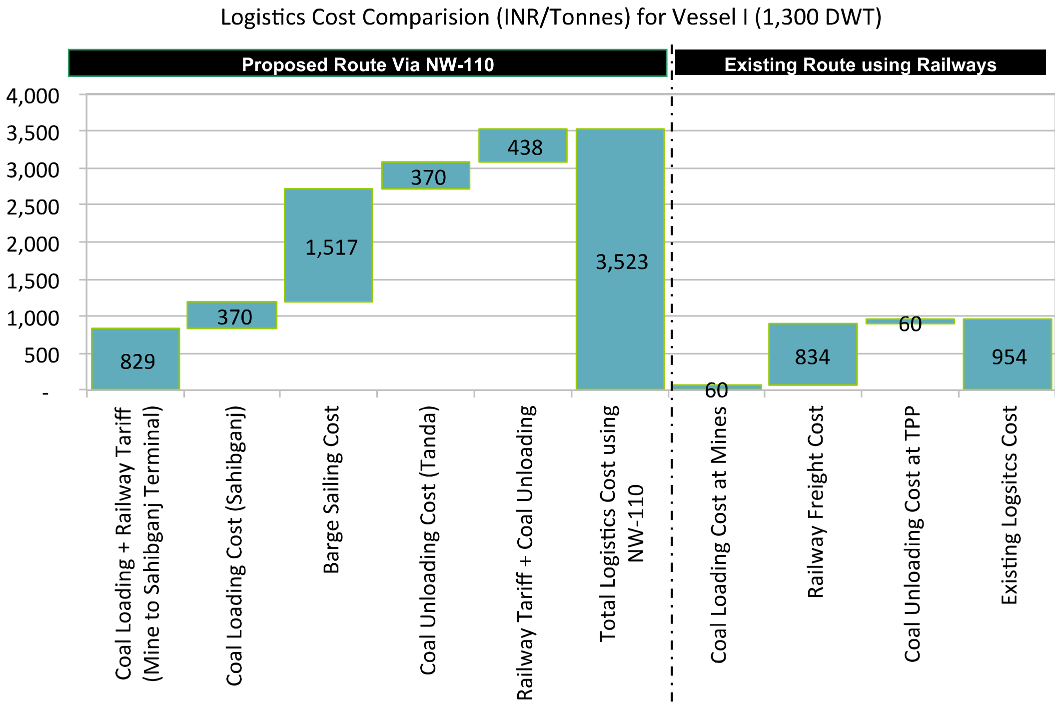


Fig. 6.98 Tanda Logistic Cost Comparison b/w IWAI Vessel I & Existing Route

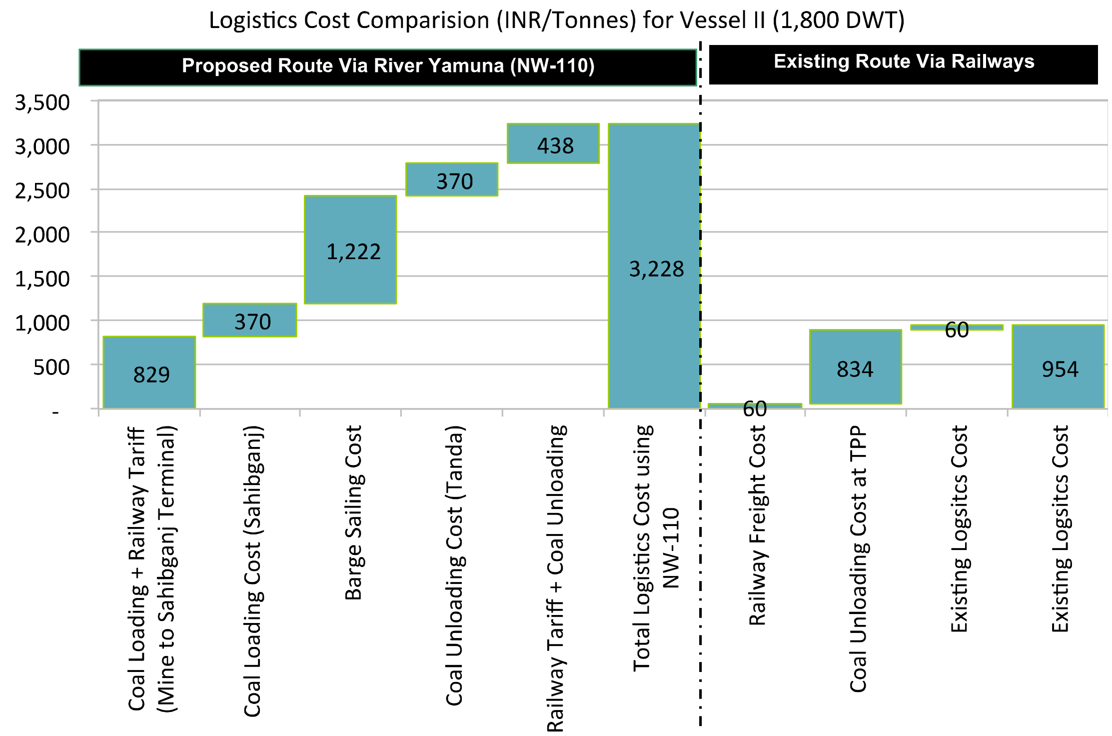


Fig. 6.99 Tanda Logistic Cost Comparison b/w IWAI Vessel II & Existing Route

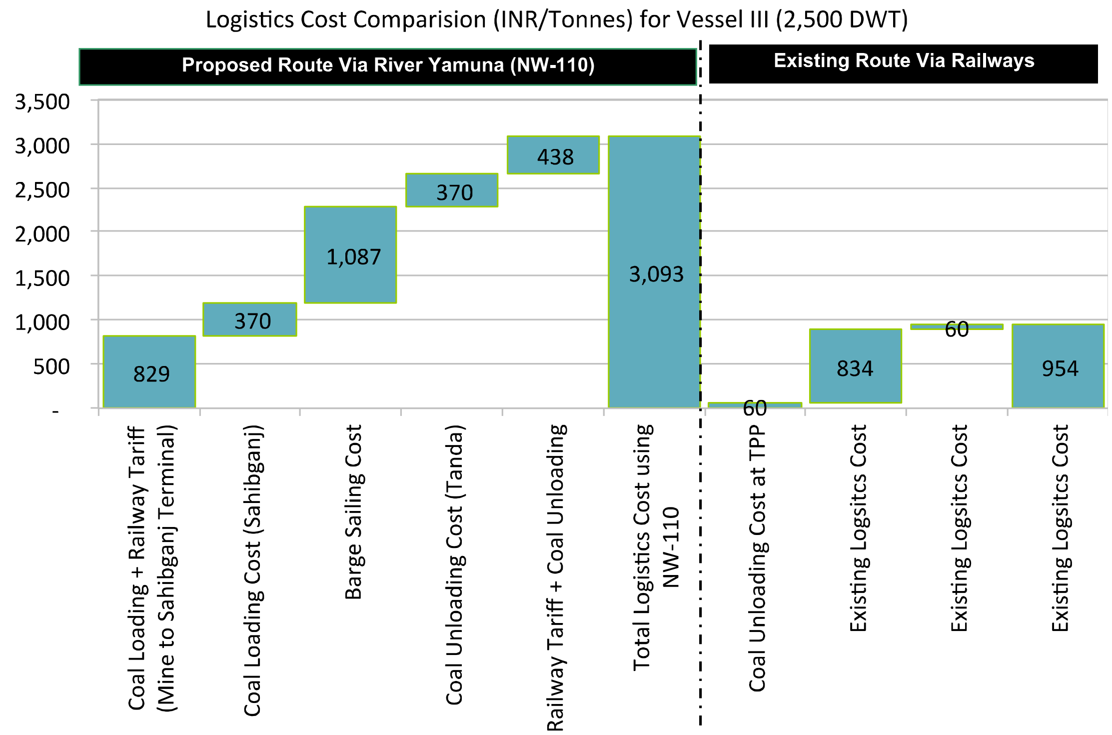


Fig. 6.100 Tanda Logistic Cost Comparison b/w IWAI Vessel III & Existing Route

6.13.8 Terminal 3 - Unchhahar Thermal Power Plant

6.13.8.1Origin –Destination Movement – Mapping

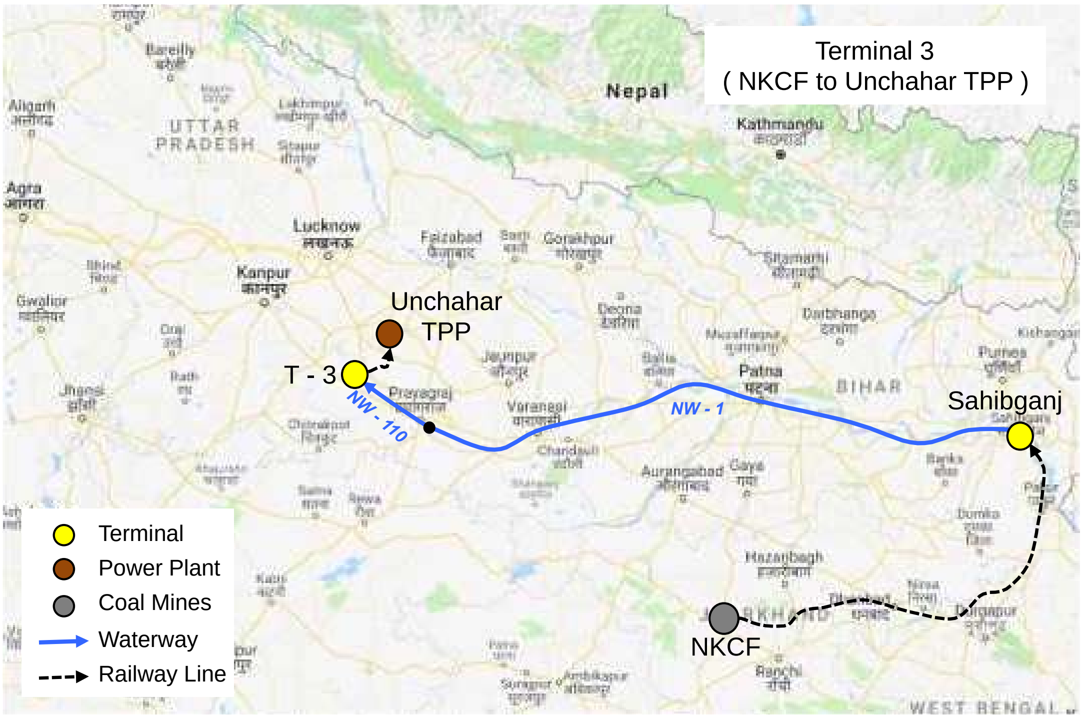


Fig. 6.101 Origin Destination Movement on River Yamuna (NW 110)

6.13.8.2Logistic Cost Comparison - Standard Vessels

- **Logistics Cost Comparison – INR Per Ton-Km**

Unchahar TPP has installed capacity of 1,050 mw and requires 5,005 thousand tons of coal p.a. This TPP too procures domestic coal from North Karanpura Coal Fields. Following graph represent per ton coal transportation cost under each type of vessels using waterway (NW 1+ NW110) for two cases i.e. one way ballast & No ballast. Per ton km cost depicted in figure below is for waterway transportation alone. First & last mile cost of transportation has not been factored in the calculation shown in figure.

Domestic/imported coal movement for TPP in Uttar Pradesh would originate from Sahibganj. The unit cost of transportation reduces with increase in sizes of barge and class waterways. Loaded speed & Ballast speed has been considered 6 knots & 9 knots respectively for all class of waterway.

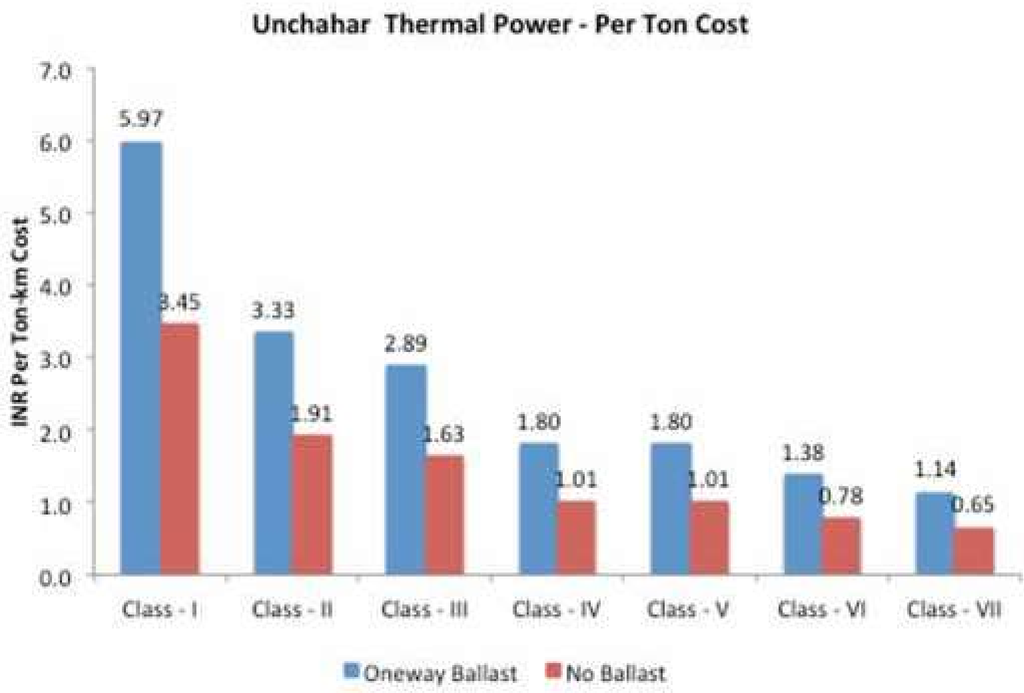


Fig. 6.102 Unchahar TPP Per ton/km cost for IWAI's Vessels

- **Cumulative Logistics Cost Comparison – INR Per Ton**
  The following table shows Cumulative Logistics Cost Comparison for Unchahar Power Plant for Class III, IV and VI.

Table 6.123 Unchaharlogistics cost for different classes- One Way Ballast

Particulars	Class - III	Class - IV	Class - VI	Railway Cost
Barge DWT	500	1000	2000	
Cost of Coal Loading at Mine	60.0	60.0	60.0	60.0
Railway Tariff (Mine to Sahibganj Terminal)	768.6	768.6	768.6	
Cost of Unloading Rake at Sahibganj Terminal	60.0	60.0	60.0	
Stacking Cost at Sahibganj Terminal	110.0	110.0	110.0	
Cost at Sahibganj Terminal	200.0	200.0	200.0	
Lock Operation Cost - Assuming	-	-	-	
Feeder Barge - Sailing Cost	2,620.1	1,634.3	1,254.1	
Charges for Jetty (Mahewa Kachhar)	200.0	200.0	200.0	
Storage & Material Handling	110.0	110.0	110.0	
Cost of Coal Loading Rake at Unchahar	60.0	60.0	60.0	
Railway Tariff at Unchahar	205.6	205.6	205.6	899.4
Coal Unloading at Unchahar	60.0	60.0	60.0	60.0
Total Cost	**4,454**	**3,468**	**3,088**	**1,019**

Logistics Cost Comparison for Unchahar Power Plant is done for Class III, IV and VI waterways in the following charts.

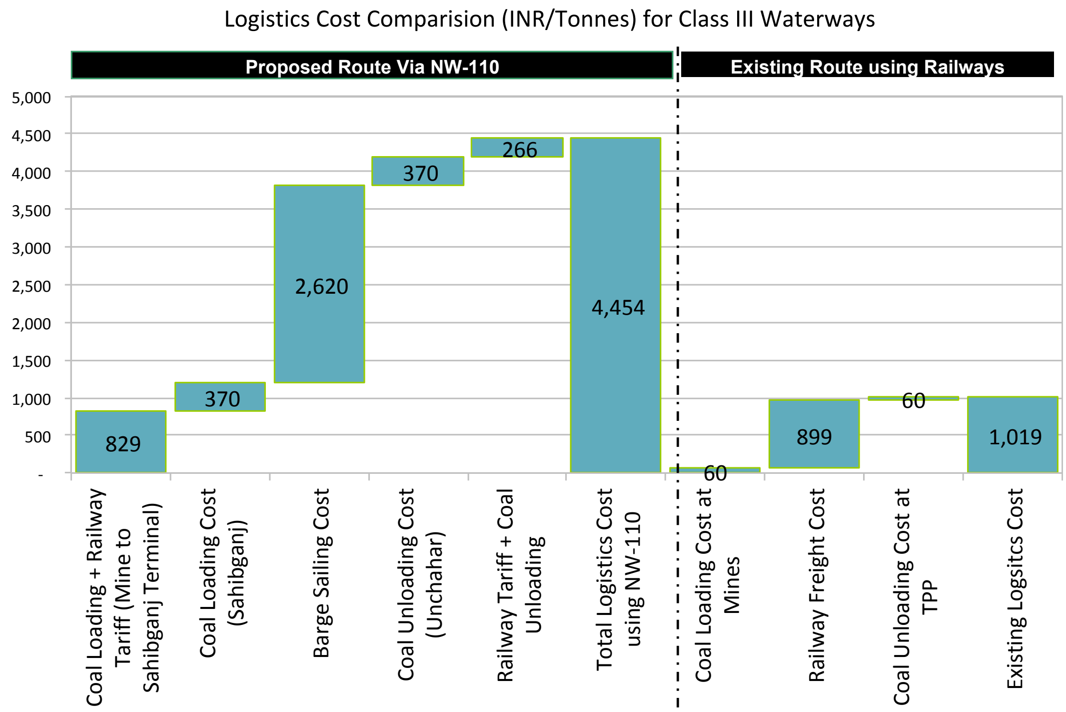


Fig. 6.103 Unchahar Logistics cost comparison b/w Road, Rail & IWT for Class III

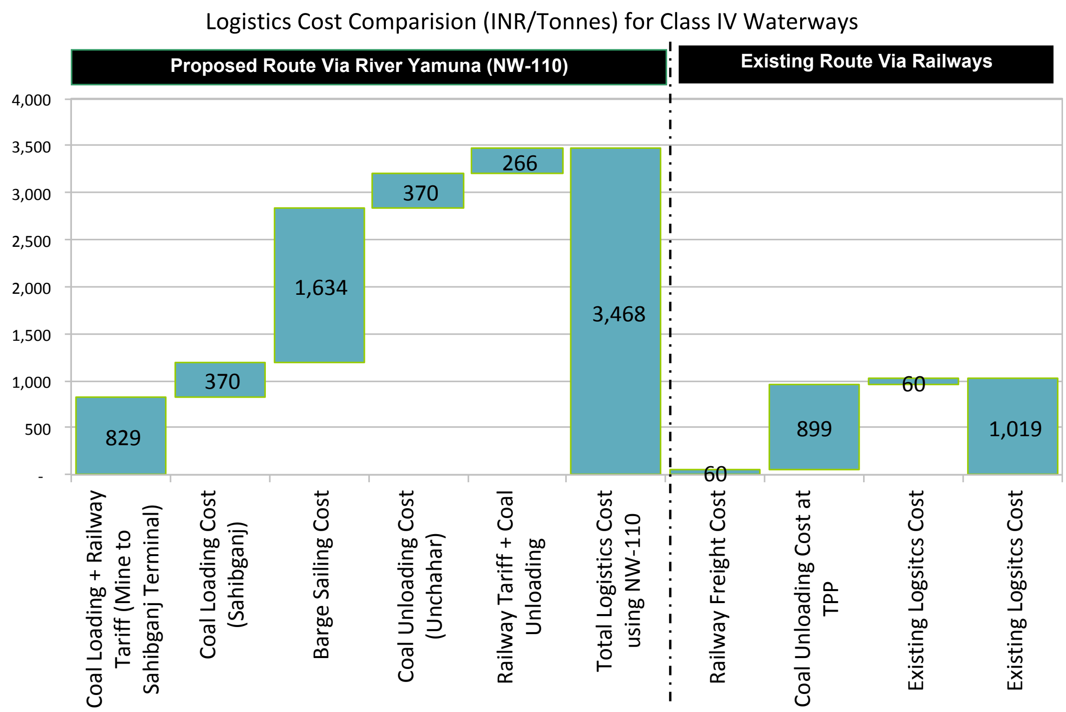


Fig. 6.104 Unchahar Logistics cost comparison b/w Road, Rail & IWT for Class IV

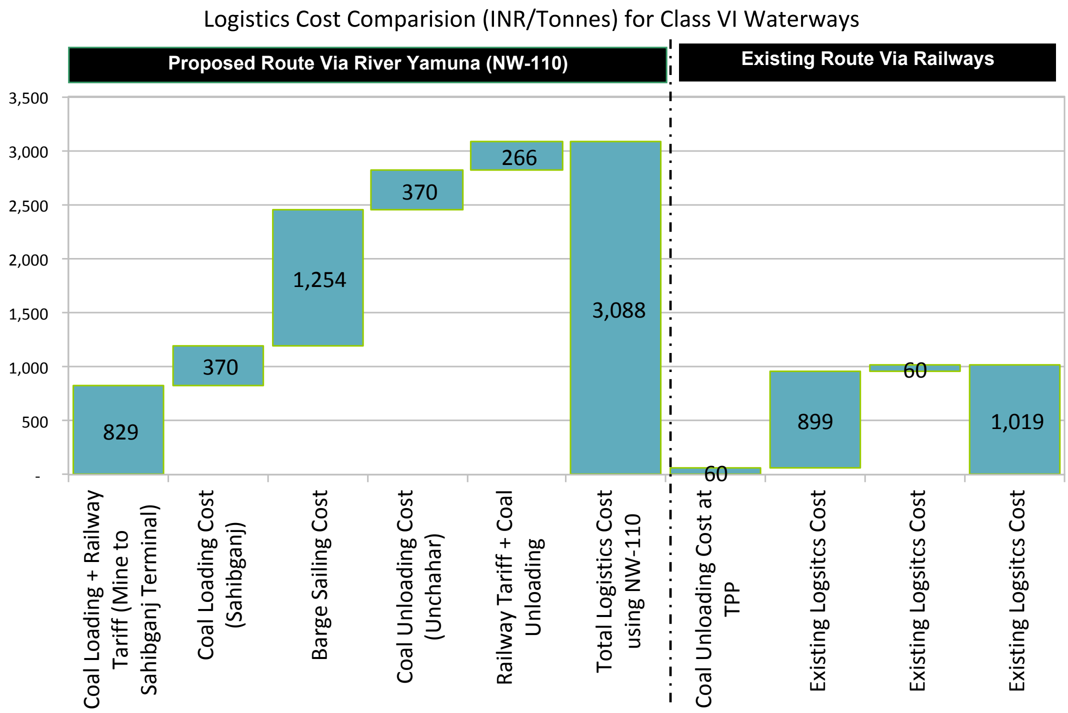


Fig. 6.105 Unchahar Logistics cost comparison b/w Road, Rail & IWT for Class VI

6.13.8.3Logistic Cost Comparison - IWAI Designed Vessels

- **Logistics Cost Comparison– INR Per Ton-Km**

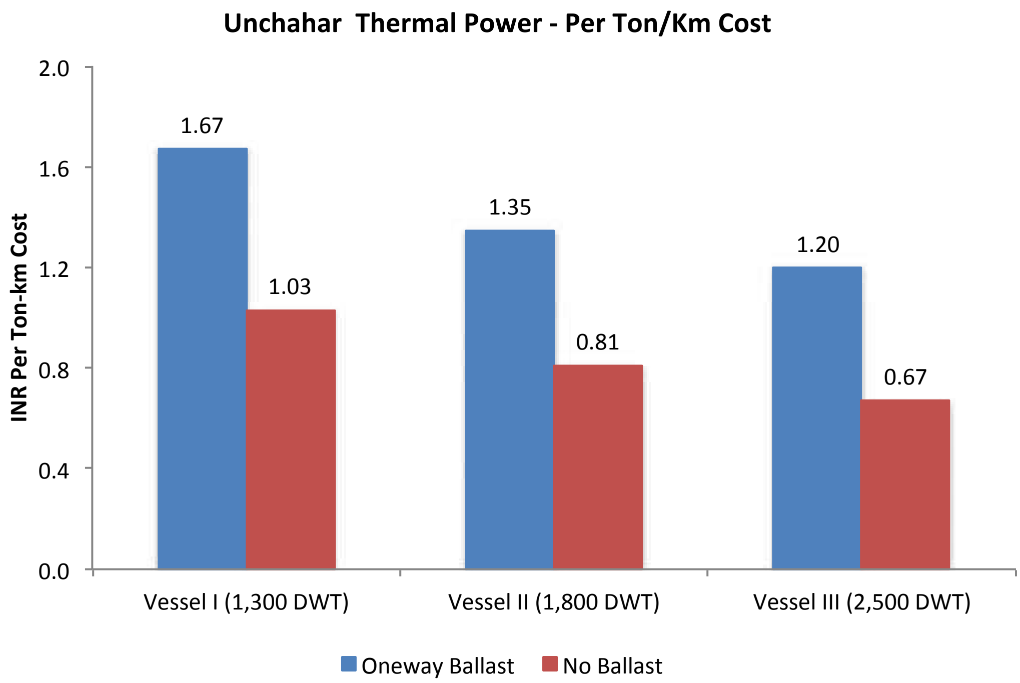


Fig. 6.106 Unchahar TPP Per ton/km cost for IWAI's Vessels

- **Cumulative Logistics Cost Comparison – INR Per Ton**

The following table shows Cumulative Logistics Cost Comparison for Unchahar Power Plant, for IWAI's special designed vessels, i.e. Vessel I (1,300 DWT), II (1,800 DWT) and III (2,500 DWT).

Table 6.124 Unchaharlogistics cost for different classes- One Way Ballast

Particulars	Vessel I	Vessel II	Vessel III	Railway Cost
Barge DWT	1,300	1,800	2,500	n/a
Cost of Coal Loading at Mine	60	60	60	60
Railway Tariff (Mine to Sahibganj Terminal)	769	769	769	
Cost of Unloading Rake at Sahibganj Terminal	60	60	60	
Stacking Cost at Sahibganj Terminal	110	110	110	
Cost at Sahibganj Terminal	200	200	200	
Lock Operation Cost - Assuming	-	-	-	
Feeder Barge - Sailing Cost	1,517	1,222	1,087	
Charges for Jetty (Mahewa Kachhar)	200	200	200	
Storage & Material Handling	110	110	110	
Cost of Coal Loading Rake at Unchahar	60	60	60	
Railway Tariff at Unchahar	206	206	206	899
Coal Unloading at Unchahar	60	60	60	60
Total Cost	**3,351**	**3,056**	**2,921**	**1,019**

Logistics Cost Comparison for Unchahar Power Plant is done for IWAI's special Class of vessels, i.e. Vessel I, II and III in the following charts.

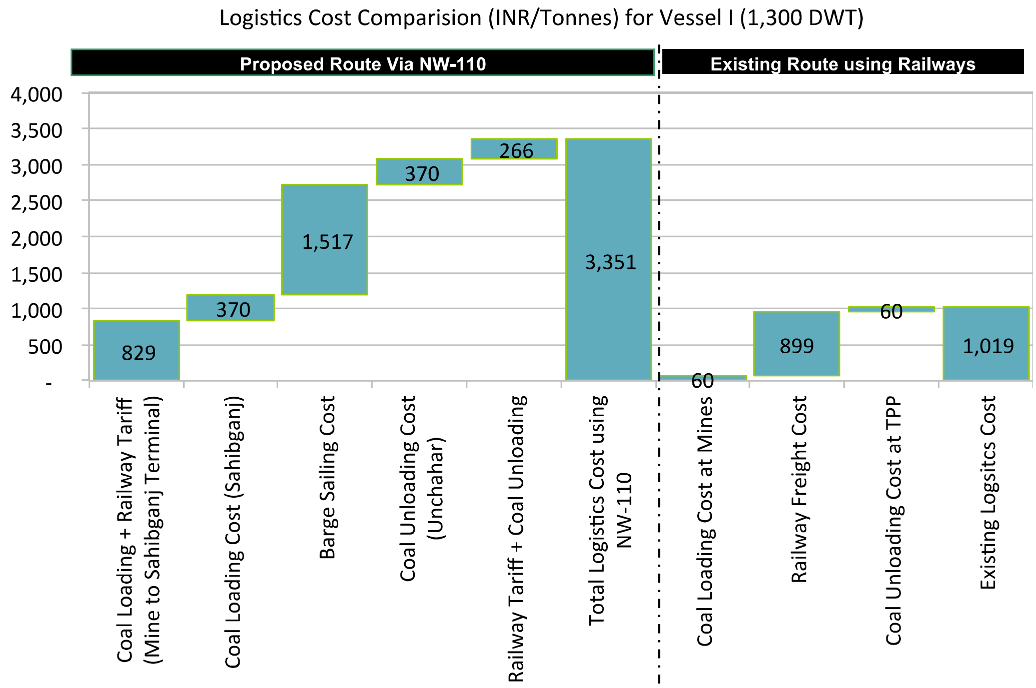


Fig. 6.107 Unchahar Logistic Cost Comparison b/w IWAI Vessel I & Existing Route

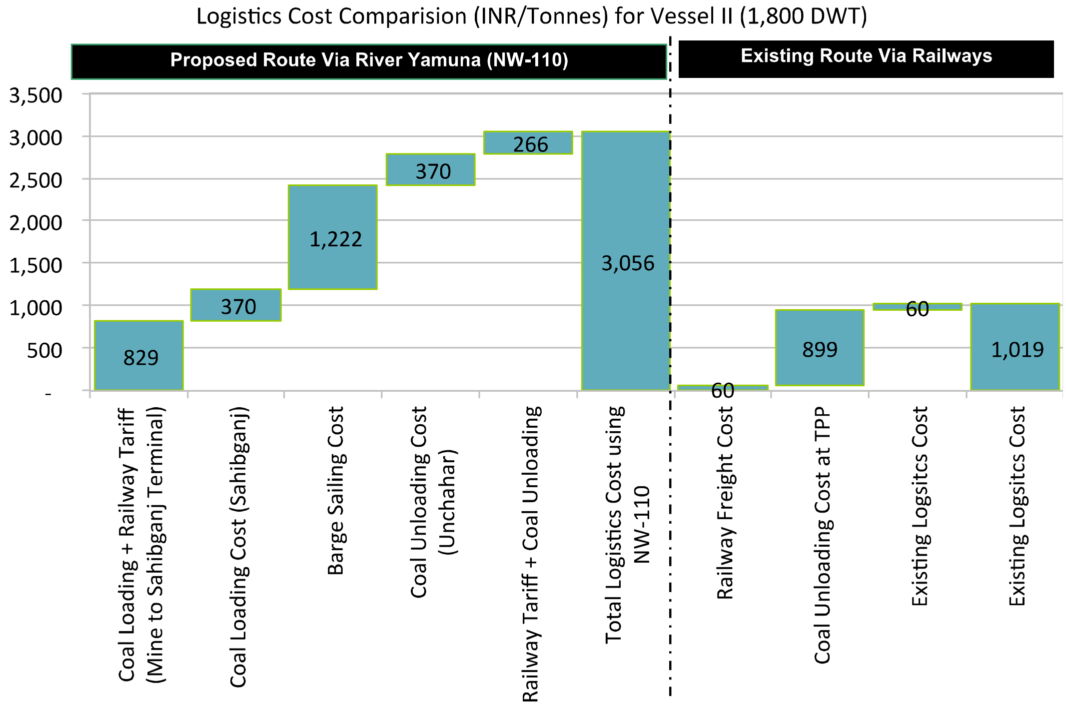


Fig. 6.108 Unchahar Logistic Cost Comparison b/w IWAI Vessel II & Existing Route

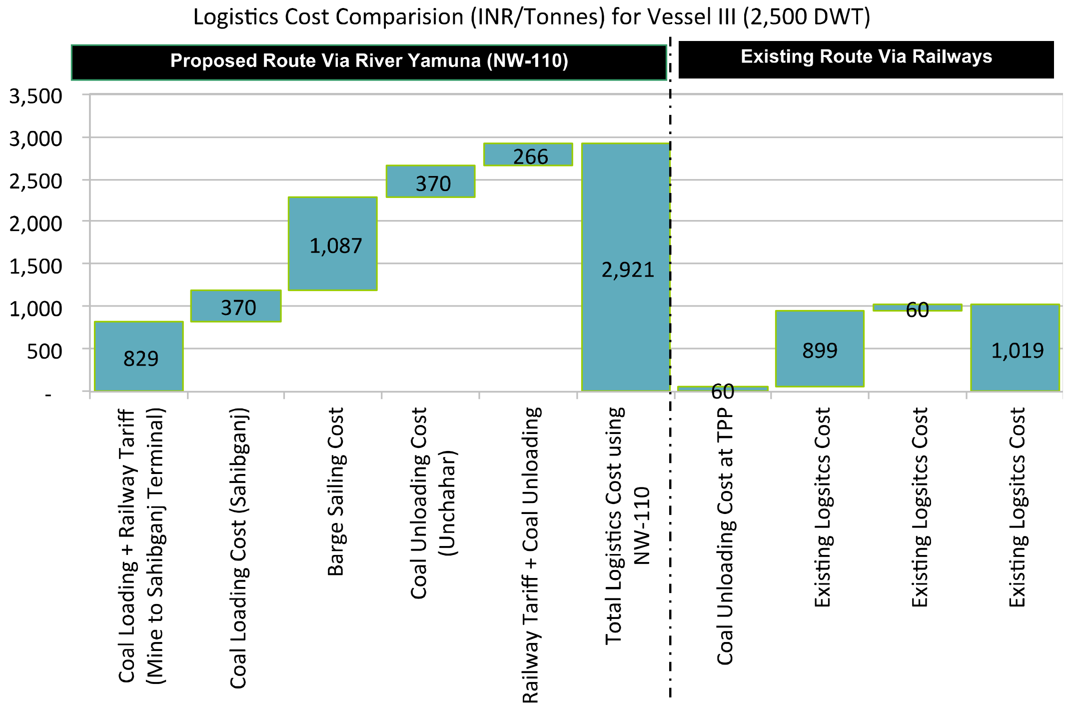


Fig. 6.109 Unchahar Logistic Cost Comparison b/w IWAI Vessel III & Existing Route

6.13.9 Terminal 4 - Panki Power Plant

6.13.9.1Origin –Destination Movement – Mapping

Fig. 6.110 Origin Destination Movement on River Yamuna (NW 110)

6.13.9.2Logistic Cost Comparison - Standard Vessels

- **Logistics Cost Comparison – INR Per Ton-Km**

Panki TPP that has installed capacity of 210mw requires 917 thousand tons of coal annually to generate power. Domestic coal is procured from BCCL / ECL mines. Following graph represent per ton coal transportation cost under each type of vessels using waterway (NW 1+ NW110) for two cases i.e. one way ballast & No ballast per ton km cost depicted in figure below is for waterway transportation alone.

First & last mile cost of transportation has not been factored in the calculation shown in figure. Domestic/imported coal movement for TPP in Uttar Pradesh would originate from Sahibganj. The unit cost of transportation reduces with increase in sizes of barge and class waterways. Loaded speed & Ballast speed has been considered 6 knots& 9 knots respectively for all class of waterway.

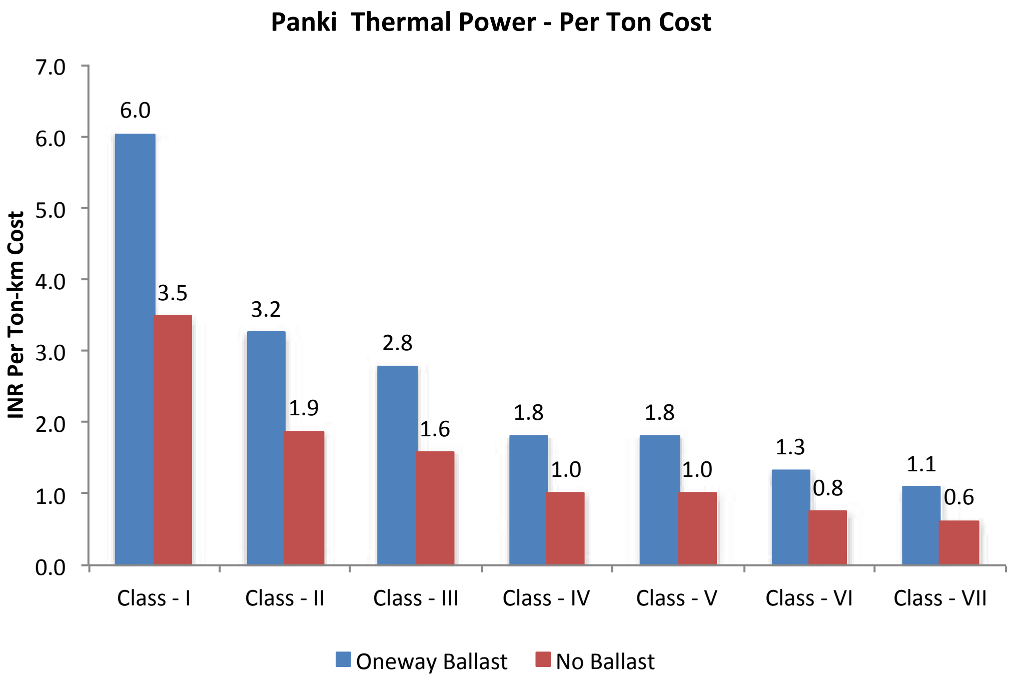


Fig. 6.111 Panki TPP Per ton/km cost for waterway

IWAI intends to develop NW 110 for handling class III & class IV size of vessels. Following table describes end-to-end total logistic cost comparison of present & proposed mode of transportation.

- **Cumulative Logistics Cost Comparison – INR Per Ton**

The following table shows Cumulative Logistics Cost Comparison for Panki Power Plant for Class III, IV and VI.

Table 6.125 Pankilogistics cost for different classes- One Way Ballast

Particulars	Class - III	Class - IV	Class - VII	Railway Cost
Barge DWT	500	1000	4000	
Cost of Coal Loading at Mine	60.0	60.0	60.0	60.0
Railway Tariff (Mine to Sahibganj Terminal)	378.0	378.0	378.0	
Cost of Unloading Rake at Sahibganj Terminal	60.0	60.0	60.0	
Stacking Cost at Sahibganj Terminal	110.0	110.0	110.0	
Cost at Sahibganj Terminal	200.0	200.0	200.0	
Lock Operation Cost - Assuming	-	-	-	
Feeder Barge - Sailing Cost	3,208.4	2,085.1	1,260.7	
Charges for Jetty (Daulatpur)	200.0	200.0	200.0	
Storage & Material Handling	110.0	110.0	110.0	
Cost of Coal Loading Rake at Daulatpur	60.0	60.0	60.0	
Railway Tariff at Panki	250.7	250.7	250.7	1,158.0
Coal Unloading at Panki	60.0	60.0	60.0	60.0
Total Cost	**4,697**	**3,574**	**2,749**	**1,278**

Logistics Cost Comparison for Panki Power Plant is done for Class III, IV and VI waterways in the following charts.

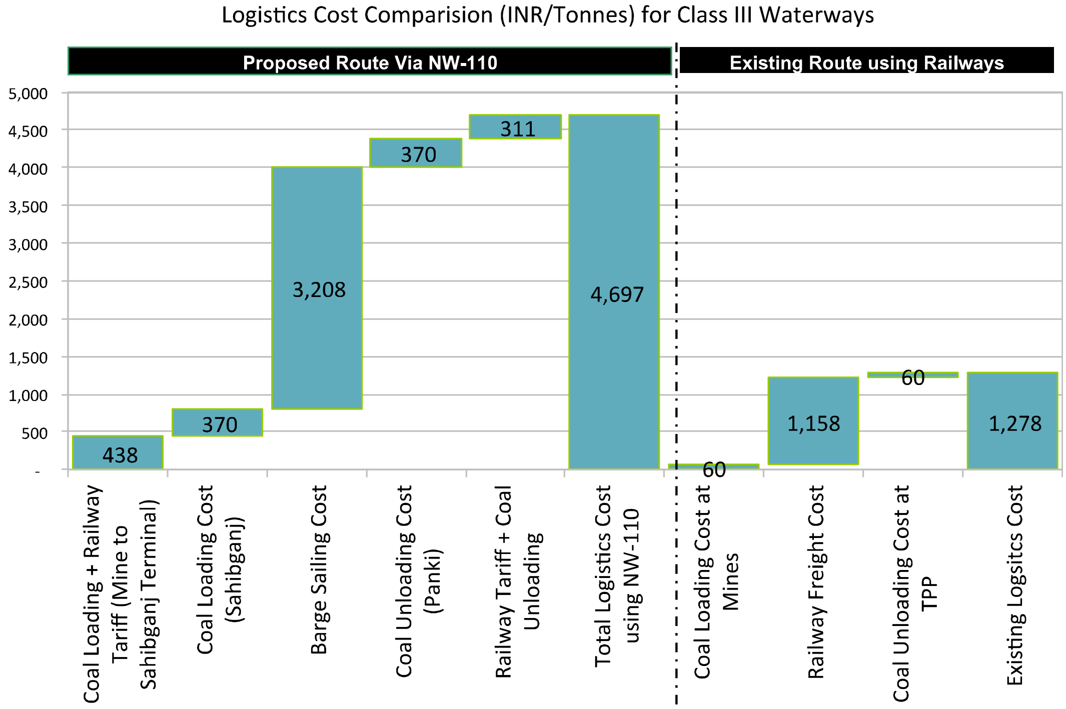


Fig. 6.112 Panki Logistics cost comparison b/w Road, Rail & IWT for Class III

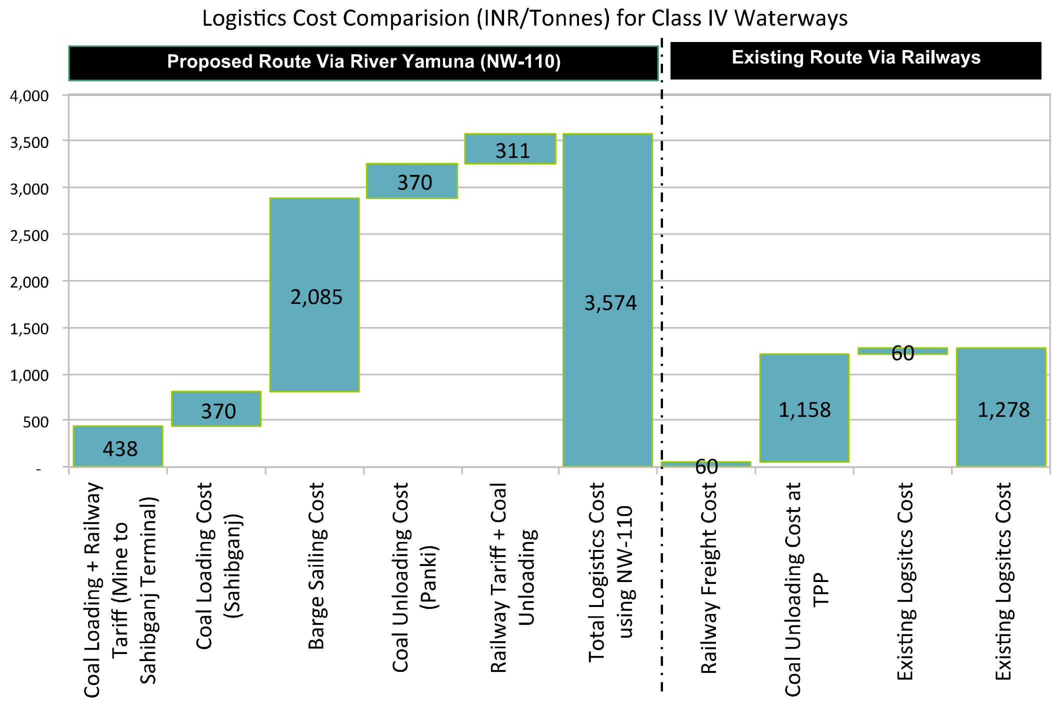


Fig. 6.113 Panki Logistics cost comparison b/w Road, Rail & IWT for Class IV

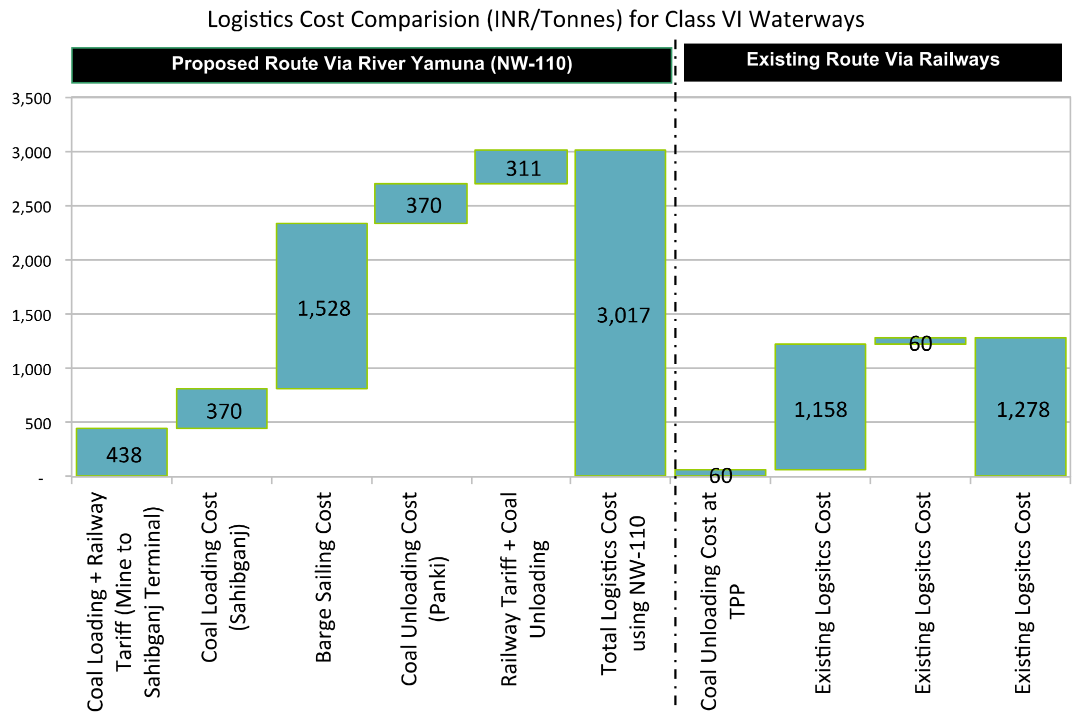


Fig. 6.114 Panki Logistics cost comparison b/w Road, Rail & IWT for Class VI

6.13.9.3 Logistic Cost Comparison – IWAI Vessels

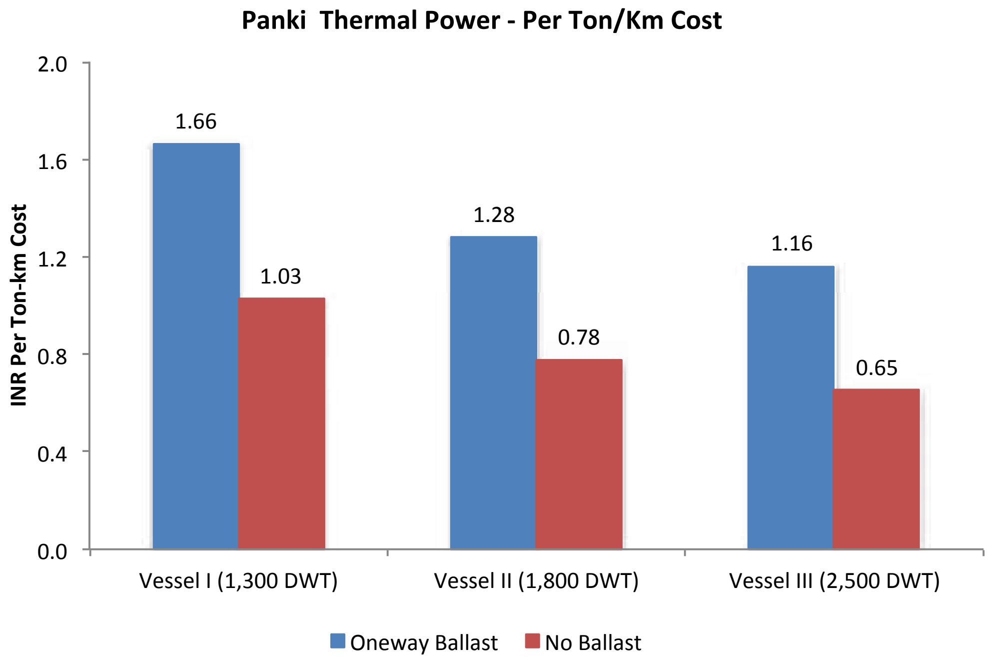


Fig. 6.115 Per ton/km logistic cost using IWAI's vessels

- **Cumulative Logistics Cost Comparison – INR Per Ton**

The following table shows Cumulative Logistics Cost Comparison for Panki Power Plant, for IWAI's special designed vessels, i.e. Vessel I (1,300 DWT), II (1,800 DWT) and III (2,500 DWT).

Table 6.126 Pankilogistics cost for different classes- One Way Ballast

Particulars	Vessel I	Vessel II	Vessel III	Railway Cost
Barge DWT	1,300	1,800	2,500	n/a
Cost of Coal Loading at Mine	60	60	60	60
Railway Tariff (Mine to Sahibganj Terminal)	378	378	378	
Cost of Unloading Rake at Sahibganj Terminal	60	60	60	
Stacking Cost at Sahibganj Terminal	110	110	110	
Cost at Sahibganj Terminal	200	200	200	
Lock Operation Cost - Assuming	-	-	-	
Feeder Barge - Sailing Cost	1,917	1,475	1,338	
Charges for Jetty (Daulatpur)	200	200	200	
Storage & Material Handling	110	110	110	
Cost of Coal Loading Rake at Daulatpur	60	60	60	
Railway Tariff at Panki	251	251	251	1,158.0
Coal Unloading at Panki	60	60	60	60
Total Cost	**3,406**	**2,964**	**2,827**	**1,278**

Logistics Cost Comparison for Panki Power Plant is done for IWAI's special Class of vessels, i.e. Vessel I, II and III in the following charts.

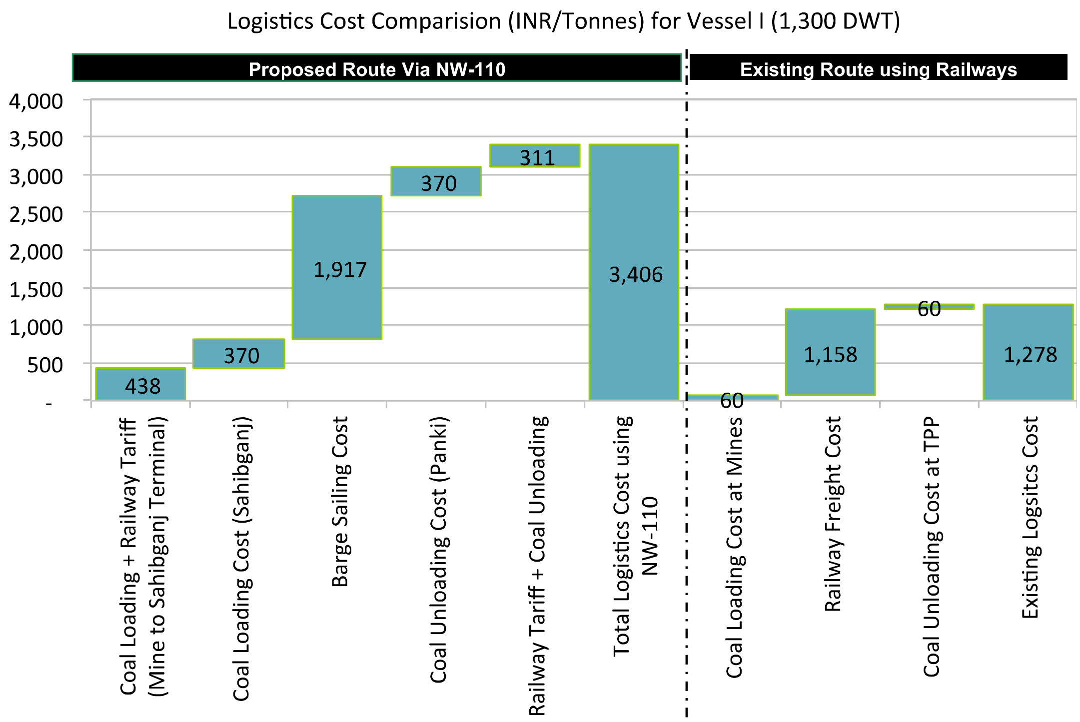


Fig. 6.116 Panki Logistic Cost Comparison b/w IWAI Vessel I & Existing Route

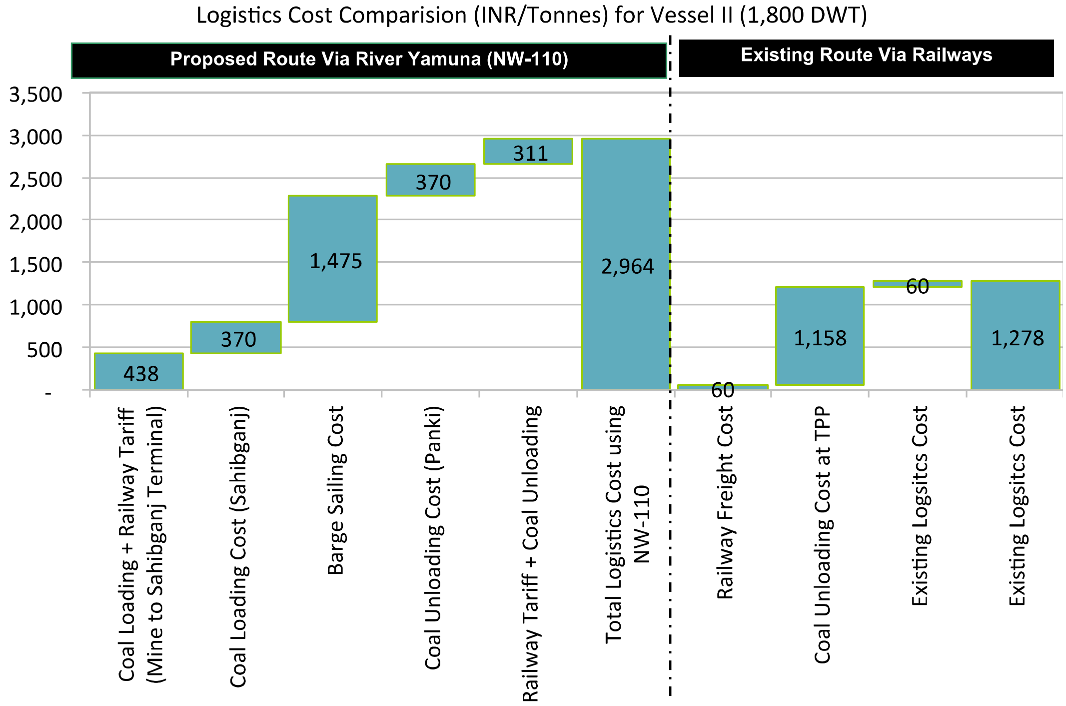


Fig. 6.117 Logistic Cost Comparison b/w IWAI Vessel II & Existing Route

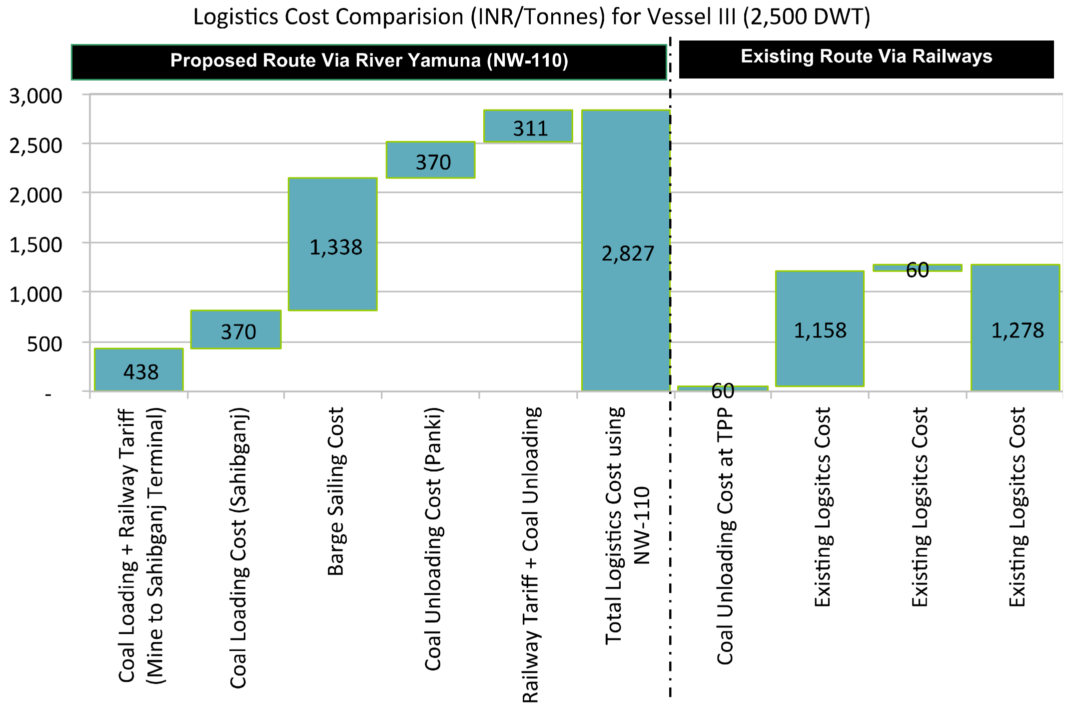


Fig. 6.118 Logistic Cost Comparison b/w IWAI Vessel III & Existing Route

6.13.10Terminal 4 - Parichha Power Plant

6.13.10.1Origin –Destination Movement – Mapping

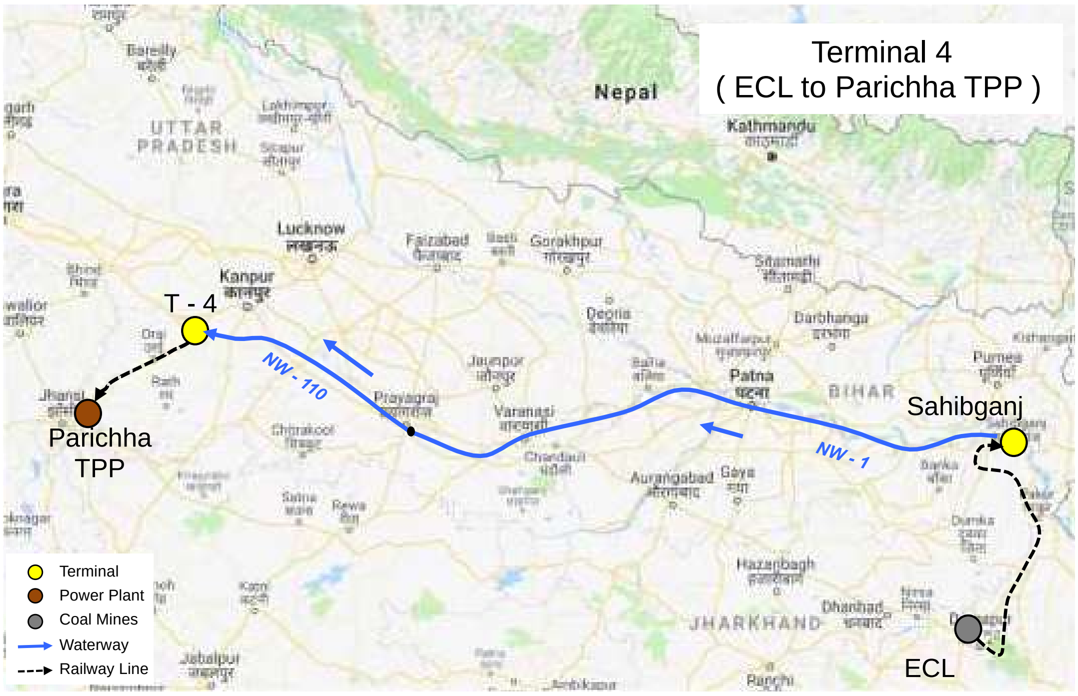


Fig. 6.119 Origin Destination Movement on River Yamuna (NW 110)

6.13.10.2Logistic Cost Comparison – Standard Vessels

- **Logistics Cost Comparison – INR Per Ton-Km**

Parichha TPP procures coal from ECL. It has installed capacity of 1,140 mw. Parichha requires 4,859 thousand tons of coal annually. Following graph represent per ton coal transportation cost under each type of vessels using waterway (NW 1+ NW110) for two cases i.e. one way ballast & No ballast per ton km cost depicted in figure below is for waterway transportation alone.

First & last mile cost of transportation has not been factored in the calculation shown in figure. Domestic/imported coal movement for TPP in Uttar Pradesh would originate from Sahibganj. The unit cost of transportation reduces with increase in sizes of barge and class waterways. Loaded speed & Ballast speed has been considered 6 knots& 9 knots respectively for all class of waterway.

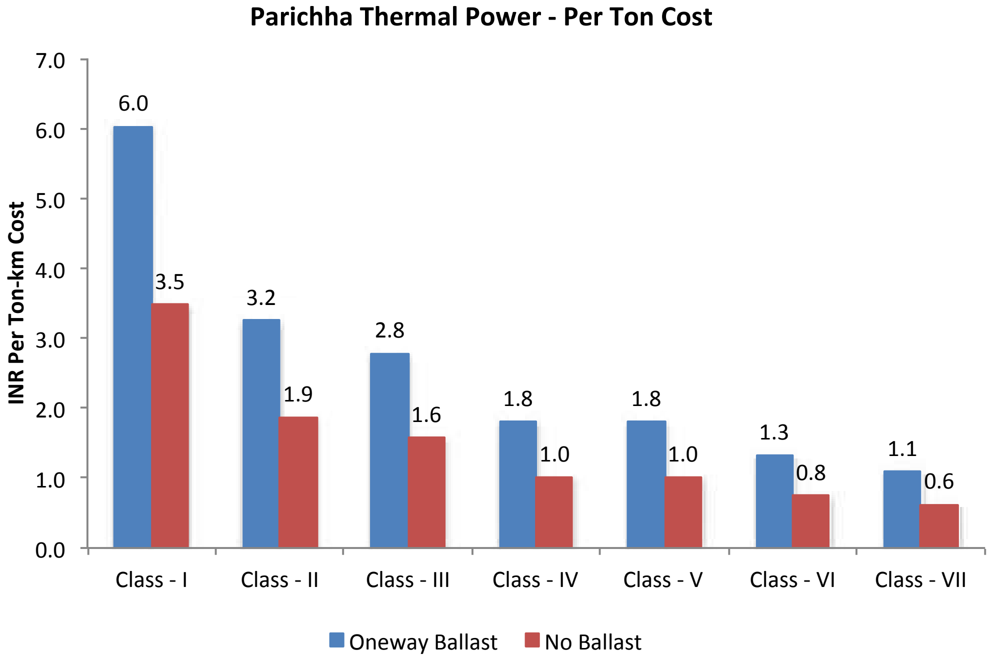


Fig. 6.120 Parichha TPP Per ton/km cost for waterway

In case of no ballast case, TPP could transport/export 9.3lac tons of fly ash for other industrial use using Haldia port. IWAI intends to develop NW 110 for handling class III & class IV size of vessels. Following table describes end-to-end total logistic cost comparison of present & proposed mode of transportation.

- **Cumulative Logistics Cost Comparison – INR Per Ton**

The following table shows Cumulative Logistics Cost Comparison for Parichha Power Plant for Class III, IV and VI.

Table 6.127 Parichha logistics cost for different classes- One Way Ballast

	Class - III	Class - IV	Class - VII	Railway Cost
Barge DWT	500	1000	4000	
Cost of Coal Loading at Mine	60.0	60.0	60.0	60.0
Railway Tariff (Mine to Sahibganj Terminal)	378.0	378.0	378.0	
Cost of Unloading Rake at Sahibganj Terminal	60.0	60.0	60.0	
Stacking Cost at Sahibganj Terminal	110.0	110.0	110.0	
Cost at Sahibganj Terminal	200.0	200.0	200.0	
Lock Operation Cost - Assuming	-	-	-	
Feeder Barge - Sailing Cost	3,208.4	2,085.1	1,260.7	
Charges for Jetty (Daulatpur)	200.0	200.0	200.0	
Storage & Material Handling	110.0	110.0	110.0	
Cost of Coal Loading Rake at Daulatpur	60.0	60.0	60.0	
Railway Tariff at Daulatpur	250.7	250.7	250.7	1,478.4
Coal Unloading at Daulatpur	60.0	60.0	60.0	60.0
Total Cost	**4,697**	**3,574**	**2,749**	**1,598**

Logistics Cost Comparison for Parichha Power Plant is done for Class III, IV and VI waterways in the following charts.

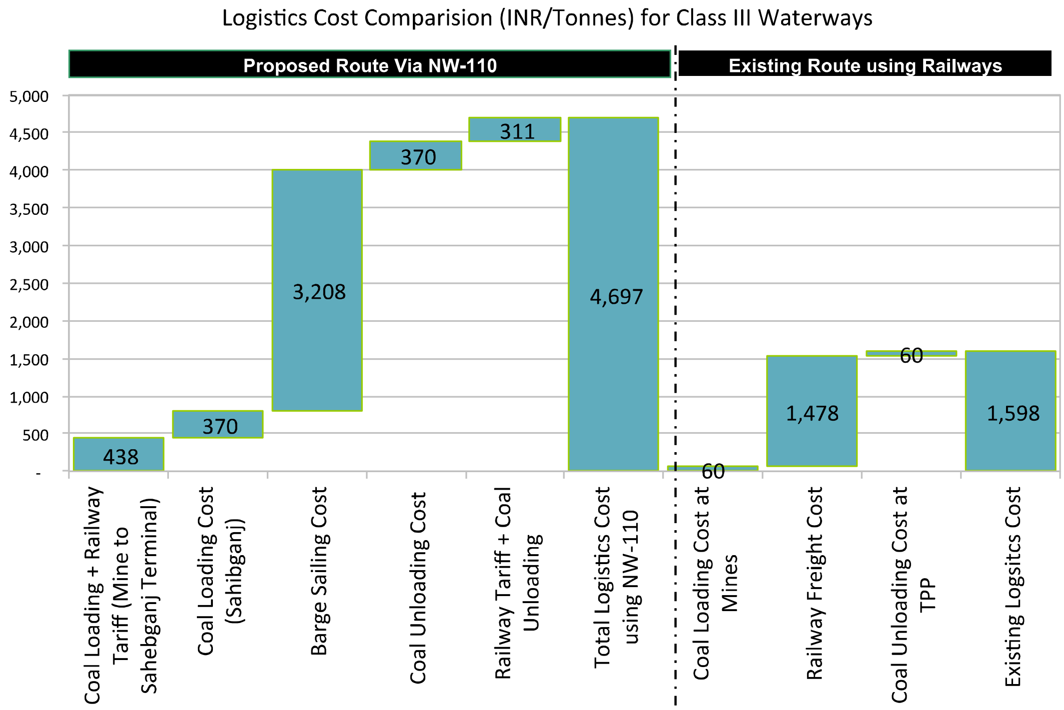


Fig. 6.121 Parichha Logistics cost comparison b/w Road, Rail & IWT for Class III

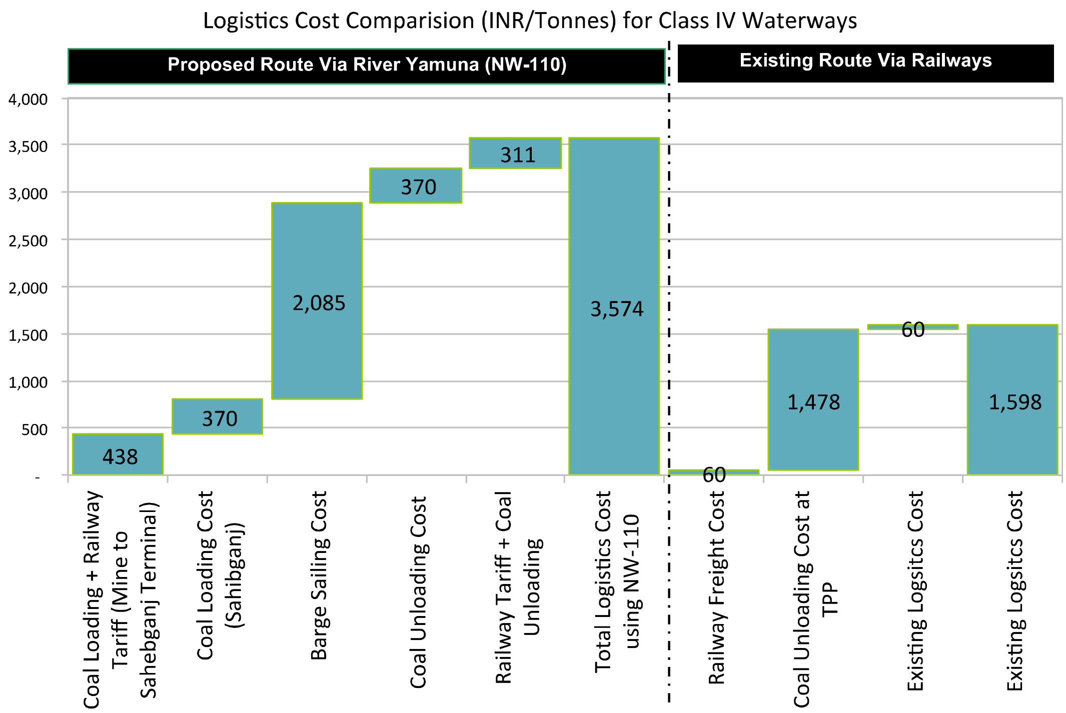


Fig. 6.122 Parichha Logistics cost comparison b/w Road, Rail & IWT for Class IV

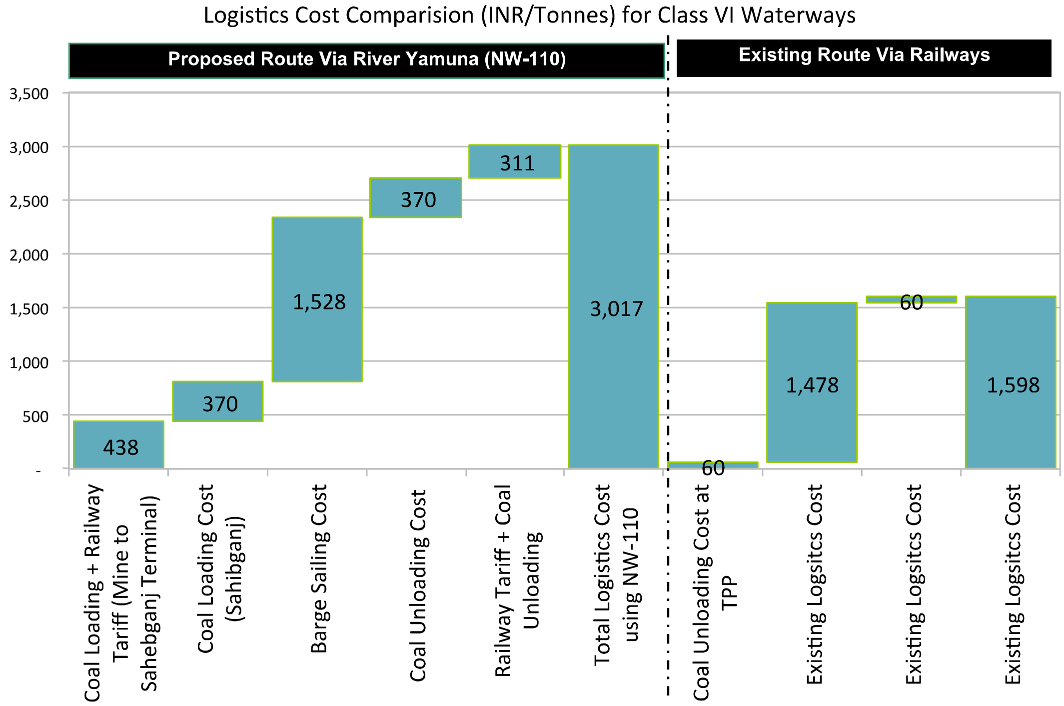


Fig. 6.123 Parichha Logistics cost comparison b/w Road, Rail & IWT for Class VI

6.13.10.3Logistic Cost Comparison – IWAI Vessels

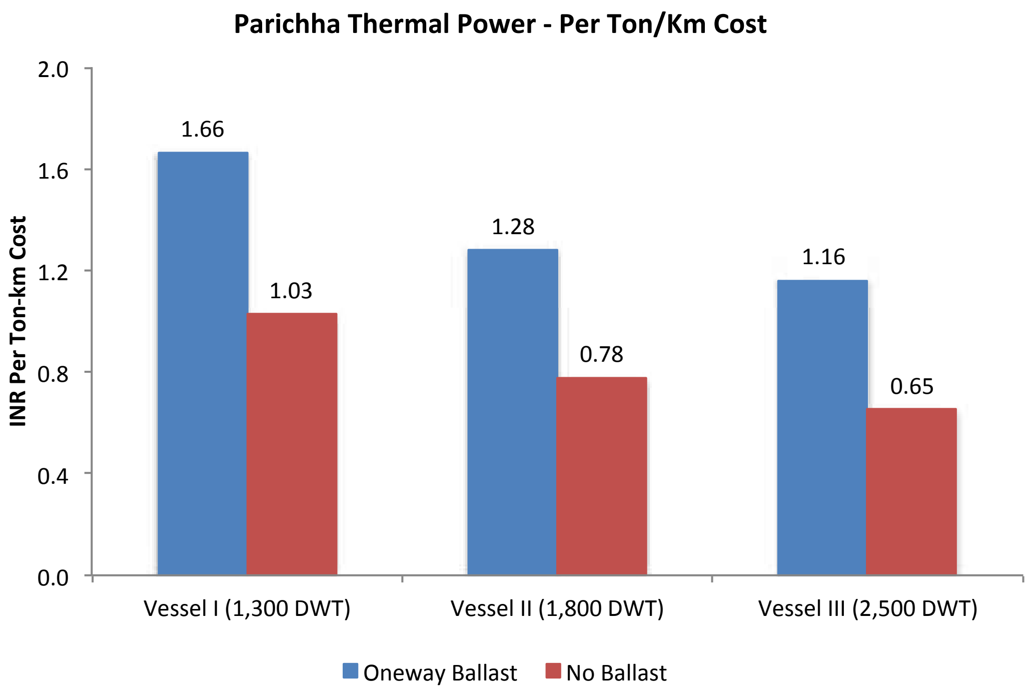


Fig. 6.124 Per ton/km logistic cost for IWAI's vessels

- **Cumulative Logistics Cost Comparison – INR Per Ton**

The following table shows Cumulative Logistics Cost Comparison for Parichha Power Plant, for IWAI's special designed vessels, i.e. Vessel I (1,300 DWT), II (1,800 DWT) and III (2,500 DWT).

Table 6.128 Parichha logistics cost for different classes- One Way Ballast

Particulars	Vessel I	Vessel II	Vessel III	Railway Cost
Barge DWT	1,300	1,800	2,500	n/a
Cost of Coal Loading at Mine	60	60	60	60
Railway Tariff (Mine to Sahibganj Terminal)	378	378	378	1,478
Cost of Unloading Rake at Sahibganj Terminal	60	60	60	
Stacking Cost at Sahibganj Terminal	110	110	110	
Cost at Sahibganj Terminal	200	200	200	
Lock Operation Cost - Assuming	-	-	-	
Feeder Barge - Sailing Cost	1,917	1,475	1,338	
Charges for Jetty (Daulatpur)	200	200	200	
Storage & Material Handling	110	110	110	
Cost of Coal Loading Rake at Daulatpur	60	60	60	
Railway Tariff at Daulatpur	251	251	251	
Coal Unloading at Daulatpur	60	60	60	60
Total Cost	**3,406**	**2,964**	**2,827**	**1,598**

Logistics Cost Comparison for Parichha Power Plant is done for IWAI's special Class of vessels, i.e. Vessel I, II and III in the following charts.

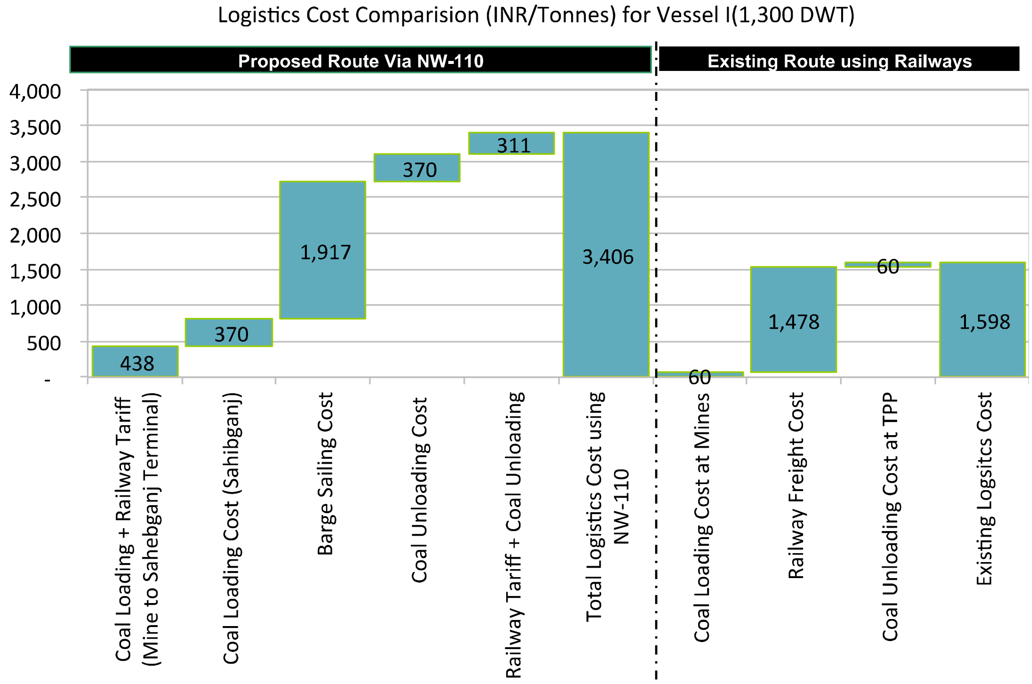


Fig. 6.125 Parichha Logistic Cost Comparison b/w IWAI Vessel I & Existing Route

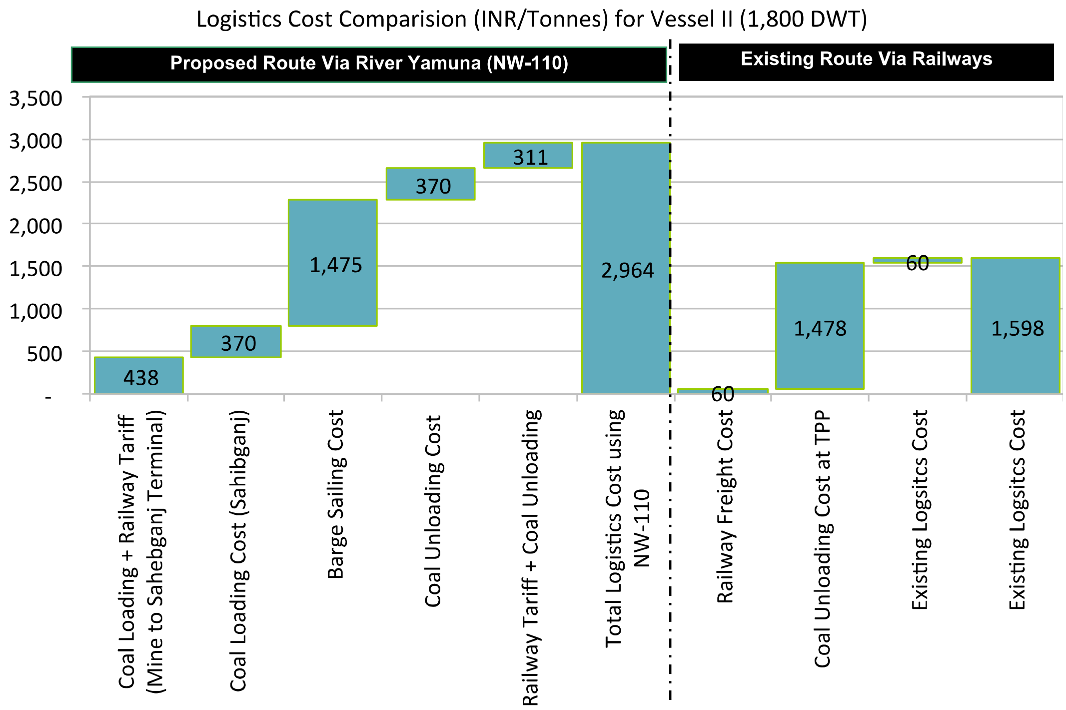


Fig. 6.126 Parichha Logistic Cost Comparison b/w IWAI Vessel II & Existing Route

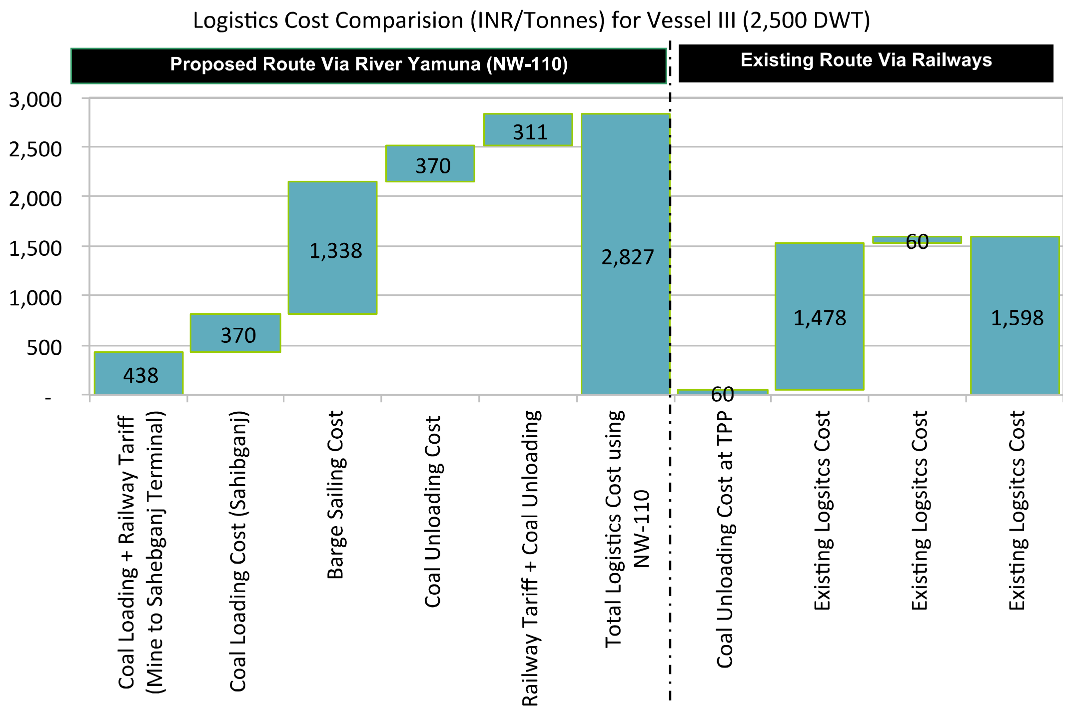


Fig. 6.127 Parichha Logistic Cost Comparison b/w IWAI Vessel III & Existing Route

6.13.11Terminal 5 - Bara Power Plant

6.13.11.1Origin –Destination Movement - Mapping

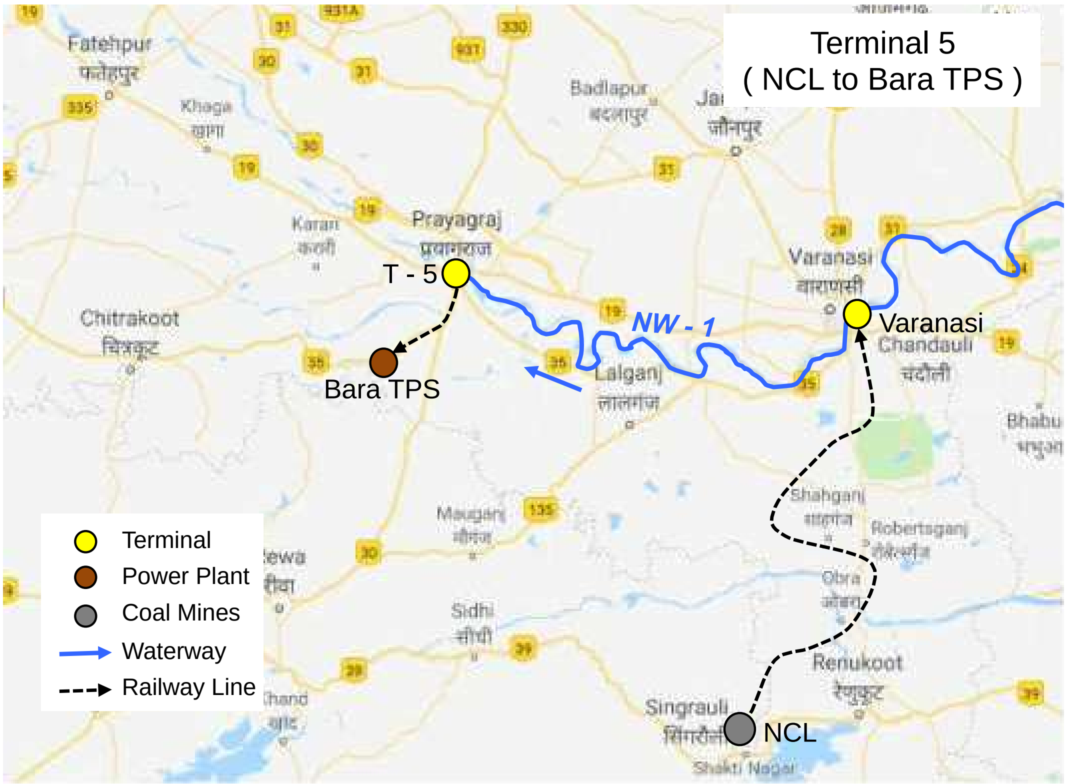


Fig. 6.128 Origin Destination Movement on River Yamuna (NW110)

6.13.11.2Logistic Cost Comparison – Standard Vessels

- **Logistics Cost Comparison – INR Per Ton-Km**

Bara TPP has installed capacity of 1,980 mw. Its annual coal requirement is 8,445 thousand tons. Bara TPP procures coal from Northern Coal Fields of Madhya Pradesh. Following graph represent per ton coal transportation cost under each type of vessels using waterway (NW 1+ NW110) for two cases i.e. One way ballast & No ballast per ton km cost depicted in figure below is for waterway transportation alone. First & last mile cost of transportation has not been factored in the calculation shown in figure.

Domestic/imported coal movement for TPP in Uttar Pradesh would originate from Sahibganj. The unit cost of transportation reduces with increase in sizes of barge and class waterways. Loaded speed & Ballast speed has been considered 6 knots& 9 knots respectively for all class of waterway.

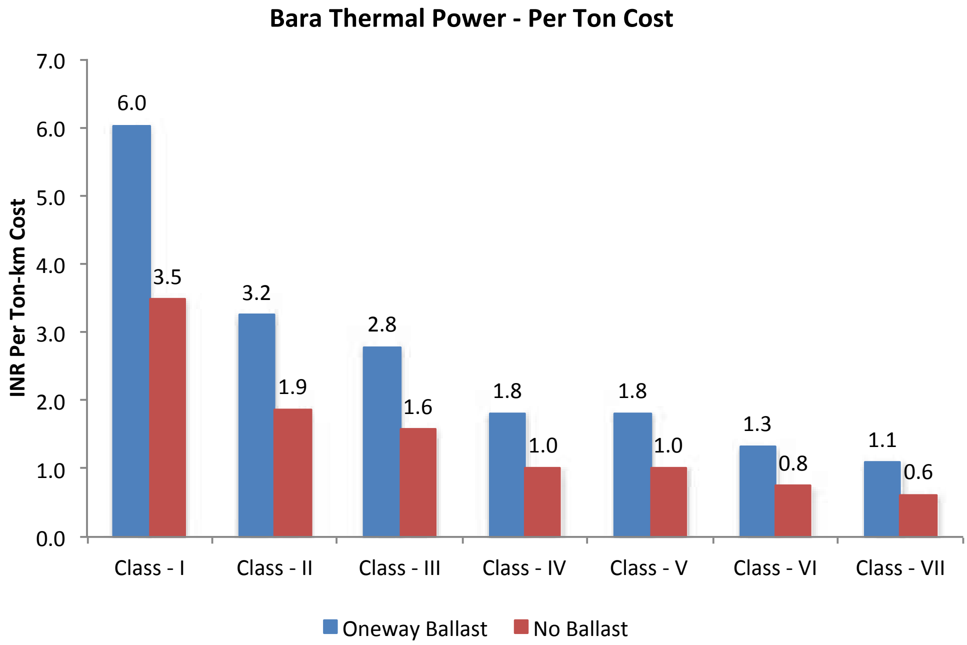


Fig. 6.129 Bara TPP Per ton/km cost for waterway

In case of no ballast case, fly ash could be exported using Haldia port for other industrial use. IWAI intends to develop NW 110 for handling class III & class IV size of vessels. Following table describes end-to-end total logistic cost comparison of present & proposed mode of transportation.

- **Cumulative Logistics Cost Comparison – INR Per Ton**

The following table shows Cumulative Logistics Cost Comparison for Bara Power Plant for Class III, IV and VI.

Table 6.129 Bara logistics cost for different classes- OneWay Ballast

	Class - III	Class - IV	Class - VI	Railway Cost
Barge DWT	500	1000	2000	
Cost of Coal Loading at Mine	60.0	60.0	60.0	60.0
Railway Tariff (Mine to Sahibganj Terminal)	378.0	378.0	378.0	
Cost of Unloading Rake at Sahibganj Terminal	60.0	60.0	60.0	
Stacking Cost at Sahibganj Terminal	110.0	110.0	110.0	
Cost at Sahibganj Terminal	200.0	200.0	200.0	
Lock Operation Cost - Assuming	-	-	-	
Feeder Barge - Sailing Cost	3,208.4	2,085.1	1,528.1	
Charges for Jetty (Prayagraj)	200.0	200.0	200.0	
Storage & Material Handling	110.0	110.0	110.0	
Cost of Coal Loading Rake at Prayagraj	60.0	60.0	60.0	
Railway Tariff at Bara	205.6	205.6	205.6	899.4
Coal Unloading at Bara	60.0	60.0	60.0	60.0
Total Cost	**4,652**	**3,529**	**2,972**	**1,019**

Logistics Cost Comparison for Bara Power Plant is done for Class III, IV and VI waterways in the following charts.

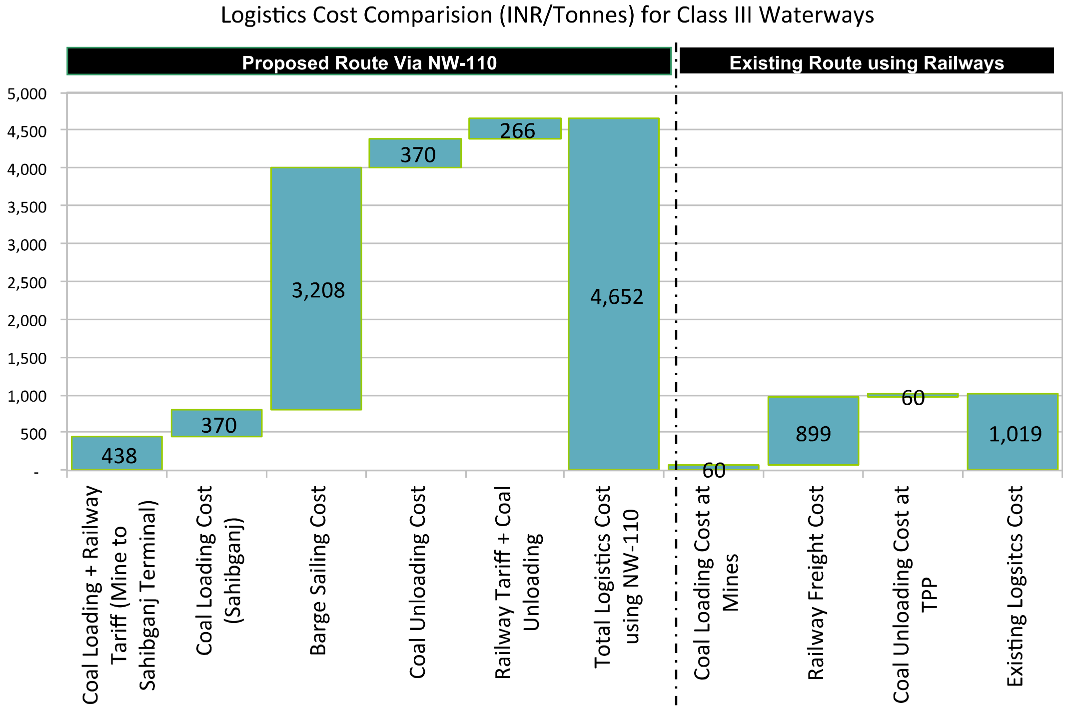


Fig. 6.130 Bara Logistics cost comparison b/w Road, Rail & IWT for Class III

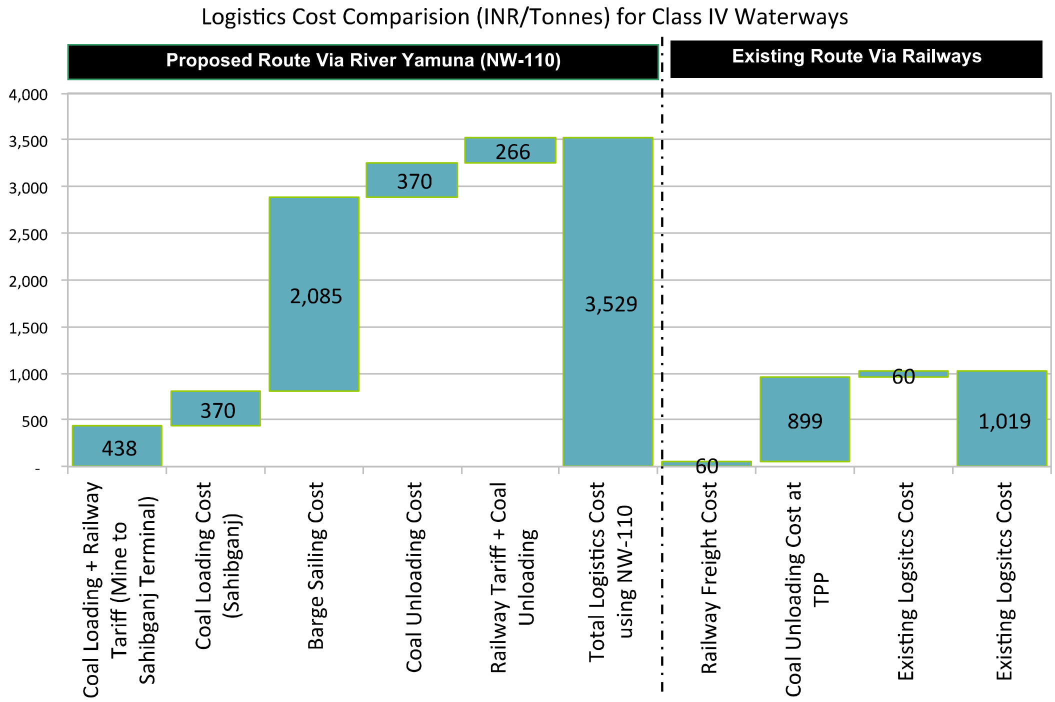


Fig. 6.131 Bara Logistics cost comparison bb/w Road, Rail & IWT for Class IV

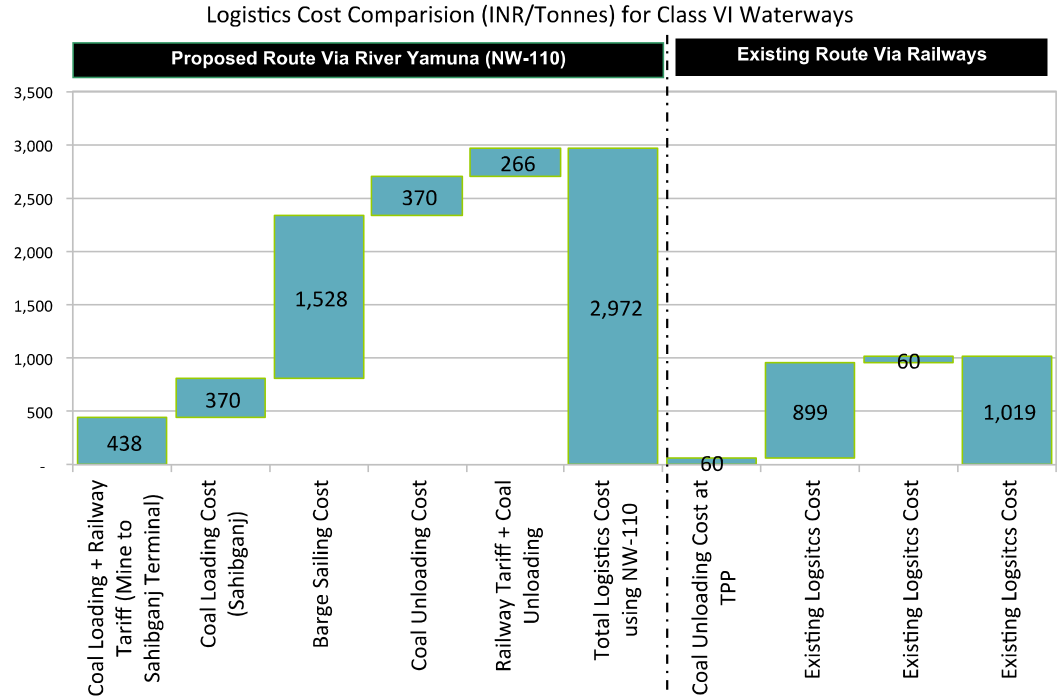


Fig. 6.132 Bara Logistics cost comparison b/w Road, Rail & IWT for Class VI

6.13.11.3Logistic Cost Comparison – IWAI Vessels

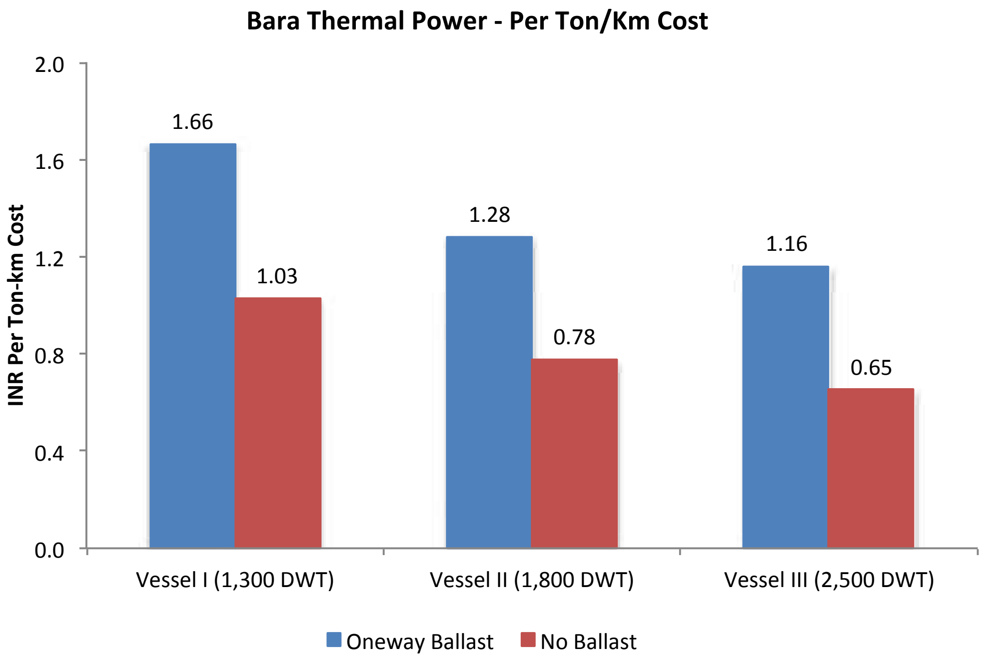


Fig. 6.133 Per ton/km logistic cost using IWAI's vessels

- **Cumulative Logistics Cost Comparison – INR Per Ton**

The following table shows Cumulative Logistics Cost Comparison for Bara Power Plant, for IWAI's special designed vessels, i.e. Vessel I (1,300 DWT), II (1,800 DWT) and III (2,500 DWT).

Table 6.130 Bara logistics cost for different classes- OneWay Ballast

Particulars	Vessel I	Vessel II	Vessel III	Railway Cost
Barge DWT	1,300	1,800	2,500	n/a
Cost of Coal Loading at Mine	60	60	60	60
Railway Tariff (Mine to Sahibganj Terminal)	378	378	378	899
Cost of Unloading Rake at Sahibganj Terminal	60	60	60	
Stacking Cost at Sahibganj Terminal	110	110	110	
Cost at Sahibganj Terminal	200	200	200	
Lock Operation Cost - Assuming	-	-	-	
Feeder Barge - Sailing Cost	1,917	1,475	1,338	
Charges for Jetty (Prayagraj)	200	200	200	
Storage & Material Handling	110	110	110	
Cost of Coal Loading Rake at Prayagraj	60	60	60	
Railway Tariff at Bara	206	206	206	
Coal Unloading at Bara	60	60	60	60
Total Cost	**3,361**	**2,919**	**2,782**	**1,019**

Logistics Cost Comparison for Bara Power Plant is done for IWAI's special Class of vessels, i.e. Vessel I, II and III in the following charts.

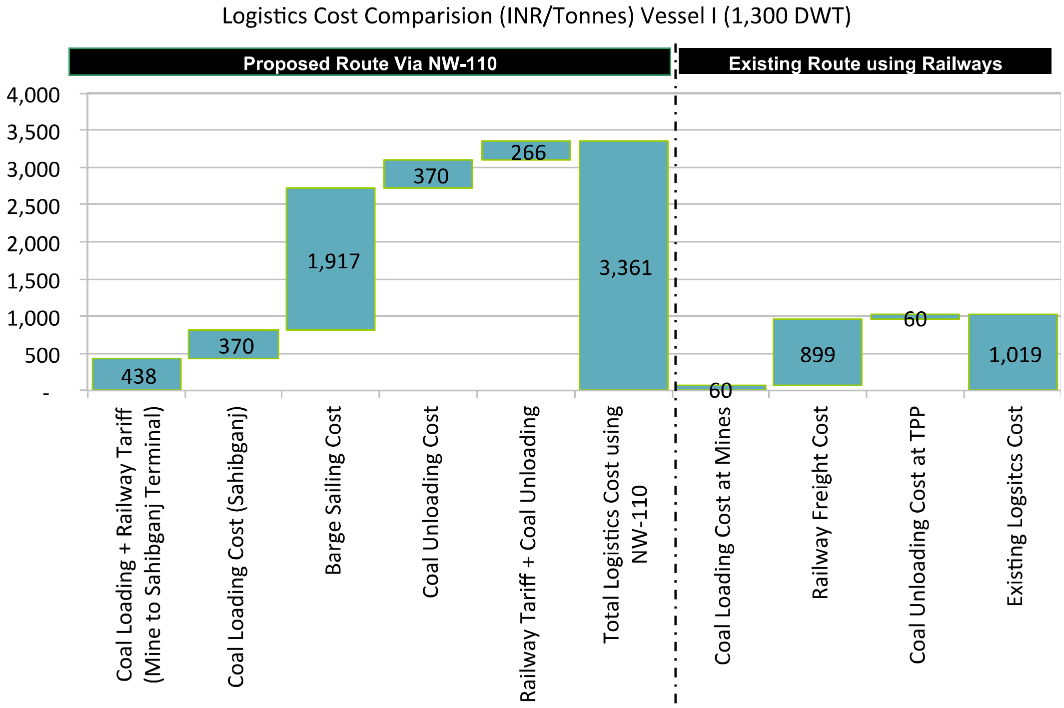


Fig. 6.134 Bara Logistic Cost Comparison b/w IWAI Vessel I & Existing Route

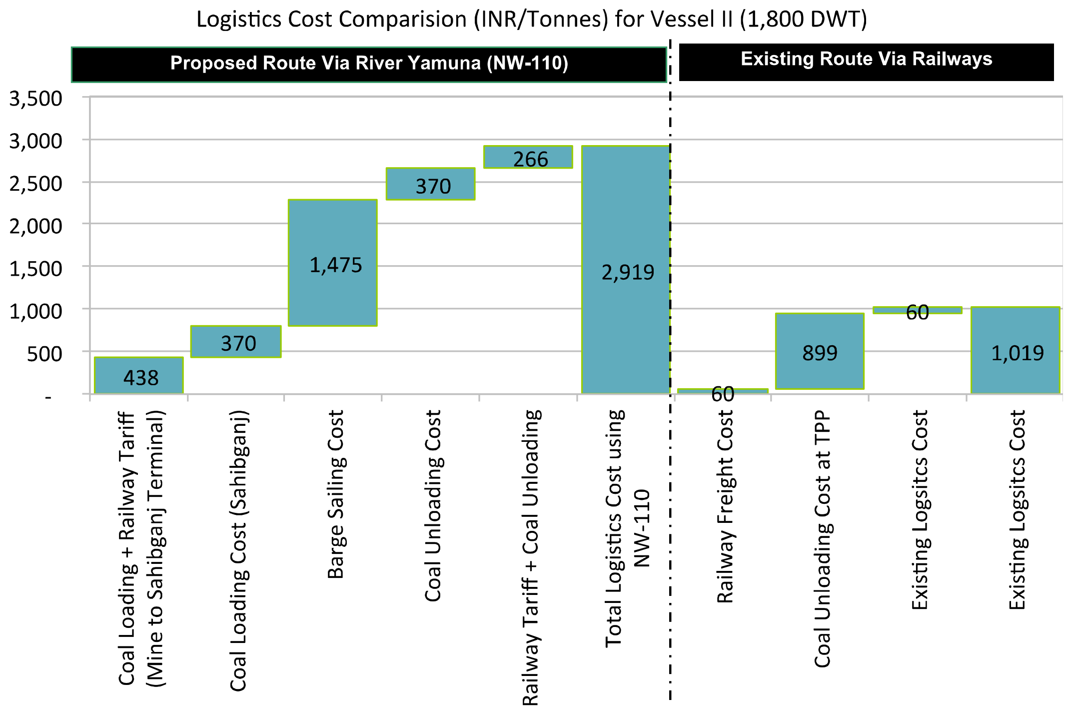


Fig. 6.135 Bara Logistic Cost Comparison b/w IWAI Vessel II & Existing Route

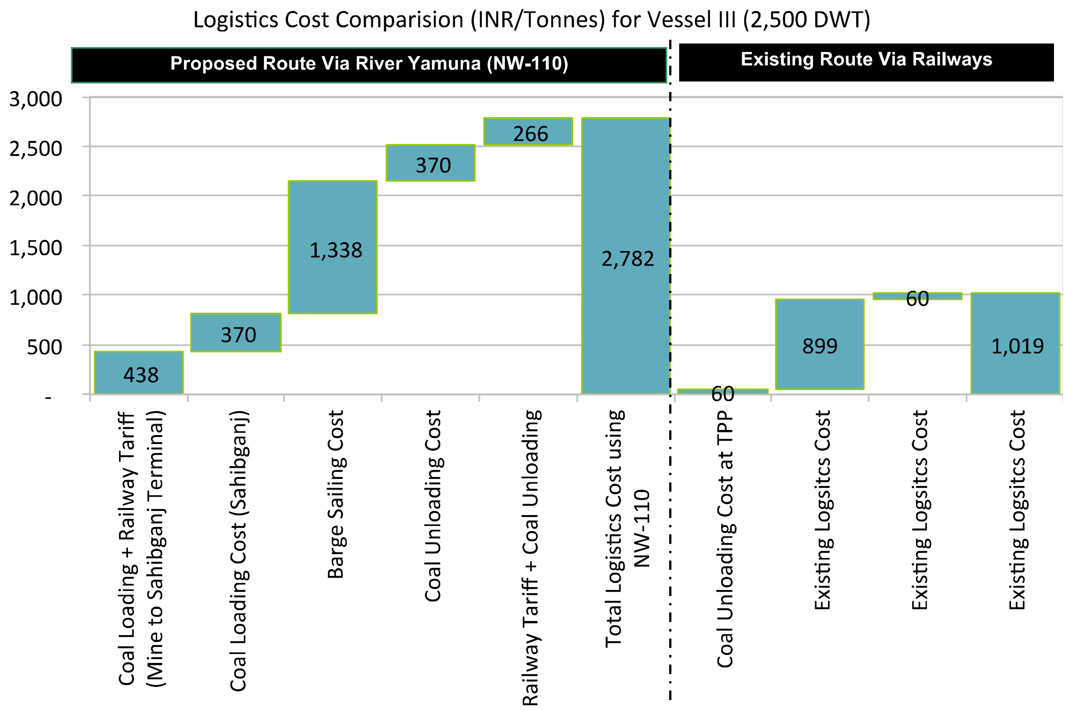


Fig. 6.136 Bara Logistic Cost Comparison b/w IWAI Vessel III & Existing Route

6.13.12Terminal 5 - Meja Power Plant

6.13.12.1Origin –Destination Movement - Mapping

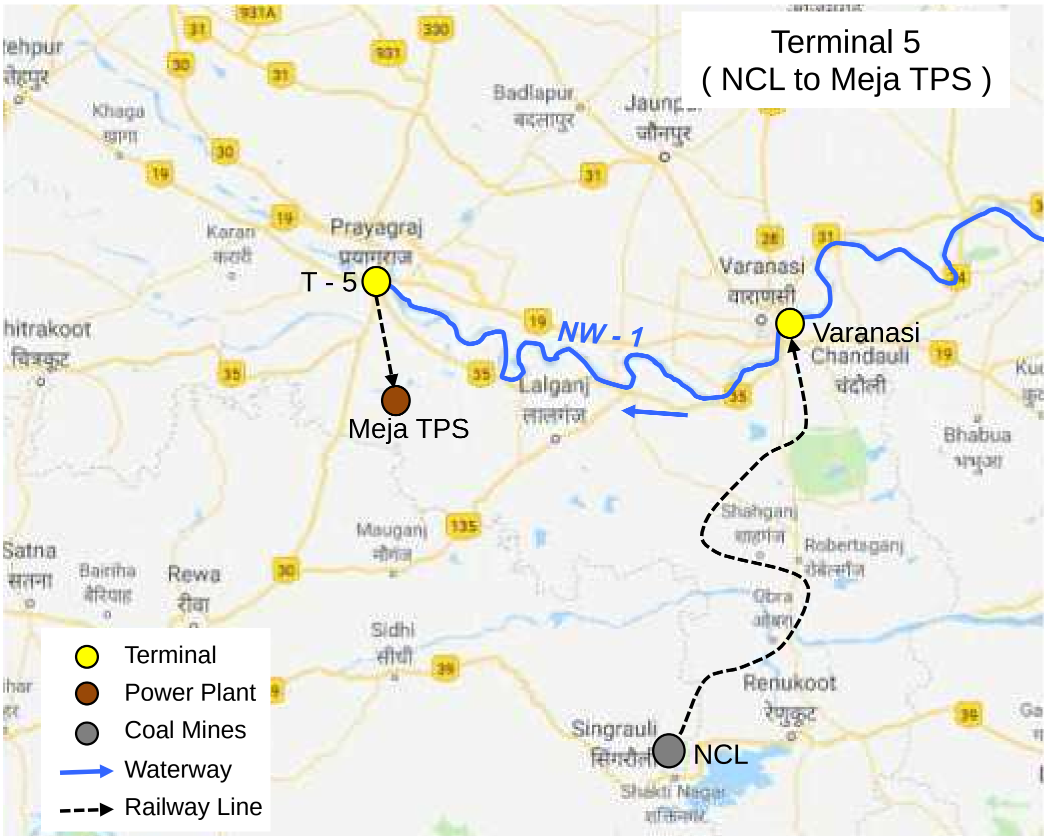


Fig. 6.137 Origin Destination Movement on River Yamuna (NW110)

6.13.12.2Logistic Cost Comparison – Standard Vessels

- **Logistics Cost Comparison – INR Per Ton-Km**

Meja TPP's annual coal requirement would be 5,630 thousand tons. Following graph represent per ton coal transportation cost under each type of vessels using waterway (NW 1+ NW110) for two cases i.e. One way ballast & No ballast per ton km cost depicted in figure below is for waterway transportation alone.

First & last mile cost of transportation has not been factored in the calculation shown in figure. Domestic/imported coal movement for TPP in Uttar Pradesh would originate from Sahibganj. The unit cost of transportation reduces with increase in sizes of barge and class waterways. Loaded speed & Ballast speed has been considered 6 knots& 9 knots respectively for all class of waterway.

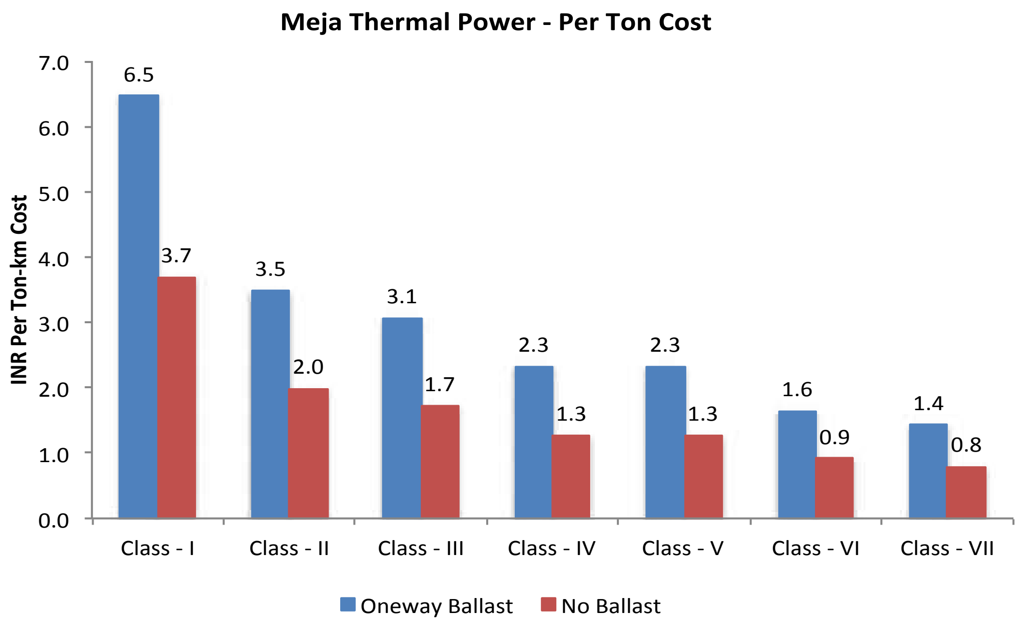


Fig. 6.138 Meja TPP Per ton/km cost for waterway

In case of no ballast case, TPP would transport fly ash for other industrial use. IWAI intends to develop NW 110 for handling class III & class IV size of vessels. Following table describes end-to-end total logistic cost comparison of present & proposed mode of transportation.

- **Cumulative Logistics Cost Comparison – INR Per Ton**

The following table shows Cumulative Logistics Cost Comparison for Meja Power Plant for Class III, IV and VI.

Table 6.131 Meja logistics cost for different classes- OneWay Ballast

	Class - III	Class - IV	Class - VI	Railway Cost
Barge DWT	500	1000	2000	
Cost of Coal Loading at Mine	60.0	60.0	60.0	60.0
Railway Tariff (Mine to Sahibganj Terminal)	314.2	314.2	314.2	
Cost of Unloading Rake at Sahibganj Terminal	60.0	60.0	60.0	
Stacking Cost at Sahibganj Terminal	110.0	110.0	110.0	
Cost at Sahibganj Terminal	200.0	200.0	200.0	
Lock Operation Cost - Assuming	-	-	-	
Feeder Barge - Sailing Cost	675.3	511.9	362.8	
Charges for Jetty (Prayagraj)	200.0	200.0	200.0	
Storage & Material Handling	110.0	110.0	110.0	
Cost of Coal Loading Rake at Prayagraj	60.0	60.0	60.0	
Railway Tariff at Meja	205.6	205.6	205.6	411.1
Coal Unloading at Meja	60.0	60.0	60.0	60.0
Total Cost	**2,055**	**1,892**	**1,743**	**531**

Logistics Cost Comparison for Meja Power Plant is done for Class III, IV and VI waterways in the following charts.

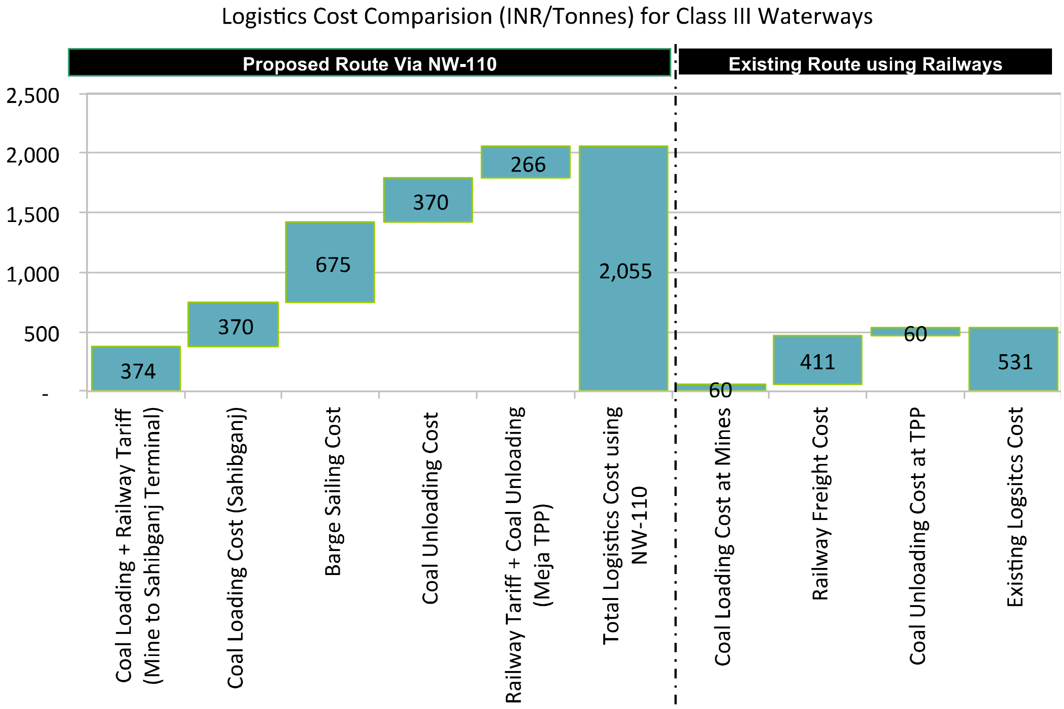


Fig. 6.139 Meja Logistics cost comparison b/w Road, Rail & IWT for Class III

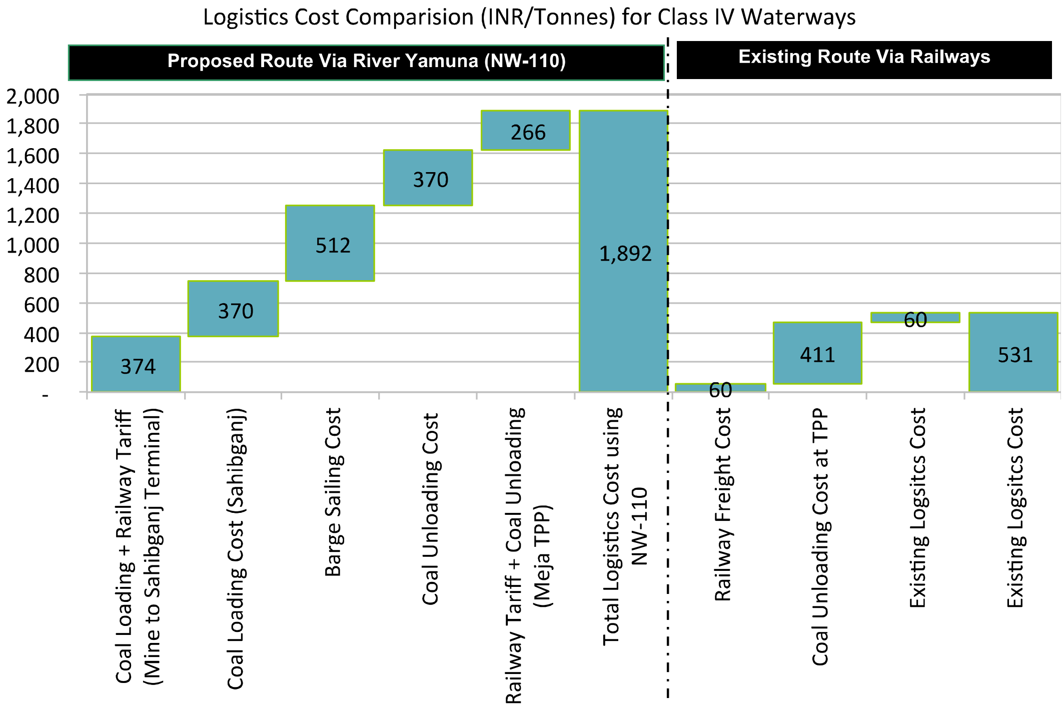


Fig. 6.140 Meja Logistics cost comparison b/w Road, Rail & IWT for Class IV

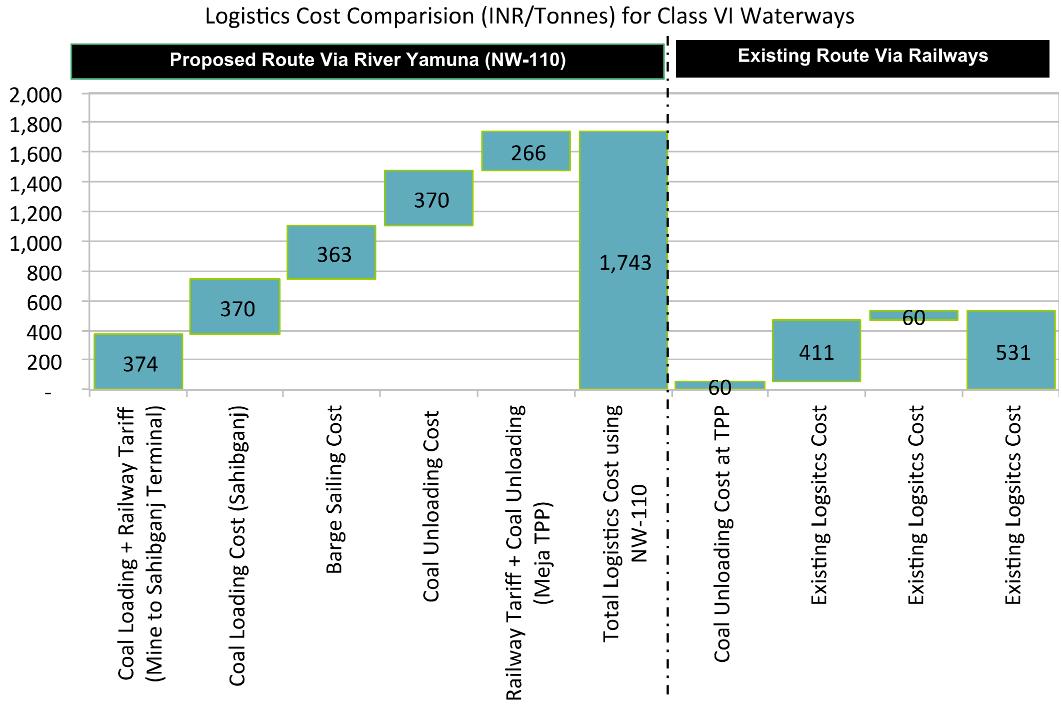


Fig. 6.141 Meja Logistics cost comparison b/w Road, Rail & IWT for Class VI

6.13.12.3 Logistic Cost Comparison – IWAI Vessels

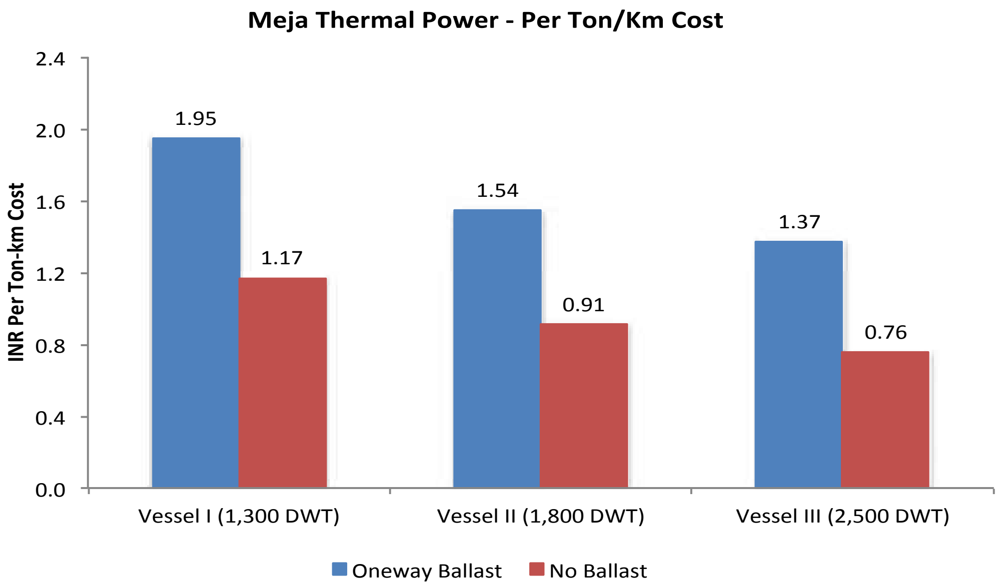


Fig. 6.142 Meja TPP Per ton/km logistic cost using IWAI's vessels

- **Cumulative Logistics Cost Comparison – INR Per Ton**

The following table shows Cumulative Logistics Cost Comparison for Meja Power Plant, for IWAI's special designed vessels, i.e. Vessel I (1,300 DWT), II (1,800 DWT) and III (2,500 DWT).

Table 6.132 Meja logistics cost for different classes- OneWay Ballast

Particulars	Vessel I	Vessel II	Vessel III	Railway Cost
Barge DWT	1,300	1,800	2,500	NA
Cost of Coal Loading at Mine	60	60	60	60
Railway Tariff (Mine to Sahibganj Terminal)	314	314	314	411
Cost of Unloading Rake at Sahibganj Terminal	60	60	60	
Stacking Cost at Sahibganj Terminal	110	110	110	
Cost at Sahibganj Terminal	200	200	200	
Lock Operation Cost - Assuming	-	-	-	
Feeder Barge - Sailing Cost	428	340	301	
Charges for Jetty (Prayagraj)	200	200	200	
Storage & Material Handling	110	110	110	
Cost of Coal Loading Rake at Prayagraj	60	60	60	
Railway Tariff at Meja	206	206	206	
Coal Unloading at Meja	60	60	60	60
Total Cost	**1,808**	**1,719**	**1,681**	**531**

Logistics Cost Comparison for Meja Power Plant is done for IWAI's special Class of vessels, i.e. Vessel I, II and III in the following charts.

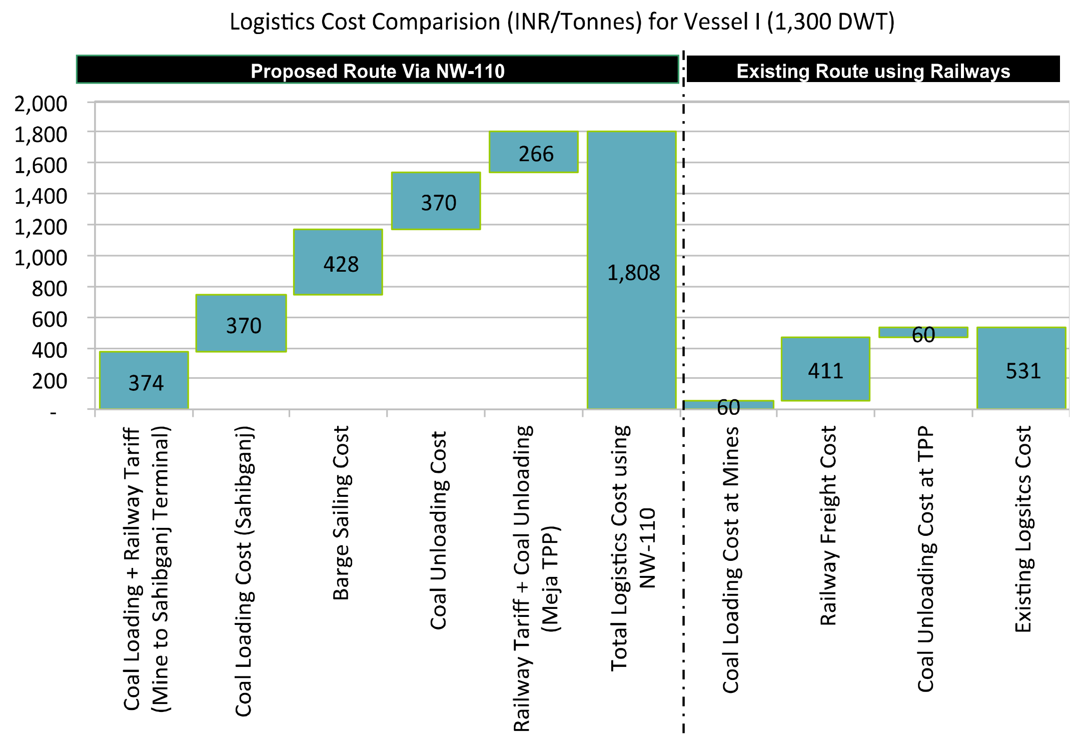


Fig. 6.143 Meja Logistic Cost Comparison b/w IWAI Vessel I & Existing Route

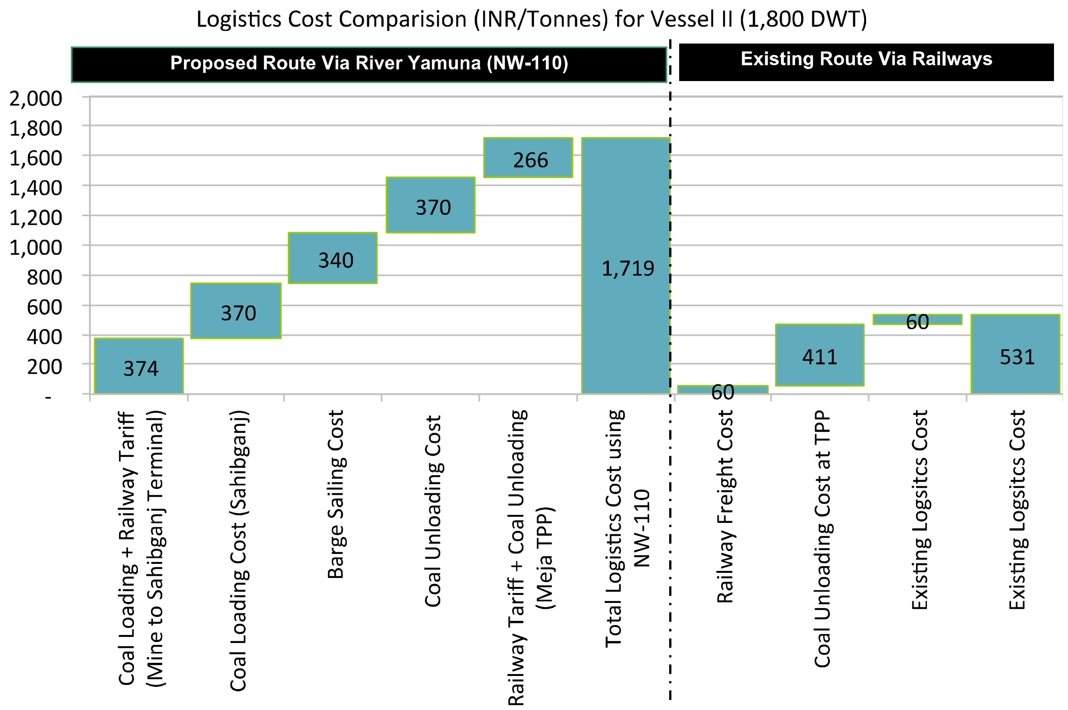


Fig. 6.144 Meja Logistic Cost Comparison b/w IWAI Vessel II & Existing Route

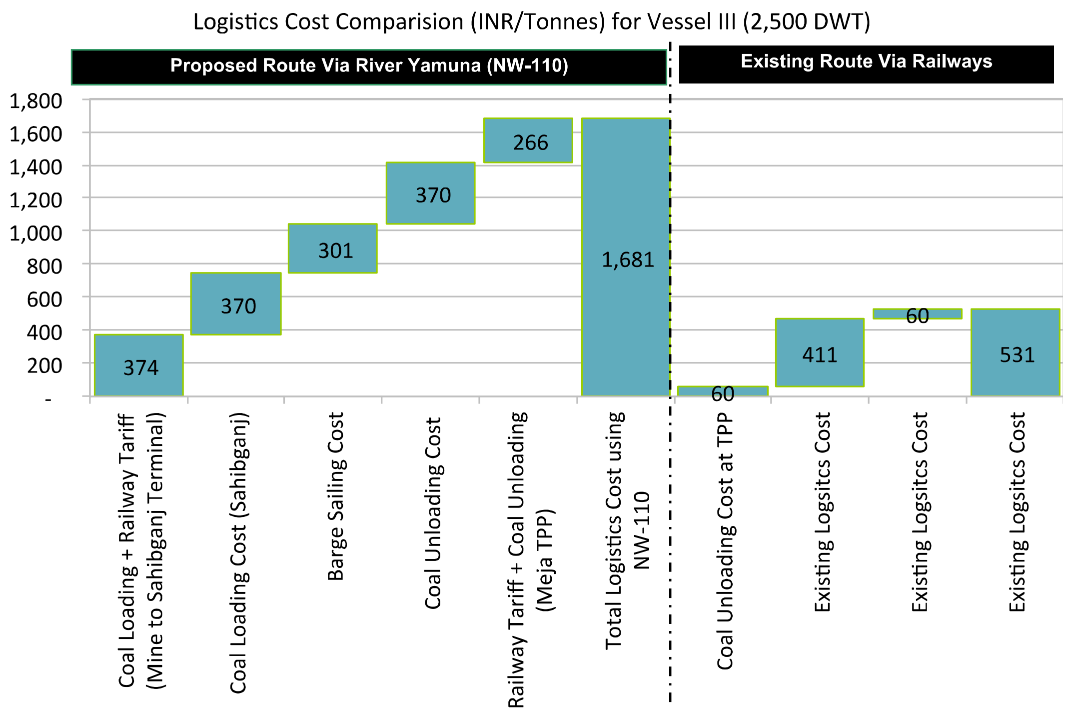


Fig. 6.145 Meja Logistic Cost Comparison b/w IWAI Vessel III & Existing Route

6.13.13Terminal 6, 7 & 8 – Sugar

6.13.13.1Sugar from Northern UP to Kanpur, Prayagraj and Haldia (Export)

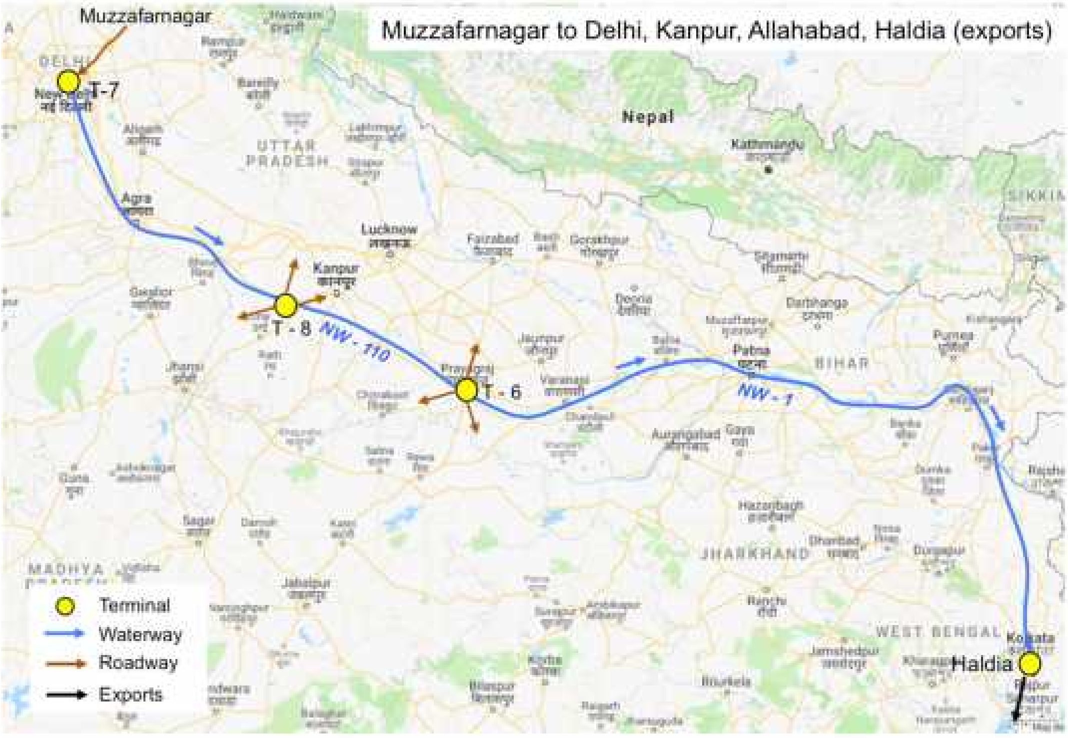


Fig. 6.146 OD Pair Mapping for Sugar Transportation

- **Shamli to Daulatpur (Terminal 8)**

  Most of the sugar mills of the state are located between Shamli- Muzaffarnagar. Due to concentration of sugar mills in Shamli, it is proposed that sugar from Shamli would be transported using NW 110 and would be unloaded at Terminal 8 (Daulatpur) for local distribution. This section would discuss logistics cost comparison for Sugar movement between Shamli to Daulatpur on NW 110.

6.13.13.2Logistic Cost Comparison (Standard Vessels)

Sugar would originate from Shamli and would be handled at Daulatpur (Terminal 8). Following graph represent per ton sugar transportation cost under each type of vessels using waterway (NW110) for two cases, i.e. one way ballast & No ballast. Per ton km cost depicted in figure below is for waterway transportation alone. First & last mile cost of transportation has not been factored in the calculation shown in figure. The unit cost of transportation reduces with increase in sizes of barge and class of waterways. Loaded speed & Ballast speed has been considered 6 knots& 9 knots respectively for all class of waterway.

- **Logistics Cost Comparison – INR Per Ton-Km**

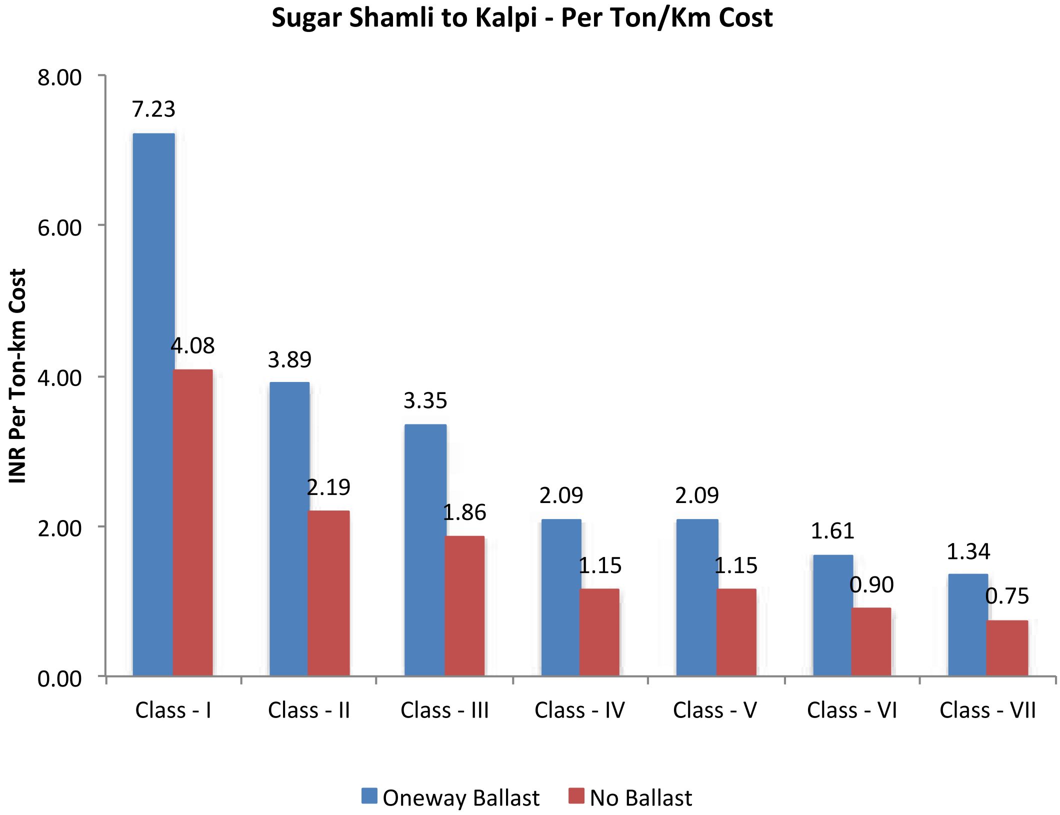


Fig. 6.147 Shamli to Kanpur (T-8) Per ton/km cost for waterway

- **Cumulative Logistics Cost Comparison – INR Per Ton**

The following table shows Cumulative Logistics Cost Comparison for Sugar Movement from Shamli to Kanpur for Class III, IV and VI.

Table 6.133 Shamli to Kanpur logistics cost for different classes- OneWay Ballast

Particulars	Class - III	Class - IV	Class - VI	Railway Cost
Barge DWT	500	1000	2000	
Cost of Sugar Loading at Source (Muzzafarnagar/Shamli)	143.0	143.0	143.0	143.0
Sugar Unloading + Railway Tariff (Source to Terminal 7)	224.8	224.8	224.8	
Cost of Unloading Rake at Terminal 7	143.0	143.0	143.0	
Stacking Cost at Terminal 7	110.0	110.0	110.0	
Cost at Terminal 7	270.0	270.0	270.0	
Feeder Barge - Sailing Cost	2,337.3	1,455.7	1,126.8	
Charges for Jetty Terminal 8	270.0	270.0	270.0	
Storage & Material Handling	110.0	110.0	110.0	
Cost of Sugar Loading Rake at Terminal 8	60.0	60.0	60.0	
Railway Tariff at Kanpur	338.9	338.9	338.9	1,209.9
Sugar Unloading at Kanpur and nearby distribution areas	143.0	143.0	143.0	143.0
Total Cost	**4,150**	**3,268**	**2,940**	**1,496**

Logistics Cost Comparison for Sugar Movement (from Shamli to Kanpur) is done for Class III, IV and VI waterways in the following charts.

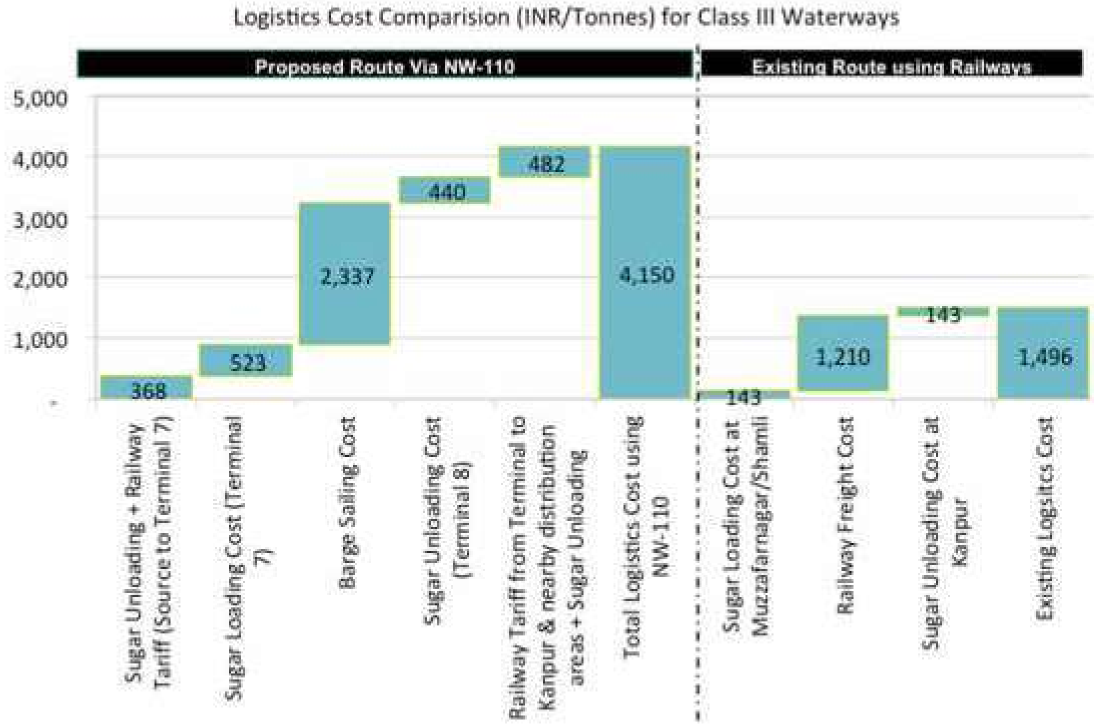


Fig. 6.148 Logistics cost comparison b/w Road, Rail & IWT for Class III

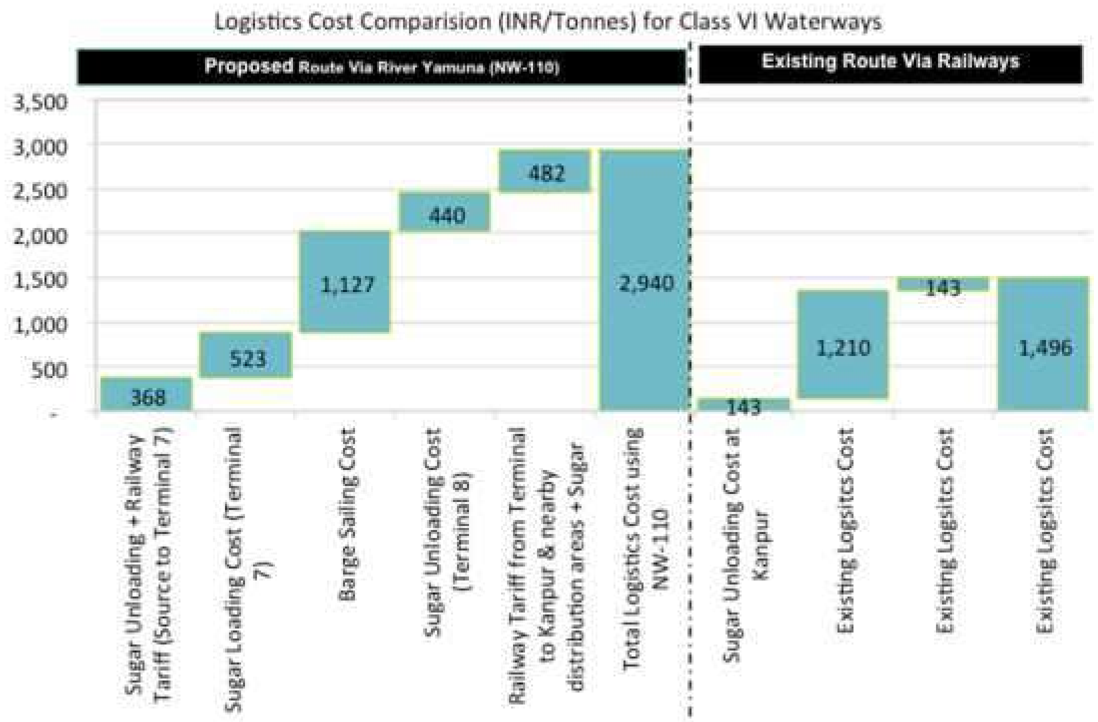


Fig. 6.149 Logistics cost comparison b/w Road, Rail & IWT for Class IV

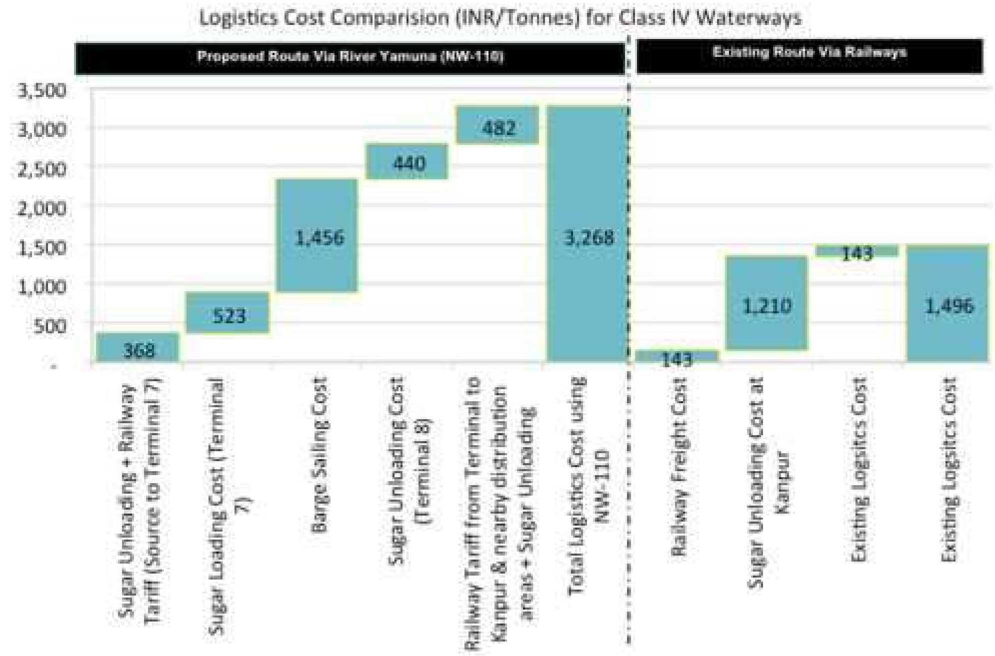


Fig. 6.150 Logistics cost comparison b/w Road, Rail & IWT for Class VI

- **Shamli to Prayagraj (Terminal 6)**

It is proposed that sugar produced in Shamli would be transported to Prayagraj, using NW 110. This sugar would be unloaded at Terminal 6 for local distribution. This section would discuss logistics cost comparison for Sugar movement between Shamli to Prayagraj on NW 110.

6.13.13.3Logistic Cost Comparison - Standard Vessels

Sugar would originate from Shamli and would be handled at Prayagraj (Terminal 6). Following graph represent per ton sugar transportation cost under each type of vessels using waterway (NW110) for two cases, i.e. one way ballast & No ballast. Per ton km cost depicted in figure below is for waterway transportation alone. First & last mile cost of transportation has not been factored in the calculation shown in figure. The unit cost of transportation reduces with increase in sizes of barge and class of waterways.

- **Logistics Cost Comparison – INR Per Ton-Km**

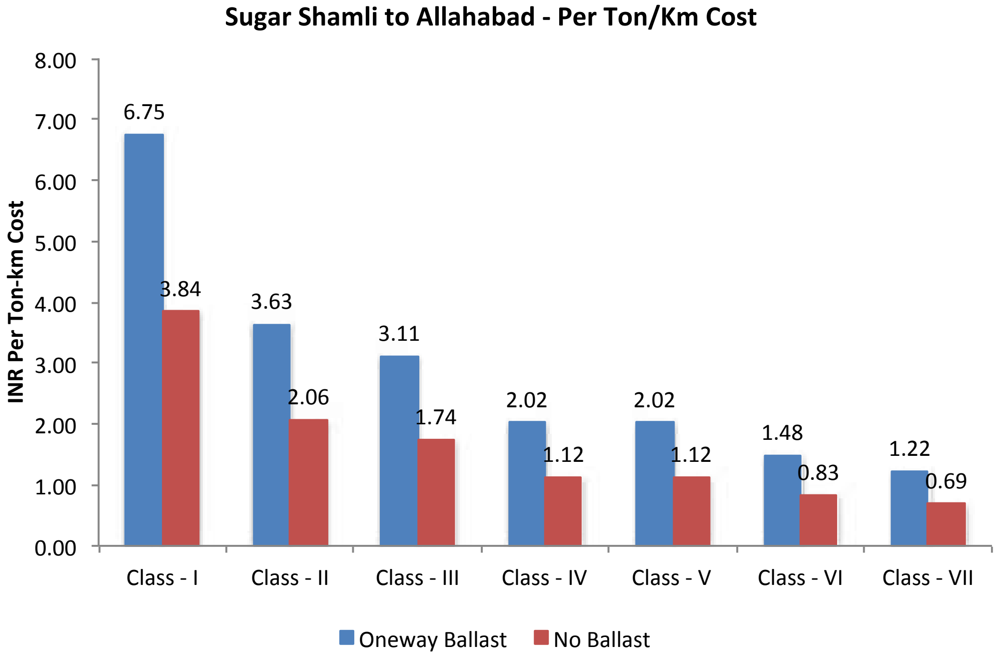


Fig. 6.151 Shamli to Prayagraj (T-6) Per ton/km cost for waterway

- **Cumulative Logistics Cost Comparison – INR Per Ton**

Table 6 .134 Shamli to Prayagraj logistics cost for different classes- OneWay Ballast

	Class - III	Class - IV	Class - VI	Railway Cost
Barge DWT	500	1000	2000	
Cost of Sugar Loading at Source (Shamli)	143.0	143.0	143.0	143.0
Sugar Unloading + Railway Tariff (Source to Terminal 7)	224.8	224.8	224.8	
Cost of Unloading Rake at Terminal 7	143.0	143.0	143.0	
Stacking Cost at HaldiaTerminal	110.0	110.0	110.0	
Cost at Terminal 7	270.0	270.0	270.0	
Feeder Barge - Sailing Cost	3,248.6	2,109.1	1,547.3	
Charges for Jetty Terminal 7)	270.0	270.0	270.0	
Storage & Material Handling	110.0	110.0	110.0	
Cost of Sugar Loading at Prayagraj	60.0	60.0	60.0	
Railway Tariff at Prayagraj	281.7	281.7	281.7	864.5
Sugar Unloading at Prayagraj	143.0	143.0	143.0	143.0
Total Cost	**5,004**	**3,865**	**3,303**	**1,151**

Logistics Cost Comparison for Sugar Movement from Shamli to Prayagraj is done for Class III, IV and VI waterways in the following charts.

Fig. 6.152 Logistics cost comparison b/w Road, Rail & IWT for Class III

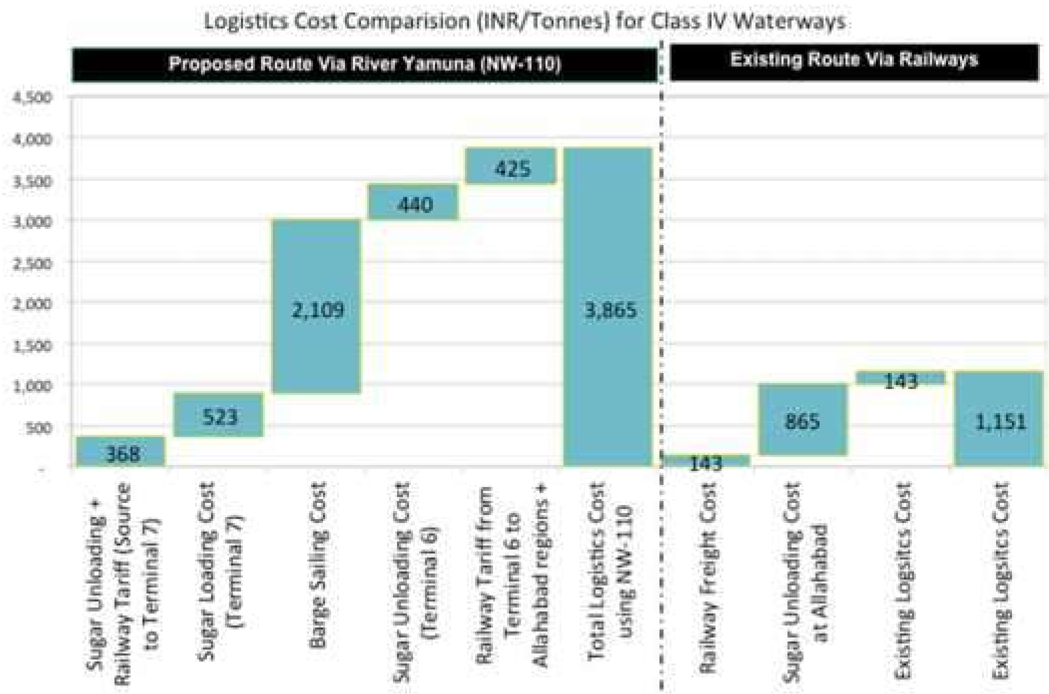


Fig. 6.153 Logistics cost comparison b/w Road, Rail & IWT for Class IV

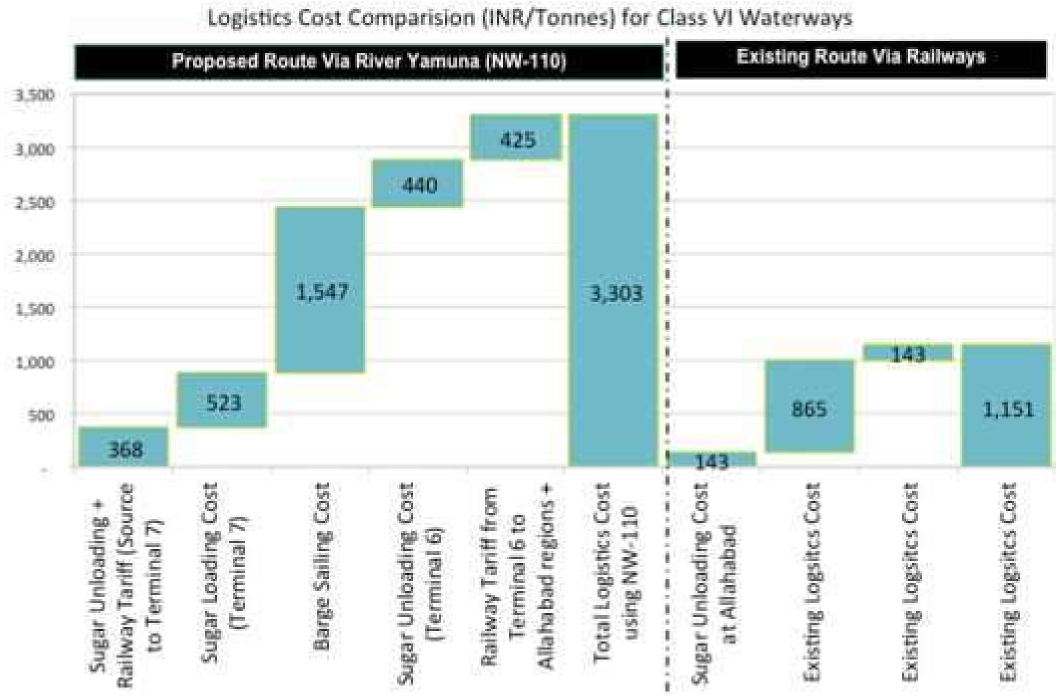


Fig. 6.154 Logistics cost comparison b/w Road, Rail & IWT for Class VI

- **Shamli to Haldia (Export)**

It is proposed that sugar produced in Shamli would be transported to Haldia, using NW 110. This sugar would be locally distributed and exported from Haldia Port. This section would discuss logistics cost comparison for Sugar movement between Shamli to Haldia on NW 110.

6.13.13.4Logistic Cost Comparison - Standard Vessels

Sugar would originate from Shamli and would be handled at Haldia Terminal on NW 1 (River Ganga). Following graph represent per ton sugar transportation cost under each type of vessels using waterway (NW110 + NW 1) for two cases, i.e. One way ballast & No ballast. Per ton km cost depicted in figure below is for waterway transportation alone.

First & last mile cost of transportation has not been factored in the calculation shown in figure. The unit cost of transportation reduces with increase in sizes of barge and class of waterways. Loaded speed & Ballast speed has been considered 6 knots& 9 knots respectively for all class of waterway.

- **Logistics Cost Comparison – INR Per Ton-Km**

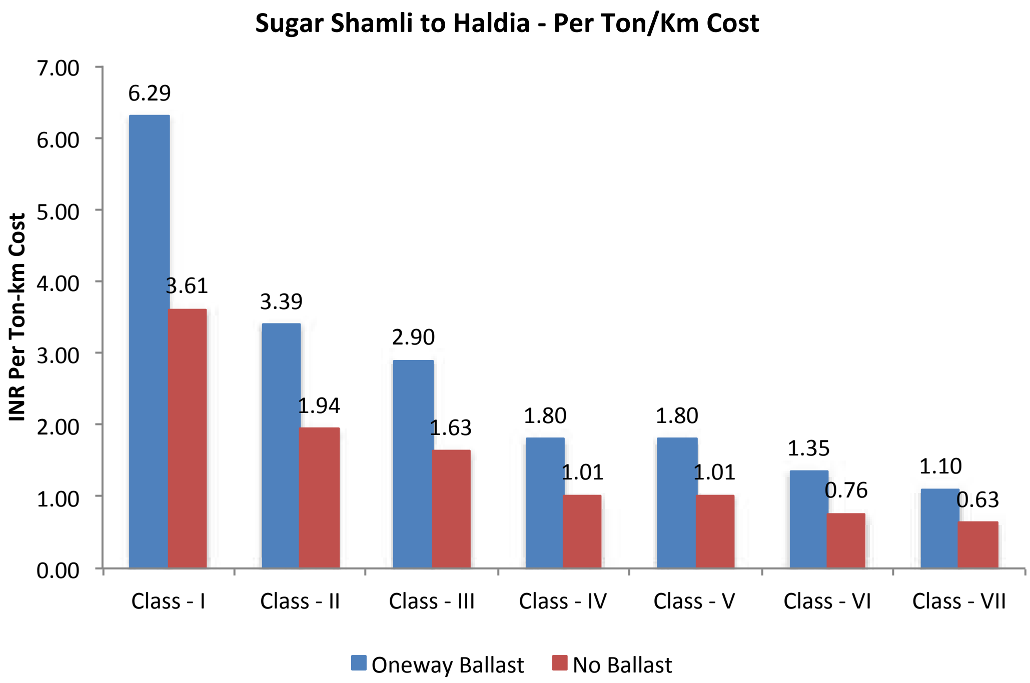


Fig.6.155 Shamli to Haldia Per ton/km cost for waterway

- **Cumulative Logistics Cost Comparison – INR Per Ton**

The following table shows Cumulative Logistics Cost Comparison for Sugar Movement from Shamli to Haldia for Class III, IV and VI.

Table 6.135 Shamli to Haldia logistics cost for different classes- OneWay Ballast

	Class - III	Class - IV	Class - VI	Railway Cost
Barge DWT	500	1000	2000	
Cost of Sugar Loading at Source (Muzzafarnagar/Shamli)	143.0	143.0	143.0	143.0
Sugar Unloading + Railway Tariff (Source to Terminal 7)	224.8	224.8	224.8	
Cost of Unloading Rake at Terminal 7	126.0	126.0	126.0	
Stacking Cost at Terminal 7	110.0	110.0	110.0	
Cost at Terminal 7	270.0	270.0	270.0	
Feeder Barge - Sailing Cost	7,731.9	4,808.0	3,606.4	
Charges for Jetty Terminal (Haldia)	270.0	270.0	270.0	
Storage & Material Handling	110.0	110.0	110.0	
Cost of Sugar Loading Rake at Haldia	60.0	60.0	60.0	
Railway Tariff at Haldia	-	-	-	1,785.9
Sugar Unloading at Haldia	143.0	143.0	143.0	143.0
Total Cost	**9,189**	**6,265**	**5,063**	**2,072**

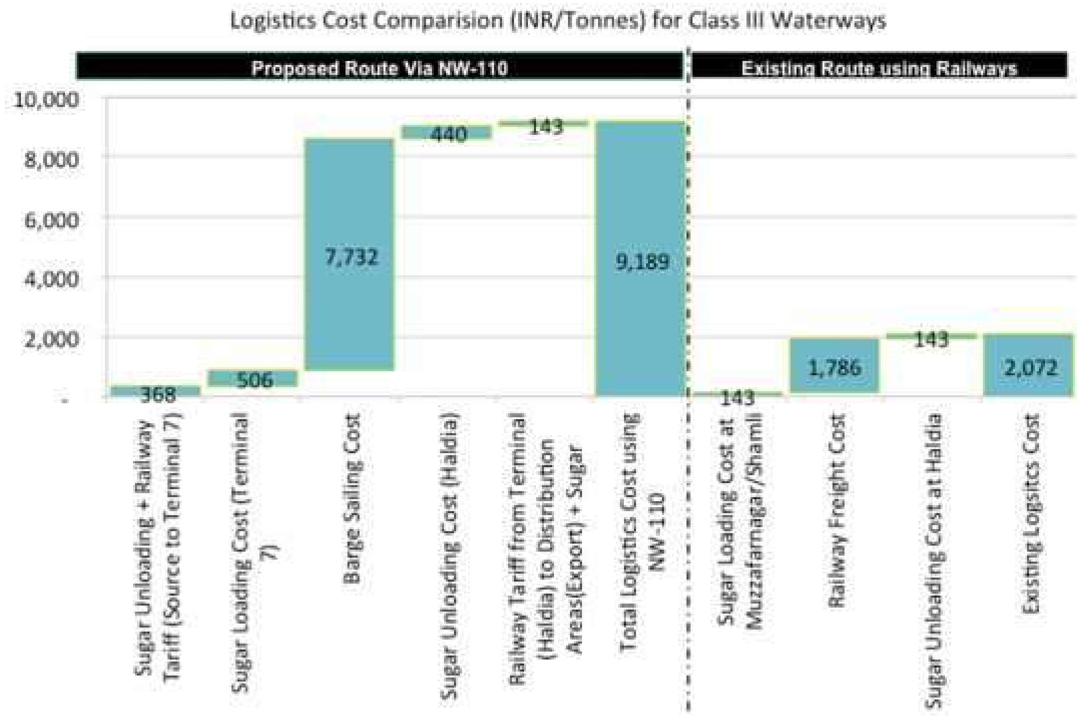


Fig.6.156 Logistics cost comparison b/w Road, Rail & IWT for Class III

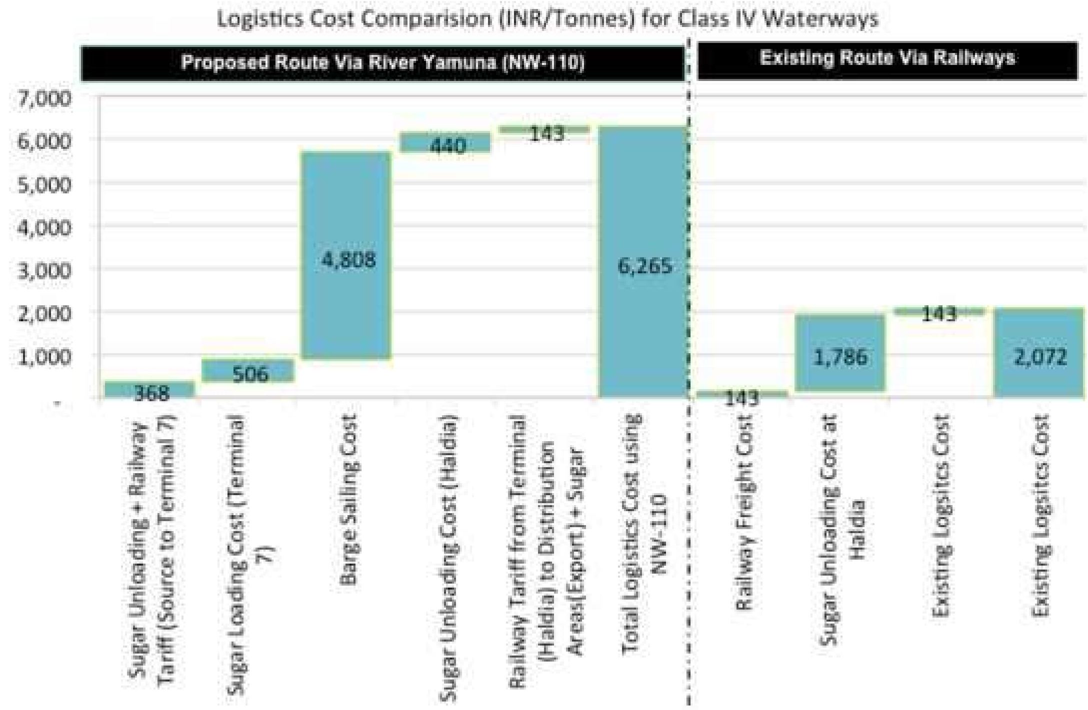


Fig.6.157 Logistics cost comparison b/w Road, Rail & IWT for Class IV

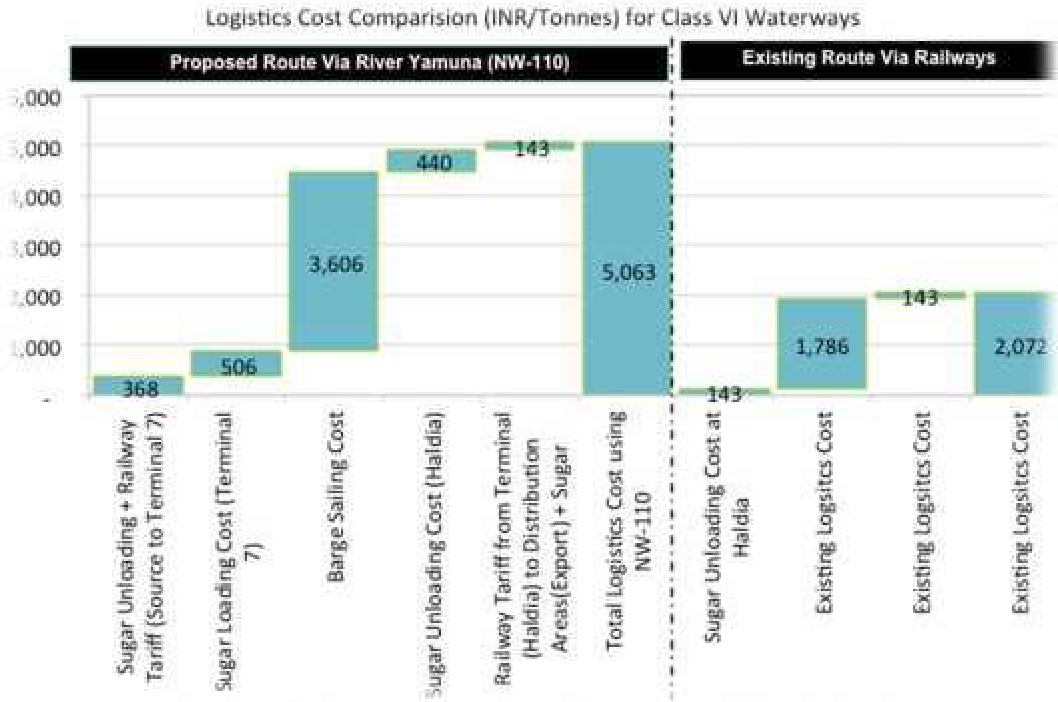


Fig.6.158 Logistics cost comparison b/w Road, Rail & IWT for Class VI

6.13.14Terminal 8 – Iron & Steel

6.13.14.1Iron & Steel from Orissa to Kanpur

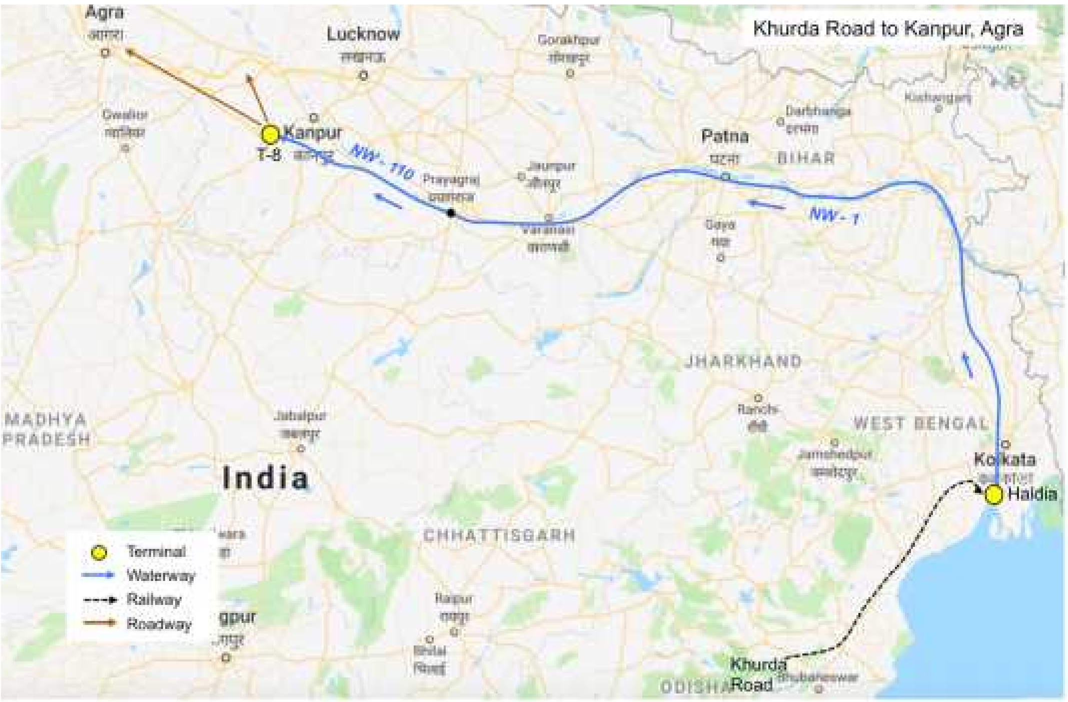


Fig. 6.159 OD Pair Mapping for Iron & Steel Transportation

6.13.14.2 Logistic Cost Comparison (Standard Vessels)

Iron & steel, which originate from Khurda (Odisha), would be transported using NW 110 and NW 1. This iron & steel would be unloaded at Terminal 8 and would be distributed to Agra and nearby districts. This section would discuss logistics cost comparison for iron & steel movement between Khurda to Kanpur on NW 110.

- **Logistics Cost Comparison – INR Per Ton-Km**

Iron & Steel would originate from Khurda (Orissa) and would be handled at Terminal 8. Following graph represent per ton iron & steel transportation cost under each type of vessels using waterway (NW110 + NW1) for two cases, i.e. One way ballast & No ballast. Per ton km cost depicted in figure below is for waterway transportation alone. First & last mile cost of transportation has not been factored in the calculation shown in figure. The unit cost of transportation reduces with increase in sizes of barge and class of waterways. Loaded speed & Ballast speed has been considered 6 knots & 9 knots respectively for all class of waterway.

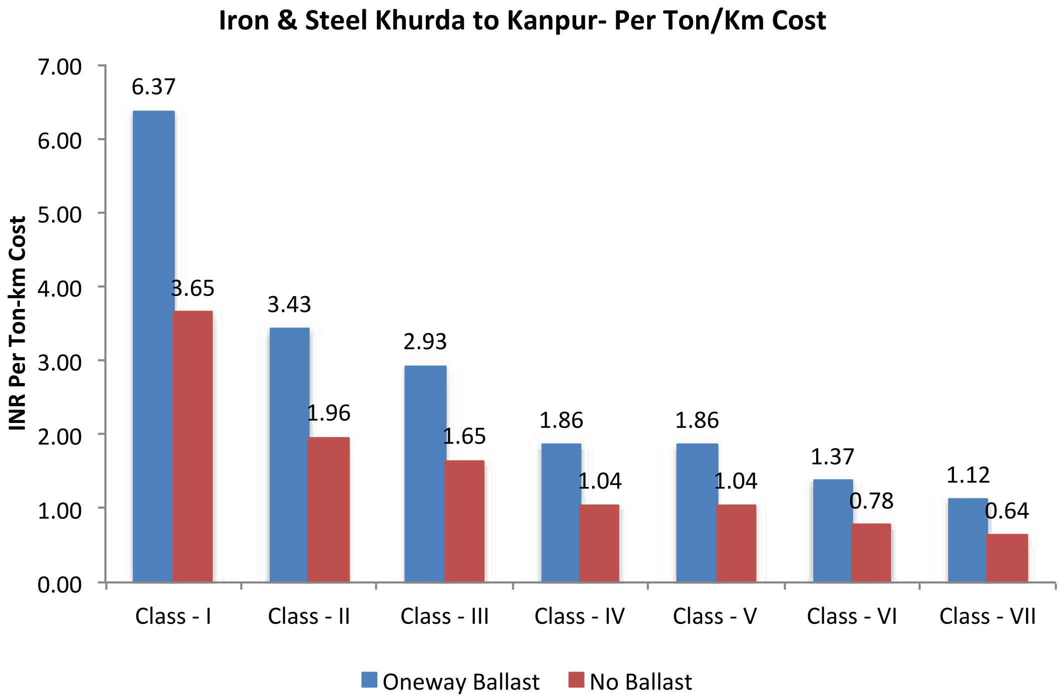


Fig. 6.160 Khurda to Kanpur (T-8) Per ton/km cost for waterway

- **Cumulative Logistics Cost Comparison – INR Per Ton**

The following table shows Cumulative Logistics Cost Comparison for iron & steel movement (Khurda to Kanpur) for Class III, IV and VI.

Table 6.136 Khurda to Kanpur logistics cost for different classes- OneWay Ballast

Particulars	Class - III	Class - IV	Class - VI	Railway Cost
Barge DWT	500	1000	2000	
Cost of Iron & Steel Loading at Source	159.5	159.5	159.5	159.5
Iron & Steel Unloading + Railway Tariff (Source to Haldia Terminal)	687.6	687.6	687.6	
Cost of Unloading Rake at Haldia Terminal	90.0	90.0	90.0	
Stacking Cost at Haldia Terminal	30.0	30.0	30.0	
Cost at Haldia Terminal	82.5	82.5	82.5	
Feeder Barge - Sailing Cost	5,766.8	3,673.4	2,705.4	
Charges for Jetty Terminal 8	82.5	82.5	82.5	
Storage & Material Handling	30.0	30.0	30.0	
Cost of Iron & Steel Loading Rake at Kanpur	30.0	30.0	30.0	
Railway Tariff at Kanpur	285.3	285.3	285.3	2,266.8
Iron & Steel Unloading at Kanpur	90.0	90.0	90.0	90.0
Total Cost	**7,334**	**5,241**	**4,273**	**2,516**

Logistics Cost Comparison for iron & steel movement (Khurda to Kanpur) is done for Class III, IV and VI waterways in the following charts.

Fig. 6.161 Logistics cost comparison b/w Road, Rail & IWT for Class III

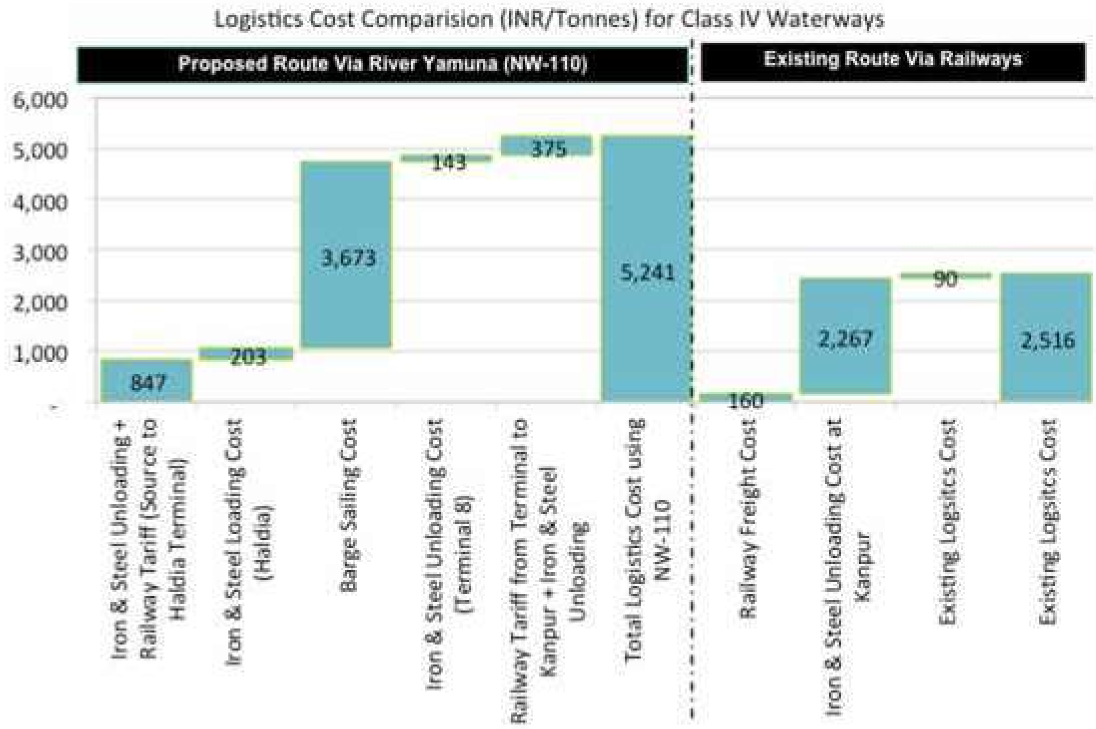


Fig. 6.162 Logistics cost comparison b/w Road, Rail & IWT for Class IV

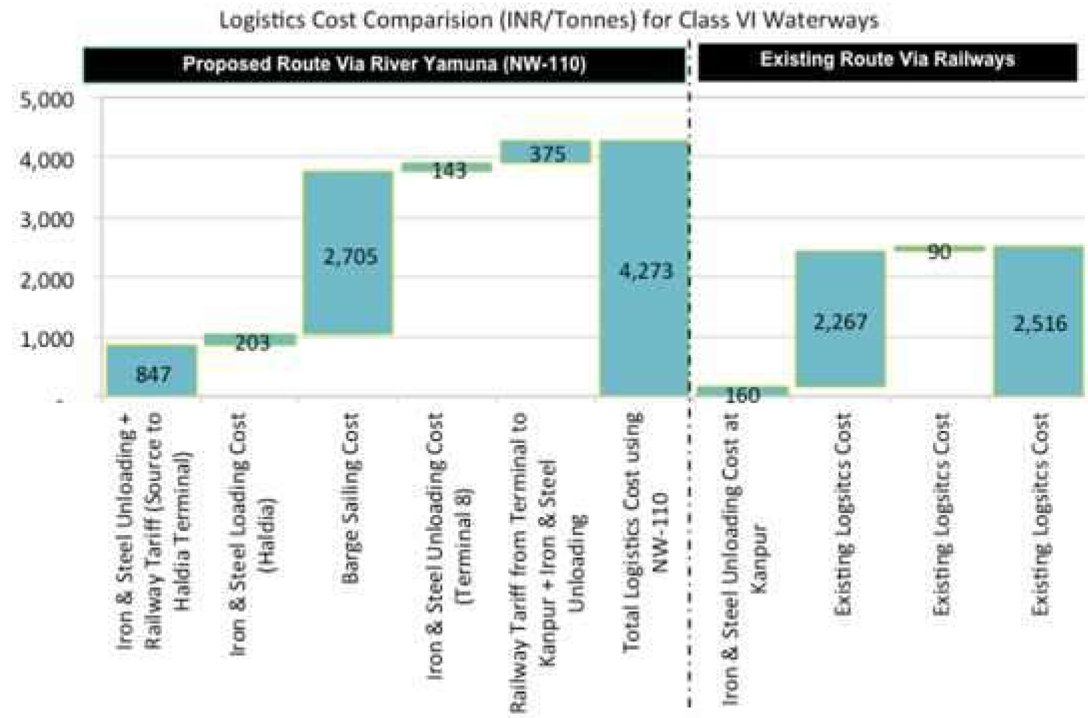


Fig. 6.163 Logistics cost comparison b/w Road, Rail & IWT for Class VI

6.13.15Terminal 7 – Imported Iron & Steel

6.13.15.1 Import of Iron & Steel from Haldia to Madanpur Khadar (Terminal 7)

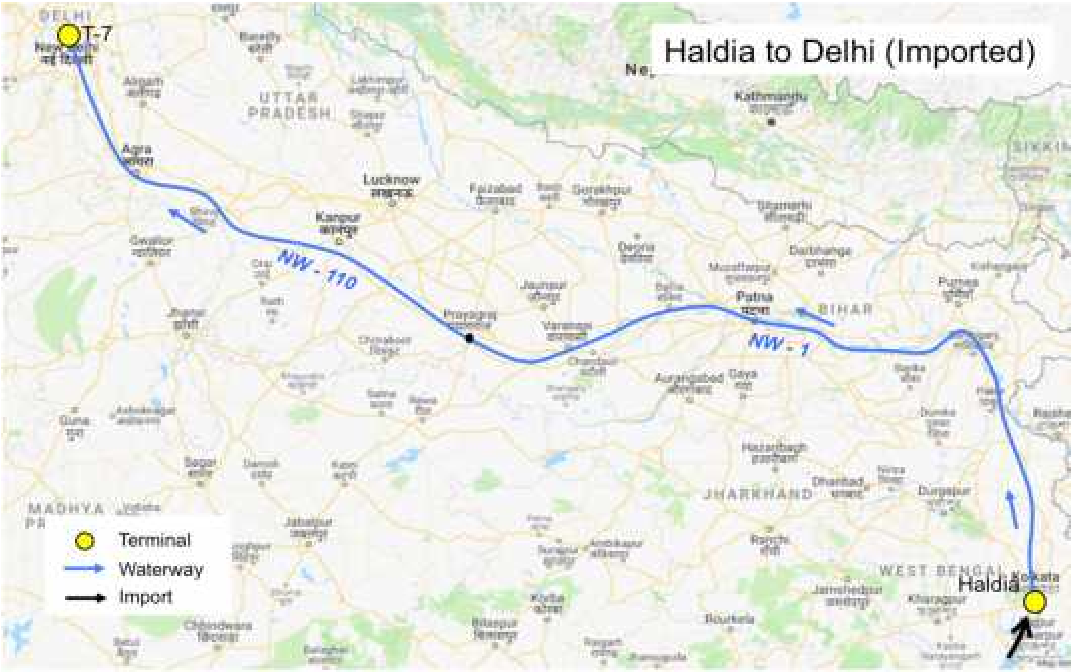


Fig. 6.164 OD Pair Mapping for Iron & Steel Transportation

6.13.15.2Logistic Cost Comparison - Standard Vessels

Imported Iron & steel from Haldia Port would be transported using NW 110 and NW 1. This iron & steel would be unloaded at Terminal 7 (Madanpur Khadar) and would be locally distributed. Automobile industries of the region are major consumers of iron & steel. This section would discuss logistics cost comparison for iron & steel movement between Haldia Port (NW1) to Madanpur Khadar on NW 110.

- **Logistics Cost Comparison – INR Per Ton-Km**

Iron & Steel would originate from Haldia Port and would be destined to Terminal 7 on NW 110. Following graph represent per ton iron & steel transportation cost under each type of vessels using waterway (NW110 + NW1) for two cases, i.e. One way ballast & No ballast. Per ton km cost depicted in figure below is for waterway transportation alone. First & last mile cost of transportation has not been factored in the calculation shown in figure.

The unit cost of transportation reduces with increase in sizes of barge and class of waterways. Loaded speed & Ballast speed has been considered 6 knots& 9 knots respectively for all class of waterway.

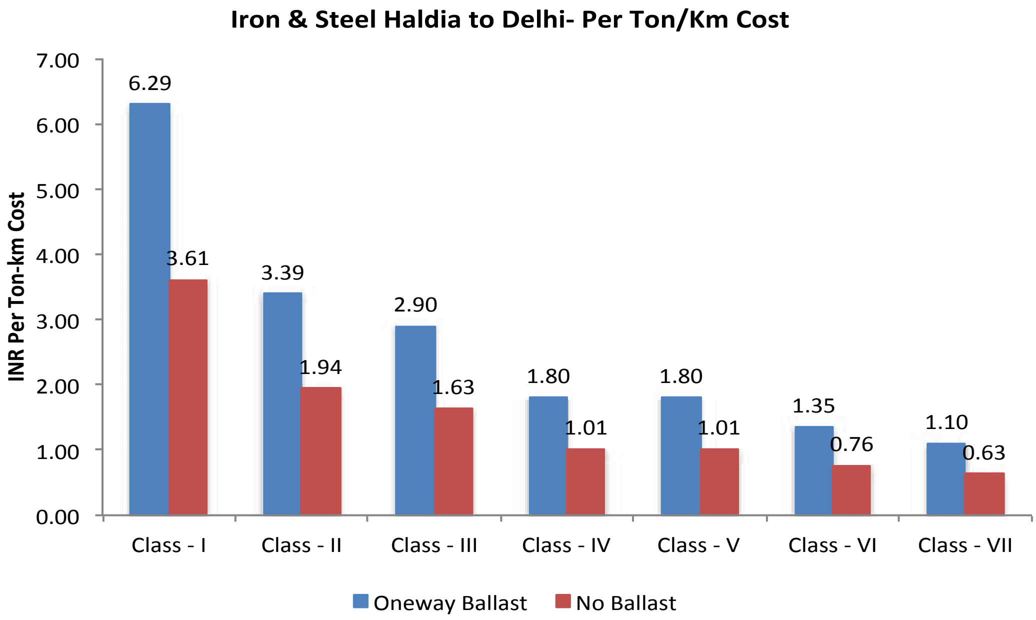


Fig. 6.165 Haldia to Delhi (T-6) Per ton/km cost for waterway

- **Cumulative Logistics Cost Comparison – INR Per Ton**

The following table shows Cumulative Logistics Cost Comparison for iron & steel movement (Haldia to Madanpur Khadar) for Class III, IV and VI.

Table 6.137 Haldia to Delhi logistics cost for different classes- OneWay Ballast

Particulars	Class - III	Class - IV	Class - VI	Railway Cost
Barge DWT	500	1000	2000	
Cost of Iron & Steel Loading at Source (Khurda mines)	159.5	159.5	159.5	159.5
Cost of Unloading Rake at Haldia Terminal	159.5	159.5	159.5	
Stacking Cost at HaldiaTerminal	110.0	110.0	110.0	
Cost at Haldia Terminal	270.0	270.0	270.0	
Feeder Barge - Sailing Cost	7,731.9	4,808.0	3,606.4	
Charges for Jetty Terminal 7	270.0	270.0	270.0	
Storage & Material Handling	110.0	110.0	110.0	
Cost of Iron & Steel Loading Rake at Terminal 7	60.0	60.0	60.0	
Railway Tariff at NCR Cluster/Manesar	234.0	234.0	234.0	
Iron & Steel Unloading at NCR Cluster/Manesar	159.5	159.5	159.5	159.5
Total Cost	**9,264**	**6,341**	**5,139**	**2,727**

Logistics Cost Comparison for iron & steel movement (Haldia to Madanpur Khadar) is done for Class III, IV and VI waterways in the following charts.

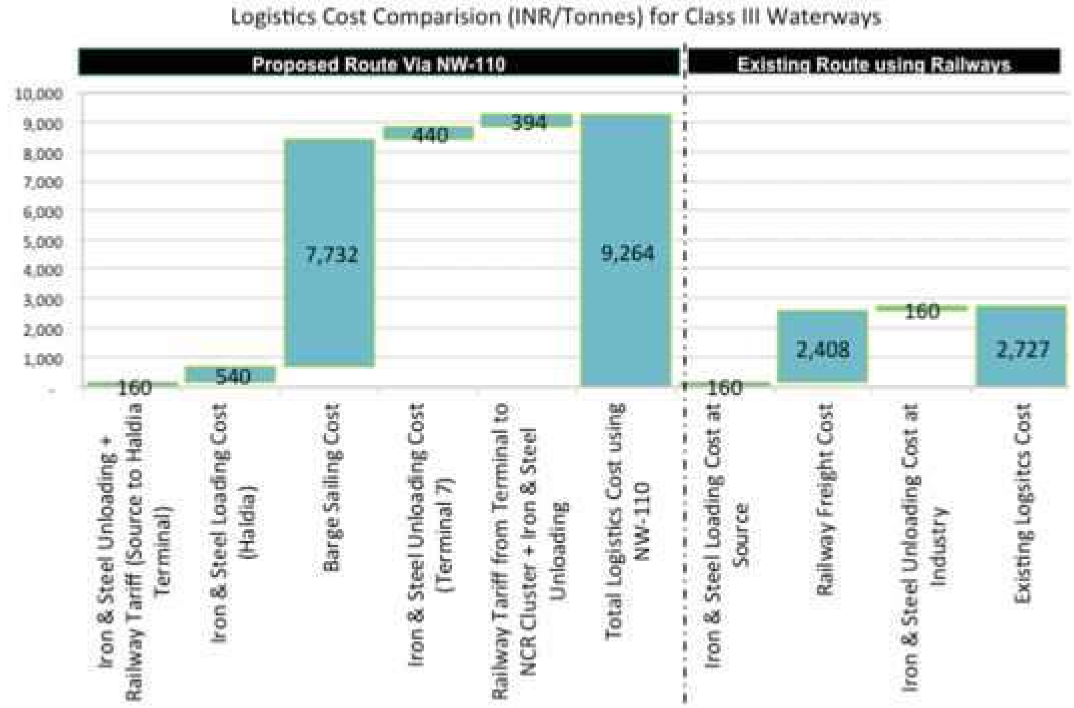


Fig. 6.166 Logistics cost comparison b/w Road, Rail & IWT for Class III

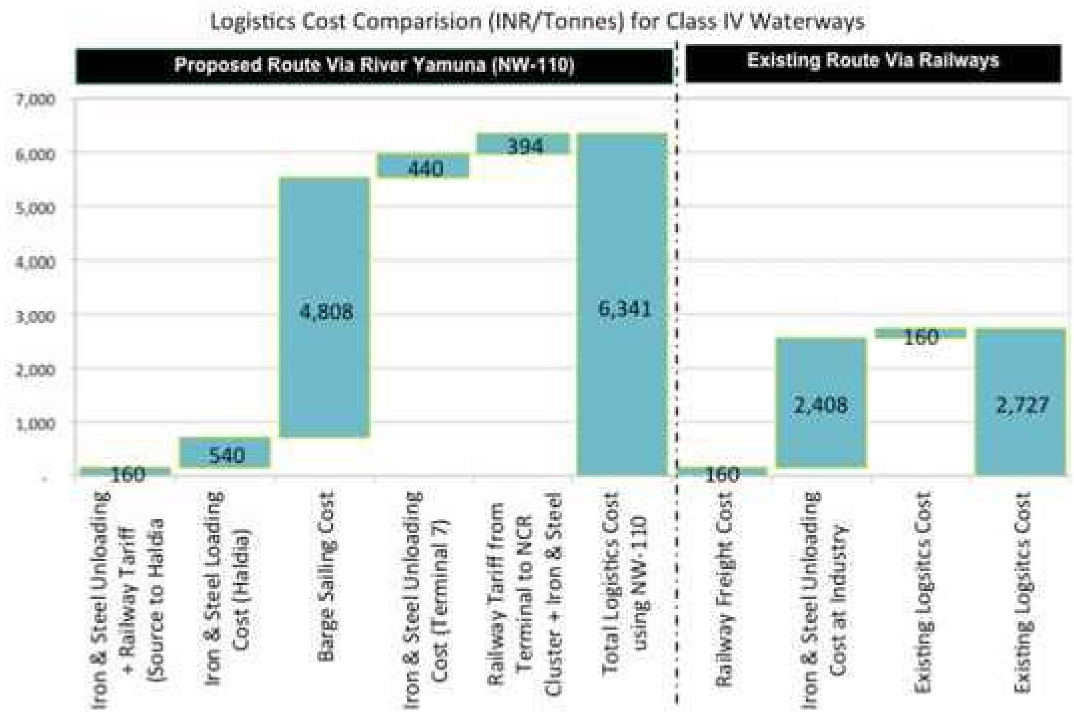


Fig. 6.167 Logistics cost comparison b/w Road, Rail & IWT for Class IV

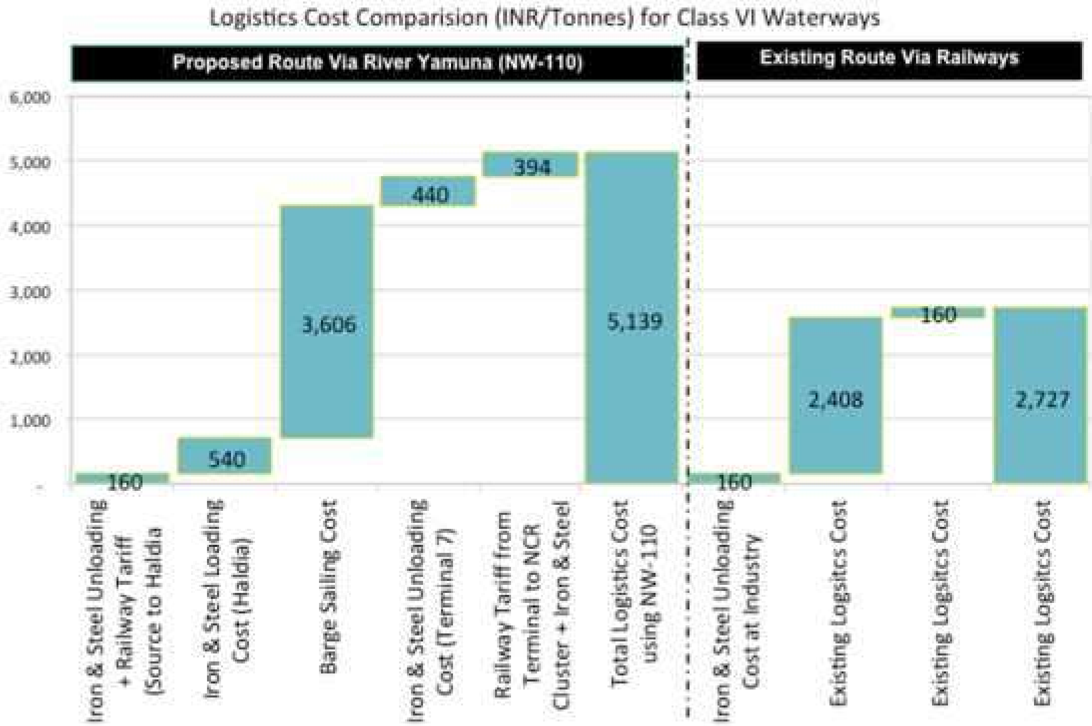


Fig. 6.168 Logistics cost comparison b/w Road, Rail & IWT for Class VI

6.13.16Terminal 6 & 7 – Fertilizer

6.13.16.1Fertilizer from Phulpur (Terminal 6) to Daulatpur (Terminal 8)

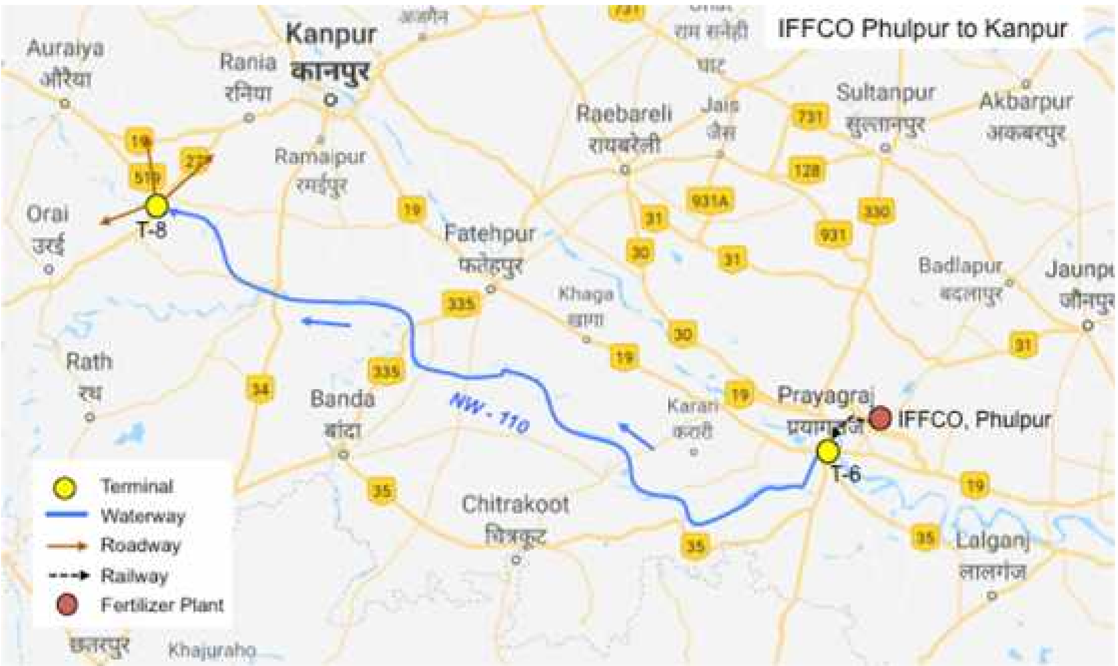


Fig. 6.169 OD Pair Mapping for Fertilizer Transportation

6.13.16.2Logistic Cost Comparison - Standard Vessels

Fertilizer, which would be produced in IIFCO Phulpur Plant would be transported using NW 110 and be unloaded at Daulatpur for getting distributed in the nearby districts.

- **Logistics Cost Comparison – INR Per Ton-Km**

Fertilizer would originate from IIFCO Phulpur Plant and would be destined to Terminal 8 (Daulatpur) on NW 110. Following graph represent per ton fertilizer transportation cost under each type of vessels using waterway (NW110) for two cases, i.e. one way ballast & No ballast. Per ton km cost depicted in figure below is for waterway transportation alone. First & last mile cost of transportation has not been factored in the calculation shown in figure. The unit cost of transportation reduces with increase in sizes of barge and class of waterways. Loaded speed & Ballast speed has been considered 6 knots& 9 knots respectively for all class of waterway.

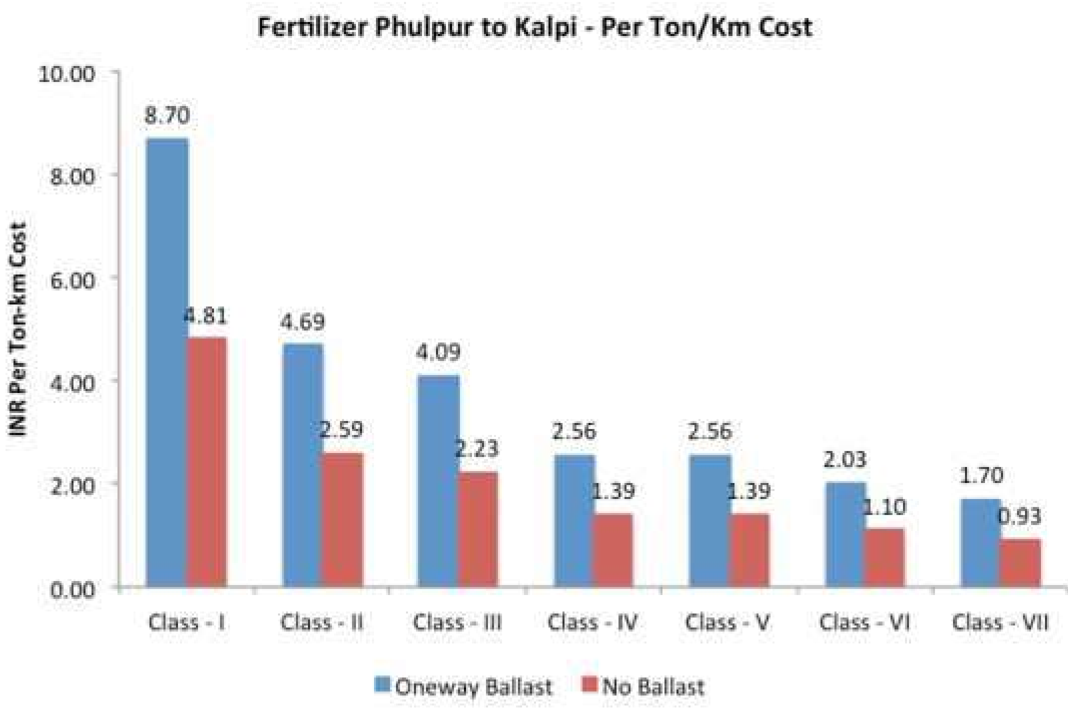


Fig. 6.170 Terminal 6 to Terminal 8 Per ton/km cost for waterway

- **Cumulative Logistics Cost Comparison – INR Per Ton**

The following table shows Cumulative Logistics Cost Comparison for fertilizer movement (Phulpur to Daulatpur) for Class III, IV and VI.

Table 6.138 Total logistics cost River Transportation- OneWay Ballast

Particulars	Class - III	Class - IV	Class - VI	Railway Cost
Barge DWT	500	1000	2000	
Cost of Fertiliser Loading at Source	159.5	159.5	159.5	159.5
Fertilisers Unloading + Railway Tariff (Phulpur - Terminal 6)	184.3	184.3	184.3	
Cost of Unloading Rake at Terminal 8	159.5	159.5	159.5	
Stacking Cost at Terminal 8	110.0	110.0	110.0	
Cost at Terminal 8	270.0	270.0	270.0	
Feeder Barge - Sailing Cost	1,416.8	885.6	701.8	
Charges for Jetty Terminal 8)	270.0	270.0	270.0	
Storage & Material Handling	110.0	110.0	110.0	
Cost of Fertiliser Loading Rake at Kanpur	60.0	60.0	60.0	
Railway Tariff at Kanpur	184.3	184.3	184.3	338.9
Fertiliser Unloading at Kanpur	159.5	159.5	159.5	159.5
Total Cost	**3,084**	**2,553**	**2,369**	**658**

Logistics Cost Comparison for fertilizer movement (Phulpur to Daulatpur) is done for Class III, IV and VI waterways in the following charts.

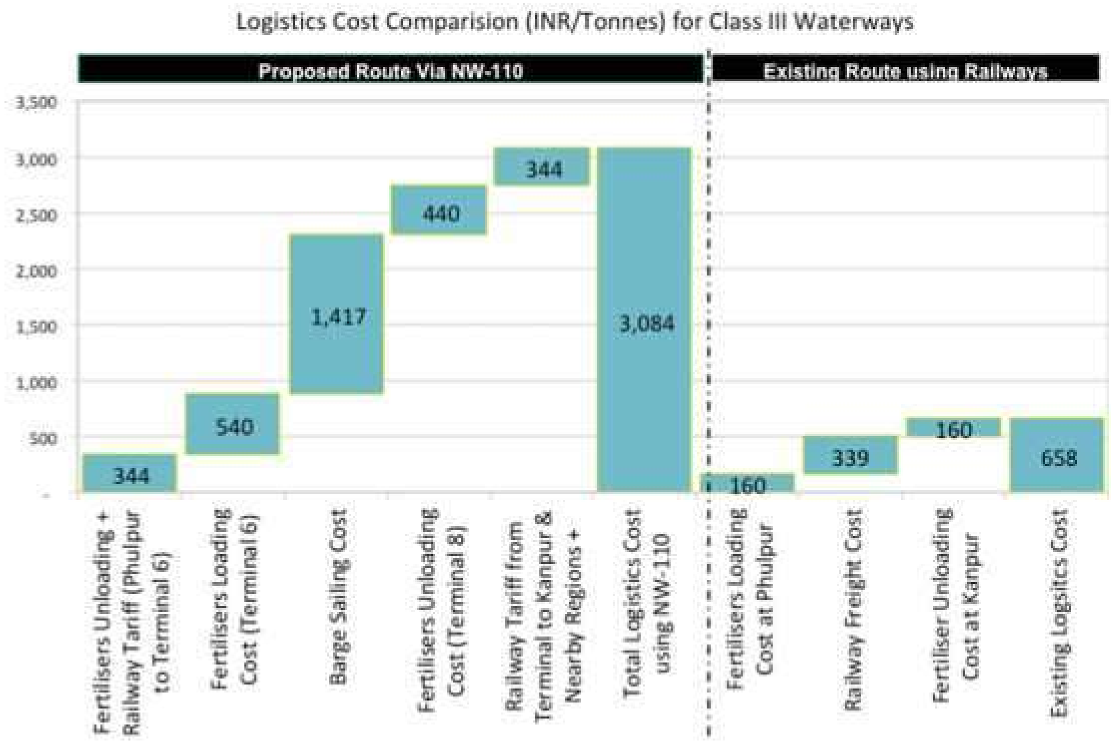


Fig. 6.171 Logistics cost comparison b/w Road, Rail & IWT for Class IV

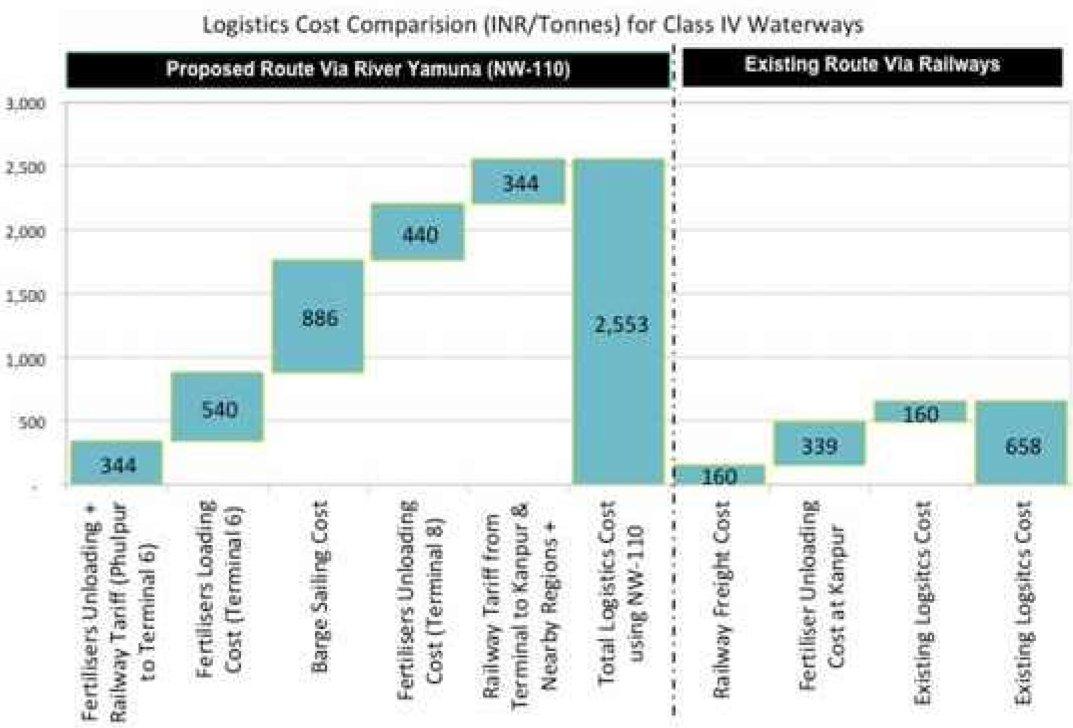


Fig. 6.172 Logistics cost comparison b/w Road, Rail & IWT for Class IV

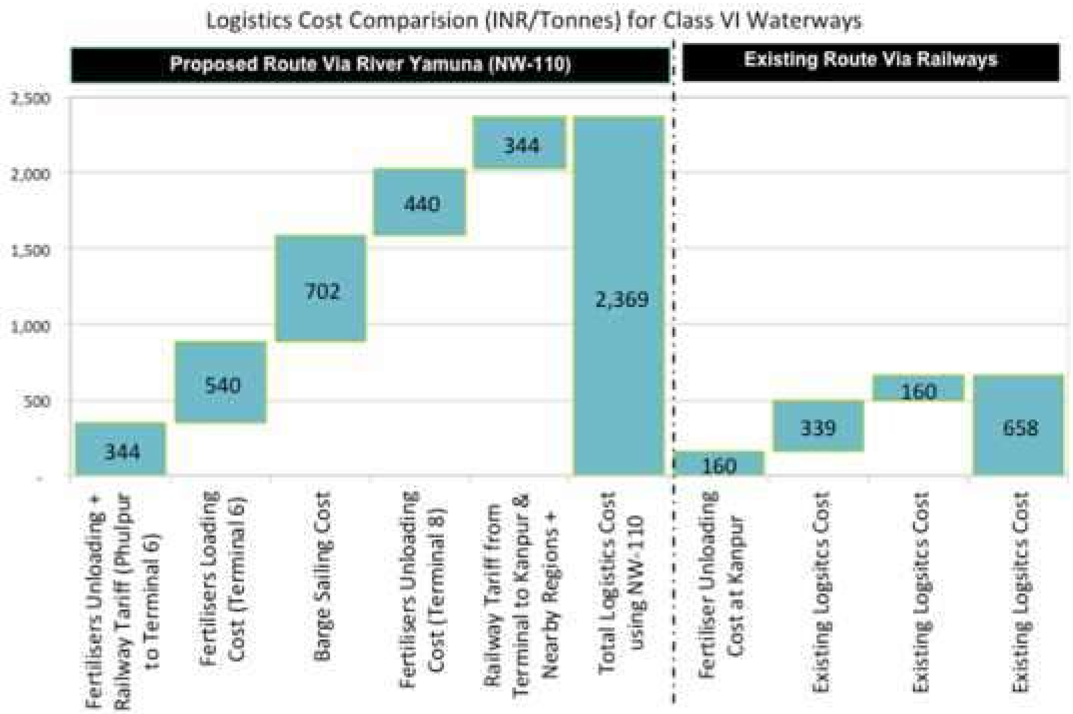


Fig. 6.173 Logistics cost comparison b/w Road, Rail & IWT for Class IV

6.13.17Terminal 7, 6& 8- Food Grains

6.13.17.1Food Grains from Punjab to Prayagraj

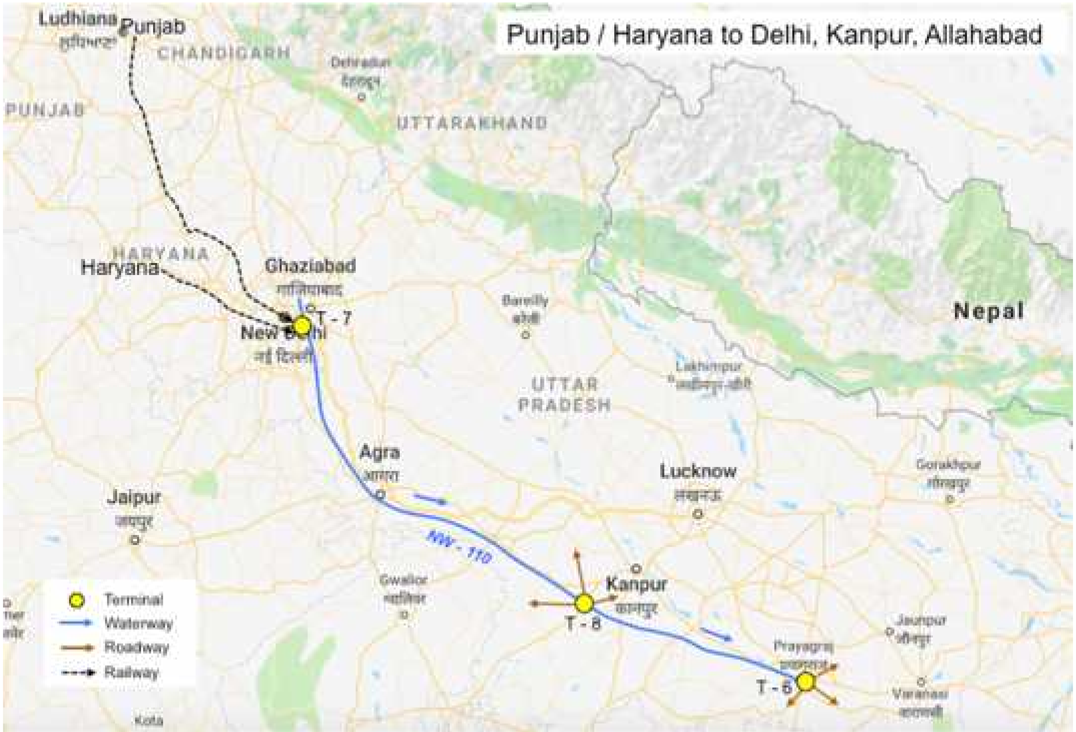


Fig. 6.174 OD Pair Mapping for Fertilizer Transportation

6.13.17.2Logistic Cost Comparison - Standard Vessels

It is proposed that Food grains from Punjab would be transported to Prayagraj, using NW 110. In Terminal 6 (Prayagraj), food grains would be unloaded and locally distributed.

- **Logistics Cost Comparison – INR Per Ton-Km**

Food grains would originate from Punjab and would be destined to Terminal 6 (Prayagraj) on NW 110. Following graph represent per ton Food grains transportation cost under each type of vessels using waterway (NW110) for two cases, i.e. one way ballast & No ballast. Per ton km cost depicted in figure below is for waterway transportation alone.

First & last mile cost of transportation has not been factored in the calculation shown in figure. The unit cost of transportation reduces with increase in sizes of barge and class of waterways. Loaded speed & Ballast speed has been considered 6 knots& 9 knots respectively for all class of waterway.

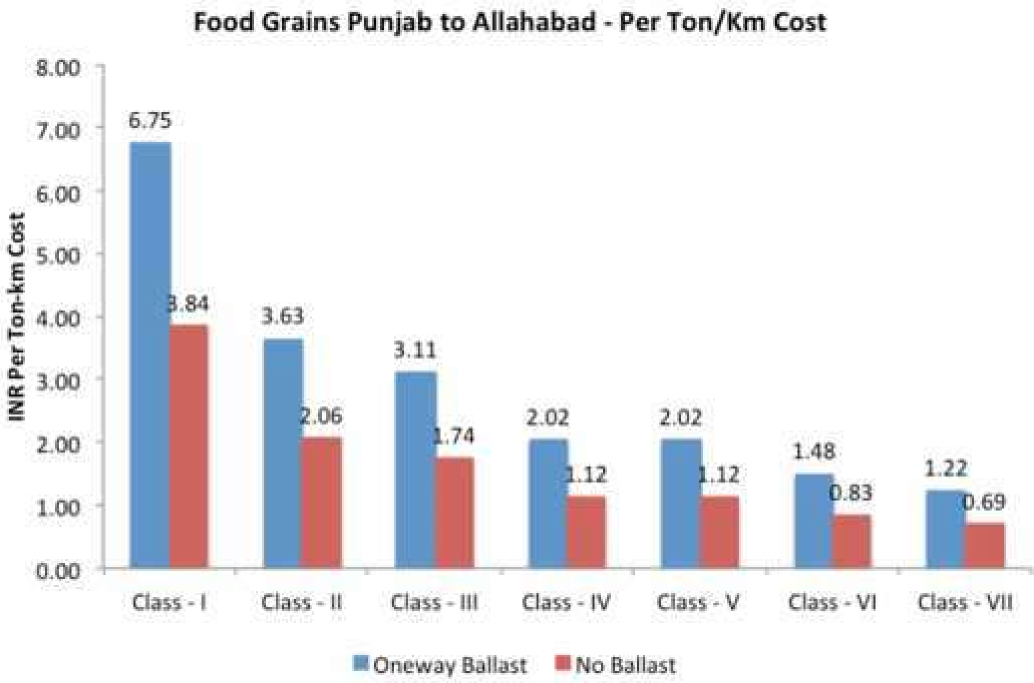


Fig. 6.175 Terminal 7 to Terminal 6 Per ton/km cost for waterway

- **Cumulative Logistics Cost Comparison – INR Per Ton**

The following table shows Cumulative Logistics Cost Comparison for food grains movement (Punjab to Prayagraj) for Class III, IV and VI.

Table 6.139 Total logistics cost River Transportation- OneWay Ballast

Particulars	Class - III	Class - IV	Class - VI	Railway Cost
Barge DWT	500	1000	2000	
Cost of Food Grains Loading at Source (Ludhiana FCI)	143.0	143.0	143.0	143.0
Food Grains Unloading + Railway Tariff	454.2	454.2	454.2	
Cost of Unloading Rake at Terminal 7	143.0	143.0	143.0	
Stacking Cost at Terminal 7	110.0	110.0	110.0	
Cost at Terminal 7	270.0	270.0	270.0	
Feeder Barge - Sailing Cost	3,248.6	2,109.1	1,547.3	
Charges for Jetty Terminal 6 (unloading)	270.0	270.0	270.0	
Storage & Material Handling	110.0	110.0	110.0	
Cost of Food Grains Loading Rake at Terminal 6	60.0	60.0	60.0	
Railway Tariff at Prayagraj FCI	281.7	281.7	281.7	1,556.6
Food Grains Unloading at Prayagraj FCI	143.0	143.0	143.0	143.0
Total Cost	**5,233**	**4,094**	**3,532**	**1,843**

Logistics Cost Comparison for Food grain movement from Punjab to Prayagraj is done for Class III, IV and VI waterways in the following charts.

Fig. 6.176 Logistics cost comparison (INR/Tonne) for Class III

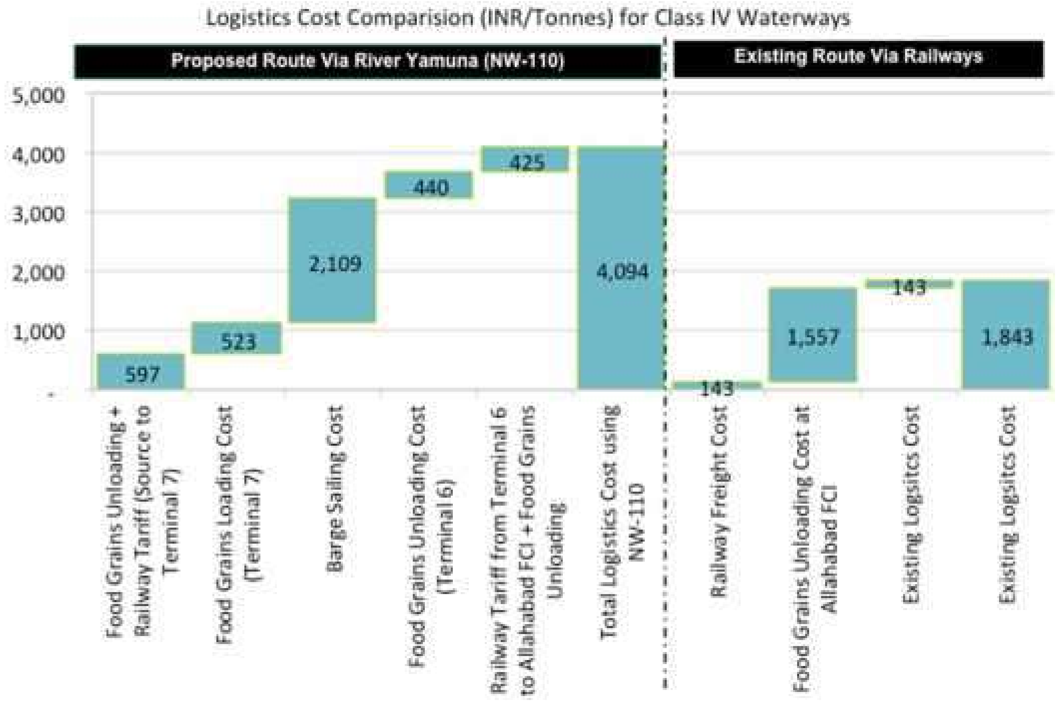


Fig. 6.177 Logistics cost comparison (INR/Tonne) for Class IV

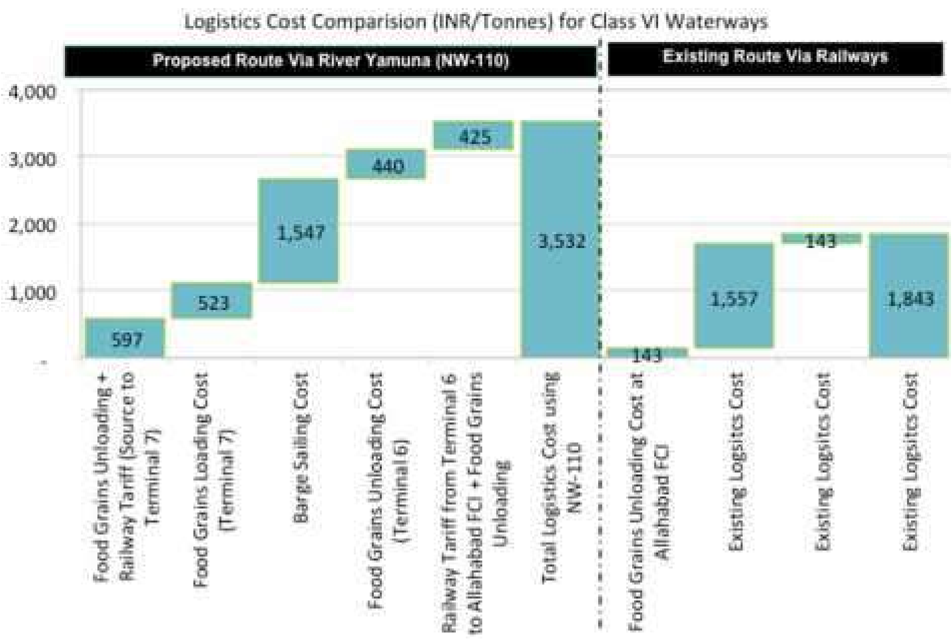


Fig. 6.178 Logistics cost comparison (INR/Tonne) for Class VI

6.13.18Food Grains from Punjab to Daulatpur (Terminal 8)

It is proposed that Food grains from Punjab would be transported to Daulatpur, using NW 110. In Daulatpur, food grains would be unloaded and locally distributed.

- **Logistics Cost Comparison – INR Per Ton-Km**
  Food grains would originate from Punjab and would be destined to Terminal 8 (Daulatpur) on NW 110. Following graph represent per ton Food grains transportation cost under each type of vessels using waterway (NW110) for two cases, i.e. one way ballast & No ballast. Per ton km cost depicted in figure below is for waterway transportation alone. First & last mile cost of transportation has not been factored in the calculation shown in figure

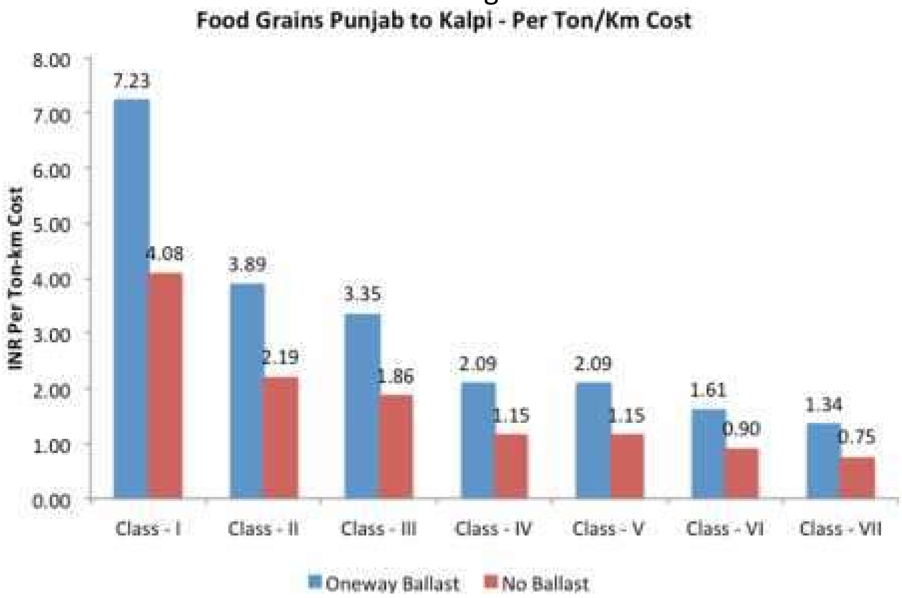


Fig. 6.179 Terminal 7 to Terminal 8 per ton/km cost for waterway

- **Cumulative Logistics Cost Comparison – INR Per Ton**

The following table shows Cumulative Logistics Cost Comparison for food grains movement (Punjab to Daulatpur) for Class III, IV and VI.

Table 6.140 Total logistics cost River Transportation- OneWay Ballast

Particulars	Class - III	Class - IV	Class - VI	Railway Cost
Barge DWT	500	1000	2000	
Cost of Food Grains Loading at Source (Ludhiana FCI)	143.0	143.0	143.0	143.0
Food Grains Unloading + Railway Tariff (Source to Terminal 7)	454.2	454.2	454.2	
Cost of Unloading Rake at Terminal 7	90.0	90.0	90.0	
Stacking Cost at Terminal 7	110.0	110.0	110.0	
Cost at Terminal 7	270.0	270.0	270.0	
Feeder Barge - Sailing Cost	2,337.3	1,455.7	1,126.8	
Charges for Jetty Terminal 8	270.0	270.0	270.0	
Storage & Material Handling	110.0	110.0	110.0	
Cost of Food Grains Loading Rake at Kanpur FCI	60.0	60.0	60.0	
Railway Tariff at Kanpur FCI	338.9	338.9	338.9	1,209.9
Food Grains Unloading at Kanpur FCI	90.0	90.0	90.0	90.0
Total Cost	**4,273**	**3,392**	**3,063**	**1,443**

Fig. 6.180 Logistics cost comparison (INR/Tonne) for Class III

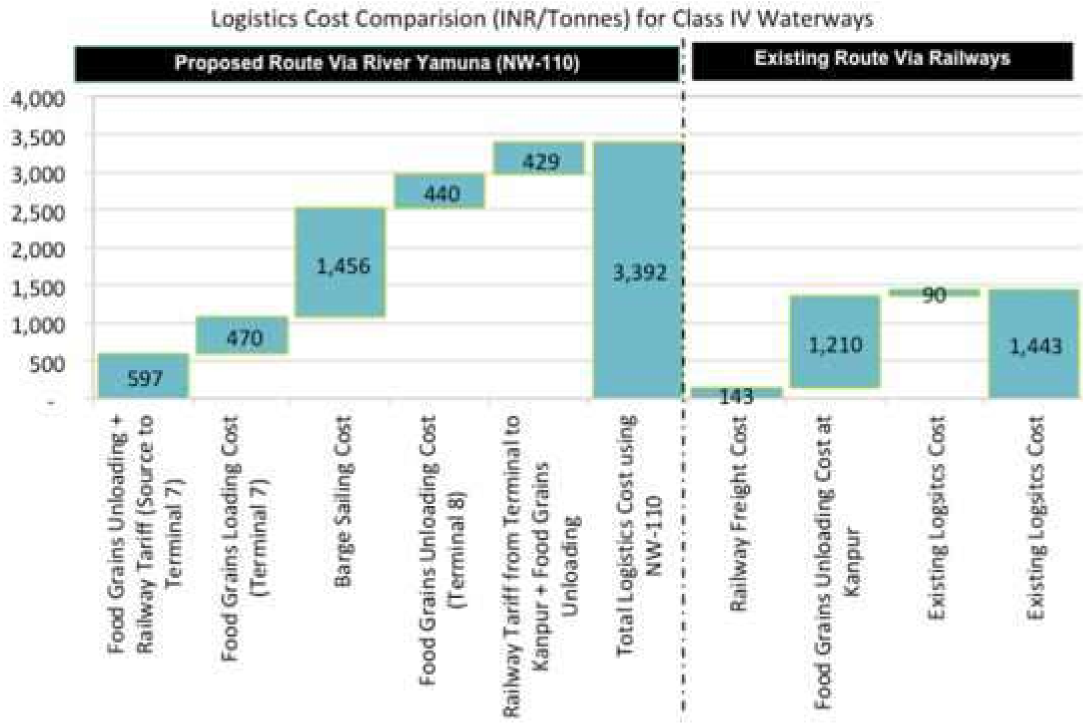


Fig. 6.181 Logistics cost comparison (INR/Tonne) for Class IV

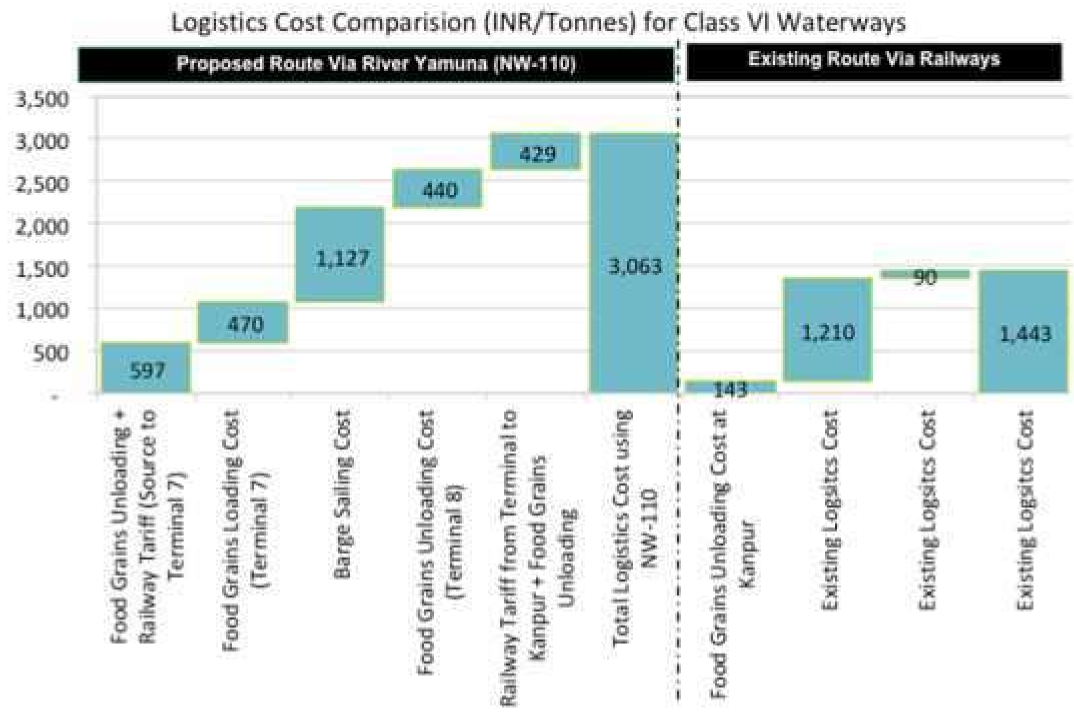


Fig. 6.182 Logistics cost comparison (INR/Tonne) for Class VI

6.14 Market Development Plan

Inland Waterway Transportation (IWT) is playing an important role in national transport systems. Water transportation is considered to be safe, energy efficient and environment friendly mode of transport. India is estimated to have nearly 14,500 km of navigable inland waterways, but the exploitation of this sector has remained neglected and underutilized.

IWT would be effective and can play an important role when ports and waterway connections are available in combination with high transport demand and industrial activities. It is necessary to establish connecting transport networks, along with a well-developed waterway infrastructure on NW 110. Road and/or rail connections should be available at a place of loading/ unloading in order to transport the cargo to/from the producer or consumer of the transported cargoes. This would ease the transportation, as most of the production sites are not located directly at the river. The market development study of river Yamuna would focus to highlight advantages of IWT; identify challenges of IWT in the region, suggestive methods, and strategic areas to promote IWT at river Yamuna. The section would also study Government policies, subsidies and incentives for IWT promotion.

6.14.1 Objective

The objective of the market development study is to foster the development of the inland waterway transport on River Yamuna (NW 110) in a manner that will lead to realization of an efficient, sustainable and safe waterway transportation system. The specific objectives related to the development of IWT in river Yamuna are following:

- Identify obstacles that hinder the intensive use of the waterway transport mode and develop strategies and policies to overcome them
- Create infrastructure and policies to facilitate possibility of shifting cargo traffic to NW 110
- Define the requirement for a successful integration of the waterway transport system into intermodal transport chains on NW 110
- Prepare guidelines for the integration of the waterway transport on River Yamuna into logistics chains
- Elaborate the concepts and strategies for the future actions to make inland waterway transport on NW 110 sustainable
- Work for Environmental conservation of the river and surrounding areas

6.14.2 Benefits of using IWT

Despite the benefits for using IWT, the mode has not been utilized majorly in India. Compared to other countries like Europe and China, inland waterway in India is used so far for only miniscule trade. Recently, with the initiative of the Shipping Ministry of India, IWT is seriously considered as an alternate mode of transportation in every part of the country. Transport by inland waterways should be preferred in order to relieve heavily congested transport corridors. Inland waterway in River Yamuna (NW 110), which passes through major cities like Delhi, Mathura, Agra, Kanpur and Prayagraj would be used for transporting coal for power plants, industrial cargo, other commodities as well as tourists. By creating favourable conditions for further development of inland waterways, the Government could encourage more companies to use this mode of transport. The government could promote IWT on river Yamuna by implementing green policies, changing budgetary priorities and achieving efficiency throughout all transport systems, gaining Economies of scale and scope.

6.14.3 Strategic Areas for promoting IWT on river Yamuna

This section comprises numerous actions and measures to boost transport on inland waterways. The development of river Yamuna as IWT and supportive infrastructure would help to attract industries and people to the waterway. Following strategic areas could be considered for the development of IWT at river Yamuna.

6.14.3.1Economic Sector

- **Improve market condition**

  Expand reliable IWT services by integrating Inland Navigation within the transport logistics chain. If transport costs would be low on NW 110, then industries would be attracted and market for NW 110 would gradually expand.

- **Enhance Infrastructure**

  Improve multi modal network by integrating inland waterway on river Yamuna. With the development of NW 110, it is necessary to develop supporting infrastructure, roadway & railway, connecting the proposed terminals on river Yamuna.

- **Public- Private Partnership**

  Involve private players for development, maintenance and operation of inland waterway on river Yamuna.

6.14.3.2Environmental Sector

- **Adaptation of inland navigation infrastructure**

  Adaptation of inland navigation infrastructure is vital to conserve environment. With rapid climate change, utilization of waterway should be encouraged.

Evaluate the environmental impacts related to dredging, bandalling, construction etc. on river Yamuna.

Evaluate the environmental impacts of the different modes of transportation
IWT is the most fuel-efficient mode of transportation for moving bulk raw materials and bulky goods. It is the least energy intensive method of freight transportation when moving equivalent amounts of cargo. It consumes less energy than alternative modes per ton-kilometer.

6.14.3.3 Socio- economic Sector

- **Raise image and awareness**
  Inland navigation could be promoted as a successful partner in business. There is a need to establish promotion centers for IWT.Government should raise public awareness of the benefits of using waterway on NW 110 for a wide range of activities, from commercial use, like inland water transport and cruising to other recreational uses.

- **Develop human resources**
  To promote IWT, it is important to enhance labour mobility, attract workforce and invest in human capital.

6.14.4 Major Bottlenecks &Suggestive Methods

Major challenges are identified, which could threaten the viability of IWT at River Yamuna and its integration into the whole logistics chain. These challenges and suggestive methods are listed below.

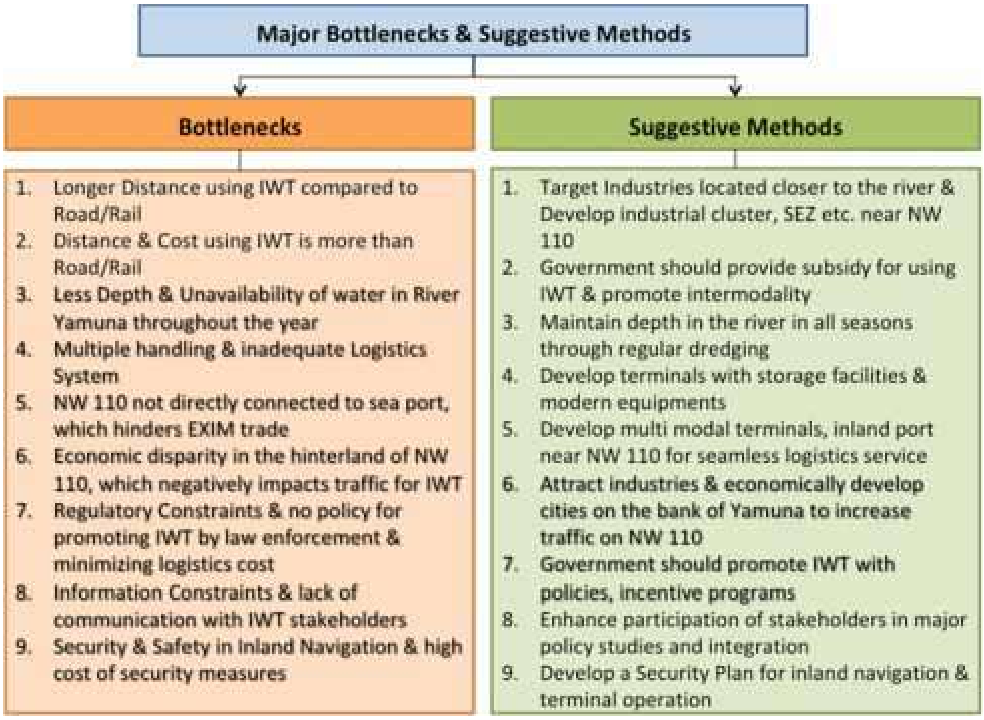


Fig. 6.183 Major Bottlenecks & Suggestive Methods

The above mentioned bottlenecks and suggestive methods for each bottleneck are described in detail below.

6.14.4.1 Longer distance using IWT compared to Road/Rail

The major bottleneck for the viability of NW 110 is that using inland waterway in river Yamuna would take longer distance and more time as compared to roadway and railway. The below image depicts the comparison of IWT distance with existing mode of transportation, i.e. roadways.

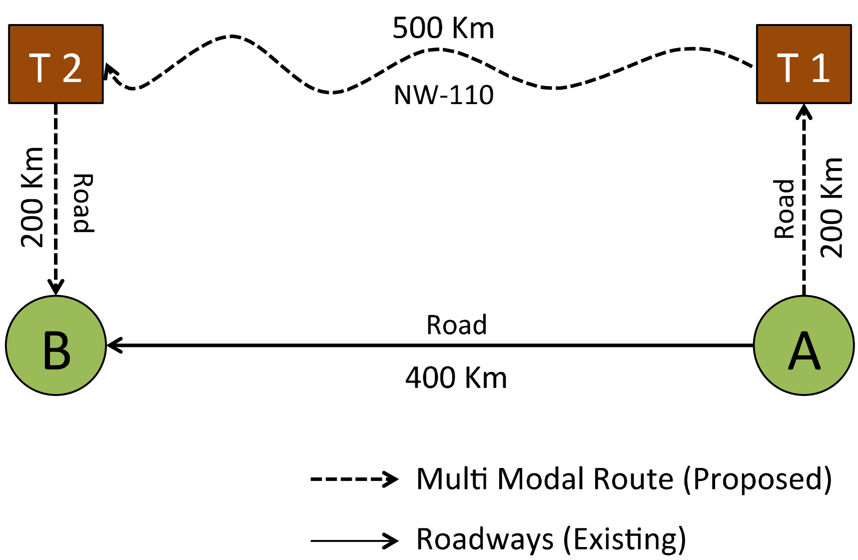


Fig. 6.184 Comparison of Different Modes (IWT, Road & Rail)

As shown in the above image, transportation through IWT would take longer distance and more time. Whereas, roadways would take shorter distance and less time. For instance, if cargo from Point A needs to be transported to Point B, there is direct road connectivity and it takes 400 kms. In case of IWT, cargo needs to be moved from Point A to Terminal 1 on the waterway for loading. Movement from Point A to Terminal 1 would be done by roadways (200 kms). Further, from the loading terminal, cargo would move in vessels on the river, covering stretch of 500 kms and would reach T 2. From T 2, after unloading cargo would further move to the destination Point B, by covering 200 kms distance on roadways. Overall, by using IWT, the total distance covered by multi modal mode (using roadways & waterways) is 900 kms. This distance is more than twice covered by roadways. Hence, IWT would take longer time for transportation. Due to this constraint, industries with time sensitive cargo would not prefer IWT. Other industries would also prefer roadways and railways for their cargo transportation to save time and cost.

Suggestive Method

To attract traffic to NW 110, those industries should be targeted first, which are located closer to the river. Due to the constraint of longer distance using IWT, only 100 kms. of radius is considered as hinterland of NW 110. Industries, which are located far from NW 110 (more than 100 kms.) would not prefer NW 110 for their cargo transportation.

Industries should be encouraged to develop their new plants closer to the river. Development of industrial cluster and other infrastructure, like SEZ, warehouses would increase traffic on NW 110 in future.

All the industrial and city developments take place using transport convenience in mind. The industries need uninterrupted to procure and transport raw materials to their plants. They also need to transport their finished products to market. Government of India through Ministry of Railways has made unprecedented investments on expansion of Railways. This has led to Railways becoming one of the prominent and cost-effective modes of transportation for long distance movement of cargo as well as passengers. Industries, which are backbone of economy, are mostly developed around railways. Thermal Power Plants, Fertilisers, Steel Plants, Cement Plants and other types of industries have setup their plants with railway connectivity in mind. Majority of them have a railway siding inside their plants. This becomes a big deterrent for IWAI to compete with Indian Railways and its transportation system for cost, time and efficiency. Hence, Government would have to make suitable investments on infrastructure and policy to bring waterways at par with railways to make it compete with it.

6.14.4.2 Distance and Cost using IWT is more than Road/Rail

Compared to existing modes of transportation, like roadways and railways, IWT is longer in distance due to the morphology of the river. River Yamuna has curves and bends, which increase the navigational distance. For instance, in case of River Yamuna, IWT length from Delhi to Prayagraj is 1,050 km, whereas the distance by railways and roadway is very less, i.e. 650 kms and 700 kms respectively. There exists good infrastructure of railway and roadway in the hinterland of NW 110, which run parallel to the navigable stretch of the river. Similar to NW 110, in NW 1 also, IWT covers longer distance than other modes.

To understand the difference in distance by different modes of transportation, NW 110 and NW 1 could be taken as examples. As shown in the above figure, river stretch from Delhi to Prayagraj in river Yamuna (NW 110) is 1,050 km long. Whereas, the parallel running railway is merely 650 km long and roadway is 700 km. The reason for huge difference in distance between IWT and railway/roadway is the shape of the river, which has bends and curves. River Yamuna is not straight like roadway and railway. Due to shorter distance, cost of transportation in roadways and railways would be cheaper than IWT. To integrate IWT in the logistics chain and to keep the cost of transportation similar to roadway and railway, it is necessary that IWT is at least 40% cheaper to be at par with railway cost and around 35% cheaper to be at par with roadway cost.

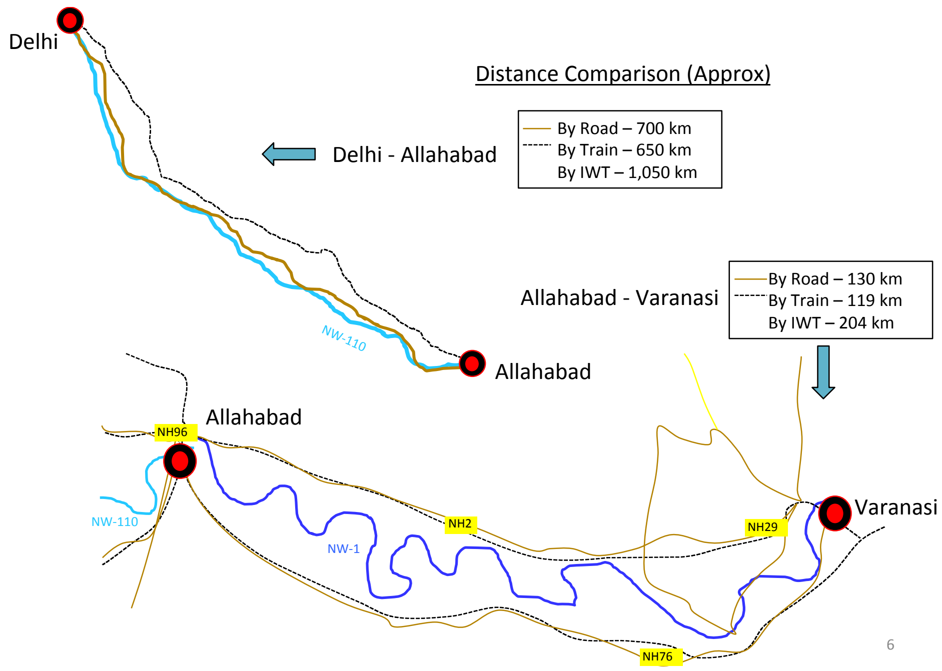


Fig. 6.184 Distance Comparison by IWT, Road & Rail

The stretch between Prayagraj to Varanasi (NW 1), river Ganga is almost serpentine in shape. Due to the curvy shape, the inland waterway's length is 204 kms. whereas parallel railway is only 119 kms. and roadway is 130 kms. To promote IWT and make it viable in this stretch, it is necessary that transportation cost of IWT is 36% cheaper to be at par with roadway cost and40% cheaper to be equal to railway cost. If IWT cost higher than existing modes, industries would not opt for IWT for transportation of their cargo. The below table depicts logistics cost of roadway, railway and IWT as calculated by IWAI.

Table 6.141 General Logistics Cost Comparison (INR/Tonnes)

Mode of Transportation	Carrier Type	Carrying Capacity (MT)	Vehicle Operating Cost (INR Per ton/Km)	Energy Consumption (Liter/T-Km)
Roadways	10 WH Trucks	16	1.17	0.0313
Railways	40 Wagons	2,200	1.009	0.0089
IWT	IWT Vessels	2,000	0.843	0.0048

Note: 1 Standard 2000 DWT vessel is compared to 125 Truck Loads and almost 1 complete train rake (40 rail wagons) load from existing road & rail infrastructure.
Source: IWAI

As shown in the above table, based on IWAI's natural and established calculation, vehicle operating cost (Per ton/km) for IWT is less than roadways and railways.

Even though vehicle operating cost is less using IWT, the cost would be higher due to the longer distance IWT covers. Figure5-54 Comparison of Different Modes of Transportation (IWT, Road & Rail) that shows how IWT covers 500 kms as compared to parallel roadways, which takes 400 kms. The below table depicts clearly that in NW 110 (stretch between Delhi to Prayagraj) and NW 1 (stretch between Prayagraj to Varanasi); vehicle operating cost is higher in IWT than roadways and railways. However, IWT has the advantage in energy consumption. IWT consumes less energy than roadway and railway.

Table 6.142 Comparison of Vehicle Operating Cost & Energy Consumption

Mode of Transportation	Distance (Km)	Vehicle Operating Cost (INR Per ton/Km)	Total Vehicle Operating Cost (INR)	Energy Consumption (Liter/T-Km)	Total Energy Consumption (Liter)
Delhi- Prayagraj (NW 110)					
Roadway	700	1.17	819	0.0313	21.91
Railway	650	1.009	656	0.0089	5.79
IWT	1,050	0.843	885	0.0048	5.04
Prayagraj- Varanasi (NW 1)					
Roadway	130	1.17	152	0.0313	4.07
Railway	119	1.009	120	0.0089	1.06
IWT	204	0.843	172	0.0048	0.98

As shown in the above table, both the instances of NW 110 and NW 1 are based on the assumption and idealistic scenario that source and destination of cargo are located beside river Yamuna (NW 110). Even though origin and destination of cargo are located closer to NW 110, cost of transportation using IWT is higher compared to other modes due to longer distance. If in realistic scenario, origin and destination of cargo were located few kilometres away from river Yamuna, then cost would increase more by adding transportation cost of first and last mile connectivity through multi modal transportation. The total vehicle operating cost, usingmultimodal (IWT and roadways) for cargo transportation from origin to destination, would be much higher than merely using roadways or railways. Hence, longer distance and higher cost is a major bottleneck for the viability of NW 110.

Suggestive Method

Government should provide subsidy to industries for using IWT. If logistics cost of IWT is cheaper than the existing modes then despite the constraint of long distance, industries would prefer IWT. Subsidy and cheaper logistic cost would be a driving force for NW 110 to attract industries, which are located near to the river as well as far from the river. Government should also promote intermodality to reduce transport and logistics cost.

6.14.4.3 Less depth and unavailability of water in River Yamuna throughout the year

Due to less water in some of the parts in river Yamuna, maintaining the depth of the river would be a challenge. It is difficult to preserve navigability year-round, as in some places, the river completely dry up during post monsoon period.

River Yamuna lacks depth throughout the year and at different stretches along the length of the course. To maintain the depth, there is a need to undertake dredging on an ongoing basis. Due to heavy sediment loads, the dredging will need to be quite frequent, leading to higher costs that could threaten the viability of the waterway.

Suggestive Method

To make NW 110 sustainable for water transportation, it is necessary to maintain depth in River Yamuna throughout the year. Regular dredging to a sufficient depth would ensure water availability in NW 110 in all seasons. This would enable water navigation throughout the year.

6.14.4.4 Multiple handling and Inadequate Logistics System

The inherent disadvantage of IWT is the need for multiple handling. Interfaces with other transport modes, such as roads and railways, are crucial to overcome the disadvantage of double handling. Operating difficulties and the high cost of port handling is another challenge.

Suggestive Method

Inland ports or multi modal terminals play an important role in facilitating supply chain flows through efficient logistics. In case of river Yamuna, three multi modal terminals are proposed, Terminal 6, 7& 8. These terminals would be equipped with adequate storage facilities and modern handling equipment.

6.14.4.5 NW 110 not directly connected to sea port, which hinders EXIM trade

Limited waterway network and the location of ports (which are very far away) is one of the major challenges. There is no major or non-major port in the hinterland of river Yamuna. Haldia Port, which is the nearest port, also does not fall in the hinterland. To facilitate transportation of cargo from the hinterland to Haldia Port, combination of NW 110 (River Yamuna) and NW 1 (River Ganga) would be used. For EXIM trade, it is necessary to create multimodal chains and seamless transfers at nodes to lower transport costs.

Suggestive Method

Develop multi modal terminal and inland/ dry port near NW 110, which would provide logistics services, transhipment and inter modal connectivity for cargo transportation. For a user, availability of seamless, multimodal last-mile connectivity to and from the terminal on NW 110is a big advantage.

6.14.4.6 Economic disparity in the hinterland of NW 110

For a profitable IWT service, a balanced traffic flow is required to enable shipping lines to calculate a competitive freight rate for different customers. The disparity in economic development in the hinterland of river Yamuna leads to unbalanced cargo flows, which make it difficult to run a profitable IWT service. Also, there is problem related to the consignment sizes. Small consignment would not be ideal for waterway transport service on river Yamuna.

Suggestive Method

Reduce economic disparity in the hinterland, and coordinate planning and development of transport and land use of the cities/towns, which fall in the hinterland of NW 110. Economic development would result in maximum traffic volume in the waterway.

6.14.4.7 Regulatory Constraints

At present, integrated transport planning to minimize logistics costs and law enforcement capability is not adequate. The many policy directives to encourage IWT development focus on promotion of infrastructure and give little consideration to market players, such as shippers or forwarders, policy instruments, implementation arrangements, and financial support.

Suggestive Method

The Government should act as an advocate to promote policies, which make waterways more attractive and easier to use. It should direct inland waterway transport incentive programs toward market players to pursue them to opt IWT as choice of transport mode and integrate it in their intermodal transport chain.

6.14.4.8 Information Constraints

Lack of institutionalized communication among IWT stakeholders is a hurdle. Many shippers are not aware of the ability and opportunities coming out of the IWT system on NW 110. There is a need of effective communication channels among shipping lines, forwarders and government.

Suggestive Method

Enhance participation of stakeholders in major policy studies and integration. The Government should demonstrate the economic and environmental benefits of waterway transport to stakeholders through a coordinated, long-term approach. This would encourage stakeholders to increase their participation in IWT on river Yamuna. Regular communication with the stakeholders and addressing their needs and requirements is necessary for improving customer service.

6.14.4.9 Security &Safety in Inland Navigation

Safety and security of staffs, passengers, vessels, terminal infrastructure, equipment and cargo is one of the major concerns. Like Ports, the areas of inland navigation are also threatened by terrorist attacks. Security measures would be required for safety in terminals and on vessels. High cost associated with the security measures would further hinder the viability of IWT.

Suggestive Method

IWAI needs to developa security plan for IWT infrastructure and other facilities on NW 110. The security plan must include measures to prevent unauthorized access in terminals, measures to prevent weapons or dangerous substance on board of vessels or in terminals, procedures to respond to security threats, evacuation process during emergency, duties of personnel responsible for security etc.

6.15 Comparison of IWT, Railway & Roadway

Rail and road are traditional modes of transportation in India. At present, railway and roadway are used extensively in the hinterland of river Yamuna. Roads are preferred for short distance, even for bulk cargo, whereas railway is mostly used for long distance transportation, usually between distant states.

With the development of IWT at river Yamuna, opportunities will open up when intermodal services are available at the planned multi-modal terminals (MMTs). For some companies a MMT would provide immense advantages for their commodities on NW 110, as origins and destinations of their cargoes lay exactly on NW110 route. Roll-on/roll-off facilities for heavy lift and ODC (over dimensional cargo) should be provided which will surely offer a lot of opportunities to meet the requirement for transporting such commodities along NW 110.

Inland waterways unlike other modes of transport are considered to be the cheapest form of transport due to its capability of carrying larger volumes. Even the smallest of the container/bulk ships significantly outpace the carrying capacities of road/rail. SWOT analysis of the three modes of transportation, IWT, Rail and Road is done below.

6.15.1 SWOT Analysis of IWT

Strength

- Large transport capacities of bulk cargo and ODC (Over Dimensional Cargo) per shipment
- Small risk of accidents and breakdowns
- No congestion on waterways
- Environmentally friendly mode

- Easily accessible to both banks of river, while other modes are dependent on bridges on the rivers

Weakness
- Time to operation limited to daytime
- Limited area of operation, depending on sufficient depth of waterways
- Low transport speed; the usually required timely delivery depends on organization of multimodal chain
- No door-to-door services, as producers and/or users are not located directly on the waterway

Opportunity
- Comparatively low investment costs for waterways (mostly naturally available) and low operations cost of IWT
- Safe mode for hazardous cargo
- More service flexibility than rail
- Very limited land requirement
- When equipment for other modes is limited or restricted by law or size (e.g. high & heavy transports) IWT can be faster in the overall transport
- Potential for simultaneous development of a river for power generation, flood control, navigation, irrigation, industrial uses and recreation.

Threats
- Operation is interrupted in some seasons due to weather condition, when water level is low or high
- Rivers may change course leading to navigation problem

6.15.2 SWOT Analysis of Rail

Strength
- High speed over long distance
- Large transport capacity per shipment
- Limited operating cost, esp. labour cost
- Fixed routes and schedules, hence service is very likely more uniformed, regular and certain than other modes
- Limited accidents and breakdowns; cargo can be protected from exposure to sun, rain and wind

Weakness
- Large investment in construction, maintenance and overhead; investments are immobile, i.e. in case of insufficient traffic the investment cannot be shifted and resources are wasted
- Inflexibility of routes and timings, which cannot be adjusted to individual requirements
- Transport is not economical for short distances and small transport loads
- No service in rural areas because of high capital requirement

- Hardly any door-to-door transport possible; usually service is tied to particular track and intermediate handling involves high cost and more time

Opportunity
- Dependable mode of transport as being least affected by adverse weather conditions and time of day

Threats
- Limited number of carriers so that the lack of competition may lead to inefficiencies and higher costs
- Rail in the hinterland of NW 110 is working at or beyond capacity limits

6.15.3 SWOT Analysis of Road

Strength
- Road offers door-to-door service, which reduces transfer cost and also reduces the risk of damage of cargo
- Good service in rural areas as exchange of goods between large towns and small villages is possible only by road
- Flexible service as routes and timings can be adjusted and changed to individual requirements

Weakness
- Higher risk of accidents and breakdown
- Limited transport volume per shipment
- Unsuitable and costly for transporting bulk cargo and ODC
- Restrictions for ODC/ heavy load transportation
- Emits carbon and causes pollution
- Lack of organization, can be irregular and undependable

Opportunity
- Suitable for short distance
- Transport is more independent of schedules
- Cost of constructing, operating and maintaining roads is lower than railways
- Road is mostly required for the first and last mile transport of rail and IWT cargo

Threats
- Road congestion often leads to delays
- Road dimension is India is often inadequate, roads are often in bad condition and poorly maintained
- Less reliable during rainy season, when roads may be unfit and unsafe to use
- Heavy tax burden on motor transport in India

6.16 IWT Promotion & Incentives in Europe & China

Countries, like Europe and China have applied national IWT policies of their own. The economics of water transport are strongly tied up with the location of industrial activities in a country. European industry, which is mostly located close to waterways, has favoured IWT, especially for bulk products.

A comparative overview of European Union (EU) incentive and development programs to initiate IWT indicates the wide range of instruments for a mature EU transport industry, infrastructure and market driven forces. These market driven forces help in deciding which transport mode will be chosen to serve the market. The Netherlands and Germany remain the largest inland shipping nations in the EU, followed by Belgium and France. Together, almost 84% of the volumes by barge are shipped on their territory and they account for 77% of the overall transport performance. By modal share, the Netherlands, Romania and Bulgaria have most goods carried by inland shipping.

Another comparative overview of the Chinese incentive and development programs to initiate and support inland-waterway transport. It also indicates the engagement of the national ministries and departments in implementation of rules and regulations. The Indian IWT transport market is currently in a less mature stage. It could follow models of highly developed IWT markets, like Europe and China for policies, subsidies and regulations for the development and integration of IWT in multi modal supply chain.

6.16.1 Policies & Subsidies in favour of IWT in Europe

In Europe, IWT is considered as a complementary mode of transportation. IWT plays an important role in Europe for transportation of goods from EU's major ports to the hinterland. In Europe, IWT is significant for the movement of freight than passengers. Passenger traffic in European IWT is less compared to freight traffic. IWT is extensively used for transporting commodities like metal ores, coke and refined petroleum, agricultural products etc. as well as containers. IWT has significant contribution in multi modal transport and container movement. The Netherlands and Germany together account for a large share of container transportation through IWT. Other countries like Hungary, Romania, Austria and Slovakia also increased their share in container transportation through IWT.

Most of European industrial centers can be reached by inland navigation. The Rhine-Danube network, with a length of 14,360 km, alone represents nearly half of the inland waterways of international importance.

The European Union (EU) has implemented several successful programs to promote IWT and intermodal transport, and to take freight off roads since 2003. These programs are mentioned below;

- The Marco Polo program gives grants in the crucial start-up phase of direct modal-shift or traffic avoidance projects or projects providing supporting services that enable freight to switch from road to rail and waterborne systems efficiently and profitably.
- The Trans- European Network for Transport (TEN-T) that aims to help connect industrial regions and urban areas; link them to ports and help establish an interoperable, intelligent traffic and transport system. Integration of good navigation status in TEN-T ensures the quality of existing infrastructure.
- INTERREG IV-A Upper Rhine that intends to support development of the Upper Rhine into an internationally competitive cross-border knowledge and innovation region.
- NAIADES that promote inland waterway transport and focuses on five strategic areas for a comprehensive inland waterway transport policy: market, fleet, jobs and skills, image and infrastructure.
- NAIADES 2, the EU inland waterway transport action plan is in implementation with harmonization of technical requirements, education and greening of the fleet. It aims to improve the economic and environmental performance of IWT.
- PLATINA that was designed to support implementation of the NAIADES European inland navigation program.
- PLATINA 2 that was designed as a multi-disciplinary project to implement the European Action Program for the promotion of inland waterway transport (NAIADES 2).

The policy instruments that are applied for promoting IWT differ between European Union (EU)-level and the national and sub-national levels, because of different political competences.

6.16.2 EU-level policy instruments

The most important instruments on European Union-level are listed below:

- Co-funding of infrastructure projects through a Fund for the development of the Trans – European Network for Transport (TEN-T). This fund is to encourage Member States to invest in infrastructure (including port infrastructure), which is of international importance to Europe. The fund, renamed as Connecting-Europe-Facility, co-finances up to 20% of the infrastructure works and up to 50% of studies in the preparation phase like feasibility studies, design studies and environmental impact assessments. To some extent, it can also provide co-funding of infrastructure related facilities, like Liquefied Natural Gas (LNG)-bunkering facilities and port information systems. The remaining part of funding usually is provided by the relevant lower level authorities and sometimes by private sector.
- Co-funding of research and development studies. These studies are mainly of large scale and with good representation of the relevant market players and other stakeholders. The study addresses technological innovations, like cleaner engines, cargo handling systems, improved port operations,

optimizing information flows between operators and authorities, information and communication systems for navigation, and supply chain optimization etc.

- Co-funding of pilots or other implementation steps for transport quality and efficiency improvements on similar topics as mentioned above, for example for pilots of implementing port information systems or for developing a network of LNG-bunkering and related training of port staff on security issues.
- Co-funding of modal shift actions. The instrument Marco Polo II opened for IWT companies in 2007. The instrument supports IWT-operators by taking a share of the risk in the start-up phase of a new service. The EU-contribution is always below the operational losses in the first 3 years of operation and required is a business plan that demonstrates viability of the service at the latest after 3 years.

EU-funding program NAIADES is presented in detail below. The Government of India could follow this model for the development and implementation of inland waterway in River Yamuna.

6.16.3 EU funding program NAIADES

IWT plays an important role for the transport of goods in Europe. More than 37,000 kms.of waterways connect a large number of cities and industrial regions. Around 21 Member States out of 28 have inland waterways, 13 of which have an interconnected waterway networks. The policy to promote inland waterway transport in Europe is encapsulated in the NAIADES Action Programme. This Programme comprises numerous actions and measures to boost transport on inland waterways. The programme would run until 2020 and is to be implemented by the European Commission, the Member States and the industry itself.

The European Commission aims to promote and strengthen the competitive position of inland waterways in the transport system, and to facilitate its integration into the intermodal logistics chain. The Commission is promoting inland waterway transport through various funding and financing programmes, such as the Connecting Europe Facility, Horizon 2020, and the European Fund for Strategic Investments and through the Cohesion policy. Apart from the above listed Policies & Subsidies to promote IWT in Europe, European Union has implemented following

- Introduction of low sulphur fuel for IWT vessels
- Development of digital river information services to facilitate logistics services and make inland waterway easy to use and reliable mode in multi-modal supply chain.
- Education and training of all involved staffs
- Providing electronic navigational charts for smooth operation
- Optimisation of lock and bridge schedules to reduce waiting times, the overall duration of the voyage and to optimise energy use.
- Proper berth management for booking of berth space

6.16.4 Policies & Subsidies in favour of IWT in People's Republic of China

China's inland waterway transport (IWT) network is well developed in terms of length and freight handling. There are a large number of inland port facilities with berths for large vessels. However, due to significant underfunding, the country's inland waterways and IWT infrastructure suffered.

China has a tripartite system of IWT management. The Ministry of Transport (MOT) of China has the overall responsibility for policy and administration of inland waterways. Delivery of IWT infrastructure and enforcement of regulations on the two most important sub-systems, the Yangtze and Pearl Rivers, are delegated to specialized River Administrations that are responsible to MOT.

While China, like the USA, operates a policy of cabotage in IWT, it is trying to encourage international investment and participation in inland port and logistics industries.Traffic on the China IWT system has been increasing rapidly in recent years.

In 2007, the government's National Development and Reform Commission and MOT issued the National Plan for Inland Waterways and Ports, with a planning horizon from 2007 to 2020. The plan evaluated the country's system of inland waterways, ports, and transport; analysed the advantages and functions of IWT; and proposed comprehensive long-term inland waterways and ports development. The plan has details of intended improvements to each of the country's following main IWT systems in rivers,

- Yangtze River
- Pearl River
- Grand Canal
- Huaihe
- Heilongjiang
- Songliao,
- Minjiang

In each case, it is taking a network approach by designing interlinked routes that can accommodate large and modern vessels. These improvements include a combination of channel dredging, new or upgraded locks (many combined with hydropower generation facilities) and new and upgraded terminals for both bulk and container traffic.

After development, the high-class waterway (Class III and above) will be around 19,000 km in 2020 compared to less than 9,000 km in 2006. The high- class system will extend to 20 provinces, including 56 cities with populations greater than 500,000, and will serve a catchment area that contains approximately a quarter of the population of China.Some of the Opinions, published by MOT for promoting IWT in China are listed below,

- In February 2006, MOT published the "National Outline for the Development of Ship-Class Standardization on Inland Waterways", which requires Provincial transport authorities develop the navigation industry by relying on technological innovations and progress.
- In January 2011, the State Council issued "Opinions on Accelerating the Development of Water Transport on the Yangtze River", which requires governments at all levels shall be devoted to integrating water transport with other modes of transport involving highways, railways, aviation, and pipelines, developing multimodal transport; and strengthening comparative advantages and combination efficiency of various transportation means.
- In May 2013, MOT issued the "Guiding Opinions on Promoting the Development of Green, Recycling-Oriented, and Low-Carbon Transportation. "The Opinions mandated provincial transport authorities to (a) strengthen technological research and development on green, recycling-oriented, and low-carbon transportation; (b) promote scientific and technological breakthroughs including R&D and application of key technology for intelligent transportation, and the research and demonstration of the key technology for emergency response to transportation pollution and pollution control.
- In August 2013, MOT issued the "Notice on Issuing the Action Programs (Year 2013–2020) on Accelerating the Development of Water Transport on the Yangtze River and Other Inland Waters," in which Governments were required to strengthen planning and construction of inland waterways, which connect with coastal ports. Furthermore, governments at all levels shall make efforts to (a) speed up development of large-scale port areas for special purpose at major ports and part of the key ports along inland rivers, especially terminals for handling containers, automobile Ro-Ro handling, and bulk commodities; and (b) develop multimodal transport and port logistics.
- In April 2014, the Ministry of Finance and the MOT promulgated the "Management Measures for Subsidy on Ship-Class Standardization on Inland Waters. "The policy encourages cargo vessel replacement by providing subsidies. It also provides subsidies for vessels to install sewage cabin.

For the development and promotion of inland waterways, there are several regulations issued in China, such as Regulations for Strengthening Safety Management of IWT Enterprises, Regulations for Renewal and Renovation of Ships of Local Shipping Enterprises, Regulation for Management of Water Transportation and Regulations for Navigation Channels.

China introduced foreign capital for the construction of ports and waterways. Loans from the World Bank, the Asian Development Bank, the Overseas Joint Foundation and foreign governments are used, and foreign traders are encouraged to invest in the construction and operation of ports and waterways. For the latter, the State Council issued in 1985 "Provisional Regulations of the People's Republic of China on Preferential Treatment of Joint Investment of China and Foreign Countries in Construction of Ports and Waterways". Later, the Ministry of Communications formulated some policies. The Regulations and Policies include the following contents.

- Joint investment is encouraged in the construction and operation of public wharves. Joint- venture enterprises are allowed to conduct such businesses as loading and unloading, freight storage, dismantling and installation, packing, and domestic transportation.
- The time limit of operation for the joint-venture enterprise can exceed 30 years. The specific time limit for a joint-venture enterprise is defined by the parties involved, but it cannot exceed 50 years according to related laws. If a longer period is needed, an application must be made and submitted to the State Council for approval.
- Joint-venture enterprises managing loading and unloading can fix the rate of charge themselves and report to the Ministry of Communications or the local department of communications and the pricing department for the record.
- Besides their main business, joint –venture enterprises are allowed to be engaged in other port-related projects whose period of construction is short, which need a comparatively small investment, and whose profit is high.
- Joint-venture enterprises are allowed to rent wharves and run loading and unloading.
- Foreign traders are allowed to construct freight owners' wharves and special waterways with their own capital.
- When foreign traders develop and manage large stretches of land, they are allowed to construct and manage special ports and wharves.
- Domestic freight owners and shipping enterprises are allowed to construct and manage special wharves, to rent wharves for the shipping of their own freight, and to invest in the excavation of special waterways. Special wharf owners are allowed to open their surplus berths to other vessels and run loading and unloading.

6.16.5 Suggestions for IWT Promotion & Incentives in India

Compared to IWT in Europe and China, IWT market in India is in an early stage and needs lots of support through policies and incentives from the Government. Prior to that huge investment is required for inland waterways and associated infrastructure. Adequate infrastructure is required for the success of IWT.

Crucial tasks related to IWT development, such as terminal construction, operation and maintenance would involve private investors. The private sector has the capability and willingness to invest in barge ownership, operation and supporting services such as barge building, maintenance and repair. The Government should provide grant of 100% tax exemption to investors for five years.

Availability of barges is another important issue. It is necessary that number of barges, which would be deployed in NW 110, is adequate to handle the traffic. With increase in traffic volume, the number of barges should increase in future. To encourage IWT fleet expansion, vessel building subsidy of 30% should be provided to ship owners for inland waterway vessels built in Indian shipyards.

Earlier, Central Government used to provide 30% subsidy to private investors in the construction of barges. This subsidy was provided in order to reduce the capital burden on the IWT operators, and to enhance their profitability. However, this policy expired on 2007. This policy should be revived in order to attract more and more private investors in National waterways.

Tourism and related activities in inland waterway in NW 110 offer good potential. Government should encourage local and private parties with appropriate local investments and operational control, wherever relevant.

To encourage IWT in river Yamuna, Government of India should incorporate best policies and incentives by referring examples of European and Chinese governmental policies and subsidies. In initial phase, the waterway in Yamuna would need Government support and favourable policies. The government should provide freight subsidy to encourage private sector participation in the sector. The subsidy would at least make the operations viable.

There should be support to fleet modernization, promotion and awareness campaigns. In order to further exploit the potential of inland waterway transport in river Yamuna, the strengthening of its market position, its integration into co-modal or multi- modal transport chains, the deployment of new technologies including River Information Services (RIS) and their interoperability with other intelligent transport systems would be important steps.

Government should make policies to shift road and rail cargo movement to inland waterways. The objective of the policy would be to reduce congestion on overburdened roadways and railways and encourage industries to use inland waterways. For example, through policies, Government could shift transportation of hazardous cargo from roadways and railways to IWT on river Yamuna. The implementation of this policy would make the transportation of hazardous cargo safe and environmental friendly. This would also curb issues like accidents caused by these cargoes on roadways and railways.

CHAPTER 7

WATERWAY AND INFRASTRUCTURE ANALYSIS

7.1 General

The identified stretch of river Yamuna NW 110 is currently utilized for passenger movement in various places. There exist some Ghats for handling this movement. However, at present, there is no cargo movement on the river.

Terminals are proposed to be developed on the defined stretch of NW 110. A total of 19 terminals are proposed to be constructed across 6 cities, including Delhi, Mathura, Agra, Jalaun, Kanpur and Prayagraj. Locations are identified for development of the terminals. These proposed terminals have been classified into 2 categories, Cargo Terminal and Passenger terminal. Cargo terminals are based on financial viability and location as industrial clusters located in the region. Traffic, availability of land and connectivity are the major decisive factors for the identification of terminals on NW 110.

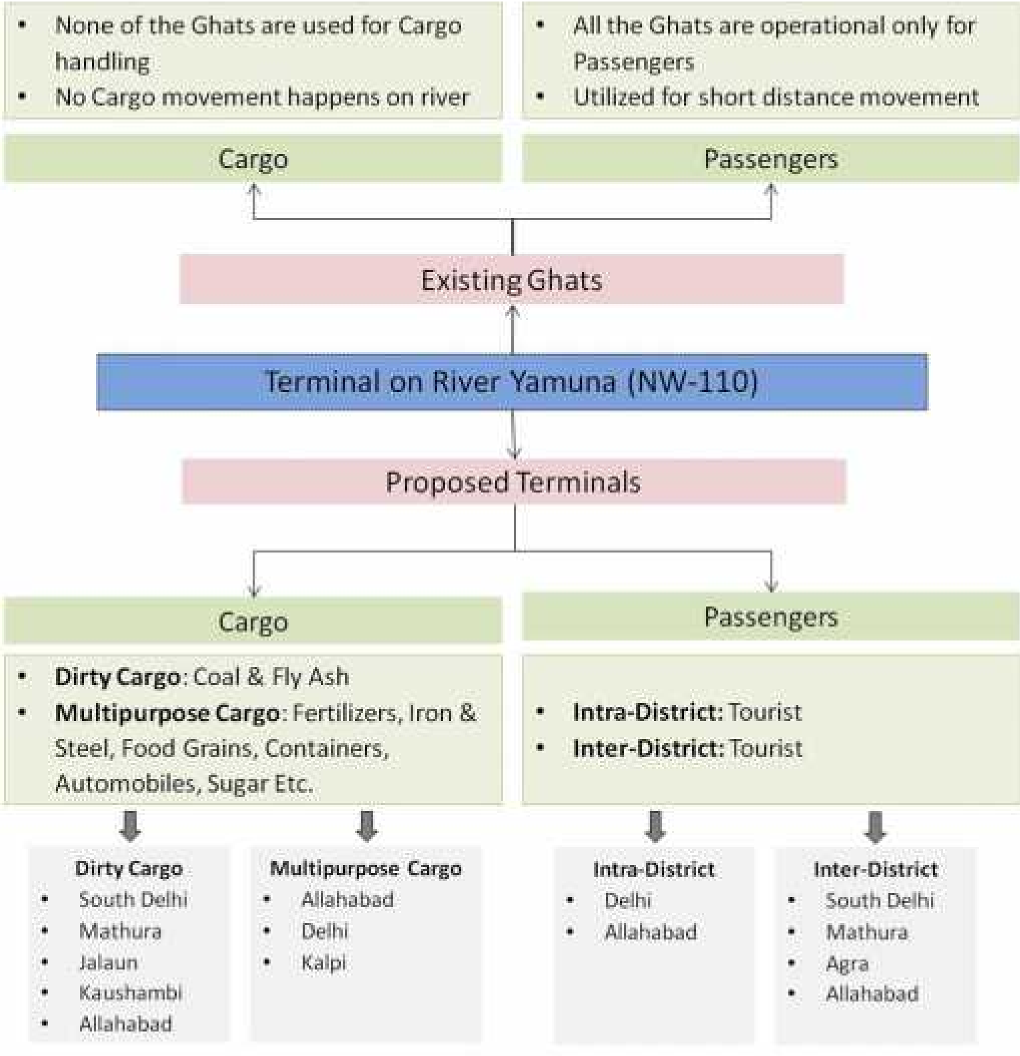


Fig. 7.1 Existing & Proposed Ghats/Terminals on NW-110

Cargo terminals are categorized in two sub categories, Dirty Cargo and Multi-purpose cargo. These proposed terminals on NW 110 will facilitate the bulk transportation of material and products, like coal, fertilizer, food grains, iron & steel etc. through barges. Automobile would be transported using car carriers. Passenger terminals are categorized in two sub categories, Intra district and Inter district terminal. Intra district terminals would handle local passenger/ tourist traffic for across/along the river movement. Intra district terminals would be developed in Delhi and Prayagraj. In Delhi, 3 intra district terminals would be developed for serving passenger and tourist traffic. Prayagraj would house 4 intra district terminals, due to concentration of tourist traffic near Sangam. Inter district terminals would handle tourist traffic for long distance cruise ride, from Delhi to Prayagrajon NW 110 and further to Varanasi on NW 1. Inter district terminals would be developed in Delhi, Mathura, Agra and Prayagraj. These IWAI terminals would be an integral part of the waterway development on river Yamuna that involves development of the 1,089 kms long NW 110 between Delhi and Prayagraj.

7.2 Existing Ghats / Terminals

There exist several Ghats on river Yamuna, no terminal is developed yet. Number of Ghats in Prayagraj is more compared to other places, which fall within the identified stretch of NW 110. These Ghats in Prayagraj are mostly used for travelling to and fro from Sangam. Ghats on other locations are used for fishing and religious purpose. The figure below depicts the existingGhats and their location on river Yamuna. Some of these Ghats are identified to be developed as full-fledged terminals.

Fig. 7.2 Existing Major Ghats on NW-110

7.3 Proposed Terminals

The location of the proposed terminals has been identified by considering the following requirements.

- Availability of land for terminal
- Availability of water depth at terminal site
- Availability of cargo and industries near by
- Approach between terminal, nearby city and destination industry.

Total 19 terminals are proposed at NW 110 for handling cargo and passengers. These terminals are located at various locations, on the bank of river Yamuna. This section would discuss each terminal in detail.

Cargo Terminal 1 and Terminal 7 are proposed 2km downstream of Okhla barrage to avoid any modification in barrages and bridges also the coal coming from mines of Jharkhand will be distributed to NTPC Dadri and Badarpur plant which are nearer to the this terminal location. Other terminals are also proposed on similar basis this has been described in clause.

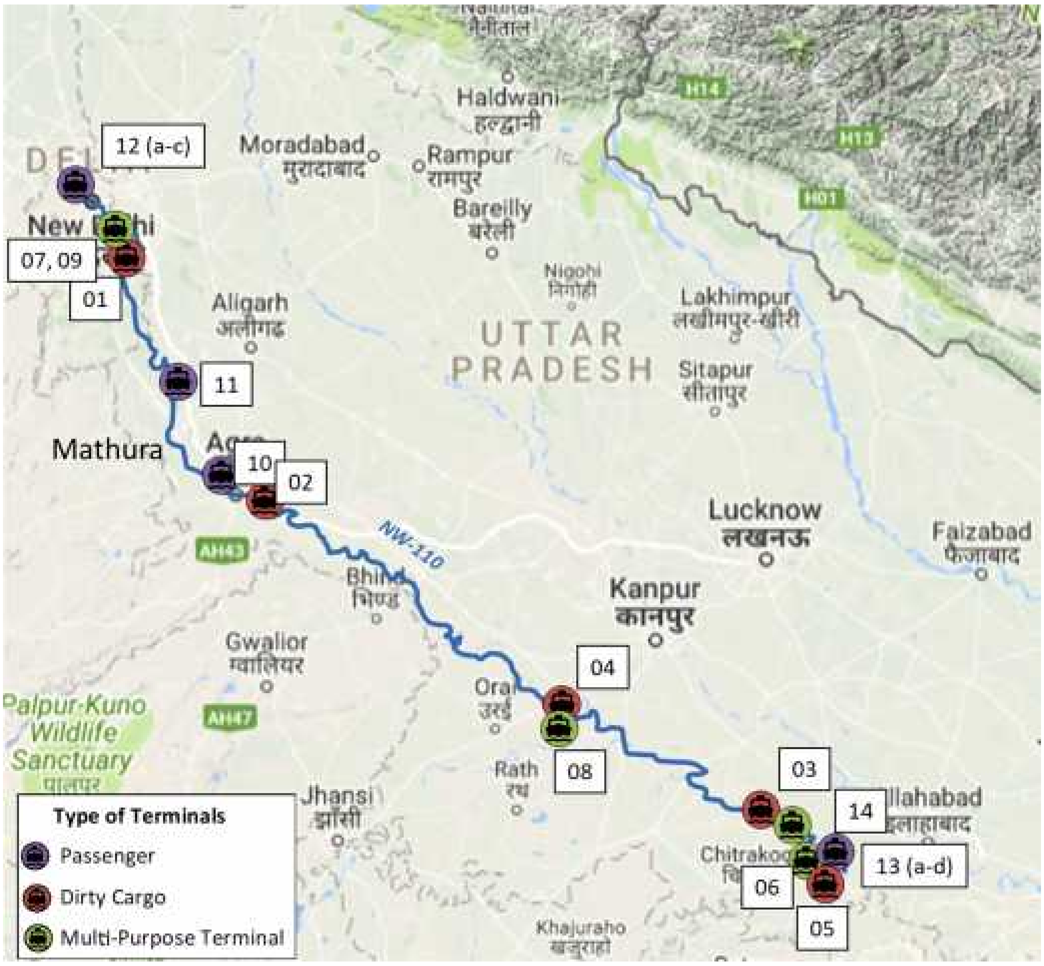


Fig. 7.3 Proposed Terminals on NW 110

7.4 Proposed Cargo Terminals

Total 9 terminals are proposed at various locations for handling cargo in NW 110. The proposed terminals are categorized based on classification of cargo into clean cargo and dirty cargo, volume of cargo, origin- destination of cargo and probable mode of transporting these cargoes. This classification has been undertaken to accommodate different types of vessels for handling cargo, type of the terminal, its location and proposed infrastructure in and around the terminal. The terminal location and infrastructures need to be separate for clean cargo and dirty cargo. The terminal proposed for handling clean cargo could also handle finished products, though the material handling equipment on the terminal would be different. Finished products are mostly carried in containers or break bulk form. Bulk materials are carried in large volumes. Acquisition of vessels and creation of handling facilities would be determined based on the target cargo. For example, the handling mechanism proposed at the terminal would be different for finished product, bulk materials and automobile.

As shown in the below table, coal handling terminals (Terminal 1-5) would cater to the coal (procured & imported) requirement of the numerous power plants in the hinterland. Terminal 6, 7 & 8 are proposed as multipurpose terminals for handling clean and multipurpose cargo, like iron & steel, automobile, food grains, sugar, containers etc. Terminal 7 & 8 would help in seamless movement of overseas trade as well as the domestic freight transportation.

At present, all the thermal power plants located in the hinterland of NW 110 use railway for procuring coal from mines. Like coal, other commodities, like iron & steel, fertilizer, food grains, sugar etc. also use railway. Railway route is shorter compared to the proposed multi modal route. Also, loading and unloading of coal at various points would be time consuming. However, waterway is environment friendly mode of transport and is the most suitable mode for transporting bulk cargo. Development of national waterways would provide an alternate mode of transportation for cargo movement. This development would reduce burden on railways. At present, railway is struggling to provide seamless service to power plants. Use of inland waterway for transporting coal in the hinterland of NW 110 would ensure that there is no shortage of coal in the power plants. The possibility of cargo movement by the river route on a big scale is explored. There is huge potential for cargo movement through national waterways. It is necessary that Government would provide subsidy for facilitating waterway operations and motivating industries to use waterways. Without subsidy, the waterway operations would not be self sustainable at the initial stage. For promoting inland waterways, it is necessary that Government provides financial incentives for inland navigation and assistance for integrating inland waterways into the multimodal logistic chains.

Table 7.1 Details of Proposed Terminals with projected Traffic on NW-110

Locations	Districts	Latitude/ Longitude	Chainage (Km)	Cargo	Projected Traffic ('000 T)				
					Fy 17	Fy 22	Fy 27	Fy 37	Fy 47
Dirty Cargo									
1. Madanpur Khadar	South Delhi	28°31'7.39"N/ 77°20'19.06"E	1047.8	Coal	1,083	1,592	2,032	2,866	3,851
2. Samogar Mustkil	Agra	27°10'53.83"N/ 78°8'3.89"E	731.0	Coal	636	934	1,192	1,682	2,260
				Fly Ash	263	386	493	572	632
3. Mahewa Khachhar	Kaushambhi	25°23'23.10"N/ 81°9'34.83"E	98.0	Coal	750	1,102	1,407	1,985	2,667
				Fly Ash	361	530	677	785	867
4.Dilauliya Kachhar	Kanpur Dehat	26°7'44.63"N/ 79°45'49.34"E	349.2	Coal	682	1,002	1,279	1,803	2,424
				Fly Ash	586	861	1,099	1,275	1,408
5. Near Naini Bridge	Prayagraj	25°25'25.69"N/ 81°51'39.33"E	3.0	Coal	1,407	2,068	2,639	3,723	5,003
				Fly Ash	571	839	1,071	1,242	1,372
Multipurpose Cargo									
6. Near Jamuna Bridge	Prayagraj	25°25'15.19"N/ 81°50'59.98"E	4.2	Fertilizer, Food grains, Sugar	527	695	848	1,037	1,128
				Automobiles ('000 PCU)	32	41	52	70	93
7. Madanpur Khadar	South Delhi	28°31'45.09"N/ 77°19'48.17"E	1049.0	Food grains, Sugar, Iron & Steel	805	1,077	1,329	1,703	1,986
				Automobiles ('000 PCU)	63	81	103	139	186
				Containers ('000 TEU)	250	351	470	657	840
8.Daulatpur	Kanpur Dehat	26°7'54.75"N/ 79°45'20.31"E	349.8	Food grains, Sugar, Iron & Steel, Fertilizer	702	913	1,114	1,382	1,529
				Automobiles ('000 PCU)	32	41	52	70	93
Ro-Ro Terminal									
14.Bakshi Moda	Prayagraj	25°24'23.20"N/ 81°48'34.26"E	8.5	Stone Chips/Silica Sand/ Other Commodities ('000 Trucks)	12.7	12.7	14.9	17.1	19.1

Note: FY 17 is considered as a base year

7.4.1 Terminal 1 – Madanpur Khadar, Near Okhla Barrage, Delhi

Terminal 1 is proposed at Madanpur Khadar, near Okhla Barrage for handling dirty cargo, i.e. coal. Two more terminals are proposed at Madanpur Khadar, on the other side of the river. These terminals are 7 & 9, for handling multipurpose clean cargo and tourist traffic respectively. Terminal 1 would handle only coal for two thermal power plants, NTPC, Dadri and Badarpur Thermal Power Station. The terminal is strategically located near Okhla barrage on the bank of Yamuna. A road passes near the terminal. An approach road would be required to connect the terminal to this road.

- **NTPC, Dadri**

There is a thermal power plant of NTPC at Dadri in Gautambudhnagar, Uttar Pradesh. At present, the plant procures coal from Piparwar mines (Jharkhand) by railway. About 8,128 thousand tonnes of coal from Jharkhand is transported annually by railway to meet the requirements of NTPC's Dadri plant. A portion of this volume could be diverted to the waterway route in NW 110. NTPC, Dadri could import coal (as per requirement) from Haldia Port and gets it transported to Dadri plant by using waterways, NW 1 and NW 110.

Coal, extracted from Jharkhand mines are transported directly to NTPC, Dadri by railway. This coal movement by railway route from Jharkhand mines to Dadri could be diverted to National Waterways. Coal from mines in Jharkhand could be transported to Patna Ghat by railway. Patna Ghat is located on the bank of Ganga on NW 1; hence coal could be transported further in barges on NW 1 to Prayagraj. Further, it would be transported in NW 110 from Prayagraj to Madanpur Khadar (Terminal 1). NTPC thermal plant is about 38 km away from Terminal 1 by roadways. Considering availability of a freight station in Okhla, it is proposed that coal would be unloaded from barges at Terminal 1 for onward movement by railway to NTPC, Dadri plant. NTPC plant has its own siding at Dadri for handling coal.

- **NTPC, Badarpur**

Badarpur Thermal Power Station is located at Badarpur area in NCT Delhi. This plant is located on the opposite side of the river from the terminal. The plant was shut down due to environmental issues, as it alleviates the acute air pollution of Delhi. As per Central Electric Authority, the plant has started its operation recently. Environment Pollution Prevention and Control Authority (EPCA) have proposed to close down the plant by July 2018. At present, the plant is operational, hence it is considered as an opportunity for NW 110. However, if in future, the plant gets closed, it would not provide any opportunity for the waterway movement in NW 110.

NTPC Badarpur procures coal directly from Jharia/ECL (Eastern Coalfield Ltd.) mines by railway. This coal movement by railway could be diverted to the inland waterway in NW 110. It is proposed that coal from mines would be transported by railway to Sahibganj Terminal in Bihar. In Sahibganj, coal would be loaded in barges in NW 1 and would be transported to Prayagraj. Further, these coal barges would be moved in NW 110 to Madanpur Khadar, Terminal 1. The distance from Terminal 1 to Badarpur plant is only 11 km. Hence, last mile delivery to the plant from Terminal 1 could be done by roadways, with the help of fleet of trucks.

7.4.2 Terminal 2 – Samogar Mustkil, Agra

A Terminal is proposed near inner ring road, Etmadpur, Agra for handling dirty cargo, coal and fly ash. This terminal is located in Samogar Mustkil, Agra. An approach road needs to be constructed for connecting the terminal to the nearest road. Terminal 2 would be dedicated to handle coal requirement for Harduaganj Thermal Power Station and Jawaharpur Thermal Power Station. Unutilised Fly Ash from both the plants would be exported to Singapore and Bangladesh through Haldia Port. Fly Ash would be transported from the plant to the port using NW 110 and NW 1.

- **Harduaganj TPS, Aligarh**

Harduaganj TPS is located in Aligarh district of Uttar Pradesh. It procures coal from BCCL (Bharat Coking Coal Ltd.) and ECL by railway. This coal movement could be diverted to the waterway in NW 110. It is proposed that coal extracted from mines could be transported to Sahibganj by railway. The nearest freight station from ECL & BCCL is Patherdih Station; hence this station would be used for loading coal from mines. From Sahibganj, coal would be further moved in NW 1 and NW 110 and would finally reach Terminal 2 in Samogar Mustkil near Etmadpur, Agra. Coal would be unloaded from barges in this terminal and would be sent to Harduaganj (HGJ) freight station by railway.

- **Jawaharpur TPS, Etah**

Jawaharpur TPS is an upcoming thermal power plant, located at Etah district in Uttar Pradesh. This plant will be commissioned in 2021. According to UPRVUNL (U.P Rajya Vidyut Utpadan Nigam Ltd.), the plant would procure coal from Northern Coalfield Ltd. (NCL) mines. A portion of this coal requirement could be shifted to the waterway. Coal from mines would be loaded in Singrauli (SGRL) freight station and would be moved to Varanasi. In Varanasi, it would be loaded in barges and using NW 1 and further NW 110, coal would get transported to Terminal 2. From the terminal, again it would be loaded in freight train and reach the destination, i.e. Jawaharpur Kamsan Halt (JWK).

7.4.3 Terminal 3 – Mahewa Kachhar, Kaushambhi

Terminal 3 is proposed near Mahewaghat Yamuna Bridge in Kaushambhi district. This bridge connects Chitrakoot and Prayagraj. The location of the terminal is part of Mahewa Khachhar village. The terminal has good connectivity. There is a need to develop an approach road from the terminal to the nearest road, i.e. SH 94. This proposed terminal would handle Coal and Fly Ash for two thermal power plants, i.e. NTPC, Tanda and Unchahar TPP.

- **Feroze Gandhi Unchahar TPP**

Feroze Gandhi Unchahar Thermal Power Plant is located at Unchahar in Rae Bareli district. Coal for the plant is derived from mines of Northern Karanpura Coal Fields (NKCF) by railways. Coal from NKCF mines would be transported by railway to Sahibganj Terminal in NW 1. From Sahibganj, coal movement would be done in barges through NW 1 and further in NW 110 till Terminal 3. Coal would be unloaded at Terminal 3 and would be transported by railway to Feroz Gandhi Thermal Project Siding (FGTP).

Fig. 7.4 Terminal 3 - Mahewa Kachhar

- **NTPC Tanda**

NTPC Tanda is a thermal power plant, located in Ambedkar Nagar district. The plant procures coal from NKCF by railway. It is proposed that a portion of coal requirement of this plant could be diverted to the inland waterway in NW 110.

Multi modal transportation would be used for coal movement between mines to NTPC Tanda plant. Coal from NKCF mines would be transported by railway to Sahibganj Terminal in Bihar. Bachra Railway Siding at Ray (BCSR) is the nearest freight station from the mines; hence it would be used for loading coal in freight wagons. Coal would be shifted from railway to waterway in Sahibganj. It would be transported ahead in barges through NW 1 and further in NW 110 till Terminal 3 in Kaushambi. From Terminal 3, again railway would be used to transport coal to railway siding at Tanda Thermal Powerhouse (TTPH).

7.4.4 Terminal 4 –Dilauliya Kachhar, Kanpur Dehat

Terminal 4 is proposed at Dilauliya Kachhar in Kanpur Dehat district. The other terminal, Terminal 8, which would be a multipurpose terminal, would be developed on the same side of the river. Terminal 4 would be located beside Railway Bridge near Kanpur- Jhansi Highway, i.e. NH 27. The huge land parcel near the railway bridge is currently open and unutilized. This land is ideal for developing proposed terminal 4 due to availability of big open land and good connectivity. An approach road is required to be developed for connecting the terminal to the nearest national highway. Terminal 4 is proposed for handling coal requirement of three thermal power plants located in the hinterland, Parichha TPP, Panki TPP and Rosa TPP. The terminal would also be used for transporting fly Ash generated from these plants to Haldia Port. From Haldia Port, fly ash would be exported to Singapore and Bangladesh.

- **Parichha TPP**

Parichha Thermal Power Station is located at Parichha in Jhansi district. The plant is located on the bank of river Betwa, which is a tributary of river Yamuna. Coal for this plant is fed from mines of BCCL and ECL by railway. This coal could be partially shifted to the inland waterway. By using multi modal route coal could be transported from mines to the plant. Coal from mines could be loaded in wagons at the nearest freight station, i.e. Jamtara siding (CCSJ) and could be unloaded at Sahibganj. From Sahibganj terminal in NW 1, coal could be moved further ahead in NW 110 and brought at Terminal 4. From the terminal, coal could be shifted by railway to the siding of Parichha TPP in Jhansi.

- **Panki TPP**

Panki Thermal Power Station is located at Panki in Kanpur district. The plant procures coal from BCCL and ECL by railway. Part of this coal movement could be moved through waterway. Coal from mines could be brought to Sahibganj terminal by railway. From Sahibganj terminal in NW 1, coal could be transported ahead in NW 110 and unloaded at Terminal 4. From the terminal, coal could be shifted by railway to Panki (PNK) freight station.

➢ **Rosa TPP**

Rosa Power Plant is located at Rosa village in Shahjahanpur. This power plant is very far from Terminal 4, still there is possibility to divert imported coal requirement of this plant to NW 110. At present, Rosa TPP procures coal from Ashoka Coal mines of Central Coalfields Limited. As these mines are very far from the inland waterway, hence there is no opportunity to divert coal from mines. Rosa TPP also imports coal. It is proposed that Rosa TPP could import coal from Haldia Port. In Haldia Port, coal would be loaded in Haldia Dock Comp Bulk (HDCB) and would be transported ahead using NW 1 and NW 110. Coal would be unloaded at terminal 4 and would be sent ahead to railway siding of Rosa TPP by railway.

7.4.5 Terminal 5 – Near Naini Bridge, Prayagraj

Terminal 5 is proposed beside Naini Bridge (New Yamuna Bridge) in Prayagraj. It is a cable bridge and is part of NH 30. There is another bridge near the terminal on the river, i.e. Old Naini Bridge (Old Yamuna Bridge). The terminal has good connectivity. The terminal is proposed for handling coal requirement of Meja Thermal Power Station and Bara Thermal Power Station. This terminal would also be used for transporting fly ash from these plants to Haldia Port for exporting to Singapore and Bangladesh.

➢ **Meja TPS**

Meja Thermal Power Station is an under construction thermal power plant located in Meja Tehsil in Prayagraj district. Unit 1 was commissioned in March 2018. Unit 2 will also be commissioned in 2018. According to UPRVUNL (U.P Rajya Vidyut Utpadan Nigam Ltd.), the plant would procure coal from Northern Coalfield Ltd. (NCL) mines. This coal requirement could be partially shifted to the waterway. It is proposed coal from mines would be loaded in Singrauli (SGRL) freight station and would be transported to Varanasi. In Varanasi, it would be loaded in barges and using NW 1 and NW 110, coal would get transported to Terminal 2. From the terminal, it would be loaded in freight train and reach Meja Road (MJA), which is the nearest freight station from the plant.

➢ **Bara TPS**

The plant procures coal from NCL mines. This coal could be partially shifted to national waterway. Coal from mines would be loaded in Singrauli (SGRL) freight station and would be transported to Varanasi. Coal would be loaded in barges in Varanasi terminal and would be moved ahead using NW 1 and NW 110 till Terminal 5 in Prayagraj. From the terminal, coal would be loaded in freight train and reach Bevara (BVAR) freight station, which is the nearest freight station from the plant.

Fig. 7.5 Terminal 5 – Near Naini Bridge

7.4.6 Terminal 6 – Mahewa East, (Near Jamuna Bridge) Prayagraj

Terminal 6 is proposed beside Jamuna Bridge (Old Naini Bridge or Old Yamuna Bridge). The bridge connects to NH 2 and NH 76. Naini Bridge (New Yamuna Bridge), which is a part of NH 30, is another bridge near the terminal. The terminal has good connectivity. This terminal would be a multipurpose terminal and would be dedicated to handle clean cargo. It is proposed that fertilizer from IFFCO, Phulpur Unit, and Prayagraj would be handled at this terminal. Fertilizer which originates from IFFCO, Phulpur gets distributed in the hinterland. At present, IFFCO uses railway for distribution in Uttar Pradesh. After development of the waterway in river Yamuna, fertilizer would be transported from IFFCO Phulpur plant to Terminal 6 in Prayagraj by roadways. Fertilizer would be loaded in barges in Terminal 6 and would be transported ahead in NW 110 towards Delhi. Fertilizer would be unloaded at two terminals; Terminal 8 in Kanpur. From these terminals, fertilizer would be distributed in the region using roadways. Apart from fertilizer, Sugar, Food Grains would also be handled at this terminal. Both Sugar & Food Grains would be unloaded at this terminal for internal distribution in Uttar Pradesh. Food Grains from Punjab/Haryana would be transported using rail and road to the terminal 7 for loading. From Terminal 7, it would move through waterways for getting distributed in Kanpur &Prayagraj districts. Sugar from Muzaffarnagar would be transported by roadway for loading at terminal 7. This sugar would be distributed in UP & West Bengal. For distribution in UP, Daulatpur, Kanpur Dehat (Terminal 8)&Prayagraj (terminal 6) would be used.

7.4.7 Terminal 7 – Madanpur Khadar, Delhi

A multipurpose terminal is proposed near Okhla Barrage, Delhi. Excellent road connectivity, which gives accessibility to most of the parts of Delhi, NCR and nearby cities, makes this location an ideal place for development of terminal 7. This terminal would be used for handling containers and clean cargo, iron & steel, sugar, food grains and automobile. The terminal had been identified for initiation of Car Carrier service for transportation of automobile.

- **Container**

Terminal 7 would be used for the export-import container trade of the hinterland. The Exim traffic is majorly derived by industrial, manufacturing & other trade sectors. Developments in these sectors could aid to register substantial growth on container trade. Container trade from Northern region, like Delhi, NCR, and Uttar Pradesh could use waterway to move their containers to Haldia / Kolkata Port (Haldia International Container Terminal) for export. At present, these states are using JNPT, Pipawa and Mundra Port for their container trade. These states send containers for export to JNPT (Mumbai), Pipavav and Mundra Port by railway. From these ports, containers are exported to East Asian and Southeast Asian countries, like South Korea, China, Singapore etc. by taking a long coastal route. Container trade by these ports (JNPT, Pipawa and Mundra) is time consuming and costly mode of transportation for industries in Delhi, NCR, UP etc. Most of the import cargo originating from Far East is also imported through JNPT, Pipawa and Mundra in spite of distance to Delhi from Singapore through Kolkata is less than the distance to Delhi via Mumbai and Gujarat. This container trade through JNPT, Pipawa and Mundra Port could be diverted to Haldia / Kolkata Port. It is proposed that containers from Delhi, NCR, UP would be loaded in feeder vessel on NW 110 and NW 1 to reach Haldia / Kolkata Port. In the port, containers would be loaded in mother vessel to be moved to the destined countries in Far East. This proposed route using waterway would be time saving and cost effective. If container handling facilities and turnaround time improve at Haldia/ Kolkata Port, the growth of containerisation is bound to accelerate.

Terminal 7 would target goods, like automobile components, electrical goods, machinery etc. These cargoes present a fair share of potential and impetus for Terminal 7 to consider setting up container handling facilities. Automobile components are the major exported commodity in this region. These components are manufactured on a large scale in NCR Cluster, which is at a distance of around 41 km from Terminal 7. Using Haldia / Kolkata Port as the outlet for evacuation of these goods from the manufacturers in the region would turn out to be a more efficient and cost-effective practice than choosing other distant alternatives, like JNPT. Same goes for imported commodities, like electrical goods, electrical machinery & parts etc. These commodities could be imported at Haldia / Kolkata Port and from there it could be distributed by using NW 1 and NW 110 in the states of the hinterland.

➢ **Automobile**

Terminal 7 is strategically located near NCR Cluster, which houses many major and non- major automobile plants. At present, vehicles manufactured in these plants are distributed in other parts of the country through roadway and railway. These automobile plants also export to other countries. This automobile movement could be partially shifted to the waterway. It is proposed that automobile could be transported on Car Carriers in NW 110 and NW 1. NW 1 is connected to Haldia Port; hence the automobile goods could be transported to Haldia Port for export. Car Carriers could also be used for local distribution of automobiles, to the distribution centres or dealers, which are located on the bank of NW 110 and NW 1.

Maruti Suzuki has already shown its willingness earlier to transport vehicles via inland waterways. With collaboration with IWAI, as a pilot project, Maruti had moved cars in barges along NW 1 from Varanasi to Haldia Port. By using waterway, Maruti intends to save logistics cost. After the development of NW 110, other automobile companies would also show interest to use waterway for distribution of vehicles in different cities in the hinterland. Shifting automobile transportation from railway and roadways to waterways would ease the congestion on the present mode of transportation. Other advantage of using waterway is cars, bikes and other commercial vehicles could be moved in much larger volumes through waterways as compared to roadways. The capacity of a Car Carrier would be more than a typical road trailer. Car Carrier on waterway could carry larger number of cars and bikes, as compared to roadways. It would reduce logistics costs and would provide a smooth transportation.

➢ **Food Grains**

Food grains would be handled at Terminal 7. Food grains, which are destined to Uttar Pradesh from northern region, would be loaded at this terminal for distribution in the hinterland of Yamuna. At present, food grains transportation takes place via railways from Punjab & Haryana to Uttar Pradesh by using their own rail siding. Part of this traffic would be diverted on Yamuna River that would be loaded at Madanpur Khadar for further distribution. This loaded food grains at terminal 7 would be unloaded at two terminals namely, Daulatpur and Prayagraj. Unloaded food grains at Daulatpur would then distribute by roadway to internal parts of Kanpur, Agra, Etawah, Auraiya and Firozabad etc. in warehouse or in main market for consumption. Unloaded food grains at Prayagraj would then distribute by roadway to internal parts of Prayagraj, Kaushambi, Chitrakoot and Banda districts of Uttar Pradesh.

➢ **Sugar**

Sugar produced in Muzaffarnagar and Shamli would get loaded at Terminal 7 at Madanpur Khadar for distributing it not only in the hinterland of Yamuna but also in West Bengal. At present, Uttar Pradesh's sugar is consumed in UP, West Bengal, MP and other nearby states. Hence, share of Sugar (final product) from Muzaffarnagar and Shamli region would be transported by roadways for loading at terminal 7. It would use NW 110 for distributing to Daulatpur and Prayagraj. Further, sugar would be transported to Kolkata by using NW 1, for distribution in West Bengal. Last mile delivery for sugar distribution from unloaded terminal would be done by roadways.

- **Iron & Steel**

Iron & Steel would be handled at Terminal 7. Imported iron & steel could be received at Haldia Port. After being unloaded at Haldia Dock Comp Bulk (HDCB), it could be further moved using NW 1 and NW 110 to Terminal 7 in Delhi. From the terminal, this cargo could be distributed to industries in the hinterland by trucks. Major consumers of imported steel, mainly steel coils are automobile industry and consumer durable industry. Multi-modal freight route, using national waterway and roadway could be very useful for distributing imported steel to industries, which are located in Delhi, NCR, UP and nearby states.

Terminal 7 could also be used for distribution of iron & steel manufactured domestically. Iron & Steel players, like Tata Steel, Bhushan Steel could use Terminal 7 and national waterway to distribute their products in Delhi or nearby cities. NW 110, along with NW 1 would play a crucial role in bridging the gap between area of production and area of consumption.

7.4.8 Terminal 8 – Daulatpur, Kanpur Dehat

A multipurpose terminal (Terminal 8) is proposed at Daulatpur, Kanpur Dehat district. This terminal would be located beside bridge on Jhansi- Kanpur Highway, i.e. NH 27. There is another bridge on Kanpur- Jhansi Highway, which runs parallel to the first bridge. Both the bridges are part of NH 27. The identified location for Terminal 8 has open land and good connectivity. An approach road is required to be developed here.

This terminal is proposed to handle clean cargo, like iron & steel, sugar and food grains. Apart from iron & steel and food grains, Terminal 8 would also be used for unloading fertilizer, which originated from IFFCO, Phulpur for local distribution. Iron & steel, which is procured from different states for distribution in the hinterland, could be diverted to waterway. For example, Bhushan Steel from Khurda Road, Odisha sends iron & steel to Agra by railway. This consignment gets unloaded at Yamuna Bridge Station, Agra. Some part of this iron & steel movement could be shifted to national waterway. It is proposed that iron & steel from Bhushan Steel plant, Khurda Road would be transported to Haldia terminal by roadways. At Haldia terminal, this cargo would be loaded in barges and would be transported further using NW 1 and NW 110 till Terminal 8. From Terminal 8, iron & steel would be further moved in roadways for distribution in the hinterland. There are many companies in Kanpur and Agra, which consume iron & steel.

The terminal would also be used for handling food grains, which originates from Punjab/Haryana and destined to Uttar Pradesh, situated on the bank of NW 110. Food grains could be partially shifted to the waterway. It is proposed that food grains from Punjab/Haryana could be loaded in Madanpur Khadar Terminal and would be distributed via NW 110 to Daulatpur, Kanpur Dehat and Prayagraj; it would further be distributed to neighbouring districts by roadways.

Terminal 8 would be used for unloading sugar, which get loaded at Terminal 7. The origin of this sugar is Muzaffarnagar and Shamli in Uttar Pradesh. After getting unloaded at Terminal 8, sugar would be distributed in the hinterland. Last mile delivery for sugar distribution from unloaded terminal would be done by roadways.

7.4.9 Terminal 14– Bakshi Moda, Prayagraj

A Ro- Ro terminal has been proposed at Bakshi Moda, Prayagraj. Truck movement on Ro-Ro from proposed Lawayan terminal (NW 1) to proposed terminal at Bakshi Moda (NW 110) has been proposed. Trucks would move from NH 76 and reach Lawayan terminal, where they would be loaded in Ro-Ro. Further, trucks would move using NW 1 and NW 110 till Bakshi Moda. A terminal could be developed at Bakshi Moda, which could be used for roll-off of trucks from Ro-Ro. These trucks would serve this region, where there are many construction sites.

Stone chips originated from Meja, Mirzapur (Chunar tensile) & Sonebhadra (Chopan & Dudhinagar Tehsil) mines could be transported through NW 1 and NW 110. Thus, truck movement between mines and city of Prayagraj could be shifted to waterway. This would also solve the problem of road congestion (mainly Naini Bridge) due to movement of heavy vehicles i.e. trucks on roads.

7.5 Proposed Passenger Terminals

Passenger terminals are identified, considering existing inter and intra district passenger movement on river Yamuna. The proposed facilities, infrastructure and other development required on NW 110, river Yamuna could be evaluated for inter district terminals and intra-district terminals. Both inter and intra district terminals are discussed in this section. For intra district movement, terminals are proposed in Prayagraj and New Delhi. These terminals have been identified based on the market survey and analysis of the needs of local economy and population. Other than New Delhi and Prayagraj, passenger transportation for the local travel in cities of river Yamuna has been discarded. Inter district terminals are proposed to handle movement in 3 routes,

- ✓ New Delhi- Vrindavan
- ✓ Vrindavan- Agra
- ✓ Agra- Prayagraj- Varanasi

The above-mentioned routes are busy and have good connectivity. However, there is heavy congestion in these routes and there is a need to develop an alternate mode of transportation. Passengers usually choose any mode of transportation based on time, cost and reliability. Distance of waterways is at least 1 km away from the city. Hence, any person willing to use waterways to travel to another city has to first travel a few kilometres to reach the water terminal. Also, water transportation is slower than roadways. The development of Yamuna Expressway along with 6 lane National highways has further reduced transportation time in the hinterland of Yamuna. People have access to good roadways for their daily commute; hence there is no requirement of terminals on other cities.

Proposed terminals at New Delhi and Prayagraj would mostly be catering tourists visiting various locations on the bank of River Yamuna. These terminals would be handling passengers and tourists likely to make local travels. In New Delhi, three intra district terminals are proposed, at Tronica City, Sonia Vihar and Jagatpur. In these terminals, water taxi could be developed for tourists. In Prayagraj, four intra district terminals are proposed, at Sujawan Ghat, Saraswati Ghat, Near Boat Club and Hanuman Ghat. These terminals would handle large number of pilgrims, tourists who visit Sangam throughout the year. The traffic increases dramatically near Sangam during Kumbh. For catering such large traffic for intra district river movement, four well-developed terminals would be very useful.

7.5.1 Inter-District

The tourist/passenger transportation on river Yamuna could be evaluated for inter district movement of tourists. River cruising is the fastest growing segment of the travel industry. River cruising is already developed in other countries, especially in Europe. There is a potential for cruise service on inland waterways in India. This cruise service would attract domestic &foreign tourists, who seeks unconventional mode of travel. River cruise would provide them an opportunity to explore the tourist places located on the bank of the river as well as enjoy the leisure ride on scenic waters of Yamuna.

This section analyses prospects of tourist transportation on river Yamuna. Prospect of starting a cruise service between New Delhi to Prayagraj using NW 110 would be explored. After Prayagraj, the cruise would sail ahead till Varanasi via NW 1. This long distance cruise service would start from Delhi (Madanpur Khadar) and would cross through cities, like Mathura, Vrindavan, Agra, Prayagraj etc., located on the bank of river Yamuna.

Table 7.2 Summarised Details of Inter-District Passenger Terminal ('000)

Locations	Districts	Lat/Long	Chainage (Km)	Fy 22	Fy 27	Fy 37	Fy 47
9. Madanpur Khadar	South Delhi	28°32'0.90"N / 77°19'34.82"E	1,050	605	668	737	815
10. Near Taj Mahal	Agra	27°10'37.23"N/ 78° 2'20.96"E	742.4	298	326	359	398
11. Vrindavan	Mathura	27°33'57.12"N/ 77°42'28.17"E	858.5	367	405	447	494
13a. Sujawan Ghat	Prayagraj	25°19'9.88"N/ 81°47'27.04"E	19.5	60	63	69	77

Tourists could disembark on places, like Mathura, Agra, Prayagraj etc. and would do sightseeing in and around these cities. After sightseeing, tourists would return to the cruise for sailing ahead on the waterway. There would be passenger terminals on the aforementioned places, which would facilitate this tourist movement. These inter district terminals are discussed below in detail.

7.5.1.1 Terminal 9- Madanpur Khadar, Delhi

Terminal 9 is proposed at Madanpur Khadar, near Okhla Barrage and it would be developed to handle tourist traffic. This terminal would be an important point in NW 110. Terminal 9 would be the start point for cruises in inter district route from Delhi to Prayagraj. Tourists would board cruise at Madanpur Khadarfor pleasure ride in river Yamuna. Inter district cruise ride would enable tourists to disembark at different terminals on the way and visit the nearby tourist places, which are located on the bank of river Yamuna. The proposed terminal has very good road, rail & metro connectivity. An approach road needs to be developed from the terminal to connect to the nearest road, Jaitpur Kalindi Kunj Road. This road further connects to Amrapali Marg, which is 2.5 km from the terminal and is well connected to Noida – Greater Noida Expressway.

There are three metro stations, which are located within 3 Km from the terminal. These stations are Okhla Bird Sanctuary, Kalindi Kunj and Jasola Vihar. Kalindi Kunj is the nearest metro station and around 2.5 km away from the terminal. Tughlakabad Station is the nearest railway station, which is around 10 Km away from the terminal. Okhla Station is located at a distance of 10.5 km. Indira Gandhi International Airport is around 26 km away from Terminal 9. Good connectivity would boost the tourist traffic in the terminal. Tourists could reach the terminal by using metro and roadways. Multi modal transportation would provide seamless travel to tourists. Tourists could easily reach the terminal in less time for boarding the cruise.

There are many places of tourist interest near Terminal 9. Some of the famous places are Okhla Bird Sanctuary, Atlantic Water World, Worlds of Wonder, and Botanic Garden of Indian Republic. Okhla Bird Sanctuary (OBS) is the major attraction near Terminal 9. It is spread over an area of 4 sq. km. wetland on the bank of river Yamuna. This wetland was formed due to the creation of Okhla Barrage. The bird species of thorny scrub, grassland and wetland are seen in the sanctuary. In this sanctuary, more than 324 bird species are sighted; out of this about 50% are migratory birds and 36% are resident birds and others are vagrant sightings. This bird sanctuary would attract nature lovers and bird watchers.

Botanic Garden of Indian Republic is another destination for nature lovers. The objective of this garden is conservation of endemic and threatened plants of the country. At present, more than 10,500 individuals of about 900 plant species brought from 23 Indian states have been conserved in different sections/areas like Economic Plant, Green Belt/Woodland, Fruit, Medicinal Plant, Cactus & Succulents, Nurseries and Water bodies.

Among major attractions are Atlantic Water World and Worlds of Wonder. Both are amusement and water parks. Atlantic Water World is spread in 5 acres of land on the waterfront of river Yamuna near Okhla Barrage. There are various types of rides and slides. Also, there is a food court with multi cuisine options. With more than twenty themed rides, Worlds of Wonder is another sought after place for tourists. There are more than 10 themed eateries are inside the premise of the park. Other parks, like Kalindi Kunj, have spacious green spaces, playground for children and places for sitting and relaxing. Tourists could walk around or simply relax in these parks. Close proximity of these tourist places from the proposed terminal would play key role to attract tourists.

7.5.1.2 Terminal 11 – Vrindavan, Mathura

Terminal 11 is proposed on the bank of river Yamuna at Panigaon Khadar in Vrindavan. It is located in Mathura district. The terminal is proposed to handle tourism traffic of inter district movement in river Yamuna. Tourists would take long distance cruise from Madanpur Khadar, which would further reach Vrindavan. Terminal 11 would play a pivotal role, as it would handle large crowd of religious and foreign tourists throughout the year. Vrindavan is a famous tourist and pilgrimage destination in the country. The terminal has good road and rail connectivity. The nearest road to the terminal is Yamuna Expressway Link Road. An approach road needs to be developed to connect the terminal with Yamuna Expressway Link Road. There is a bridge on this road, which is adjacent to the proposed terminal.

Vrindavan, along with Mathura is associated with Lord Krishna and are considered sacred places among Hindus. The distance between Vrindavan and Mathura city is around 16 km. It is said that Lord Krishna grew up and spent his childhood in Vrindavan. There are many temples in Vrindavan. Some of the famous temples are Banke Bihari Temple, Prem Mandir, ISKON Vrindavan, Madan Mohan Temple, Radha Damodar Temple and Mata Vaishno Devi Dham. Like Mathura and Vrindavan, Govardhan is also associated with Lord Krishna. It is located at a distance of around 22 km from Vrindavan. There are many legends about Krishna's life, which make Govardhan a popular pilgrimage site.

Fig. 7.6 Terminal 11 – Near Vrindavan

Devotees visit Vrindavan and Mathura throughout the year. During Holi and Krishna Janmashtami, tourist traffic increases in these places. There is considerable growth in domestic tourist traffic in Fy 17, but number of foreign tourists in Mathura didn't increase much from previous year. Development of inter district movement would attract domestic and foreign tourists to take cruise ride in river Yamuna. Tourists could disembark at Terminal 11 and visit famous temples, ashrams and other sites in Vrindavan. Then, they could further visit temples at Mathura and Govardhan. Good connectivity would help tourists to do sightseeing in these places in less time and return to the terminal for travelling ahead towards Agra, which is around 56 km away.

The proposed terminal at Vrindavan could be developed to provide tourists a pleasant and memorable travel experience. Parking facility, washroom, cafe, and canteen could be developed near the terminal. With more development around the terminal, it is very likely that tourist traffic in Vrindavan and nearby places would grow in coming years.

7.5.1.3 Terminal 10- Agra

Terminal 10 is situated conveniently opposite to Taj Mahal, one of the Seven Wonders of the World. This terminal would be a key point in NW 110, as it would handle tourist traffic for one of the largest tourism destinations in the country. Taj Mahal attracts domestic and international tourists throughout the year. This most visited monument of India alone earns a major share of revenue for the country.

The proposed terminal would be on the opposite bank of Taj Mahal. There was facility of boating at a different site near Taj Mahal; however at present, it is non-operational. There is an approach road from the terminal beside Mahtab Bagh.

Tourists have many options for sightseeing in Agra. There are many historical monuments in Agra Circle. Taj Mahal is the highlight of this destination. Other attractions are Agra Fort, Mehtab Bagh, Jama Mashjid, Moti Mashjid, Delhi Gate, Shahjahan Garden, Jahangir's Hauz, Jahangir Palace, Shish Mahal, Anguri Bagh, Diwan- e- Aam, Shilpgram etc. Tourists could also visit Fatehpur Sikri, another famous historical monument, which is located at a distance of 41 km from Taj Mahal. Despite lack of many facilities in the premise, the monument attracts a large crowd every day. Number of tourists would significantly increase, if facilities, including toilets, canteen with options for cuisine, cafe, book shop especially with books on history of India and Taj Mahal, a state-of-the-art interpretation centre, culture showcase, etc. are developed near the proposed terminal. These facilities would result in steep rise in revenues earned by Taj Mahal.

Small boats, pedal boats would be used for tourists on river Yamuna near the terminal. This boat ride would provide tourists an opportunity to enjoy the mesmerizing view of Taj Mahal from the river. To see the reflection of glorious Taj on the river water would be an unforgettable experience for tourists. Boat ride from the back side of Taj would also attractphotographers, who want to take pictures of Taj from a different perspective.

Fig. 7.7 Approach Road Connectivity to Terminal 10

Fig. 7.8 Proposed Terminal 10 Near Taj Mahal

7.5.1.4 Terminal 13a- Sujawan Ghat

Terminal 13a at Sujawan Ghat is proposed at Prayagraj for intra and inter district movement of tourists. This terminal would handle both types of tourist traffic, short distance tourists who are destined to Sangam and tourists, who would use long distance cruise service from Delhi to Prayagraj. This terminal would be developed in a large scale with big parking facility, as discussed below in Intra district section. Tourists who would take cruise ride from Madanpur Khadar (Delhi) terminal would disembark at Terminal 13a to visit Sangam and other attractions in and around Prayagraj. It is proposed that facilities, like restroom, waiting room, coffee shop, canteen, restaurant and other refreshments could be developed on this terminal. These facilities would attract short and long distance tourists to the terminal and would further boost the revenue.

7.5.2 Intra-District- Delhi

Due to increased population and demand in Delhi, there is requirement to increase options of transportations for daily commute. To cater the growing population, additional buses would be required. Further, it would lead to another challenge, i.e. finding additional piece of land for parking for additional buses. In the capital city, scarcity of space is a major hurdle. To solve the problem of growing demand and ease the burden of both DTC and DIMTS, it is proposed that water taxi could be started on river Yamuna. People would also have another mode of transportation open for their daily commute.

Table 7.3 Summarised Details of Intra- District Passenger Terminal ('000)

Locations	Districts	Lat/Long	Chainage (Km)	Fy 22	Fy 27	Fy 37	Fy 47
12a. Sonia Vihar	North-East Delhi	28°43'18.93"N/ 77°14'33.24"E	1077.5	142	149	165	182
12b. Jagatpur	North Delhi	28°44'19.76"N/ 77°13'45.90"E	1079.0				
12c. Tronica City	North Delhi	28°46'10.85"N/ 77°14'21.55"E	1081.0				

The stretch of the river between Sonia Vihar and Tronica City is identified for navigation and development of water transport facilities. It is proposed that water taxi service would start in river Yamuna to ferry passengers and tourists from Sonia Vihar to Tronica City via Jagatpur. Three terminals are proposed on the bank of Yamuna for water taxi, Sonia Vihar, Jagatpur and Tronica city. The service aims to promote tourism, reduce the burden on roadways and provide passengers an alternate mode of transportation. However, it is observed that there is good road connectivity in the three identified locations. These places are self-sufficient and people do not cross the river for their daily needs. Even after the development of water taxi in these three places, it is very unlikely that people would use the waterway for day-to-day necessities.

After the development of terminals and water taxi, people might use waterway for pleasure ride in the stretch between Sonia Vihar to Tronica City. This stretch of river Yamuna is mostly covered in thick vegetation and used for agriculture purpose. Except Sonia Vihar, area near the proposed terminals in Jagatpur and Tronica City are less populated and developed. In Jagatpur and Tronica City, human settlements are far from the river. Hence, people would need to reach terminals first for taking water taxi for their destination, which would be time consuming. Passengers may not find water taxi very attractive for daily commute, due to time sensitivity and distance from their residence.

The waterway stretch from Sonia Vihar till Tronica City has ample potential for attracting tourist traffic. This stretch of waterway would be an ideal getaway to explore greenery and wetland of river Yamuna. It would be a peaceful and relaxing experience for tourists, after the bustle and crowd they experience in the city. They could explore the calm waters of river Yamuna. Tourists from Delhi could take water taxi from Sonia Vihar and take a ride in the river. They could further explore the tourist spots located on the bank of the river, near Jagatpur and Tronica City. Three terminals in this route at Sonia Vihar, Jagatpur and Tronica City could be used for embarking and disembarking. For example, tourists could disembark at Jagatpur to visit nearby tourist attractions. After that, they could take water taxi from the same terminal to reach Tronica City to visit places. It is likely that tourism would make this waterway route commercially attractive.

7.5.2.1 Terminal 12a- Sonia Vihar

Terminal 12a is proposed on the bank of river Yamuna at Sonia Vihar. Sonia Vihar-Pushta Road passes through the identified location of the terminal. An approach road would be required for smooth connectivity from the terminal. This terminal would be the start point of the proposed waterway stretch between Sonia Vihar and Tronica City.

At present, there are pontoon bridges at Sonia Vihar for crossing the river. Small vehicles and bikes use pontoon bridges for across the river movement. There is Wazirabad Bridge on Wazirabad Road near Sonia Vihar. Currently, only one-way movement is operational in thisbridge. This bridge is getting widened and the work of widening is in progress. A Signature Bridge near Soniya Vihar is also under construction. These bridges would pose threat to the proposed water taxi. With the development of these bridges, people of the region would prefer bridges for crossing the river, instead of water taxi. Passengers who are not time sensitive would use the water taxi for across the river movement till Tronica City. The terminal would also attract people who are willing to take waterway for pleasure ride.

Fig. 7.9 Terminal 12a – Sonia Vihar

There are few temples near the terminal. A small park, Dhai Pushta Park is also located nearby. People visit this park for relaxation. This park is an open land with littleequipment installed for exercise and few chairs for sitting. The park lacks other basic facilities; still it attracts around 100 people every day. Considering the lack of recreational facility around the proposed terminal, it is proposed that a well-planned park could be developed here. This park would be equipped with facilities like toilets, canteen, cafeteria etc. This park would attract locals for walks and leisure. Tourists, who would come to the terminal for taking water taxi, would also visit the park. Development of a park and other facilities would help to attract large traffic to this terminal.

7.5.2.2 Terminal 12b- Jagatpur

Terminal 12b is proposed at Jagatpur, on the bank of river Yamuna. The terminal location is also known as Shyam Ghat. Locals use this ghat for immersion of idols during Ganpati and other religious ceremonies. Chat puja is also organized for Hindu community in this ghat. Local fishermen, who live in Jagatpur, do fishing in this stretch of the river. The identified parcel of land for the proposed terminal is surrounded by green land, used for agriculture. Residential area is at a distance of 750 meter from the terminal. There is a narrow, single lane road, named Jagatpur Bund Road, which passes through the terminal. Only 1-2 vehicles can cross at one time. It is necessary to develop a good road, to connect the terminal with the city.

Yamuna Biodiversity Park is located near Jagatpur, at a distance of approx. 2 km. from the proposed terminal 12b. The Park is presently spread over an area of approximately 457 acres. The park's objective is conservation and preservation of ecosystems of the two major landforms of Delhi, river Yamuna and the Aravalli hills. It is one of the most visited public places in Wazirabad near the proposed terminal 12b. It is a home for biologically rich wetlands, grassland communities, a wide variety of fruit yielding species and medicinal herbs. The Park also comprises native flora and fauna, which used to exist 100 years ago and then became extinct locally. It also acts as a natural conservation site for specific group of endangered plants. There is also a butterfly conservatory inside the park. The park attracts migratory birds also. One could watch Grey Herons, Black-tailed Godwits, Storks;Open bill Storks, Northern Shovellers, Pin-tailed Ducks, Spot billed Ducks, Red Wattled Lapwings etc. in this park. This place would attract students, researchers, nature lovers and photographers. This park would be major attraction for tourists, who would take the water taxi. Tourists who would take a water taxi ride from Sonia Vihar would disembark at Jagatpur. They would take roadway to reach the Park. After visiting the park, they return to the terminal to travel further in the waterway. Due to the location of Yamuna Biodiversity Park at Jagatpur, it could be assumed that Terminal 12b would be handling large number of tourists.

Fig. 7.10 Terminal 12b – Jagatpur

7.5.2.3 Terminal 12c- Tronica City

Terminal 12c is proposed at Tronica City in Ghaziabad. There is already an existing approach road that connects the terminal with the nearest road, Tronica City Road. This terminal would be used for handling passengers and tourists. Locals of the region would take a water taxi from this terminal to reach Sonia Vihar and could travel further by using roadways. Water taxi would provide people with another mode of transportation.

Like Jagatpur, this proposed terminal is surrounded by agricultural land. Population is sparse near the bank of river Yamuna at Tronica City. People live far from the river stretch. Due to the long distance between residential area and the terminal, it is very unlikely that passengers would use the water taxi service here. Locals have access to roads from the city to reach different places by roadways. The water taxi service might not attract a large number of passenger traffic, but this service is likely to emerge as a major tourist attraction.

Tourists would use the water taxi for enjoying a ride in river Yamuna. The view of green fields, surrounding the river would be a memorable experience for tourists. The stretch of the river near Tronica City is in contrast to the chaos and overcrowded parts of New Delhi. A ride in water taxi near Tronica City would provide tourists some serene and peaceful moments.

Fig. 7.11 Terminal 12c– Tronica City

7.5.3 Intra-District- Prayagraj

Four terminals are identified as Intra district terminals at Prayagraj for handling tourist and passenger traffic. Except Sujawan Ghat, all three terminals, Saraswati Ghat, Hanuman Ghat and terminal near Boat Club are located near Sangam. These terminals would boost travel across NW 110 in Prayagraj.

These terminals have been recommended to target the expected rise in tourist traffic near Sangam. It is proposed that these terminals would be developed before Kumbh 2019 to handle the surge in the number of pilgrims and tourists. Prayagraj receives large number of tourists and devotees throughout the year because Triveni Sangam is considered one of the most sacred places and most visited places in India. Due to upcoming Kumbh in 2019, Prayagraj's tourist traffic would increase dramatically. These four intra district terminals would not only be used for handling large number of pilgrims and tourists near Sangam, but also to ease travel between these four terminals. Boats and ferries are important means of internal transportation between these terminals and Sangam.

Prayagraj is popular for culture and religious tourism. Most of the tourism is centred on Sangam, which is one of the most sacred places for pilgrims in India. The nature of tourism in the region suggests that pilgrims mostly focus on religious activities near Sangam and not very keen on other recreational activities. However, if the four proposed terminals are well developed with attractive infrastructure and facilities, then tourists and pilgrims would also explore other options of recreation in Prayagraj. Initially, people would visit these terminals mostly for taking boat ride to Sangam or other terminals. During this visit, they would be aware of the new facilities and other recreational options in the terminals and would willingly explore them.

Table 7.4 Summarised Details of Intra- District Passenger Terminal ('000)

Locations of Ghats	Lat/Long	Chainage (Km)	Fy 17	Fy 22	Fy 27	Fy 37	Fy 47
13a. Sujawan	25°19'9.88"N/ 81°47'27.04"E	19.5	153	169	178	196	217
13b. Saraswati	25°25'49.58"N/ 81°52'7.57"E	3.4	87	97	101	112	124
13c. Near Boat Club	25°25'41.55"N/ 81°51'18.75"E	4.0	109	121	127	140	155
13d. Hanuman	25°25'19.17"N/ 81°51'6.11"E	2.0	87	97	101	112	124

7.5.3.1 Terminal 13a- Sujawan Ghat

Terminal 13a has been proposed at Sujawan Ghat. It is approx. 20 km away from Sangam. Currently, the terminal is not used for handling passengers or cargo. Sand mining takes place in some parts of the ghat. This terminal is proposed for handling tourist traffic, which is destined to Sangam. Keeping Kumbh 2019 in mind, the State Government has planned to develop a huge vehicle parking facility near Sujawan Ghat. The objective of developing this parking facility is to keep nearby area of Sangam less crowded with vehicles. In 2019 Kumbh, it is estimated that around 15 Crore people would come to Sangam. To accommodate this large number of people, it is necessary that parking of vehicles should not be near Sangam. People would park their vehicles at parking facility near Sujawan ghat and take boat to reach Sangam. The same route could be taken for returning from Sangam.

The development of terminal at Sujawan Ghat would also be essential to increase attractiveness of the ferry service between Prayagraj and Delhi. It is proposed that a long-distance cruise service would start between Prayagraj and Delhi for passengers and tourists. Sujawan Ghat terminal is ideal to serve this cruise service, as the proposed parking facility would help for faster evacuation of passengers and tourists.

There is a large parcel of land near this proposed terminal and there is good potential for developing this land into a fully developed terminal with many facilities to attract visitors. Currently, the land parcel is mostly empty with no facility for comfort of passengers or tourists. Facilities, like restroom, waiting room, coffee shop, canteen, restaurant and other refreshments could be developed on the terminal. Visitors could enjoy cool breeze and beautiful view of river Yamuna from the restaurant and spend some peaceful time with family and friends.

Fig. 7.12 Terminal 13a – Sujawan Ghat

Fig. 7.13 Approach Road Connectivity to Terminal 13a

These facilities and infrastructure at terminal boarding point need to be developed to make them conducive and comfortable for tourists. It is essential to create services that are likely to provide comfort to tourists. This would help in creation of economic and tourism development atmosphere. These additional facilities developed at the terminal could be translated in to additional source of revenue. It is essential to establish revenue sources for terminal to become self-sustainable.

7.5.3.2 Terminal 13b- Saraswati Ghat

Terminal 13b is proposed to be developed at Saraswati Ghat. This ghat is located beside army cantonment area, near Triveni Sangam. Although the ghat is located near army cantonment, it would not affect the development of the terminal. Recreational use of the terminal space needs to be carefully managed to avoid conflict with army operations.

At present, the ghat is used as picnic spot and boating. This ghat is a scenic place with lush greenery and clean surrounding. Aarti at night is the major attraction of this ghat, which is an auspicious occasion with lighting of many lamps/candles. People also enjoy the night view from this ghat, especially sight of beautiful lightings on New Yamuna Bridge. There are facilities, like parking area, canteen and a park. The existing canteen is small and doesn’t have many facilities for the comfort of visitors. A river facing restaurant could be developed here which would be another attraction. Tourists could relax and spend some good time here. If this ghat is developed properly, it would attract large number of tourists. There is a need to develop other facilities, like restroom, cafeteria etc. at the proposed terminal.

Fig. 7.14 Terminal 13b – Saraswati Ghat

Currently, small wooden boats are used in this ghat. These traditional old boats could be replaced with pedal boats, so that tourists could enjoy and experience the best view from the river. It would be more joyous ride as tourists would be able to experience all this at their own pace. Pedal boats provide them time and space to explore every part of the waterway near the terminal. People could come to this terminal for picnic and fun outing. Apart from having fun on the Ghat and pedal boat ride, tourists could take another boat ride to Sangam. Big boats with enough sitting capacity (around 15-20 people) could be used for transportation between Saraswati Ghat and Sangam. Ticket counter for boat ride need to be developed at the terminal.

7.5.3.3 Terminal 13c- Near Boat Club

A terminal is proposed to be developed near Boat Club for handling tourists and passengers. The Boat club is run by Boat Club Society with assistance from Prayagraj Development Authority. Boat Club Complex is a double storied building. It is situated in between two bridges of river Yamuna, Old Naini Bridge (Old Yamuna Bridge) and Naini Bridge (New Yamuna Bridge), which is a cable bridge. Yamuna Bank Road is the nearest road from Boat Club. Because of the operations of Boat Club, an approach road to the terminal is already developed. This terminal has good connectivity which would ease the traffic, even during peak season.

Fig. 7.15 Terminal 13c – Boat Club

The club has a wide range of customised boats for customers with different budgets. Boat rides are available for general public on payment of fixed tariff. There are speed boats and cruise boats with capacity of 16-20 people and small rubber boats for a trip to Sangam. Tourism department, along with the club, arrange water sports festival in this club every year in February. At present, Boat Club provides various types of water sports activities like Parasailing, Kayaking, Canoeing, Wind Surfing, Yachting, Optimist Sailing, Shallow Water Driving, Joy-Rafting and Water-Scootering. These sports activities would attract tourists throughout the year. Availability of tourism activities in the waterway near the Boat Club would help to boost tourism in the region. With the development of this proposed terminal, it can be assumed that number of tourists for water sports and other boating facilities would increase manifold. Keeping the projected tourist volume in the terminal, there is a need to develop other related facilities, like restroom, changing room, cafeteria, canteen for the refreshment and comfort of tourists.

7.5.3.4 Terminal 13d- Hanuman Ghat

At present, Hanuman Ghat is non-operational. This ghat could be developed as a full-fledged terminal for handling passengers and tourists. There is no approach road to reach this ghat. At present, there is a dirt road that leads to the ghat.

Fig. 7.16 Terminal 13d – Hanuman Ghat

There is a need to develop an approach road from the ghat for connecting to Arail Road, which is the nearest road, passing through the ghat. Old Naini Bridge (Old Yamuna Bridge) is adjacent to this terminal. Accessibility of roadways, bridge and ferry service in NW 110 from Terminal 13d would be effective for multimodal transportation of passengers and tourists. Passengers and tourists could reach till the terminal, using roadways and take boat/ferry to reach Sangam. This multimodal transportation would be very useful during Kumbh, when evacuation of people would be a major challenge.Like, other three proposed terminals in Prayagraj, in Hanuman Ghat also, facilities like restroom, cafeteria, and canteen could be developed for tourists and passengers. These facilities would provide tourists with a variety of entertainment, sightseeing, leisure activities etc. The breath-taking view of river Yamuna would mesmerize the tourists.

7.6 Infrastructure Planning

The section would discuss infrastructure planning for cargo terminals and passenger terminals. Some of the infrastructures and facilities would be same in both types of terminals, like Administrative building. However, cargo handling terminals would be equipped with various equipment and cargo handling mechanism. Whereas, passenger terminals would be developed with adequate facilities for passengers and tourists.

7.6.1 Coal Terminal - Infrastructure

5 terminals are proposed on NW 110 for handling coal. This section would discuss in detail planning for jetty and other infrastructure, cargo handling equipment and mechanism. Brief description of the proposed facilities and other required equipment is given in this section for terminal planning.

- **Jetty Infrastructure**

The cargo transfer from jetty to the coal stockpile yard has been planned with the help of manual handling including excavator, douser, etc. It could later be mechanised with rise of coal traffic. The mechanisation would require interconnected conveyor system that could handle coal with cargo carrying capacity 1600 tonnes per hour. The conveyor system would be serviced by the mobile hoppers at the jetty. However, low traffic volumes initially require internal handling and loading of coal using hydraulic excavators. These excavators would efficiently unload coal from the barges to jetty. Tipper trucks could be used to transport coal from Jetty to the stackyard. The present manual coal handling capacity has been assumed to be 800 tonnes an hour for unloading from Barge to Jetty.

The coal terminal would receive coal from ECL mines or imported coal using Haldia Port countries like Indonesia, South Africa, etc. The local coal would be transported using river barges with load point at NW 1. The size of the barge would depend upon the classification of waterways based on round the year availability of water and navigation depth. This analysis has been considered assuming terminal should be able to handle river vessels with following classifications.

- **Cargo handling Equipment**

Following cargo handling equipment/machines have been proposed for coal-handling terminal at the Coal terminal in Yamuna Port

- ✓ Tipper Trucks
- ✓ Excavators
- ✓ Pay loader and/or Dozer
- ✓ Water Sprinkler

- **Tipper Trucks**

Tipper Trucks are ideal for local transportation coal from jetty to the stack yard. Each of the tipper truck would have carrying capacity of about 20 tonnes. Hydraulic excavators would be used to load coal from the jetty to the tipper trucks. These tipper trucks would then unload the coal on to the Coal stackyard.

- **Excavator**

The preferred Hydraulic Excavator will have a zero-tail-swing design, which will allow these excavators to rotate fully without being obstructed in their tail portion. Their independent-swing boom and 360-degree rotation will allow these excavators to operate in close quarters comfortably and manoeuvre itself readily around obstacles. The excavator’s standard coupler will accommodate a wide variety of available attachments such as brakes, breakers and augers. These excavators will have a maximum digging reach of about 15ft and a maximum digging depth of around 8ft. Excavator’s long-arm/heavy-counterweight option provides the operator with an option to increase its digging depth and reach.

Excavator’s heavy-duty case frame will provide it with a solid, stable platform that will resist dirt and material build-up. Its rubber track’s steel cores will keep it from cracking and the large-diameter drive sprockets and track idles will increase undercarriage’s durability. The boom and arm stiffness are enhanced due to its single-pin swing-post design. It will also enhance the structural integrity of the digging components.

- **Pay loader/Dozers**

A wheeled Pay loader will be employed for moving the cargo around the terminals stackyard before they are loaded onto railways rakes. The Pay loader will, preferably, have a programmable clutch cut-off in order to increase productivity in all sorts of conditions. While engaging the brakes, the transmission that is maintained will be disconnected. This allows the Pay loader to perform smooth dumps, fast cycles and no machine rollback.

- **Water sprinklers**

One of the major concerns for a port handling such dirty cargo is the impact it has on the environment. Right from the loading to the unloading point, the exposure of such cargo poses environmental concerns. There are numbers of methods and measures commercially available that can either remove the causes of pollution completely or minimize it to an almost non-existent level. Water Sprinklers are one of the prominent and cost-effective solutions for suppressing dust. Water sprinklers are necessary to reduce dust generated from the coal dumped on the stackyard. These water sprinklers are essential for handling dirty cargo such as coal in environment friendly way.

➢ **Rail Siding**

Rail siding has to be developed to facilitate for inland transportation of coal from the IWAI Terminal to the power plant. The rakes would have to be loaded in the stackyard of IWAI with the help of Dozers and Pay loaders. The initial movement of cargo during this process is where dust particles are most probable of being generated. Hence, the most effective way of suppressing dust at this point is by creating a water mist layer within the wagon. Using a number of nozzles within a limited area is how the suppression will be carried out.

➢ **Admin Buildings**

Located close to the proposed terminal site, the Administrative office would serve as the base for the terminal. The building would be required for administration of the terminal. 0.5 Acre land would be required for development of administration building.

The Management team, in-charge officers, mechanical engineers and other personnel would use the building as their work base. Administration work, like clearance for terminal, collection of levy and other charges for the services and facilities of the terminal, monitoring of services, handling data for Payroll purpose, other paperwork, documentation etc. would be done in this building. The building would be used for administrative works to ensure effective, smooth and efficient functioning of the terminal, inclusive of loading/unloading of cargo, docking/undocking of vessels, dredging service etc.

➢ **Lighting & Miscellaneous**

Block estimate of electrical power requirement has been worked out considering the following items

- ✓ General power requirement for lights, fans, ventilation, cooling, and miscellaneous electrical equipment to be used for water supply, communication etc.
- ✓ Machinery, firefighting pumps, cranes, etc.

Summarising power requirement for various activities essential in Terminal
- ✓ Adequate Power Requirement for Vessels
- ✓ Sufficient Power requirement for operating electrical equipment, pumps etc.
- ✓ Power supply for mechanised loading/unloading systems

Plant and Machinery covers machinery operating on electric power in the production centres including all cranes and welding machines including all automatic, semi-automatic, and manual welding machines.

7.6.2 Multi-Purpose Cargo Infrastructure Planning

Terminal 6, 7 & 8 are proposed as multipurpose terminals for handling clean and multipurpose cargo, like iron & steel, food grains, sugar, containers etc. Terminal 6 would be developed at Mahewa East (Near Jamuna Bridge) in Prayagraj district, Terminal 7 is located at Madanpur Khadar, Delhi and Terminal 8 is located at Daulatpur in Kanpur Dehat district. Adequate infrastructure needs to be developed in and around these multi modal terminals. The key infrastructures proposed to be developed in Multi Modal Terminals are shown in below table.

Table 7.5 Proposed Infrastructure at Multi Modal Terminals

Proposed Infrastructure	Terminal 6 (Prayagraj)	Terminal 7 (Delhi)	Terminal 8 (Kanpur Dehat)
Logistics Park	✗	✗	✓
Industrial Park	✗	✗	✓
Warehouse	✓	✗	✓
Silo	✓	✓	✓

This section would discuss in detail the required infrastructures as shown in the above table.

- **Terminal 6**

Terminal 6 would be developed near Jamuna Bridge in Prayagraj. It would be dedicated to handle fertilizer from IFFCO, Phulpur Unit. Apart from fertilizer, Sugar, Food Grains would also be handled at this terminal. It is proposed that for storage of food grains 2 no. of Silo would be developed near Terminal 6. For storage and handling of sugar and fertilizer, 1 Warehouse would be developed near the Terminal.

If the volume of food grains increases and there is requirement for storage of additional food grains, then the surplus food grains could be stored in bagged form in the warehouse. If cargo volume of targeted commodities increases in future, then the warehouse could be upgraded.

- **Terminal 7**

Terminal 7 would be developed in Madanpur Khadar near Okhla barrage in Delhi. This terminal would be used for handling containers and clean cargo, iron & steel, sugar, food grains and automobile. The Terminal would also be used for unloading fertilizer from IFFCO, Phulpur for local distribution. It is proposed that for storage of food grains 2 no. of Silo would be developed near this terminal.

- **Terminal 8**

Availability of large land parcel near Terminal 8 makes it the ideal location for the development of a Logistics Park and Industrial Park. These facilities would attract existing as well as upcoming industries of the hinterland. Development of Logistics and Industrial Park will certainly boost the efficiency of Terminal 8andthe whole IWT system in river Yamuna.2 no. of Silos would also be developed for storage of food grains.

The proposed infrastructures could be developed through Public-Private Partnership.

The planning of the multipurpose terminals should be such that jetty, warehouses, silos, Logistics Park, Industrial Park are well connected and connectivity with rail and road are already in place.

7.6.2.1 Logistics Park

Development of a logistic park in Terminal 8in Kanpur would not only boost the attractiveness of this terminal but also would make this region in Kanpur the Warehousing & Logistics Hub. Development of a Logistic Park on the bank of NW 110 in Kanpur would have many advantages, which are listed below.

- This Park would provide modern and logistics facilities.
- It would benefit the existing industries, traders and farmers by providing cost effective warehousing and logistics facilities
- It would provide a large domestic market for companies storing their products.
- It would generate employment in the region.

Logistic Park is mostly developed in areas that are closer to the customer. Establishment of Logistic Park near the multi modal terminal would not only target the hinterland of the terminal, but would also target the neighbouring districts. The large warehouses and storage infrastructure in the Logistics Park facilitate supply of finished products, raw materials, spare parts etc. and help in reducing logistics costs and optimize delivery time. It becomes commercially attractive for storing finished products, raw materials and spares for a longer period of time. On demand from customers, they are shipped to final destination at short notice. This has led to manufacturers creating storage and warehousing infrastructure closer to consumption centre. For instance, Logistics Park and Industrial Park near Terminal 8 would provide large market for manufacturers of Kanpur and nearby districts. The strategic and conducive location of the terminal would help the Logistics Park to attract industries to NW 110 for transportation of their cargo through inland waterway.

Logistics Park would facilitate storage of goods and their movement to consumption clusters through rail or road. This would optimize logistics processes through economies of scale. The processing zone located in the Logistics Park would have warehouses of industries, traders of iron &steel, fertilizer sector, etc. Products generated from factories located in the hinterland could be brought to this Logistics Park for storage. Some of the items are repackaged. Items supplied to the Park are in large volume. However, the final products are repackaged in smaller consignments ready to be delivered to final consumers at distribution stage.

The zone area would have large warehouses. All infrastructures, connecting road with warehouses and external connectivity need to be planned considering uninterrupted flow of cargo.

Logistics Parks provide several facilities to users. To set up a successful Logistics Park near Terminal 8 on NW 110, IWAI would require investing to provide the following supportive facilities.

7.6.2.2 Warehousing

Due to the versatile cargo mix targeted by Terminal 8, it is essential to design warehouses that could accommodate all types of cargo in Logistics Park. Covered Warehouses would be developed for storage of various types of commodities. Warehouse should be equipped with highly efficient cargo storage facilities. Bagged storage in warehouse can accommodate multi commodities. A well-planned Warehousing space performs valuable functions that support the movement of materials, storing goods, processing products, de-aggregating vehicle loads, assembling shipments etc.

Storage is one of the most crucial aspects of a Logistics Park. Both Multi Modal Terminals, 6& 8 would have Warehouse facilities. These terminals would handle commodities of various categories, like iron & steel, fertilizers, sugar and food grains. Considering the various types of commodities, the terminal targets to handle, following types of warehouse facilities could be developed in Logistics Park in Terminal 8.

- Customized warehouse –Some of the targeted commodities require a separate warehousing structure. For instance, iron & steel and fertilizer will have distinct warehousing requirements. Customized warehouses for some commodities (which require customized warehouse) could be developed in Logistics Park to attract maximum cargo.

- General warehouse – Apart from customized warehouse, a general warehouse will be useful for storing items, which do not require any customized facilities. For example, for storing sugar, there is no need of a customized warehouse. Sugar could be packed in bags and stored in the warehouse.

7.6.2.3 Enhanced Transportation Facilities

Terminal 8 would have to ensure enhanced transportation facilities for easy movement of goods to and from Logistics Park. These include Road, Rail and IWT transportation. Parking area and truck terminal need to be developed.

A clearly identifiable access should be provided to the main entrance of the Logistics Park. At all times, service traffic should be segregated from other traffic and pedestrians to ensure ease-of-movement of goods within the Logistics Park. Access routes would be clearly marked to address situations arising out in case of emergency.

7.6.2.4 Supportive Infrastructure

A Logistics Park will have to provide an advanced support infrastructure to its users. Such support infrastructure includes:

- ✓ Sufficient and wide roads connecting the park, for the free flow of two way traffic all throughout the day
- ✓ Space for multiple clients and industries and for future expansion
- ✓ Ample parking space for truck and office parking
- ✓ Security
- ✓ Power back up
- ✓ Integrated park management to handle general maintenance, landscaping, security &waste management
- ✓ State-of-the art warehousing facilities
- ✓ Emergency services (Firefighting system & Ambulance)
- ✓ Public facilities like canteen, banking, office space and other service facilities
- ✓ Plant for storage and treatment of water
- ✓ Sewerage treatment plan
- ✓ Green area or an open space

7.6.2.5 Warehouse Design for Logistics Park

Planning and designing of Warehouses and other support infrastructure is most essential part of developing Logistics Park. A Logistics Park gets to store a wide range of semi-finished products and finished products. The type of products and their size and volume vary in large range. Hence, there is a need to introduce varsity in the design and layout of warehouses for Logistics Park.

The warehouses proposed in the Logistics Park of Terminal 8 would mostly have Bulk cargo like fertilizer and sugar. Break bulk cargo, like Iron & Steel would also be handled. Apart from the present types of cargo, the logistics park could also target upcoming industries in the proposed Industrial Park. Raw material and finished products from these upcoming industries could also be stored in these warehouses.

While designing warehouse for Logistics Park at the Terminal, the developer would have to consider several aspects related to building design, landscaping, utilities and more. The key aspects that need to be considered when designing a warehouse are discussed below.

- **Building Design**

The facility should comprise of separate space for administration, warehouse and command areas. Access to all areas of the administrative section should be provided through internal circulation corridors. The minimum width of the internal corridors should be five feet. Also, the ceiling height & material and floor material of the internal corridors should be similar to that of the adjoining office space.

- **Landscaping**

To define the main entrance and the warehouse site, landscaping elements should be used. Landscaping will help improve the attractiveness of the site. It can also be used as a natural separation between parking areas.

- **Utilities**

The site of warehouse should have all essential utilities such as:

✓ Water
✓ Sewerage
✓ Natural gas
✓ Sprinkler system
✓ Electricity
✓ Telephone
✓ Fire alarm

- **Security**

Only authorized people should be allowed between the administrative office and the warehouse facility to ensure adequate security for the goods stored in the Logistics Park.

- **Loading dock**

The Logistics Park should have a covered or open loading dock. Covered loading dock has advantage of protection from elements, like rain and sun. In covered loading dock, handling goods become easier during monsoon. The operating area of the Logistics Park where activities like receiving, shipping, packaging and distribution are carried out should be easily accessible from the loading dock.

- **Architectural aspects**

There should be a strong correlation between the architectural and interior design of the facility. Modular systems furniture should be used to ensure maximum space utilization. Wherever possible, the use of natural light in the Logistics Park should be considered.

- **Scope for expansion**

The Logistics Park should be designed in such a way that it can accommodate change and expansion in the future. Projected future needs should be taken into account to ensure cost-effective expansion without having to entirely redesign the original construction.

7.6.2.6 Industrial Park

Development of an organized Industrial Park near multi modal terminal (Terminal 8) in Kanpur would attract industries (big & small) for setting up their plants in the park. Giant industrial players would also evaluate option of setting up their units in this park. Kanpur is an industrial hub of Uttar Pradesh.
The existing and upcoming industries of Kanpur could use the industrial park for setting up their manufacturing plants there. Among the many benefits of Industrial Park, one is that it would facilitate ease of doing business and promote employment generation in the region.

Industrial parks are generally developed in the vicinity of Port or at location where strong road or rail connectivity exists for smooth transportation. Many financial incentives and assistance or tax redemption is offered to industries for setting up their units in these parks. In industrial park, mixed activities are carried out ranging from production, storage, transportation etc. The area required for warehousing and production differs as per operations of Industrial Units. Industrial Park on the bank of Yamuna would be connected to Kolkata/Haldia Port using NW110 and NW 1. Apart from waterway connectivity, it would have national highway/railway connectivity. This makes the ideal scenario for the development of such park near Kanpur and Prayagraj Terminal. The development of Industrial Park would help to boost the economy of Kanpur &Prayagraj districts by providing employment opportunities.

Due to ongoing Eastern & Western Freight corridor project that passes through Uttar Pradesh, State Government is initiating to develop industrial parks to boost the economy. This initiative would complement the development of NW 110 as well. Proposed freight corridor development would automatically help to boost the development of Industrial Parks in the vicinity for faster turnaround.

As per Indian state's policy, minimum 20 ha.of land is required to develop industrial park for food & agro industry which would have at least 10 industrial units.

At present Kanpur Dehat does not have large-scale industrial units. Kanpur terminal is proposed to handle food grain, automobile, sugar, fertilizer, iron & steel etc. hence Food based industries, Iron & steel; Automobile assembly units, etc. could be set up in the proposed industrial park at Kanpur. This would enable to develop Kanpur Dehat as industrial hub.

Prayagraj is a tourism hub hence proposed industrial park nearby terminal 6 and 5 would not be as big as Kanpur. Prayagraj terminal is proposed to handle food grain, sugar, fertilizer etc. Small-scale units such as re packaging, distribution, warehousing etc. could be set up at Prayagraj Industrial Park.

Apart from above mentioned industrial units, other industries could as well set up their manufacturing units in this Industrial Park due to various benefits offered.

Following are common guidelines to be followed for developing Industrial Park at Kanpur &Prayagraj.

(i) Industrial park must follow urban development authority guidelines when developing common infrastructure facility.
(ii) Industrial activity should be carried out within 65% of the total land area allotted for Industrial Parks. Other area should be utilized for development of amenities such as fire & Safety facilities, Security facilities, Canteen, ATM, Primary health centre, ancillary logistic facilities etc.
(iii) Truck parking area at entry/exit points is to be developed to facilitate incoming & outgoing traffic from Industrial parks. Cranes & heavy weight lifting equipment should be available to load/unload cargo on truck/rail/barges etc.
(iv) Apart from above mentioned points, no commercial activity should take place within the premise of Industrial Park.
(v) If the proposed industrial park is coming within the premises of Defence (within 500 m) then necessary clearance license must be obtained.
(vi) Residential area for workers should be available within the radius of 10 km to save travel time.
(vii) Industrial Park should not be developed on ecological & other sensitive areas such as Taj Mahal or religious/historic places. Hence ideal location for the development of this park would be that location where industrial

activity is carried out either on small or bigger scale, i.e. Kanpur &Prayagraj. This would help to boost the cargo traffic on NW110.

(viii) Industrial park should be at least 1/2 km away from flood plain area of river. Industrial park must have Road & Rail connectivity within the range of ½ km.

(ix) Kanpur &Prayagraj Terminal has road/rail connectivity within close proximity of terminal. Yamuna Bridge connects to Prayagraj terminal. Jhansi Kanpur highway connects to Kanpur terminal.

As per State Government Policy 2017, Food, textile, IT and Pharma industrial park would be developed around the vicinity of national highways, expressways etc. Logistic facilities, truck terminals & accommodation within industrial park would be promoted. The State Government would focus on promoting private industrial parks around Lucknow-Kanpur, Kanpur- Prayagraj and Varanasi-Prayagraj zones. This policy compliments the development of industrial park nearby proposed terminal on NW110.

7.6.2.7 Silo

Silos are primarily the large tank type structures for storage of food grains or other materials in monitored atmosphere. As silos are tank type, high vertical structures, wheat or other grains are stored in bulk form only. Silos are used by a wide range of industries to store bulk solids in large quantities.

For Terminal 6, 7 and 8, Steel silos are recommended. 2 no. of steel silos could be built near these Terminals. Each silo would have a storage capacity of 5,000 tonnes. As each multi modal terminal on NW 110 would be equipped with 2 silos; hence they could store 10,000 tonnes of food grains. Being a river-side installation, low load-bearing capacity requirement makes the Steel silos a suitable choice. These Steel Silos could be built faster in 10-12 months. The industrial life of a steel silo is 25-30 yrs.

It is proposed that flat-bottom steel silos would be developed near Terminal 6, 7 & 8. Capacity wise, flat-bottom silos are preferred worldwide as they offer larger space per unit cost. This type of silo has an elegant system of grain discharge.

Silos are capable of not just storing grains but also maintaining the grains' quality by controlling the atmosphere within its enclosure. Silo structures follow a scientific method of storing grains, which enables better preservation of food grain sin bulk and for longer periods. It enhances the shelf life of food grains.

Following is a visual representation of a typical flat-bottom Steel Silo:

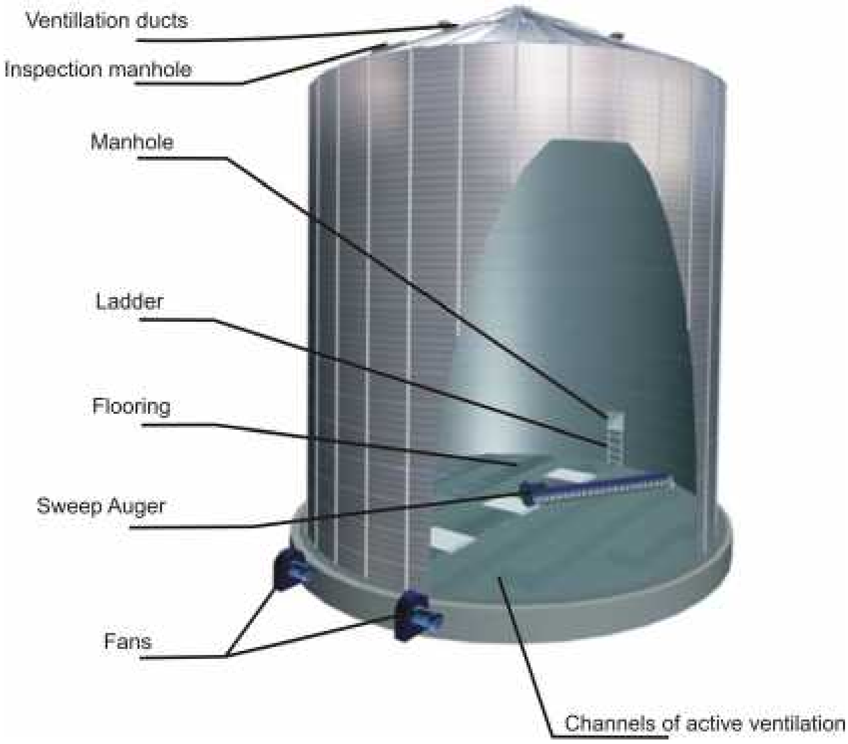


Fig. 7.17 Flat Bottom Steel Silo

Source: SKESS Corporation

Features, such as aeration (drying), fumigation and temperature monitoring and control make modern silos a necessary infrastructure in the grain processing and transportation industry. With changing weather and moisture content in grains, their volume is bound to undergo changes when stored inside the silo. A steel silo is flexible enough to allow for a modest degree of expansion when grains' volume increases due to rise in moisture content. Once grains enter the silo, they will be treated further to minimize damage caused by fluctuations in temperature, heat and moisture. Further, advantages in erection and maintaining the original grain quality makes Steel Silo the perfect storage solution in the context.
If food grains are stored in Silos and transported in bulk, losses due to theft, pilferage and transportation would be negligible compared to food grains storage in bags in conventional warehouses. If land is taken into account, silos are cheaper than building conventional warehouses. Silo is a vertical storage facility; hence it requires smaller parcel of land for development.

7.6.2.8 Utilities required for Proposed Silos

- ✓ Electricity
- ✓ Water Supply
- ✓ Fire Detection & Fighting System
- ✓ Sewerage

Facilities, like adequate parking space and good road & rail connectivity would complement the efficiency of Silos in Terminal 6, 7& 8. Parking facility of these terminals could be used for parking food grain trucks and unloading/loading of grains. Well-developed internal roads and good road & rail connectivity from Terminals would enable smooth transportation of grains to the Silo facility and dispatch of the grains from the facility.

7.7 Dirty Cargo – Handling Process

It is proposed that 5 terminals would be developed on NW 110 for handling coal and fly ash. Terminal 1 would handle only coal, whereas four other terminals (Terminal 2, 3, 4 & 5) would handle both coal and fly ash. The below table shows the location of these 5 terminals handling dirty cargo.

Table 7.6 Details of Dirty Cargo Handling Terminals on NW 110

Terminal	Location	Districts	Lat/Long	Chainage (Km)	Cargo
1	Madanpur Khadar	South Delhi	28°31'7.39"N / 77°20'19.06"E	1047.8	Coal
2	Samogar Mustkil	Agra	27°10'53.83"N/ 78°8'3.89"E	731.0	Coal
					Fly Ash
3	Mahewa Khachhar	Kaushambhi	25°23'23.10"N / 81° 9'34.83"E	98.0	Coal
					Fly Ash
4	Dilauliya Kachhar	Kanpur Dehat	26° 7'44.63"N / 79°45'49.34"E	349.2	Coal
					Fly Ash
5	Near Naini Bridge	Prayagraj	25°25'25.69"N / 81°51'39.33"E	3.0	Coal
					Fly Ash

As shown in the above table, coal handling terminals (Terminal 1-5) would cater to the coal (procured & imported) requirement of the numerous power plants in the hinterland. Terminal 1-5 would receive coal from various mines like Piparwar mines, Eastern Coalfield Ltd. (ECL), Bharat Coking Coal Ltd. (BCCL), Northern Coalfield Ltd. (NCL), Northern Karanpura Coal Fields (NKCF) and Central Coalfields Ltd. (CCL). Coal from these mines would be brought to the nearest terminal on NW 1 through railways and from NW 1; it would be further moved on NW 110. This coal would be unloaded at Terminal 1-5 and would further be transported to the destined thermal power plants. This section would discuss coal and fly ash handling process, evacuation process, storage facilities etc. in these terminals.

- **Terminal 1 – Madanpur Khadar, Delhi**

Terminal 1 would handle coal for two thermal power plants, NTPC, Dadri and Badarpur Thermal Power Station. Considering availability of a freight station in Okhla, it is proposed that coal from Terminal 1 would be transported to these power plants by railway. NTPC plant would receive this cargo on its own railway siding at Dadri.

- **Terminal 2 – Etmadpur, Agra**

Terminal 2 would be dedicated to handle coal requirement for Harduaganj Thermal Power Station and Jawaharpur Thermal Power Station. The terminal would also handle fly ash. Coal would be unloaded from barges in this terminal and would be sent to Harduaganj (HGJ) freight station by railway. Harduaganj TPS is located in Aligarh district of Uttar Pradesh. Jawaharpur TPS is an upcoming thermal power plant, located at Etah district in Uttar Pradesh. From the terminal, coal would be evacuated in freight train and reach the destination, i.e. Jawaharpur Kamsan Halt (JWK).

- **Terminal 3 – Mahewa Kachhar, Kaushambhi**

Terminal 3 would handle coal and fly ash for two thermal power plants, i.e. NTPC, Tanda and Unchahar TPP. Coal would be unloaded at Terminal 3 and would be further transported to Unchahar TPP by railway. This coal cargo would be received at Feroz Gandhi Thermal Project Siding (FGTP). Railway would also be used to transport coal from the terminal to railway siding at Tanda Thermal Powerhouse (TTPH). NTPC Tanda is located in Ambedkar Nagar district.

- **Terminal 4 – Dilauliya Kachhar, Kanpur Dehat**

Terminal 4 would handle coal and fly ash. It is proposed that Terminal 4 would handle coal requirement of three thermal power plants located in the hinterland, Parichha TPP, Panki TPP and Rosa TPP. From the terminal, coal could be shifted by railway to the siding of Parichha TPP in Jhansi. For Panki TPP, coal could be evacuated from the terminal by railway and would be transported to Panki (PNK) freight station. Railway would be used for coal transported from the terminal to Rosa TPP.

- **Terminal 5 – Near Naini Bridge, Prayagraj**

Terminal 5 would handle coal and fly ash. The terminal would handle coal requirement of Meja Thermal Power Station and Bara Thermal Power Station. From the terminal, coal would be loaded in freight train and reach Meja Road (MJA), which is the nearest freight station from Meja Thermal Power Station. Railway would also be used for coal transportation from the terminal to Bara Thermal Power Station. Coal would be loaded in freight train near Terminal 5 and would further move to Bevara (BVAR) freight station, which is the nearest freight station from the plant.

7.7.1 Unloading at Jetty

The unloading system in the proposed terminals (Terminal 1-5) should be such that it would minimize dust emission and ensure provision of a clean surrounding environment. Vessels for dirty cargo would be handled at the jetty, designated for coal handling. Unloading procedure from barges could be carried out through numerous Hydraulic Excavators. The benefit of using these highly efficient excavators is that it reduces unloading time and facilitates cost savings.

The cargo transfer from jetty to the coal stockpile yard has been planned by tipper trucks. Each hydraulic excavator shall discharge the cargo, unloaded from the barge directly into the tipper truck, which in turn discharge the cargo onto the terminal stackyard. The Excavators would lift at least 3.5 MT of coal in one given scoop of the bucket attachment.

7.7.2 Coal Transfer from Jetty to Stockyard

The Excavators collect the cargo from the jetty and load it in tipper trucks. These tipper trucks will be positioned right at the dropping point of the Excavator. Excavator would be dropping the cargo directly into the truck. After the cargo is dropped into the tipper truck, cargo is moved towards the stackyard. The usage of a tipper truck ensures that coal is dumped in the stackyard with a smooth flow.

The entire mechanism is efficient as it would keep the wastage of the product to minimum. It ensures the efficient handling of the material, by opting for a streamline approach for the whole operation and minimizing pollution caused by dirty cargo handling.

One of the major concerns for a terminal, handling such dirty cargo is the impact it has on the environment. During the entire handling process, the exposure of such cargo poses environmental concerns. The whole procedure of coal handling inside the terminal would be done with care to ensure clean environment. Dust Suppression System and water sprinkler would be used to reduce air and water pollution from coal dust. Water Sprinklers are one of the prominent and cost effective solutions for suppressing dust.

7.7.3 Stack yard Operations

In Terminal 1-5, stackyard of 0.20 mnT would be developed in Phase I. The capacity of the stackyard would be upgraded to 0.5 mnT in Phase II. The stockpile capacity of around 5 tonnes per sq.m.is considered for a stack height of 6 m. The terminal’s cargo handling infrastructure would have to be designed to achieve a targeted daily throughput. The Tipper truck will continue to discharge coal in the stackyard. The height of the heap should not go beyond 6 m. Once this height is attained, tipper truck needs to be moved to another stackyard location in the terminal. Another option could be after the Tipper truck has finished discharging coal of the needed height, Pay loader or Dozer, or a combination of both will be employed to move the coal stack to another spot in the yard. This will allow the tipper truck to continue discharging coal, without allowing the height to exceed the desired limit, and providing vacant spot for further discharge by the tipper truck. Pay loader or Dozer will be employed in the terminal for stackyard operations. The stackyard for coal would be open; hence it is necessary that Water sprinklers would be used to reduce dust generated from the coal dumped on the stackyard.

7.7.4 Coal Evacuation

Terminal 1-5 would have rail siding. Each rake is fitted with 59 wagons and each wagon has the capacity of 60 MT. Therefore, a typical rake would be able to transport 3,540 T of coal, translating into a daily throughput of about 24,000 MT of coal.

For evacuation of the cargo, number of Hydraulic Excavators would be utilized. These excavators, each with a bucket capacity of roughly 3.5 MT will collect the cargo from stackyard and load them into the rake wagons stationed in the rail yard, adjacent to the coal stackyard. The railway line inside the terminal would ensure efficient evacuation of the cargo.

7.7.5 Fly Ash Handling

Terminal 2, 3, 4 & 5 would handle fly ash. Fly Ash generated from the thermal power plants in the hinterland would be exported to Singapore and Bangladesh through Haldia Port. Fly Ash would be transported from the plants to the port using NW 110 and NW 1.

The dirty cargo terminals would be equipped with equipment and mechanism to handle both coal and fly ash. The process of handling coal and fly ash in the terminal would be similar. The major difference between coal and fly ash handling is their origin and destination route is different. Coal would be received in the terminals and evacuated for getting transported to the destination, i.e. power plants. Whereas, fly ash would originate from the power plants and would be transported to the terminal using railway and further would be evacuated using waterway.

Fly ash would be stacked in the allotted stackyard, after being received in the terminal by railway. The stackyard would be open; hence it is necessary that Water sprinklers would be used to reduce dust generated from the fly ash dumped on the stackyard. For evacuation, fly ash would be moved to the jetty, where it would be loaded in vessels and then would be further moved to the port, i.e. Haldia Port for export.

7.8 Multi-Purpose Terminals – Handling Process

It is proposed that 3 multipurpose terminals would be developed on NW 110 for handling clean cargo, like fertiliser, food grains, sugar, iron & steel etc. Jetty on these three terminals would be fully equipped with equipment, ideally suited for loading and unloading bulk cargoes along with full mobile equipment like pay loaders, excavators and other units to handle bulk and bagged cargo. Forklift trucks and reach stackers are other useful equipment in multipurpose terminals.

These terminals would also have highly efficient cranes, like Mobile harbour cranes instead of large Gantry Cranes. The use of mobile harbour cranes is significantly increasing in smaller terminals with multi-purpose cargo. These cranes are versatile and flexible. They would be equipped with a variety of lifting devices, like C-hooks, hydraulic tongs, which would facilitate handling of various types of commodities. These would also reduce the required number of cranes in each multipurpose terminal, as there would not be any need for different cranes for different commodities.

The below table shows the location of 3 multipurpose terminals.

Table 7.7 Details of Multipurpose Terminals on NW 110

Terminal	Location	District	Lat/Long	Chainage (Km)	Cargo
6	Near Jamuna Bridge	Prayagraj	25°25'15.19"N/ 81°50'59.98"E	4.2	Fertiliser, Food grains, Sugar, Automobiles
7	Madanpur Khadar	Delhi	28°31'45.09"N / 77°19'48.17"E	1049	Food grains, Container, Sugar, Iron & Steel, Automobile
8	Daulatpur	Kanpur Dehat	26° 7'54.75"N/ 79°45'20.31"E	349.8	Food grains, Sugar, Iron & Steel, Fertiliser Automobiles

- **Terminal 6 – Near Jamuna Bridge, Prayagraj**

This terminal would be used for handling clean cargo, like iron & steel, sugar, food grains. The Terminal would also be used for unloading fertilizer from IFFCO, Phulpur for local distribution.

- **Terminal 7- Madanpur Khadar, Delhi**

Terminal 7 would handle containers, automobile and clean cargo, iron & steel, sugar, food grains. This terminal would be used for the export-import container trade of the hinterland, using Haldia / Kolkata Port as the outlet for evacuation of these containers. The terminal would target goods, like automobile components, electrical goods, machinery etc.

- **Terminal 8- Daulatpur, Kanpur Dehat**

This terminal would be dedicated for handling clean cargo, like iron & steel, food grains, sugar and fertiliser. Last mile delivery for sugar distribution could be done by roadways.

7.8.1 Fertiliser & Sugar

Fertiliser from IIFCO Phulpur plant would be transported in bagged form through NW 110. The terminal should be equipped with equipment and required facilities to handle fertiliser. Multi-Purpose terminals would also handle sugar, which would be in bagged form. As both, fertiliser and sugar would be in bagged form; hence both these commodities could be handled by similar equipment, facilities and process.

7.8.1.1 Unloading at Jetty

Fertiliser & Sugar would be transported in bagged forms through vessels on NW 110. This fertiliser & sugar would be unloaded at the jetty. After unloading, bags of fertiliser & sugar would be carried by forklift trucks, which would further carry it to the warehouse in the terminal premise.

7.8.1.2 Transfer from Jetty to Warehouse/ covered stackyard

The material (Fertilizer& Sugar) unloaded at jetty would need to be transported to warehouse for storage. The bagged material shall be stored at the allotted warehouse or covered stackyard.

7.8.1.3 Warehouse for storing Fertiliser & Sugar

Warehouse in themultipurpose terminals would be equipped with highly efficient cargo storage facilities. Bagged storage in warehouse can accommodate multi commodities. Fertilizer& sugar, received from the jetty in bagged form would be stacked in a warehouse.

7.8.1.4 Evacuation

Fertilizer& Sugar, stored in the warehouse in bagged form would be loaded in trucks and through roadways it would be evacuated from the terminal. Roadways would be used for short distance destinations. Where as, railway could be used for distribution in far off destinations. For railway evacuation, bagged fertilizer and sugar would be loaded in rakes in the railways yard inside the terminal.

7.8.2 Food Grains

Food grains, like wheat and rice would be handled in bulk form in the terminal. After unloading at jetty, food grains would be stored in silo and further bagged before evacuation through roadway/railway.

As all the types of food grains are compatible with each other, a single system can be used for handling them one after the other. Suitable machinery or equipment would be used in the terminal for handling food grains.

7.8.2.1 Unloading at Jetty

The food grains typically received in bulk would be unloaded at the Jetty and would be loaded in tipper trucks for further carrying it to the silo for storage. If the received food grains are already cleaned, then it could be directly sent to silo for storage, else food grain undergoes a process of cleaning for removal of dust and other foreign materials. After cleaning, food grains are moved to the storage facility.

7.8.2.2 Transfer from Jetty to Silo/Warehouse

Clean food grains would be moved in silo for storage. Here, food grains could be stored for long duration, following scientific methods, like fumigation and temperature monitoring and control.

7.8.2.3 Silo/ Warehouse for storing food grains

Steel silo would be used for the storage of food grains. These steel silos are vertical storage arrangement, will occupy least space and the food grains are fully protected from outside atmosphere. It is proposed that in Terminal 6 & 7, there would be 5 silos, whereas in Terminal 8, there would be 3 silos. Food grains can also be stored in warehouse in bagged form.

7.8.2.4 Evacuation

The grain in the transit storage in silos will be evacuated from the bottom of silos through a closed conveying system, which will transfer the grain to the grain loader specially designed for the purpose.

Further, food grains would be transferred to the bagging facility for bagging and stitching. After bagging process, the bagged food grains would be loaded in trucks for evacuation through roadways. For railway evacuation, bagged food grains would be loaded in covered rail wagons in the railway yard.

7.8.3 Iron & Steel

Iron & steel would be transported on vessels using NW 110 and would be handled in multipurpose terminals. There would be equipment and required facilities in the terminals to handle iron & steel. From the terminals, this cargo would be distributed in the hinterland by roadways.

7.8.3.1 Unloading at Jetty

Iron & steel would be unloaded at the jetty. Cranes would be used for unloading the steel coils from the jetty. Mobile harbour cranes could be used for handling steel. After unloading from the vessel, cranes would load the cargo in fork lift trucks or reach stackers for moving cargo to stackyard.

7.8.3.2 Transfer from Jetty to stack yard

There would be open stackyard in the terminals for stacking iron & steel. Iron & steel would be moved from jetty to stackyard by fork lift trucks or reach stackers.

7.8.3.3 Evacuation

Evacuation of iron & steel from terminal would be done through roadways. Cargo from Stackyard would be loaded in a trailer by crane. These trailers would have large carrying capacity and they would ensure smooth transportation of cargo from the terminal to the destination for distribution.

7.8.4 Automobile

Automobile would be handled in the multipurpose terminals. Terminal 7 (Madanpur Khadar) would be used for loading automobile and terminal 6 (Prayagraj) and 8 (Daulatpur, Kanpur Dehat) would be used for unloading automobile. These terminals would ensure smooth automotive logistics.

Automobile would be loaded in Car (Vehicle) Carrier for waterway movement on NW 110. Car Carriers are capable of transporting a wide variety of automobiles, such as Cars, Trucks, Buses etc. In the destined terminal, automobile would be unloaded from the Car Carrier and would be parked in stackyard, assigned for Automobile. This car storage area would facilitate storage of cars and other vehicles which would not immediately evacuate the terminal. For evacuation, trailers would be used. Automobile would be loaded in trailers from the storage area and then would be transported to their destination using roadways.

7.8.5 Container

Multipurpose terminal, i.e. Terminal 7 at Madanpur Khadar would be used for handling containers. Container trade from Northern region, like Delhi, NCR, Uttar Pradesh could use this terminal to load their container for transporting them through waterway to Haldia / Kolkata Port (Haldia International Container Terminal) for export.

The jetty would be developed in a manner that it would be adequate to handle clean cargo as well as containers. Containers, loaded in trailers would be received in the terminal. They would be unloaded from trailers and would be stacked in the container stacking yard. Containers would be transported to the container stacking yard by fork lift trucks or reach stackers. They would be stored in pre-designated slots in the stacking yard.

For evacuation, containers would be moved from the container yard by fork lift trucks or reach stackers and would be moved to the jetty. Further, they would be loaded in the vessels by cranes (Mobile harbour cranes). After getting loaded in the vessel, containers would be transported using NW 110 and NW 1 to reach Haldia / Kolkata Port. From the port, these containers would be shifted to the mother vessel for getting exported.

7.9 Coal Terminal Planning & Layout

7.9.1 Terminal 1 – Madanpur Khadar, Delhi

This terminal is located at Madanpur Khadar, below Okhla barrage on the right side of river Yamuna. An approach road would be required to connect the terminal to the 2-lane road (Bandh Road) that passes near the terminal. Terminal 1 is located within 1 km from Bandh Road. The area around the terminal is well developed in terms of connectivity. The Noida- Greater Noida Expressway is 2 km and the nearest Rail freight station, Tughlakabad is 12 km and Okhla freight station is 13 km from the terminal.

Fig. 7.18 Mapping of Connectivity for Terminal 1

There is an upcoming six-lane bridge parallel to the Okhla barrage, intended to connect South Delhi and Noida and reduce the traffic congestion on the existing Amrapali Bridge. Being located in the NCR region, the terminal has many Industrial Estates around it. The thermal power plants of NTPC Dadri and Badarpur are located at a distance of 38 km and 11 km from the terminal respectively. The terminal is connected to NTPC Dadri by the 2-lane Bandh road, which further connects to Vishwakarma Road- Dadri Main Marg - Kheri Road, leading to the power plant. The terminal is connected to Badarpur TPP by the 2-lane Bandh Road, which further connects to Amrapali Marg - Kalindi Kunj Mithapur Road - Shaheed Bijender Gurjar Marg, leading to the power plant. These plants are procuring coal from Piparwar mines and ECL, so in near future they can switch to waterways, generating coal traffic for the terminal.The below figure depicts satellite image of the location near Madanpur Khadar, identified for Terminal 1. The image also shows road connectivity around the terminal location.

The table below shows phase wise capacity and utilization of Terminal 1.

Table 7.8 Capacity Calculation of Terminal 1

Particulars	Phase I		Phase II		Units
	2022	2027	2037	2047	
Proposed Jetty					
Coal Traffic	1.59	2.03	2.87	3.85	mn T
Length of Terminal	125	125	250	250	m
Capacity of Barges	1,000	1,000	1,000	1,000	DWT
Parcel Size of Barges	900	900	900	900	T
Unloading Rate	800	800	800	800	T/Hr.
Barges alongside simultaneously	1	1	2	2	
Assumptions					
Hours of Operation	10	10	10	10	Hr.
Days of Operation	300	300	300	300	Days
Capacity Okhla Coal Jetty	2.4	2.4	4.8	4.8	mn T
Capacity Utilisation of Terminal	66%	85%	60%	80%	

Table 7.9 Land Area Required for Terminal 1

Particulars	Phase I		Phase II		Unit
	2022	2027	2037	2047	
Demand Assessment					
Coal Traffic Potential (mn Ton)	1.592	2.031	2.866	3.851	
Terminal Capacity	2.4	2.4	4.8	4.8	mn T
Jetty Storage as % of traffic	10%	10%	10%	10%	
Stackyard Capacity Required	0.2	0.2	0.5	0.5	mn T
Stockpile Height	6	6	6	6	m
Stockpile Capacity	5	5	5	5	Tonnes/Sq. m
Capacity Deficit (No existing, Requirement)	0.23	0.23	0.46	0.46	Acres
Stackyard area required	45,600	45,600	91,200	91,200	Sq. m
Stackyard area required	11.3	11.3	22.5	22.5	Acres
Space Margin Provided for Equipment Movement (10%)	1.1	1.1	2.3	2.3	Acres
Total Area for Stackyard	12.4	12.4	24.8	24.8	Acres
Land Area required for Terminal Facilities	2.3	2.3	2.3	2.3	Acres
Green Zone	2.7	2.7	6.7	6.7	Acres
Road, Rail & Open Space	9.3	9.3	14.7	14.7	Acres
Total Area for Coal Terminal	26.6	26.6	48.4	48.4	Acres

Fig. 7.19 Mapping of railway line extension till proposed Terminal 1

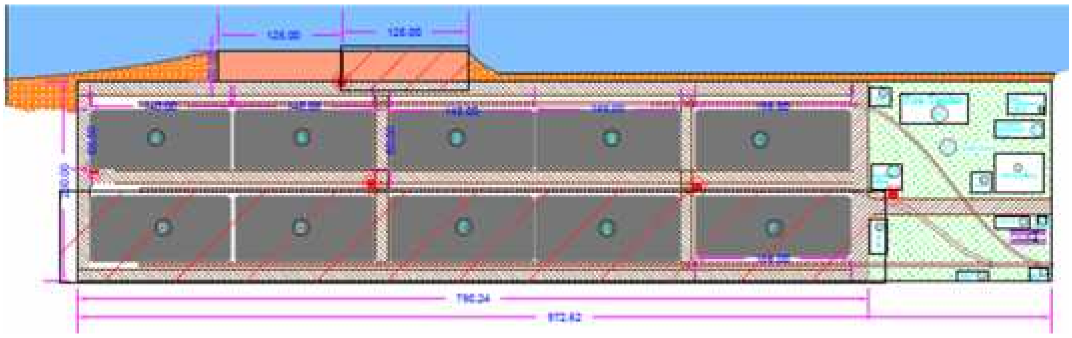


Fig. 7.20 Detailed Block Diagram for Terminal 1

Table 7.10 Rail Capacity & Evacuation Machinery Capacity for Terminal 1

Particulars	Phase I		Phase II		Unit
	2022	2027	2037	2047	
Terminal Capacity	2.4	2.4	4.8	4.8	mn T
Hours of working	10	10	10	10	Hr.
No of days of working	300	300	300	300	Days
Daily evacuation required	8,000	8,000	16,000	16,000	TPD
Rake Capacity	3,540	3,540	3,540	3,540	T
No of Rakes loading simultaneously	1	1	2	2	No
Total Rake Capacity	3,540	3,540	7,080	7,080	T
Daily rake loading (rounded off)	3	3	5	5	No
Hourly Loading required	800	800	1,600	1,600	Tones
Designated Capacity - Hydraulic Excavator	540	540	540	540	TPH
Capacity @ 70% utilisation	378	378	378	378	TPH
Number of Excavator required (rounded)	3	3	5	5	No
Evacuation Capacity of System	1,134	1,134	1,890	1,890	TPH
Evacuation System Capacity utilisation	70%	70%	80%	80%	

Particulars	Phase I		Phase II		Unit
	2022	2027	2037	2047	
Turnaround of Rake					
Rake Loading Time	3.1	3.1	1.9	1.9	Hr.
Mobilisation & De mobilisation	1.0	1.0	1.0	1.0	Hr.
Documentation	2.0	2.0	2.0	2.0	Hr.
Total Turnaround of Rake	**6.1**	**6.1**	**4.9**	**4.9**	**Hr.**

7.9.2 Terminal 2 – Samogar Mustkil, Agra

This terminal is located at Samogar Mustkil, Agra. It will be handling Coal and Fly Ash traffic only. Inner Ring road finally connects to Yamuna Expressway. An approach road needs to be constructed for connecting the terminal with the nearest road. The nearest rail freight station of Kuberpur is at a distance of 5 km. The location is surrounded by open land. The power plants of Harduaganj and Jawaharpur are located at a distance of 112 km and 95 km from the terminal respectively by road. The terminal is connected to Harduaganj TPP by Hodal-Hassanpur road, which connects with Bajna-Aligarh - Aligarh bypass road, leading to the power plant. The terminal is connected to Jawaharpur TPP by Hodal-Hassanpur road, which connects with SH22A - NH34, leading to the power plant. These plants procure coal from BCCL & NCL. These plants could shift this coal movement to waterways, generating coal traffic for the terminal.The below figure depicts satellite image of the location near Naujhil Bridge, identified for Terminal 2. The image also shows road connectivity around the proposed terminal.

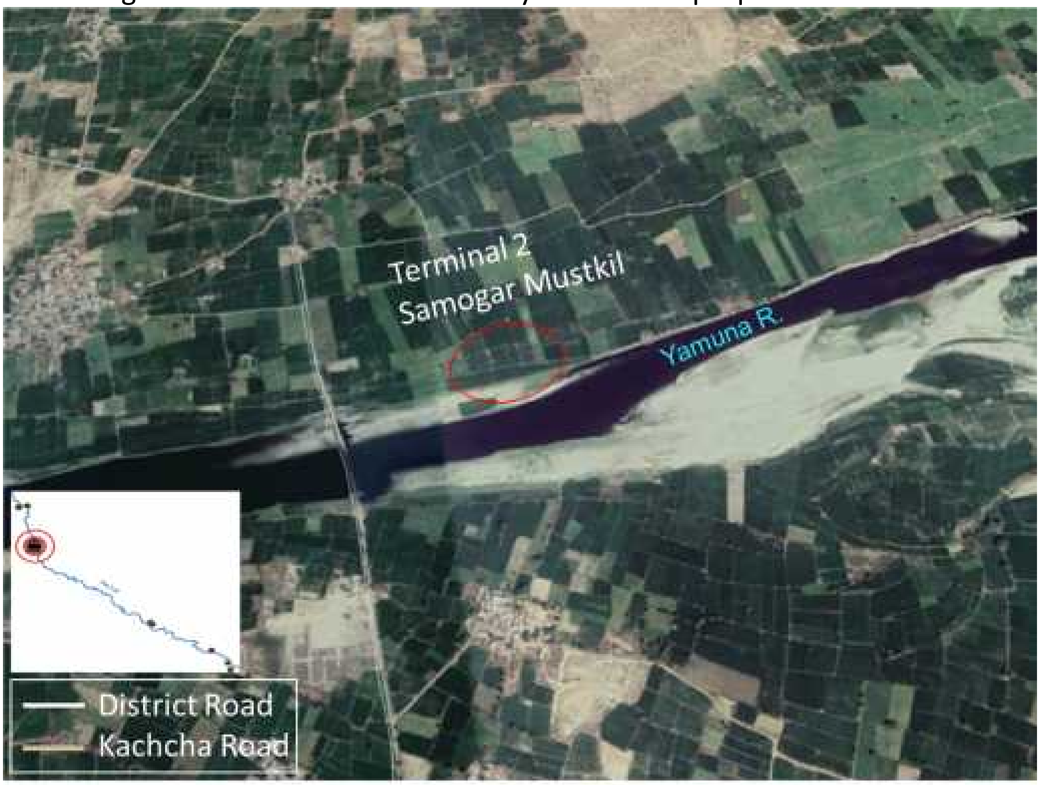


Fig. 7.21 Mapping of Connectivity for Terminal 2

The table below shows phase wise capacity and utilization of Terminal 2.

Table 7.11 Capacity Calculation of Terminal 2

Particulars	Phase I		Phase II		Units
	2022	2027	2037	2047	
Proposed Jetty					
Fly Ash Traffic	0.20	0.38	0.71	0.71	mn T
Coal Traffic	0.93	1.19	1.68	2.26	mn T
Length of Jetty	125	125	250	250	m
Capacity of Barges	1,000	1,000	1,000	1,000	DWT
Parcel Size of Barges	900	900	900	900	T
Unloading Rate - Coal	800	800	800	800	T/Hr.
Loading Rate - Fly Ash	200	200	200	200	T/Hr.
Barges alongside simultaneously	1	1	2	2	Nos.
Assumptions					
Hours of Operation	10	10	10	10	Hr.
Jetty Utilisation Share (Coal/Fly Ash)	80%	80%	80%	80%	
Days of Operation for Coal	240	240	240	240	Days
Days of Operation for Fly Ash	60	60	60	60	Days
Annual Jetty Capacity for Coal	1.92	1.92	3.84	3.84	mn T
Annual Jetty Capacity Required for Fly Ash	0.12	0.12	0.24	0.24	mn T
Total Capacity of Jetty	2.04	2.04	4.08	4.08	mn T
Capacity Utilisation of Terminal	56%	77%	59%	73%	

Table 7.12 Land Area Required for Terminal 2

Particulars	Phase I		Phase II		Unit
	2022	2027	2037	2047	
Terminal Capacity	2.04	2.04	4.08	4.08	mn T
Jetty Storage as % of traffic	10%	10%	10%	10%	
Stackyard Capacity Required	0.20	0.20	0.41	0.41	mn T
Stockpile Height	6.00	6.00	6.00	6.00	m
Stockpile Capacity	5.00	5.00	5.00	5.00	Tonnes /Sq. m
Capacity Deficit (No existing, Requirement)	0.20	0.20	0.41	0.41	Acres
Stackyard area required	40,800	40,800	81,600	81,600	Sq. m
Stackyard area required	10.07	10.07	20.13	20.13	Acres
Space Margin Provided for Equipment Movement (20%)	2.01	2.01	4.03	4.03	Acres
Total Area for Stackyard	12.08	12.08	24.16	24.16	Acres
Land Area required for Terminal Facilities	2.27	2.27	2.27	2.27	Acres
Green Zone	2.70	2.70	6.70	6.70	Acres
Rail, Road & Open Space	9.80	9.80	15.70	15.70	Acres
Total Area for Coal Terminal	26.85	26.85	48.83	48.83	Acres

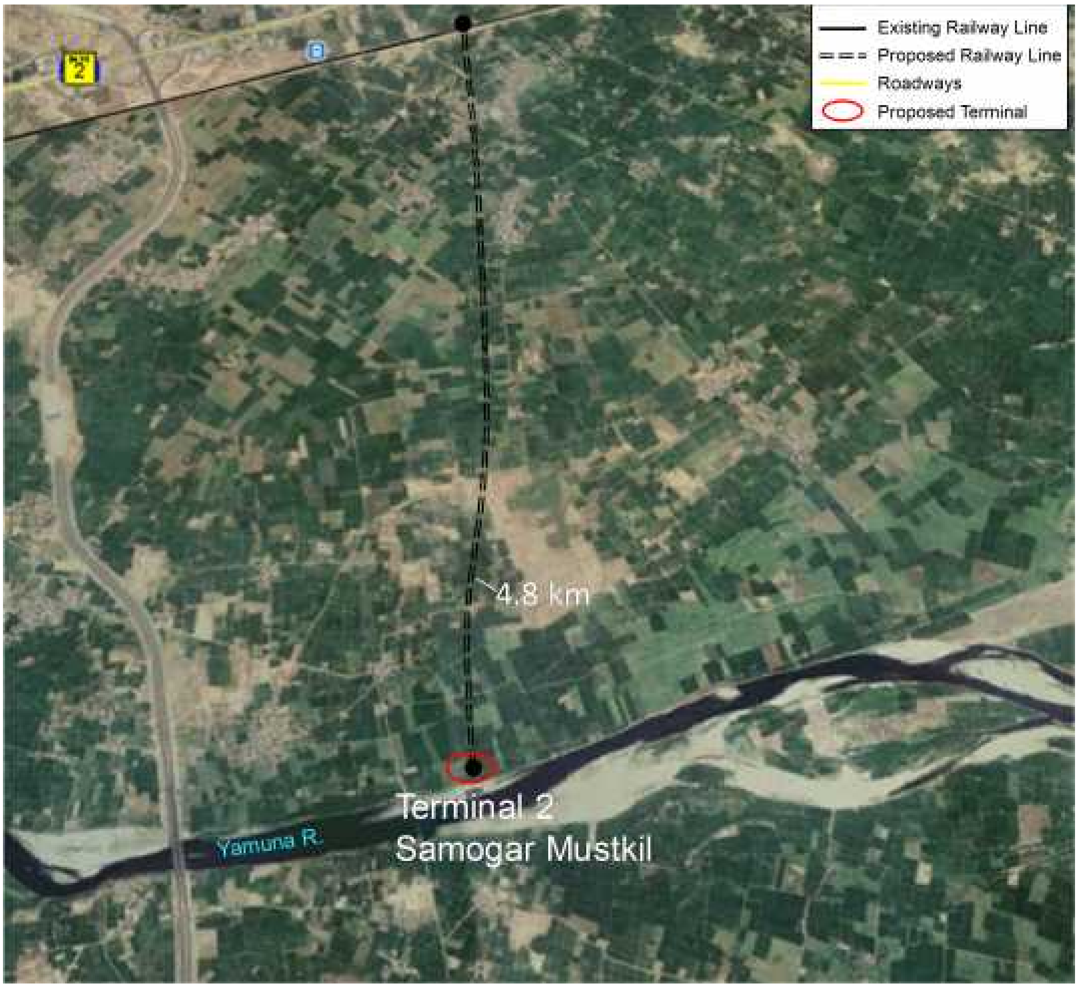


Fig. 7.22 Mapping of railway line extension till proposed Terminal 2

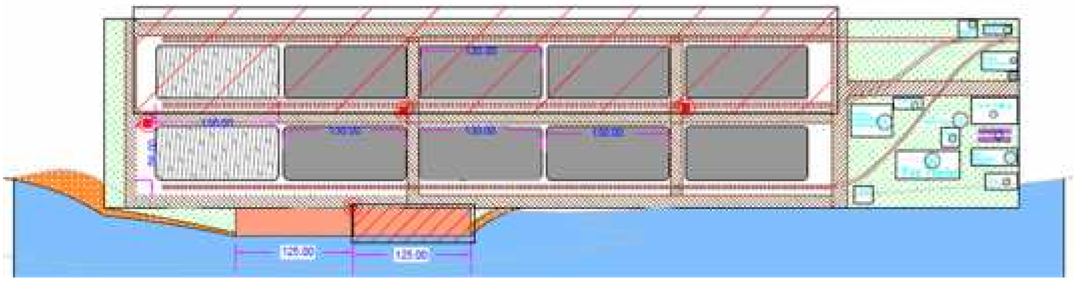


Fig. 7.23 Detailed Block Diagram for Terminal 2

Table 7.13 Rail Capacity & Evacuation Machinery Capacity for Terminal 2

Particulars	Phase I		Phase II		Unit
	2022	2027	2037	2047	
Terminal Capacity	2.0	2.0	4.1	4.1	mn T
Hours of working	10	10	10	10	Hr
No of days of working	240	240	240	240	Days
Daily evacuation required	8,500	8,500	17,000	17,000	TPD
Rake Capacity	3,540	3,540	3,540	3,540	Tones
No of Rakes loading simultaneously	1	1	2	2	No
Total Rake Capacity	3,540	3,540	7,080	7,080	
Daily rake loading (rounded off)	3	3	5	5	No
Hourly Loading required	850	850	1,700	1,700	Tones
Designated Capacity - Hydraulic Excavator	540	540	540	540	TPH

Particulars	Phase I		Phase II		Unit
	2022	2027	2037	2047	
Capacity @ 70% utilisation	378	378	378	378	TPH
Number of Excavator required (rounded)	3	3	5	5	No
Evacuation Capacity of System	1,134	1,134	1,890	1,890	TPH
Evacuation System Capacity utilisation	75%	75%	90%	90%	
Turnaround of Rake					
Rake Loading Time	3.1	3.1	1.9	1.9	Hr
Mobilisation & De mobilisation	1.0	1.0	1.0	1.0	Hr
Documentation	2.0	2.0	2.0	2.0	Hr
Total Turnaround of Rake	6.1	6.1	4.9	4.9	Hr

7.9.3 Terminal 3 – Mahewa Kachhar, Kaushambi

The terminal is located downwards Mahewaghat Yamuna Bridge on the left side of the river, in Kaushambi. It will be handling Coal and Fly Ash traffic only. The bridge is part of SH94, which further merges with NH 2 in north. The bridge connects Kaushambi and Chitrakoot. There is a need to develop an approach road to connect the terminal with the nearest road, i.e. SH94. The nearest rail freight station of Sirathu is 36 km from the terminal. There are two Industrial Estates at Bhuragarh and Parsara. The plants of NTPC Tanda and Unchahar are located at a distance of 230 km and 75.7 km from the terminal respectively. The terminal is connected to NTPC Tanda by SH94, which further connects to NH19 - NH30 - NH128 – Maya Tanda Rd, leading to the power plant. The terminal is connected to Unchahar TPP by SH94, which further connects to Ganga Bridge Rd - NH30 – Unchahar Rd, leading to the power plant. These plants procure coal from Northern Karanpura Coal Fields. This coal transportation could be switched to waterways, generating coal traffic for the terminal.

Fig. 7.24 Mapping of Connectivity for Terminal 3

The below figure depicts satellite image of the location in Mahewa Kachhar, identified for Terminal 3. The figure also shows road connectivity around the terminal location.

The table below depicts phase wise capacity and utilization of Terminal 3.

Table 7.14 Capacity Calculation of Terminal 3

Particulars	Phase I		Phase II		Units
	2022	2027	2037	2047	
Proposed Jetty					
Fly Ash Traffic	0.29	0.55	1.03	1.03	mn T
Coal Traffic	1.10	1.41	1.99	2.67	mn T
Length of Jetty	125	125	250	375	m
Capacity of Barges	1,000	1,000	1,000	1,000	DWT
Parcel Size of Barges	900	900	900	900	T
Unloading Rate - Coal	800	800	800	800	T/Hr.
Loading Rate - Fly Ash	200	200	200	200	T/Hr.
Barges alongside simultaneously	1	1	2	3	Nos.
Assumptions					
Hours of Operation	10	10	10	10	Hr.
Jetty Utilisation Share (Coal/Fly Ash)	80%	80%	80%	80%	
Days of Operation for Coal	240	240	240	240	Days
Days of Operation for Fly Ash	60	60	60	60	Days
Annual Jetty Capacity for Coal	1.92	1.92	3.84	5.76	mn T
Annual Jetty Capacity Required for Fly Ash	0.12	0.12	0.24	0.36	mn T
Total Capacity of Jetty	2.04	2.04	4.08	6.12	mn T
Capacity Utilisation of Terminal	68%	96%	74%	60%	

Table 7.15 Land Area Required for Terminal 3

Particulars	Phase I		Phase II		Unit
	2022	2027	2037	2047	
Terminal Capacity	2.04	2.04	4.08	6.12	mn T
Jetty Storage as % of traffic	0.10	0.10	0.10	0.10	
Stackyard Capacity Required	0.20	0.20	0.41	0.61	mn T
Stockpile Height	6.00	6.00	6.00	6.00	m
Stockpile Capacity	5.00	5.00	5.00	5.00	Tonnes/Sq. m
Capacity Deficit (No existing, Requirement)	0.20	0.20	0.41	0.61	Acres
Stackyard area required	40,800	40,800	81,600	1,22,400	Sq. m
Stackyard area required	10.07	10.07	20.13	30.20	Acres
Space Margin Provided for Equipment Movement (10%)	1.01	1.01	2.01	3.02	Acres
Total Area for Stackyard	11.07	11.07	22.15	33.22	Acres
Land Area required for Terminal Facilities	2.27	2.27	2.27	2.27	Acres
Green Zone	2.80	2.80	7.00	7.00	Acres
Rail, Road & Open Space	11.20	11.20	19.90	24.90	Acres
Total Area for Coal Terminal	27.34	27.34	51.31	67.39	Acres

Fig. 7.25 Mapping of railway line extension till proposed Terminal 3

Fig. 7.26 Detailed Block Diagram for Terminal 3

Table 7.16 Rail Capacity & Evacuation Machinery Capacity for Terminal 3

Particulars	Phase I		Phase II		Unit
	2022	2027	2037	2047	
Terminal Capacity	2.0	2.0	4.1	6.1	mn T
Hours of working	10	10	10	10	Hr
No of days of working	240	240	240	240	Days
Daily evacuation required	8,500	8,500	17,000	25,500	TPD
Rake Capacity	3,540	3,540	3,540	3,540	Tones
No of Rakes loading simultaneously	1	1	2	2	No
Total Rake Capacity	3,540	3,540	7,080	7,080	
Daily rake loading (rounded off)	3	3	5	8	No
Hourly Loading required	850	850	1,700	2,550	Tones
Designated Capacity - Hydraulic Excavator	540	540	540	540	TPH
Capacity @ 70% utilisation	378	378	378	378	TPH
Number of Excavator required (rounded)	3	3	5	7	No
Evacuation Capacity of System	1,134	1,134	1,890	2,646	TPH
Evacuation System Capacity utilisation	75%	75%	90%	96%	
Turnaround of Rake					
Rake Loading Time	3.1	3.1	1.9	1.3	Hr
Mobilisation & De mobilisation	1.0	1.0	1.0	1.0	Hr
Documentation	2.0	2.0	2.0	2.0	Hr
Total Turnaround of Rake	6.1	6.1	4.9	4.3	Hr

7.9.4 Terminal 4 – Dilauliya Kachhar, Kanpur Dehat

This terminal would be located beside bridge on Kanpur- Jhansi Highway, i.e. NH 27, on the left side of the river, in Kanpur Dehat. The terminal will be handling Coal and Fly Ash traffic only. The bridge connects Daulatpur to Kalpi. There exists a kuccha road, connecting the terminal to NH27. The nearest rail freight station of Pokhrayan is 15 km from the terminal.

There are nearly 8 Industrial Estates around the terminal. The thermal power plants of Parichha and Panki are located at a distance of 132 km and 68.2 km from the terminal respectively. The terminal is connected to Parichha TPP by NH27. The terminal is connected to Panki TPP by NH19/27, which further connects to Ishwari Ganj-Palara Rd, leading to the power plant.

The below figure depicts satellite image of the location near Dilauliya Kachhar in Kanpur Dehat district, identified for Terminal 4. The figure also shows road connectivity around the terminal.

Fig. 7.27 Mapping of Connectivity for Terminal 4

The table below depicts phase wise capacity and utilization of Terminal 4.

Table 7.17 Capacity Calculation of Terminal 4

Particulars	Phase I		Phase II		Units
	2022	2027	2037	2047	
Proposed Jetty					
Fly Ash Traffic	0.47	0.89	1.67	1.67	mn T
Coal Traffic	1.00	1.28	1.80	2.42	mn T
Length of Jetty	125	250	250	250	m
Barges alongside simultaneously	1	2	2	2	
Assumptions					
Hours of Operation	10	10	10	10	Hr.
Annual Jetty Capacity for Coal	1.92	3.84	3.84	5.76	mn T
Annual Jetty Capacity Required for Fly Ash	0.12	0.24	0.24	0.36	mn T
Total Capacity of Jetty	2.04	4.08	4.08	6.12	mn T
Capacity Utilisation of Terminal	72%	53%	85%	67%	

Table 7.18 Land Area Required for Terminal 4

Particulars	Phase I		Phase II		Unit
	2022	2027	2037	2047	
Terminal Capacity	2.04	4.08	4.08	6.12	mn T
Jetty Storage as % of traffic	0.10	0.10	0.10	0.10	
Stackyard Capacity Required	0.20	0.41	0.41	0.61	mn T
Stockpile Height	6.00	6.00	6.00	6.00	m
Stockpile Capacity	5.00	5.00	5.00	5.00	Tonnes/Sq. m
Capacity Deficit (No existing, Requirement)	0.20	0.41	0.41	0.61	Acres
Stackyard area required	40,800	81,600	81,600	1,22,400	Sq. m
Stackyard area required	10.07	20.13	20.13	30.20	Acres
Space Margin Provided for Equipment Movement (20%)	2.01	4.03	4.03	6.04	Acres
Total Area for Stackyard	12.08	24.16	24.16	36.24	Acres
Land Area required for Terminal Facilities	2.27	2.27	2.27	2.27	Acres
Green Zone	4.30	4.30	10.70	10.70	Acres
Rail, Road & Open Space	11.50	11.50	19.80	19.80	Acres
Total Area for Coal Terminal	30.15	42.23	56.93	69.01	Acres

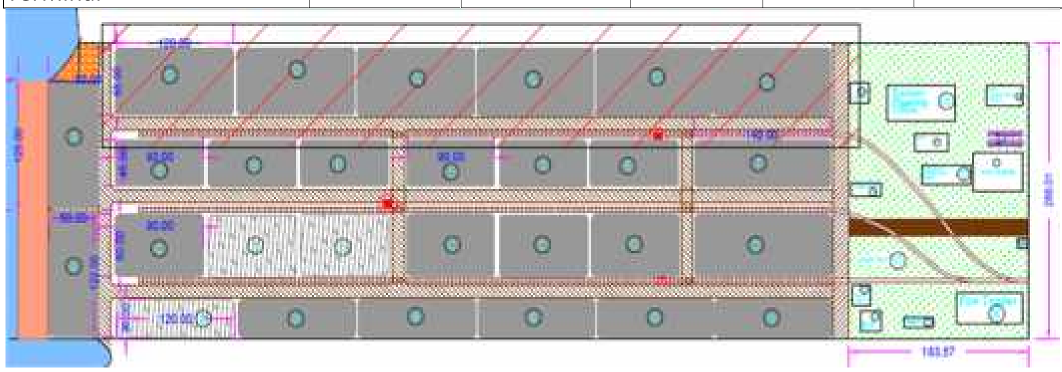


Fig. 7.28 Detailed Block Diagram for Terminal 4

Fig. 7.29 Mapping of railway line extension till proposed Terminal 4

Table 7.19 Rail Capacity & Evacuation Machinery Capacity for Terminal 4

Particulars	Phase I		Phase II		Unit
	2022	2027	2037	2047	
Terminal Capacity	2.0	4.1	4.1	6.1	mn T
Hours of working	10	10	10	10	Hr.
No of days of working	240	240	240	240	Days
Daily evacuation required	8,500	17,000	17,000	25,500	TPD
Rake Capacity	3,540	3,540	3,540	3,540	T
No of Rakes loading simultaneously	1	1	2	2	No
Total Rake Capacity	3,540	3,540	7,080	7,080	T
Daily rake loading (rounded off)	3	5	5	8	No
Hourly Loading required	850	1,700	1,700	2,550	Tones
Designated Capacity - Hydraulic Excavator	540	540	540	540	TPH
Capacity @ 70% utilisation	378	378	378	378	TPH
Number of Excavator required (rounded)	3	5	5	7	No
Evacuation Capacity of System	1,134	1,890	1,890	2,646	TPH
Evacuation System Capacity utilisation	75%	90%	90%	96%	
Turnaround of Rake					
Rake Loading Time	3.1	1.9	1.9	1.3	Hr.
Mobilisation & De mobilisation	1.0	1.0	1.0	1.0	Hr.
Documentation	2.0	2.0	2.0	2.0	Hr.
Total Turnaround of Rake	6.1	4.9	4.9	4.3	Hr.

7.9.5 Terminal 5 – Near Naini Bridge

This terminal is proposed beside Naini Bridge (New Yamuna Bridge), on the right side of the river, in Prayagraj. Naini Bridge is part of NH 30. The bridge connects the city of Prayagraj to Naini. Old Naini Bridge (Old Yamuna Bridge), which connects to NH2 and NH76, is also near the terminal. The terminal will be handling Coal and Fly Ash traffic only. There exists a kuccha road that connects the terminal to the local Arail Road. The nearest rail freight station of Naini is 4 km from the terminal. Naini and Phulpur are the two Industrial Estates around the terminal. The thermal power plants of Meja and Bara are located at a distance of 42 km and 39 km from the terminal respectively. The terminal is connected to Meja TPP by NH30, which further connects to NH35 – Kohadarghat Rd – NTPC Meja Rd, leading to the power plant. The terminal is connected to Bara TPP by NH30, which further connects to NH35, leading to the power plant.

The below figure depicts satellite image of the location near Naini Bridge, Prayagraj identified for Terminal 5. The figure also shows road connectivity around the terminal.

Fig. 7.30 Mapping of Connectivity for Terminal 5

The table below shows phase wise capacity of Terminal 5.

Table 7.20 Capacity Calculation of Terminal 5

Particulars	Phase I		Phase II		Units
	2022	2027	2037	2047	
Proposed Jetty					
Fly Ash Traffic	0.46	0.87	1.63	1.63	mn T
Coal Traffic	2.07	2.64	3.72	5.00	mn T
Length of Jetty	250	250	375	500	m
Capacity of Barges	1,000	1,000	1,000	1,000	DWT
Parcel Size of Barges	900	900	900	900	T
Unloading Rate - Coal	800	800	800	800	T/Hr.
Loading Rate - Fly Ash	200	200	200	200	T/Hr.
Barges alongside simultaneously	2	2	3	4	Nos.
Assumptions					
Hours of Operation	10	10	10	10	Hr.
Jetty Utilisation Share (Coal/Fly Ash)	80%	80%	80%	80%	Days
Days of Operation for Coal	240	240	240	240	Days

Particulars	Phase I		Phase II		Units
	2022	2027	2037	2047	
Days of Operation for Fly Ash	60	60	60	60	Days
Annual Jetty Capacity for Coal	3.84	3.84	5.76	7.68	mn T
Annual Jetty Capacity Required for Fly Ash	0.24	0.24	0.36	0.48	mn T
Total Capacity of Jetty	4.08	4.08	6.12	8.16	mn T
Capacity Utilisation of Terminal	62%	86%	87%	81%	

Table 7.21 Land Area Required for Terminal 5

Particulars	Phase I		Phase II		Unit
	2022	2027	2037	2047	
Terminal Capacity	4.08	4.08	6.12	8.16	mn T
Jetty Storage as % of traffic	9%	9%	9%	9%	
Stackyard Capacity Required	0.37	0.37	0.55	0.73	mn T
Stockpile Height	6.00	6.00	6.00	6.00	m
Stockpile Capacity	5.00	5.00	5.00	5.00	Tonnes/Sq. m
Capacity Deficit (No existing, Requirement)	0.37	0.37	0.55	0.73	Acres
Stackyard area required	73,440	73,440	1,10,160	1,46,880	Sq. m
Stackyard area required	18.12	18.12	27.18	36.24	Acres
Space Margin Provided for Equipment Movement (10%)	1.81	1.81	2.72	3.62	Acres
Total Area for Stackyard	19.93	19.93	29.90	39.86	Acres
Land Area required for Terminal Facilities	2.27	2.27	2.27	2.27	Acres
Green Zone	2.80	2.80	7.00	7.00	Acres
Rail, Road & Open Space	13.20	13.20	18.10	18.10	Acres
Total Area for Coal Terminal	38.20	38.20	57.27	67.23	Acres

Fig. 7.31 Mapping of railway line extension till proposed Terminal 5

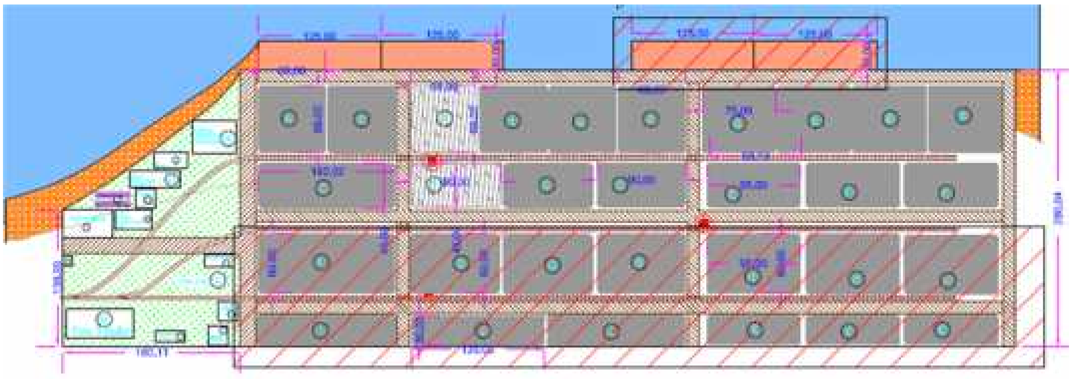


Fig. 7.32 Detailed Block Diagram for Terminal 5

Table 7.22 Rail Capacity & Evacuation Machinery Capacity for Terminal 5

Particulars	Phase I		Phase II		Unit
	2022	2027	2037	2047	
Terminal Capacity	4.1	4.1	6.1	8.2	mn T
Hours of working	10	10	10	10	Hr
No of days of working	240	240	240	240	Days
Daily evacuation required	17,000	17,000	25,500	34,000	TPD
Rake Capacity	3,540	3,540	3,540	3,540	Tones
No of Rakes loading simultaneously	1	1	2	2	No
Total Rake Capacity	3,540	3,540	7,080	7,080	
Daily rake loading (rounded off)	5	5	8	10	No
Hourly Loading required	1,700	1,700	2,550	3,400	Tones
Designated Capacity - Hydraulic Excavator	540	540	540	540	TPH
Capacity @ 70% utilisation	378	378	378	378	TPH
Number of Excavator required (rounded)	5	5	7	9	No
Evacuation Capacity of System	1,890	1,890	2,646	3,402	TPH
Evacuation System Capacity utilisation	90%	90%	96%	100%	
Turnaround of Rake					
Rake Loading Time	1.9	1.9	1.3	1.0	Hr
Mobilisation & De mobilisation	1.0	1.0	1.0	1.0	Hr
Documentation	2.0	2.0	2.0	2.0	Hr
Total Turnaround of Rake	4.9	4.9	4.3	4.0	Hr

7.10 Multipurpose Terminals Planning& Layout

Three terminals (Terminal 6, 7 & 8) are proposed on NW 110 as multipurpose terminals for handling container, iron & steel, food grains, sugar, fertilizer, automobile etc. These terminals aim to be clean cargo terminals. This section would discuss in detail planning for jetty and other infrastructure, cargo handling equipment and mechanism.

7.10.1 Terminal 6 – Near Jamuna Bridge

This terminal is beside Jamuna Bridge (Old Naini Bridge or Old Yamuna Bridge), on the right side of the river. Jamuna Bridge connects to NH 2 and NH 76. Another bridge near the terminal is Naini Bridge (New Yamuna Bridge), which is a part of NH 30. An approach road is required to connect the terminal to the nearest passing Yamuna Bridge. The terminal is proposed to handle the fertilizer traffic of IFFCO Phulpur, which is located at a distance of 30 km. The terminal is connected to IFFCO Phulpur by Naini Road, which further connects to NH30 – Prayagraj Road - Sahson Road – Phulpur Road, leading to the plant. The nearest rail freight station of Naini is 4 km from the terminal. Naini and Phulpur are the two Industrial Estates around the terminal. Apart from fertilizer, it would handle Food grains, sugar and automobiles. Terminal 6 would be termed as loading point for fertilizer and unloading point for Food grains, sugar and automobiles.The below figure depicts satellite image of the location near Jamuna Bridge, Prayagraj identified for Terminal 6. The figure shows rail and road connectivity around the terminal.

Fig. 7.33 Mapping of Connectivity for Terminal 6

The table below shows phase wise capacity of Terminal 6.

Table 7.23 Capacity calculation of Terminal 6 (3 Shifts Operational)

Jetty Operational in 3 Shifts	Phase I		Phase II		Units
	2022	2027	2037	2047	
Traffic at Proposed Jetty					
- *Automobile*	0.04	0.05	0.07	0.09	mn
- *Other Commodities (Fertilizer, Food Grains & Sugar)*	0.70	0.85	1.04	1.13	mn T
Length of Jetty	125	250	250	250	m
Capacity of Barges	1,000	1,000	1,000	1,000	DWT
Parcel Size of Barges					
- *Automobile*	350	350	350	350	Units
- *Other Commodities*	900	900	900	900	Tones
Unloading Rate					
- *Automobile*	150	150	150	150	Units/Hr
- *Other Commodities*	200	200	200	200	T/Hr
Barges alongside simultaneously	1	2	2	2	
Assumptions					
Hours of Operation	24	24	24	24	Hr

Jetty Operational in 3 Shifts	Phase I		Phase II		Units
	2022	2027	2037	2047	
Allocation of Jetty					
- Automobile	5%	5%	5%	5%	
- Other Commodities	75%	75%	75%	75%	
Days of Operation	300				
- Automobile	15	15	15	15	
- Other Commodities	225	225	225	225	
Annual Capacity of Jetty					
- Automobile	0.05	0.11	0.11	0.11	mn
- Other Commodities	1.08	2.16	2.16	2.16	mn T
Terminal Capacity Utilisation for other commodities					
- Automobile	76%	48%	65%	86%	
- Other Commodities	64%	39%	48%	52%	

Table 7.24 Capacity Calculation of Terminal 6 (2 Shifts Operational)

Jetty Operational in 2 Shifts	Phase I		Phase II		Units
	2022	2027	2037	2047	
Length of Jetty	250	250	375	375	m
Hours of Operation	16	16	16	16	Hr
Annual Capacity of Jetty					
- Automobile	0.07	0.07	0.11	0.11	mn Units
- Other Commodities	1.44	1.44	2.16	2.16	mn T
Terminal Capacity Utilisation for other commodities					
- Automobile	57%	72%	65%	86%	
- Other Commodities	48%	59%	48%	52%	

Table 7.25 Capacity Calculation of Terminal 6 (1 Shift Operational)

Jetty Operational in 1 Shift	Phase I		Phase II		Units
	2022	2027	2037	2047	
Length of Jetty	375	375	500	625	m
Hours of Operation	10	10	10	10	Hr.
Annual Capacity of Jetty					
- Automobile	0.07	0.07	0.09	0.11	mn Units
- Other Commodities	1.35	1.35	1.80	2.25	mn T
Terminal Capacity Utilisation for other commodities					
- Automobile	61%	77%	78%	83%	-
- Other Commodities	51%	63%	58%	50%	-

Table 7.26 Land Area Required for Terminal 6

Particulars	Phase I		Phase II		Unit
	2022	2027	2037	2047	
Terminal Capacity	1.08	2.16	2.16	2.16	mn T
Stackyard Capacity Required (10% storage of capacity)	0.11	0.22	0.22	0.22	mn T
Stockpile Height	6.00	6.00	6.00	6.00	m
Stockpile Capacity	5.00	5.00	5.00	5.00	Tonnes/ Sq. m
Capacity Deficit (No existing, Requirement)	0.11	0.22	0.22	0.22	Acres
Stackyard area required	21,600	43,200	43,200	43,200	Sq. m
Stackyard area required	5.33	10.66	10.66	10.66	Acres

Particulars	Phase I		Phase II		Unit
	2022	2027	2037	2047	
Space Margin Provided for Equipment Movement (10%)	0.53	1.07	1.07	1.07	Acres
Total Storage Area Requirement					
- *Automobile*	3.49	3.49	3.49	3.49	Acres
- *Other Commodities*	5.86	11.73	11.73	11.73	Acres
Land Area required for Terminal Building	2.27	2.27	2.27	2.27	Acres
Green Zone	1.80	1.80	4.40	4.40	Acres
Rail, Road & Open Space	6.20	6.20	8.40	8.40	Acres
Total Area required for Terminal	**19.62**	**25.49**	**30.29**	**30.29**	**Acres**

Fig. 7.34 Mapping of railway line extension till proposed Terminal 6

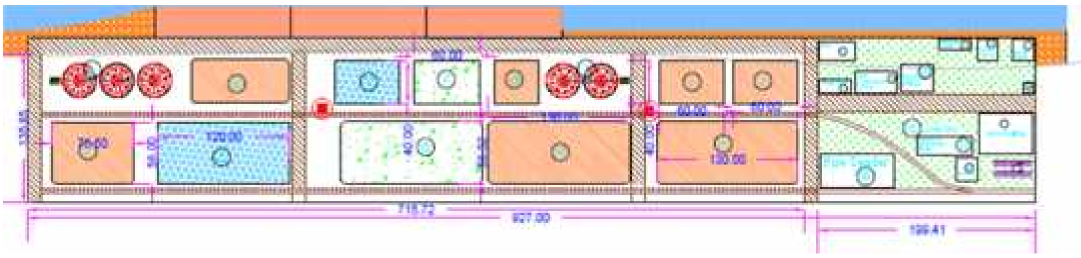


Fig. 7.35 Detailed Block Diagram for Terminal 6

7.10.2 Terminal 7 – Madanpur Khadar, Delhi

This terminal is located at Madanpur Khadar, below Okhla Barrage on the left side of the river. It is proposed as a multipurpose terminal, which will handle traffic of Iron & Steel, automobiles, containers, food grains, sugar etc.

An approach road of 0.24 km is needed to connect the terminal to the nearby kuccha road, which further connects to Jaitpur Kalindi Kunj Road. Jaitpur Kalindi Kunj Road connects to Amrapali Marg, which is 3.5 km from the terminal and is well connected to Noida – Greater Noida Expressway. There is an upcoming six-lane bridge, parallel to the Okhla Barrage intended to connect South Delhi and Noida and reduce the traffic congestion on the existing Amrapali Bridge. The nearest Rail freight station of Tughlakabad is around 10 km from the terminal. Being located in the NCR region, the terminal has many industrial estates around it.

The below figure depicts satellite image of the location at Madanpur Khadar, Delhi identified for Terminal 7. The figure also shows road connectivity around the terminal.

Fig. 7.36 Mapping of Connectivity for Terminal 7

The table below shows phase wise capacity of Terminal 7.

Table 7.27 Capacity Calculation of Terminal 7 (3 Shifts Operational)

Jetty Operational in 3 Shifts	Phase I		Phase II		Units
	2022	2027	2037	2047	
Traffic at Proposed Jetty					
- *Automobile*	0.08	0.10	0.14	0.19	mn Units
- *Container*	0.35	0.47	0.66	0.84	mn TEU
- *Other Commodities (Food Grains, Iron & Steel & Sugar)*	1.08	1.33	1.70	1.99	mn T
Length of Jetty	375	500	625	750	m
Capacity of Barges	1,000	1,000	1,000	1,000	DWT
Parcel Size of Barges					
- *Automobile*	350	350	350	350	Units
- *Container*	208	208	208	208	TEU
- *Other Commodities*	900	900	900	900	Tones

Jetty Operational in 3 Shifts	Phase I		Phase II		Units
	2022	2027	2037	2047	
Unloading Rate					
- Automobile	150	150	150	150	Units/Hr
- Container	20	20	20	20	TEU/Hr
- Other Commodities	200	200	200	200	T/Hr
Barges alongside simultaneously	3	4	5	6	
Assumptions					
Hours of Operation	24	24	24	24	Hr
Allocation of Jetty					
- Automobile	5%	5%	5%	5%	
- Container	65%	65%	65%	65%	
- Other Commodities (10% each)	30%	30%	30%	30%	
Days of Operation	300				
- Automobile	15	15	15	15	
- Container	195	195	195	195	
- Other Commodities	90	90	90	90	
Annual Capacity of Jetty					
- Automobile	0.16	0.22	0.27	0.32	mn Units
- Container	0.28	0.37	0.47	0.56	mn TEU
- Other Commodities	1.30	1.73	2.16	2.59	mn T
Terminal Capacity Utilisation for other commodities					
- Automobile	50%	48%	51%	57%	
- Container	125%	126%	140%	150%	
- Other Commodities	83%	77%	79%	77%	

Table 7.28 Capacity Calculation of Terminal 7 (2 Shifts Operational)

Jetty Operational in 2 Shifts	Phase I		Phase II		Units
	2022	2027	2037	2047	
Length of Jetty	750	875	1,000	1,250	M
Hours of Operation	16	16	16	16	Hr
Annual Capacity of Jetty					
- Automobile	0.22	0.25	0.29	0.36	mn Units
- Container	0.37	0.44	0.50	0.62	mn TEU
- Other Commodities	1.73	2.02	2.30	2.88	mn T
Terminal Capacity Utilisation for other commodities					
- Automobile	38%	41%	48%	52%	
- Container	94%	108%	132%	135%	
- Other Commodities	62%	66%	74%	69%	

Table 7.29 Capacity Calculation of Terminal 7 (1 Shift Operational)

Jetty Operational in 1 Shift	Phase I		Phase II		Units
	2022	2027	2037	2047	
Length of Jetty	1,250	1,750	2,250	2,750	m
Hours of Operation	10	10	10	10	Hr
Annual Capacity of Jetty					
- Automobile	0.23	0.32	0.41	0.50	mn Units
- Container	0.39	0.55	0.70	0.86	mn TEU
- Other Commodities	1.80	2.52	3.24	3.96	mn T
Terminal Capacity Utilisation for other commodities					

Jetty Operational in 1 Shift	Phase I		Phase II		Units
	2022	2027	2037	2047	
- *Automobile*	36%	33%	34%	38%	
- *Container*	90%	86%	94%	98%	
- *Other Commodities*	60%	53%	53%	50%	

Table 7.30 Land Area Required for Terminal 7

Particulars	Phase I		Phase II		Unit
	2022	2027	2037	2047	
Terminal Capacity	1.30	1.73	2.16	2.59	mn T
Stackyard Capacity Required	0.16	0.21	0.26	0.31	mn T
Stockpile Height	6.00	6.00	6.00	6.00	m
Stockpile Capacity	5.00	5.00	5.00	5.00	Tonnes/Sq. m
Capacity Deficit (No existing, Requirement)	0.16	0.21	0.26	0.31	Acres
Stackyard area required	31,104	41,472	51,840	62,208	Sq. m
Stackyard area required	7.67	10.23	12.79	15.35	Acres
Space Margin Provided for Equipment Movement (20%)	1.53	2.05	2.56	3.07	Acres
Total Storage Area Requirement					
- *Automobile*	6.98	6.98	6.98	6.98	Acres
- *Container*	5.00	5.00	5.00	5.00	Acres
- *Other Commodities*	9.21	12.28	15.35	18.42	Acres
Land Area required for Terminal Building	2.27	2.27	2.27	2.27	Acres
Green Zone	3.60	3.60	9.10	9.10	Acres
Rail, Road & Open Space	25.10	25.10	40.90	40.90	Acres
Total Area required for Terminal	**52.16**	**55.23**	**79.60**	**82.67**	**Acres**

Fig. 7.37 Mapping of railway line extension till proposed Terminal 7

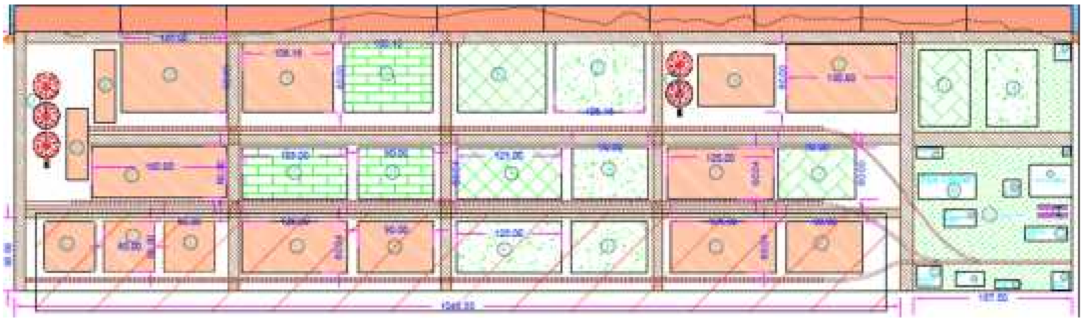


Fig. 7.38 Detailed Block Diagram for Terminal 7

7.10.3 Terminal 8 – Daulatpur, Kanpur Dehat

This terminal would be located beside bridge on Jhansi- Kanpur Highway, i.e. NH 27. The bridge connects Kalpi to Daulatpur. An approach road is required to connect the terminal to the nearest road, i.e. Kanpur- Jhansi Highway. There is another bridge on Kanpur- Jhansi Highway, which is near the terminal. Both the bridges are part of NH 27. The nearest Rail Freight station of Kalpi is 1.5 km from the terminal. There are nearly 8 industrial estates around the terminal.

The below figure depicts satellite image of the location in Daulatpur, Kanpur Dehat identified for Terminal 8. The figure shows rail and road connectivity around the terminal location.

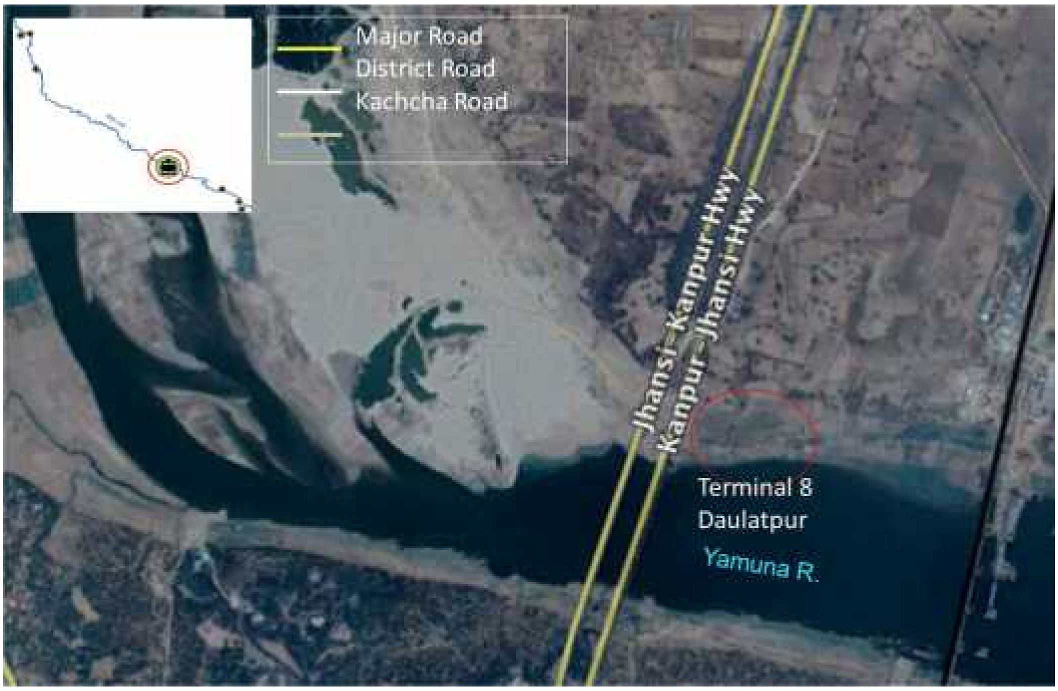


Fig. 7.39 Mapping of Connectivity for Terminal 8

The table below shows phase wise capacity of Terminal 8.

Table 7.31 Capacity Calculation of Terminal 8 (3 Shifts Operational)

Jetty Operational in 3 Shifts	Phase I		Phase II		Units
	2022	2027	2037	2047	
Traffic at Proposed Jetty					
- *Automobile*	0.04	0.05	0.07	0.09	mn Units
- *Other Commodities (Fertilizer, Food Grains, Iron & Steel & Sugar)*	0.91	1.11	1.38	1.53	mn T
Length of Jetty	125	125	250	250	m
Capacity of Barges	1,000	1,000	1,000	1,000	DWT
Parcel Size of Barges					
- *Automobile*	350	350	350	350	Units
- *Other Commodities*	900	900	900	900	Tones
Unloading Rate					
- *Automobile*	150	150	150	150	Units/Hr
- *Other Commodities*	200	200	200	200	T/Hr
Barges alongside simultaneously	1	1	2	2	
Assumptions					
Hours of Operation	24	24	24	24	Hr
Allocation of Jetty					
- *Automobile*	5%	5%	5%	5%	
- *Other Commodities*	95%	95%	95%	95%	
Days of Operation	300				
- *Automobile*	15	15	15	15	
- *Other Commodities*	285	285	285	285	
Annual Capacity of Jetty					
- *Automobile*	0.05	0.05	0.11	0.11	mn Units
- *Other Commodities*	1.37	1.37	2.74	2.74	mn T
Terminal Capacity Utilisation for other commodities					
- *Automobile*	76%	96%	65%	86%	
- *Other Commodities*	67%	81%	51%	56%	

Table 7.32 Capacity Calculation of Terminal 8 (2 Shifts Operational)

Jetty Operational in 2 Shifts	Phase I		Phase II		Units
	2022	2027	2037	2047	
Length of Jetty	250	250	375	375	m
Hours of Operation	16	16	16	16	Hr
Annual Capacity of Jetty					
- *Automobile*	0.07	0.07	0.11	0.11	mn Units
- *Other Commodities*	1.82	1.82	2.74	2.74	mn T
Terminal Capacity Utilisation for other commodities					
- *Automobile*	57%	72%	65%	86%	
- *Other Commodities*	50%	61%	51%	56%	

Table 7.33 Capacity Calculation of Terminal 8 (1 Shift Operational)

Jetty Operational in 1 Shift	Phase I		Phase II		Units
	2022	2027	2037	2047	
Length of Jetty	375	375	500	625	m
Hours of Operation	10	10	10	10	Hr
Annual Capacity of Jetty					
- *Automobile*	0.07	0.07	0.09	0.11	mn Units
- *Other Commodities*	1.71	1.71	2.28	2.85	mn T

Jetty Operational in 1 Shift	Phase I		Phase II		Units
	2022	2027	2037	2047	
Terminal Capacity Utilisation for other commodities					
- Automobile	61%	77%	78%	83%	
- Other Commodities	53%	65%	61%	54%	

Table 7.34 Land Area Required for Terminal 8

Particulars	Phase I		Phase II		Unit
	2022	2027	2037	2047	
Terminal Capacity	1.37	1.37	2.74	2.74	mn T
Stackyard Capacity Required (10% storage of capacity)	0.14	0.14	0.27	0.27	mn T
Stockpile Height	6.00	6.00	6.00	6.00	m
Stockpile Capacity	5.00	5.00	5.00	5.00	Tonnes/ Sq. m
Capacity Deficit (No existing, Requirement)	0.14	0.14	0.27	0.27	Acres
Stackyard area required	27,360	27,360	54,720	54,720	Sq. m
Stackyard area required	6.75	6.75	13.50	13.50	Acres
Space Margin Provided for Equipment Movement (20%)	1.35	1.35	2.70	2.70	Acres
Total Storage Area Requirement					
- Automobile	3.49	3.49	3.49	3.49	Acres
- Other Commodities	8.10	8.10	16.20	16.20	Acres
Land Area required for Terminal Building	2.27	2.27	2.27	2.27	Acres
Green Zone	2.20	2.20	5.50	5.50	Acres
Rail, Road & Open Space	16.50	16.50	30.00	30.00	Acres
Total Area required for Terminal	**32.56**	**32.56**	**57.46**	**57.46**	**Acres**

Fig. 7.40 Mapping of railway line extension till proposed Terminal 8

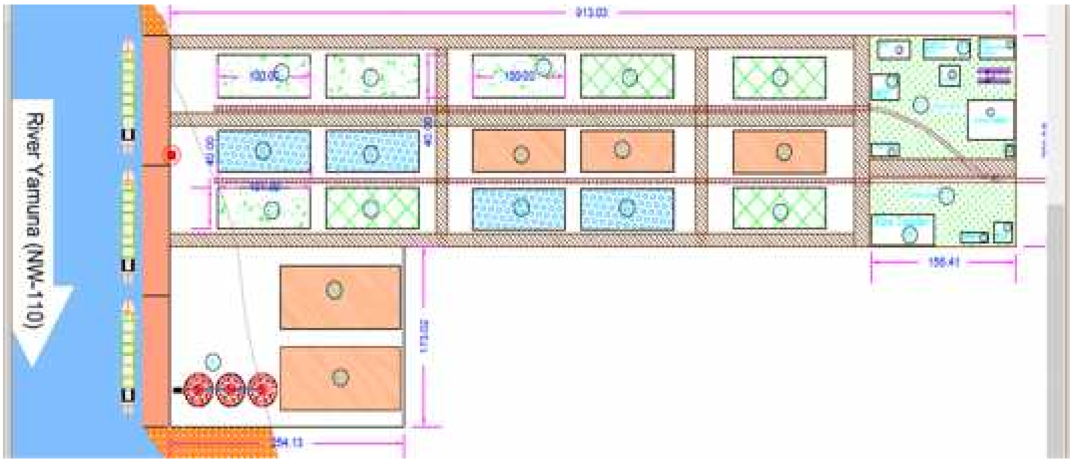


Fig. 7.41 Detailed Block Diagram for Terminal 8

7.11 Passenger Terminal Introduction & Planning

7.11.1 Inter District Passenger Terminals Introduction

3 terminals are proposed on NW 110 as inter district terminals for handling tourist traffic for long distance cruise ride, from Delhi to Prayagraj in NW 110 and further to Varanasi in NW 1. Inter district terminals would be developed in Delhi, Mathura, Agra and Prayagraj. These IWAI terminals would be an integral part of the waterway development on river Yamuna. They would attract tourists to the waterway for leisure ride on cruise and sightseeing.This section would discuss in detail planning for jetty and other infrastructure, like ticket counter, rest room, café, canteen etc. The section would discuss terminals located near Okhla Barrage, Delhi, behind Taj Mahal, Agra and Vrindavan in Mathura. Apart from these 3 inter district terminal, there would be another terminal in Sujawan Ghat in Prayagraj. This terminal would be developed in big scale and would be dedicated for handling both intra and inter district tourist/passenger traffic.

7.11.2 Inter District Passenger Terminals Infrastructure

This section would discuss in detail planning for jetty and other infrastructure for handling passengers/tourists. Tourist activities generally demand a good and aesthetic environment congenial for relaxed spending. This requires a safe landing arrangement, a furnished waiting hall with a lounge facility. The terminal facility should also include parking facility, a well-maintained park, an eatery/ restaurant and toilet facilities. No night stay accommodation is envisaged for the tourists as the tourists are meant to stay for shorter duration, not requiring any night stay.

Brief description of some of the proposed facilities is given in this section for terminal planning. Other infrastructural facilities like water supply, electrification, and firefighting with portable pumps, communication facilities, lifesavingequipment, security check areas, emergency service facilities etc. are also considered.

- **Waiting Hall**

Waiting Hall would be required in Inter District Terminals, Terminal 9, 10, 11 and 13 a. These terminals, located at Madanpur Khadar, Agra, Mathura and Sujawan Ghat would be handling tourist traffic of long-distance cruise service. It is assumed that these terminals would cater to large traffic; hence it is advised that waiting hall should be developed at these four terminals. Waiting hall should be sufficient enough to handle at least 40 no. of tourists. A hall of 100 sq. m. with separate toilet facility for ladies and gents may be adequate. There shall be changing rooms also for tourists. Separate changing room and toilet shall be provided for the operating staff of the terminal. The waiting hall would have sufficient seating arrangement for tourists/passengers. Sufficient number of electrical points shall be provided for phone/laptop charging purpose.

The roof consists of structural steel roof trusses and purlins over which asbestos cement roofing sheets are laid. About 10% of the sheeting is with translucent sheets to provide natural light during day time.

- **Admin Buildings with ticket counter**

Located close to the proposed terminal site, the Administrative office would serve as the base for the terminal. The building would be required for administration of the terminal. The building would also house a 4 window ticket counter. 4 window ticketing booths would be sufficient to cater the peak passenger load.

0.5 Acre land would be required for development of administration building. The Management team, in-charge officers and other personnel would use the building as their work base. Administration work, like paperwork, documentation etc. would be done in this building. The building would be used for administrative works to ensure effective, smooth and efficient functioning of the terminal.

- **Park**

Passenger terminal could be developed to become family friendly. This would include creating enjoyable space for women and kids. Creation of green park along with walking tracks would be very good choice to develop at the terminal. Facility for people to sit and observe nature along bank of river Yamuna could be a good experience. The park should be with horticultural planning and good landscaping. It shall have playing facilities for children. Some small rides for kids like see-saw could be put up, so that kids who visit park could have another option to enjoy. Minimum area required to build a park with equipment's for children is 3,000 sq.ft.

➢ **Café**

The terminal should have a café for refreshment of tourists and passengers. If someone is in hurry, then it is the best place to hang out. This facility would be helpful for people who value their time very much. 500 sq. feet is the minimum area required to run a small café.

➢ **Restaurant**

Restaurant could act as a waiting place for passengers. It would be difficult to arrive exactly few minutes prior to departure of ferry, when the passenger is driving from faraway places. Waterfront restaurants on the terminals would able to attract passengers to spend more time on the terminal. Minimum area required to build a restaurant with good amenities is 1,500 sq.ft. River facing restaurant could be developed at Sujawan Ghat. 1 restaurant could be developed near Taj Mahal. These restaurants would have their own toilet facilities. River facing restaurant would be developed in a larger area. It could be built on 5,000 sq.ft. of land.

➢ **The Fencing and guard room**

The area of landing facility shall be provided with 3 lined barbed wire system with RCC square pillars for supporting the fencing. The entrance to the terminal complex will be through a gate, which shall have aesthetic looks. A guard room shall be developed along with the fencing for the security of the property at site.

➢ **Other Facilities**

- Health & Safety Counter: Developing small dispensary with first aid could be beneficial. Health counter would serve both terminal staffs and passengers.
- Banking related Facilities: Developing ATM facility near terminal would be very useful for tourists and passengers. Terminal for long distance cruise service should also have facility to exchange international currency, as international tourists would also be using cruise service.
- Information Kiosk: Information Kiosk would provide historical background of the city and city map and important information about banks and hospitals etc. This would help to understand the various locations and guidelines to be followed in the city.

7.11.3 Inter District Passenger Terminals Introduction & Planning

➢ **Terminal 9 – Madanpur Khadar, Delhi**

This terminal is located at Madanpur Khadar right beside the Okhla barrage. An approach road would be required to connect the terminal to the nearby kuccha road, which further connects to Jaitpur Kalindi Kunj Road. This road further connects to Amrapali Marg. The Amrapali Marg runs over Yamuna River beside the terminal to connect Noida- Greater Noida Expressway.

The Kalindi Kunj Metro Station is just 2.5 km away from the terminal. Other two nearby metro stations, Jasola Vihar and Okhla Bird Sanctuary are located at a distance of 4.5 km from the terminal. Tughlakabad Railway station is 10 KM away and Okhla Station is 10.5 km from the terminal. There is an upcoming six-lane bridge parallel to the Okhla Barrage, intended to connect South Delhi and Noida and reduce the traffic congestion on the existing Amrapali Bridge. Okhla Bird Sanctuary is located beside the barrage on the other side of the terminal. A world of Wonder amusement Park is 7 KM away from the terminal. There is historical landmark Khari Kuan, which is 3 KM away from the terminal. There is a botanical garden, which is 8 KM away from the terminal.

The below figure depicts satellite image of the location at Madanpur Khadar, Delhi identified for Terminal 9. The figure shows road connectivity around the terminal.

Fig. 7.42 Mapping of Connectivity for Terminal 9

- **Terminal 10 – Behind Taj Mahal**

This terminal is located behind Taj Mahal, beside Taj Yamuna viewpoint. Agra has good connectivity with well-developed roadways and railways. SH 62, NH509 & NH19 are the important roads, which connect Agra with nearby cities. SH62 is 1.6 KM away from the terminal. Agra Bus Stand is located at a distance of 6.3 Km from the proposed terminal. Nearest railway station is Agra Fort Railway Station, which is approx. 3 km away from Taj Mahal. Agra Railway Station is at a distance of 6.8 Km from the terminal. The Agra Airport is located 5 km away from the city centre of Agra. The Agra Airport is also known as Kheria Airport or Agra Civil Enclave. This airport is a military base and also serves as a passenger/ public airport.

The below figure depicts satellite image of the location behind Taj Mahal in Agra, identified for Terminal 10. The figure shows road connectivity around the terminal.

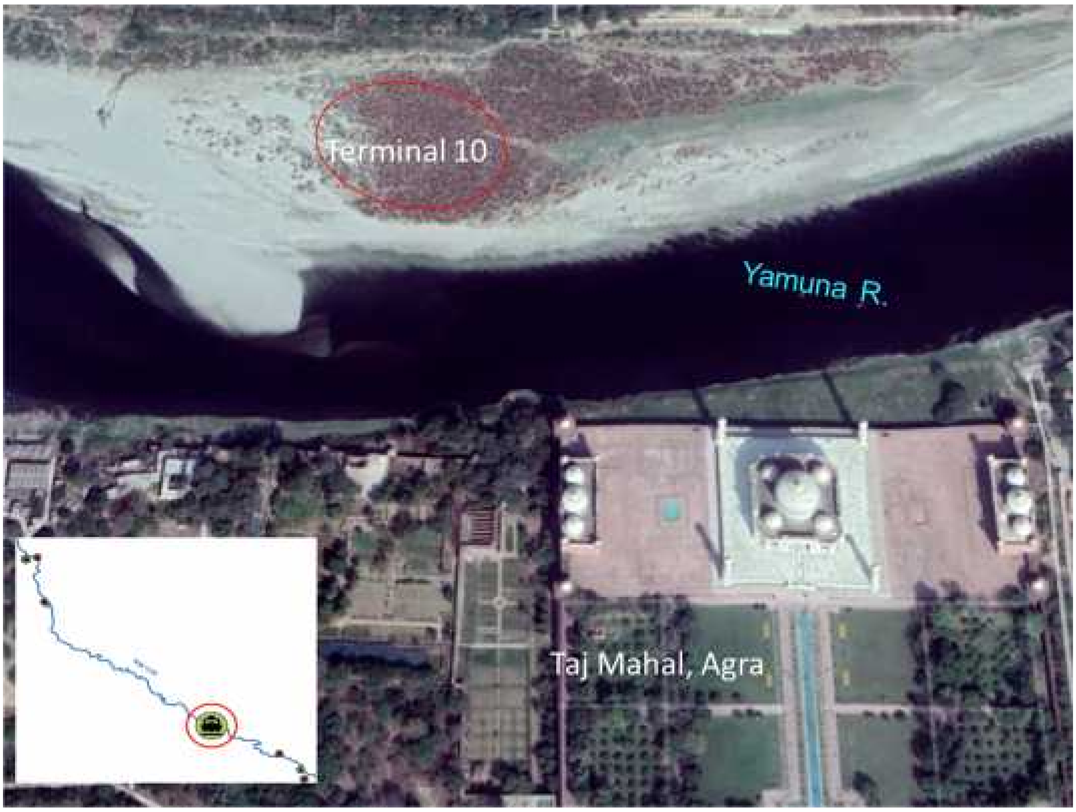


Fig. 7.43 Mapping of Connectivity for Terminal 10

- **Terminal 11 – Panigaon Khader, Mathura**

The terminal has good road and rail connectivity. The nearest road to the terminal is Yamuna Expressway Link Road, which connects Vrindavan to Yamuna Expressway. An approach road needs to be developed to connect the terminal with Yamuna Expressway Link Road. There is a bridge on this road, which is adjacent to the proposed terminal. NH19 is 9.5 KM away from the terminal. The Yamuna Expressway is just 7 KM away from the terminal. Vrindavan Bus Stand is around 2.9 Km away from the terminal. The nearest railway station is Vrindavan Railway Station, which is 4.1 Km away from the terminal. There are several ghats, namely Keshi Ghat, Chir Ghat, Imli Taal Ghat, Kaliya Ghat etc., which are 3-4 KM away from the terminal.

The below figure depicts satellite image of the location in Panigaon Khader, Vrindavan in Mathura district identified for Terminal 11. The image also shows road connectivity around the terminal location.

Fig. 7.44 Mapping of Connectivity for Terminal 11

7.11.4 Intra District Passenger Terminals Introduction & Planning

Total 7 intra district terminals are proposed to be developed for handling passenger/tourist traffic for across/along the river movement. Out of 7 terminals, 3 would be developed at Sonia Vihar, Jagatpur and Tronic City in Delhi and 4 terminals would be developed at Sujawan Ghat, Saraswati Ghat, Hanuman Ghat and Boat Club in Prayagraj. This section would discuss in detail planning for jetty and other infrastructure. The terminals would involve various amenities for tourists/passengers, including parking, rest room, café, canteen, restaurant etc.

- **Terminal 12a – Sonia Vihar, Delhi**

This terminal is located in Sonia Vihar where NH9 passes over Yamuna River, using the Wazirabad Bridge. The bridge connects Sonia Vihar and Wazirabad. Sonia Vihar-Pushta Road, also known as Prthiviraj Chouhan Marg runs parallel to Yamuna River and extends as Tronica City road eventually connecting NH709B. Right beside NH9, the construction of Signature Bridge is ongoing which would connect Wazirabad and Sonia Vihar and reduce the congestion on existing Wazirabad Bridge. Vishwavidyalya Metro Station and Vidhan Sabha Metro Station are the closest to the terminal each being 6 KM away from the terminal. Loni Railway station is the nearest passenger railway station from the terminal, being 9.6 KM away. Delhi Shahdara Junction, Delhi Railway station and Delhi Azdapur Railway station are located within 10 KM from the terminal.

The below figure depicts satellite image of the location in Sonia Vihar, Delhi identified for Terminal 12a. The image also shows road connectivity around the terminal location.

Fig. 7.45 Mapping of Connectivity for Terminal 12a

- **Terminal 12b – Jagatpur, Delhi**

This terminal is located at Shyam Ghat, which derives its name from the temple Shyam Ghat Mandir located on the bank of river Yamuna. The district Jagatpur-Bund road is the only road connectivity to and from Shyam Ghat, which connects it to the Wazirabad road. The nearest railway station is Vishwavidyalaya Metro Station, which is 7 KM away from the terminal. National Highway 9 is 6 KM away from the terminal. The Delhi Azadpur Railway Station is 11 KM away from the terminal.The below figure depicts satellite image of the location in Jagatpur, Delhi identified for Terminal 12b. The image also shows road connectivity around the terminal location.

Fig. 7.46 Mapping of Connectivity for Terminal 12b

➤ **Terminal 12c – Tronica City, Delhi**

This terminal is located near the Tronica City road and it is connected through an approach road 200 m long. The terminal is located 5 KM away from NH 709B. The nearest Railway station is Nusratabad Kharkhari, which is 9.3 KM away from the terminal. The nearest Metro station is Majlis Park which is 15 Km away from the terminal.

The below figure depicts satellite image of the location in Tronica City, Delhi identified for Terminal 12c.The image also shows road connectivity around the terminal location.

Fig. 7.47 Mapping of Connectivity for Terminal 12c

➤ **Terminal 13a– Sujawan Ghat**

This terminal is located at Sujawan Ghat and is located 18 KM away from the city of Prayagraj. The village road takes 3 KM to connect to NH 35 at Ghurpur village. The nearest passenger railway station is Iradatganj at a distance of 4 KM from the terminal. The other railway station located the terminal is Jasra, at a distance of 5 KM from the terminal. The main attraction of the ghat is the historical Sujawan Dev Temple dedicated to Lord Shiva. Another holy place is the Shitla Dham Sarjapur Temple on the banks of Yamuna, which is 2.2 KM away. During the months of June and July, every Monday and Friday a mega fair is held here.

The below figure depicts satellite image of the location in Sujawan Ghat, Prayagraj identified for Terminal 13a. The image also shows road connectivity around the terminal location.

Fig. 7.48 Mapping of Connectivity for Terminal 13a

- **Terminal 13b – Saraswati Ghat**

This terminal is located at Saraswati Ghat. NH 35 is 1.6 KM away and connected to ghat through the Parade Ground road. The Prayagraj City Railway Junction is 2.7 KM away from the ghat.

The below figure depicts satellite image of the location in Saraswati Ghat, Prayagraj identified for Terminal 13b. The image also shows road connectivity around the terminal location.

Fig. 7.49 Mapping of Connectivity for Terminal 13b

- **Terminal 13c – Boat Club**

This terminal would be developed at Yamuna Boat Club. Yamuna Boat Club is used by tourists for boating and other water sports in river Yamuna. To the left of terminal lies the Old Yamuna Bridge at 500 m distance and to the right of the terminal is the New Yamuna Bridge, which is 600m away. NH 30 is 1.5 Km away.

The below figure depicts satellite image of the location near Boat Club, Prayagrajidentified for Terminal 13c.

Fig. 7.50 Mapping of Connectivity for Terminal 13c

- **Terminal 13d –Hanuman Ghat**

This terminal is located right beside the Old Naini (Yamuna) bridge. It is on the right side of Hanuman Ghat. NH 35 and NH 30 intersection is just 1 KM away from the terminal. Prayagraj City Railway Station is just 2.9 KM away and also the nearest station from the terminal.

The below figure depicts satellite image of the location in Hanuman Ghat, Prayagraj identified for Terminal 13d. The image also shows rail and road connectivity around the terminal location.

Salient features of all terminals are given in Annexure 7.1.

Detailed Master layouts showing navigation channel alignment, existing cross structures, proposed barrages and proposed terminals are shown in Volume 2 Drawings (Drawing No. 1). Detailed Layouts of each proposed terminals are shown in Volume 2 Drawings (Drawing No. 2).

Fig. 7.51 Mapping of Connectivity for Terminal 13d

7.12 Shipbuilding & Repair

In pursuance of successful IWT movement it is essential that the following facilities for attendance to the barges plying in the route be provided

- Barge Repair - mandatory
- On route attendance
- Supply and fitment of spares
- Emergency attendance
- Route maintenance

The annual dry docking requirements of the barges may be estimated as follows:

- Mandatory dry docking - 7 days
- Special attendance for up keep – 4 days
- Emergency attendance – breakdown - 4 days
- Routine running maintenance – 5 days

7.12.1 Location of the Shipyard

It is proposed that three shipyards could be developed near the terminalsone at Chainage 349 Km Kalpi, second at Chainage 731 Km near Agra and the third at Chainage 1049 km near Okhla. This location will ensure that for reaching a dry dock, upstream or downstream barges need to travel not exceeding 300-350 km distance as upper limit.The location of the Dry-dock plays a very important role in the planning of a Dry-dock and determining its technical capability.

The shipyard locations are well connected with roadways. Very good connectivity enables the Dry-docks to quickly avail material for ship repair and ship building activities. Kanpur, Delhi NCR, Meerut, etc. is prominent for light engineering industries. These Engineers and technicians could be used for ship repair after providing small training. Availability of labour at the proposed sites would not be issue. Labour cost at the proposed locations is low. Local youths and unemployed locals could be provided vocational training facility for skill development and absorbing them in the Dry-dock.

7.12.2 Technical Planning

- **Site Analysis**
  The section describes how the proposed Dry-docks should be designed, keeping in view the type of vessels these Dry-docks can cater to and the scale of operation.

- **Draft Availability**
  The waterways would be handling small and low draft vessels. The shipyard could be used for building and repair of all types of vessels up to class VII. The waterfront of river Yamuna at both these locations appears to be calm and devoid of any strong currents. Hence, there is no need for any protection of breakwater to be created, as is the case for open sea. It is a good location for creation of Dry-dock and repair berths.

- **Land & water front availability**
  The proposed ship repair yards would have optimised infrastructure in the identified land near the proposed terminals in Prayagraj and Kanpur. It would have two berths used for repair and building. One berth would have dry dock and 2nd one would have a slipway.

- **Connectivity**
  The proposed sites in Prayagraj and Kanpur are well connected. There are ample roads, connecting the proposed sites to the nearest highway and railway station.

7.12.3 Infrastructure Planning

The proposed Shipyard has all the essential requirements to be commercially viable. Some of these could be listed as

- ✓ Existence of potential customers
- ✓ Availability of workforce
- ✓ Suitable product mix
- ✓ Efficient production process

The proposed dry-docks would cater to vessels, which would ply on NW 110 for cargo and passengers.

➢ **Product Mix and Volumes of work**

The product mix would consist of high added value small tonnage specialised ships with displacement ranging from Class I to Class VII of ships plying in river. The average repair period for ships at yard would carry from 8 days to 10 days. The ship depending upon its complicity takes around 6 days to 8 days in the dry dock and rest at the jetty for afloat repair. Small vessels would take relatively smaller time in the repair yard.

7.12.4 Dry-docking& Repair Process

Dry-docking and repair is a service, which consists of a number of smaller services (repairs) on various parts and components of the vessels. The extent and complexity of these services will vary from job to job. Hence in order to understand the business, it is imperative to understand the process of ship repair and the nature of services offered during the process. The essential repair and maintenance services could be described as follows.

- ✓ Dry-docking repair is a statutory requirement for vessels to carry out regular business
- ✓ All ships undertaking waterway trade would require periodic dry-docking repair for seamless operation. As the infrastructure and operation in river Yamuna would be new; hence all vessels would need maintenance and repair facility on the bank of NW 110. Lack of ship repair yard would adversely affect operations on national waterway.
- ✓ Availability of ship repair infrastructure on the bank of Yamuna is nil
- ✓ The identified sites are the most prominent and promising locations to generate business for ship repair yard. The two primary reasons for high prospects of ship repair business in and around Prayagraj and Kanpur are as follows
- ✓ Existence of terminals on Inland Waterway 110.
- ✓ Absence of other ship repair yard on the bank of river Yamuna

At present, there is no other infrastructure in the vicinity to undertake the repair and maintenance of vessels, which would operate in river Yamuna. A ship has to undergo periodic full-fledged repair on a calendar year basis to align themselves with safety and statutory requirements. IWAI vessel would need to be dry-docked at least twice in 5 years to assess the condition of hull and ensure its safe working condition.

7.13 New Infrastructure / Facilities Assessment

The identified locations for the proposed terminals lack infrastructure. Few Ghats near Prayagraj, like Boat Club and Saraswati Ghat have basic infrastructure, as they are currently operational. However, with the development of full-fledged terminals on all the identified locations, it is necessary to develop other supporting infrastructure and facilities. There is a need to develop approach road in most the terminals. Supporting infrastructure and facilities for cargo handling would be different from passenger/tourist terminals. For example, for coal & fly ash handling, rail siding would be required near the terminals. The below tables depict infrastructure requirement at each cargo terminal and passenger terminal.

Table 7.35 Requirement of Additional Infrastructure at each Cargo Terminal

Sr. No.	Infrastructure	Requirement at each Terminal							
		1	2	3	4	5	6	7	8
1	Multimodal Logistics Hub	✓	✓	✓	✓	✓	✓	✓	✓
2	ICD	✗	✗	✗	✗	✗	✓	✓	✓
3	Cold Storage	✗	✗	✗	✗	✗	✗	✗	✗
4	Stacking or Storage area, Warehouses	✓	✓	✓	✓	✓	✓	✓	✓
5	Rail Siding	✓	✓	✓	✓	✓	✗	✗	✗
6	Freight Depot	✓	✓	✓	✓	✓	✗	✗	✗
7	Construction of Approach Road for terminal	✓	✓	✓	✓	✓	✓	✓	✓

Table 7.36 Requirement of Additional Infrastructure at each Passenger Terminal

Sr. No.	Infrastructure	Requirement at each Terminal				
		9	10	11	12 (a, b, c)	13 (a, b, c, d)
1	Parking Area	✓	✓	✓	✓	✓
2	Cafe	✓	✓	✓	✓	✓
3	Restroom	✓	✓	✓	✓	✓
4	River Facing Restaurant	✗	✗	✗	✗	13 a&b ✓
5	Canteen	✓	✓	✓	✓	✓
6	Waiting Hall	✓	✓	✓	✓	✓
7	Book Shop (books on history, Taj Mahal, architecture etc.)	✗	✓	✗	✗	✗
8	Interpretation Centre	✗	✓	✗	✗	✗
9	Changing room	✗	✗	✗	✗	13c- ✓

7.13.1 Water Requirement for Cargo Terminals

- **Terminal 1**

Table 7.37 Annual Water Requirement- Construction Phase (Kilo Litres)

Particulars (Tons)	Phase I	Phase II	Total
Terminal	1,87,500	1,87,500	3,75,000
Stockyards	5,44,500	5,89,875	11,34,375
Roads/Rail	1,83,458	1,22,306	3,05,764
Open Spaces	34,398	22,932	57,331
Admin Offices	27,573	-	27,573
Green Zone	2,38,079	-	2,38,079
Total	**12,15,509**	**9,22,613**	**21,38,122**

Table 7.38 Daily Water Requirement- Operation Phase for Terminal 1

Particulars	Description			Water Requirements		
	Units	Phase I	Phase II	Phase I	Phase II	Units
Drinking Water						
Office Workers	People	15	25	750	1,250	Lpd
Subcontractors	People	200	350	10,000	17,500	Lpd
Barge Supply	Barges	1	2	4,000	8,000	Lpd
Total Drinking Water				**14,750**	**26,750**	
Portable Water						
Green Zone	Sq. m	27,209	27,209	2,72,090	2,72,090	Lpd
STP	Cu m	15,000	15,000	3,75,000	3,75,000	Lpd
Dust Suppression	Sq. m	43,560	47,190	21,78,000	23,59,500	Lpd
General Cleaning		58,806	58,806	2,94,028	2,94,028	Lpd
Landscaping		500	1,000	5,000	10,000	Lpd
Barge Supply	Barges	1	2	7,000	14,000	Lpd
Total Portable Water				**11,70,918**	**12,01,068**	Lpd

- **Terminal 2**

Table 7.39 Annual Water Requirement- Construction Phase (Kilo Litres)

Particulars	Phase I	Phase II	Total
Terminal	1,87,500	1,87,500	3,75,000
Stockyards	5,46,000	5,46,000	10,92,000
Roads/Rail	1,91,594	1,27,730	3,19,324
Open Spaces	35,924	23,949	59,873
Admin Offices	27,573	-	27,573
Green Zone	2,38,079	-	2,38,079
Total	**12,26,670**	**8,85,179**	**21,11,849**

Table 7.40 Daily Water Requirement- Operation Phase for Terminal 2

Particulars	Description			Water Requirements		
	Units	Phase I	Phase II	Phase I	Phase II	Units
Drinking Water						
Office Workers	People	15	25	750	1,250	Lpd
Subcontractors	People	200	350	10,000	17,500	Lpd
Barge Supply	Barges	1	2	4,000	8,000	Lpd
Total Drinking Water				**14,750**	**26,750**	
Portable Water						
Green Zone	Sq. m	27,209	27,209	2,72,090	2,72,090	Lpd
STP	Cu m	15,000	15,000	3,75,000	3,75,000	Lpd
Dust Suppression	Sq. m	43,680	43,680	21,84,000	21,84,000	Lpd
General Cleaning		60,840	60,840	3,04,198	3,04,198	Lpd
Landscaping		500	1,000	5,000	10,000	Lpd

Particulars	Description			Water Requirements		
	Units	Phase I	Phase II	Phase I	Phase II	Units
Barge Supply	Barges	1	2	7,000	14,000	Lpd
Total Portable Water				**11,81,688**	**11,93,688**	Lpd

- **Terminal 3**

Table 7.41 Annual Water Requirement- Construction Phase (Kilo Litres)

Particulars	Phase I	Phase II	Total
Terminal	1,87,500	3,75,000	5,62,500
Stack yards	7,55,625	7,55,625	15,11,250
Roads/Rail	1,60,480	2,40,720	4,01,200
Open Spaces	30,090	45,135	75,225
Admin Offices	27,573	-	27,573
Green Zone	3,65,479	-	3,65,479
Total	15,26,747	14,16,480	29,43,227

Table 7.42 Daily Water Requirement- Operation Phase for Terminal 3

Particulars	Units	Water Requirement				Units
		Phase I	Phase II	Phase I	Phase II	
Drinking Water						
Office Workers	People	15	25	750	1,250	Lpd
Subcontractors	People	200	350	10,000	17,500	Lpd
Barge Supply	Barges	1	2	4,000	8,000	Lpd
Total Drinking Water				**14,750**	**26,750**	
Portable Water						Lpd
Green Zone	Sq. m	41,769	41,769	4,17,690	4,17,690	Lpd
STP	Cu m	15,000	15,000	3,75,000	3,75,000	Lpd
Dust Suppression	Sq. m	60,450	60,450	30,22,500	30,22,500	Lpd
General Cleaning		53,061	67,680	2,65,305	3,38,400	Lpd
Landscaping		500	1,000	5,000	10,000	Lpd
Barge Supply	Barges	1	2	7,000	14,000	Lpd
Total Portable Water				**13,72,245**	**14,57,340**	Lpd

- **Terminal 4**

Table 7.43 Annual Water Requirement- Construction Phase (Kilo Litres)

Particulars	Phase I	Phase II	Total
Terminal	3,75,000	1,87,500	5,62,500
Stack yards	12,23,704	18,33,530	30,57,234
Roads/Rail	1,85,621	1,23,747	3,09,368
Open Spaces	34,804	23,203	58,007
Admin Offices	27,573	-	27,573
Green Zone	1,51,015	2,26,522	3,77,536
Total	**19,97,716**	**23,94,502**	**43,92,218**

Table 7.44 Daily Water Requirement- Operation Phase for Terminal 4

Particulars	Units	Phase I	Phase II	Phase I	Phase II	Units
	Description			Water Requirement		
Drinking Water						
Office Workers	People	15	25	750	1,250	Lpd
Subcontractors	People	200	350	10,000	17,500	Lpd
Barge Supply	Barges	1	2	4,000	8,000	Lpd
Total Drinking Water				**14,750**	**26,750**	
Portable Water						Lpd
Green Zone	Sq. m	17,259	17,259	1,72,588	1,72,588	Lpd
STP	Cu m	15,000	15,000	3,75,000	3,75,000	Lpd
Dust Suppression	Sq. m	97,896	1,46,682	48,94,816	73,34,120	Lpd
General Cleaning		63,096	63,096	3,15,481	3,15,481	Lpd
Landscaping		500	1,000	5,000	10,000	Lpd
Barge Supply	Barges	1	2	7,000	14,000	Lpd
Total Portable Water				**13,64,551**	**16,20,481**	Lpd

- **Terminal 5**

Table 7.45 Annual Water Requirement- Construction Phase (Kilo Litres)

Particulars	Phase I	Phase II	Total
Terminal	3,75,000	3,75,000	7,50,000
Stack yards	10,09,455	10,09,455	20,18,909
Roads/Rail	2,13,607	1,42,405	3,56,012
Open Spaces	40,051	26,701	66,752
Admin Offices	27,573	-	27,573
Green Zone	99,502	1,49,252	2,48,754
Total	**17,65,188**	**17,02,812**	**34,68,000**

Table 7.46 Daily Water Requirement- Operation Phase for Terminal 5

	Description			Water Requirement		
Particulars	Units	Phase I	Phase II	Phase I	Phase II	Units
Drinking Water						
Office Workers	People	15	25	750	1,250	Lpd
Subcontractors	People	200	350	10,000	17,500	Lpd
Barge Supply	Barges	1	2	4,000	8,000	Lpd
Total Drinking Water				**14,750**	**26,750**	
Portable Water						Lpd
Green Zone	Sq. m	11,372	11,372	1,13,716	1,13,716	Lpd
STP	Cu m	15,000	15,000	3,75,000	3,75,000	Lpd
Dust Suppression	Sq. m	80,756	80,756	40,37,818	40,37,818	Lpd
General Cleaning		70,093	70,093	3,50,464	3,50,464	Lpd
Landscaping		500	1,000	5,000	10,000	Lpd
Barge Supply	Barges	1	2	7,000	14,000	Lpd
Total Portable Water				**12,54,962**	**12,66,962**	Lpd

- **Terminal 6**

Table 7.47 Annual Water Requirement- Construction Phase (Kilo Litres)

Particulars	Phase I	Phase II	Total
Terminal	3,75,000	1,87,500	5,62,500
Stack yards	7,01,500	-	7,01,500
Roads/Rail	1,01,022	67,348	1,68,370
Open Spaces	18,942	12,628	31,569
Admin Offices	27,573	-	27,573
Green Zone	62,095	93,143	1,55,238
Total	12,86,132	3,60,619	16,46,751

Table 7.48 Daily Water Requirement- Operation Phase for Terminal 6

Particulars	Description			Water Requirements		
	Units	Phase I	Phase II	Phase I	Phase II	Units
Drinking Water						
Office Workers	People	15	25	750	1,250	Lpd
Subcontractors	People	200	350	10,000	17,500	Lpd
Barge Supply	Barges	1	2	4,000	8,000	Lpd
Total Drinking Water				**14,750**	**26,750**	
Portable Water						Lpd
Green Zone	Sq. m	7,097	7,097	70,966	70,966	Lpd
STP	Cu m	15,000	15,000	3,75,000	3,75,000	Lpd
Dust Suppression	Sq. m	-	-	-	-	Lpd
General Cleaning		41,947	41,947	2,09,733	2,09,733	Lpd
Landscaping		500	1,000	5,000	10,000	Lpd
Barge Supply	Barges	1	2	7,000	14,000	Lpd
Total Portable Water				**6,67,699**	**6,79,699**	Lpd

- **Terminal 7**

Table 7.49 Annual Water Requirement- Construction Phase (Kilo Litres)

Particulars	Phase I	Phase II	Total
Terminal	13,12,500	5,62,500	18,75,000
Stack yards	9,59,313	9,59,313	19,18,625
Roads/Rail	4,07,189	2,71,459	6,78,648
Open Spaces	76,348	50,899	1,27,247
Admin Offices	27,573	-	27,573
Green Zone	1,29,000	1,93,499	3,22,499
Total	29,11,922	20,37,670	49,49,591

Table 7.50 Daily Water Requirement- Operation Phase for Terminal 7

Particulars	Description			Water Requirements		
	Units	Phase I	Phase II	Phase I	Phase II	Units
Drinking Water						
Office Workers	People	15	25	750	1,250	Lpd
Subcontractors	People	200	350	10,000	17,500	Lpd

Particulars	Description			Water Requirements		
	Units	Phase I	Phase II	Phase I	Phase II	Units
Barge Supply	Barges	1	2	4,000	8,000	Lpd
Total Drinking Water				**14,750**	**26,750**	
Portable Water						Lpd
Green Zone	Sq. m	14,743	14,743	1,47,428	1,47,428	Lpd
STP	Cu m	15,000	15,000	3,75,000	3,75,000	Lpd
Dust Suppression	Sq. m	-	-	-	-	Lpd
General Cleaning		1,37,238	1,37,238	6,86,191	6,86,191	Lpd
Landscaping		500	1,000	5,000	10,000	Lpd
Barge Supply	Barges	1	2	7,000	14,000	Lpd
Total Portable Water				**12,20,619**	**12,32,619**	Lpd

- **Terminal 8**

Table 7.51 Annual Water Requirement- Construction Phase (Kilo Litres)

Particulars	Phase I	Phase II	Total
Terminal	3,75,000	1,87,500	5,62,500
Stack yards	5,07,656	5,07,656	10,15,313
Roads/Rail	6,94,722	4,63,148	11,57,870
Open Spaces	34,736	23,157	57,894
Admin Offices	27,573	-	27,573
Green Zone	77,578	1,16,366	1,93,944
Total	17,17,265	12,97,828	30,15,093

Table 7.52 Daily Water Requirement- Operation Phase for Terminal 8

Particulars	Description			Water Requirements		
	Units	Phase I	Phase II	Phase I	Phase II	Units
Drinking Water						
Office Workers	People	15	25	750	1,250	Lpd
Subcontractors	People	200	350	10,000	17,500	Lpd
Barge Supply	Barges	1	2	4,000	8,000	Lpd
Total Drinking Water				**14,750**	**26,750**	
Portable Water						Lpd
Green Zone	Sq. m	8,866	8,866	88,660	88,660	Lpd
STP	Cu m	15,000	15,000	3,75,000	3,75,000	Lpd
Dust Suppression	Sq. m	-	-	-	-	Lpd
General Cleaning		1,13,952	1,13,952	5,69,760	5,69,760	Lpd
Landscaping		500	1,000	5,000	10,000	Lpd
Barge Supply	Barges	1	2	7,000	14,000	Lpd
Total Portable Water				**10,45,420**	**10,57,420**	Lpd

7.14 Vessel Designing

River Yamuna could be developed under Class III, Class IV, or Class VI waterways. The length of Yamuna river for development is around 1,089 Km. the navigable length of the river could be used for transportation of bulk cargo. A major opportunity rests with cargo distribution at Thermal Power Plant near the stretch of Yamuna River. The plant acquires domestic coal from coal mines, albeit ceased at present. In return, the fly ash produced at the power plant as a by-product, which is unutilized could be transported back to Haldia and then finally to Singapore. In Maharashtra, power plants are already planning to transport fly ash to Singapore.

Other commodities like Fertilisers, food grains, sugar, Iron & Steel and containers could be transported or distributed via Yamuna River.

7.14.1 General Review

An optimum sized vessel has to be selected for carrying coal in Yamuna. Thermal power plants would need definite shipments of domestic as well as imported coal at regular intervals. The recent transportation of domestic coal has been undertaken by using railways. The cost of operating vessel in Yamuna should be lower as compared to the total end-to-end logistics cost using other mode of transportation like railways. The cost of transportation of any commodities using waterways is entirely dependent upon the distance of travel and volume of cargo. A large volume of cargo reduces per-tonne cost of transportation when moved using waterways. Availability of return cargo, in case of Terminals 2 to 5 at Thermal power plant, should further add to the viability of the operation. In case of lack of return cargo, barges have to make return trips without cargo. Such an operation induces cost overhead, as barges 'operational cost still applies, but without maximizing its commercial viability by carrying cargo.

The section to follow gives development details for all the terminals along the earmarked stretch of River Yamuna for waterway development. 8 terminals are for cargo handling, and other 10 for tourism and passenger ferrying.

Table 7.53 Development of Yamuna

Sr. No.	Location	Cargo	Chainage (Km)
1.	Madanpur Khadar	Coal	1051.3
2.	Samogar Mustkil	Coal, Fly Ash	731
3.	Mahewa Khachhar	Coal, Fly Ash	98.7
4.	Dilauliya Kachhar	Coal, Fly Ash	350.4
5.	Near Naini Bridge	Coal, Fly Ash	3.0
6.	Mahewa East/	Fertiliser, Food Grains, Sugar	4.2
7.	Madanpur Khadar	Iron & Steel, Automobiles, Containers, Food Grains & Sugar	1051.3
8.	Daulatpur, Kanpur Dehat	Food Grains, Iron & Steel, Sugar	350.4
9.	Madanpur Khadar	Tourism	1051.3
10.	Near Taj Mahal	Tourism	742.0
11.	Panigaon Khader	Tourism	858.5

Sr. No.	Location	Cargo	Chainage (Km)
12a.	Sonia Vihar	Tourism	1077.5
12b.	Jagatpur	Tourism	1079.0
12c	Tronica City	Tourism	1081.0
13a.	Sujawan Ghat	Tourism	19.5
13b.	Saraswati Ghat	Tourism	2.0
13c.	Near Boat Club	Tourism	3.4
13d	Hanuman Ghat	Tourism	4.0

- **Terminal 1 to 5**

Terminal 1 will have one way coal cargo from mines to plant as fly ash generated at Dadri plant is fully utilised. Terminal 2 to Terminal 5 will present opportunities for both way cargos. Domestic coal can be transported from mines via River Yamuna using barges and fly-ash from different TPP could be the return cargo.

The size, type, carrying capacity, and speed of the vessel to be deployed on River Yamuna should amount to minimum cost of operation. The cost of transporting coal on the waterway to TPP has to be lower compared to the existing cost of transporting coal via rail from mines. One-to-one cost comparison has been undertaken for comparing all the activities including cargo handling, stacking, loading in to rakes, transportation and finally unloading at Thermal plant. This cost comparison has been undertaken only for coal. As an alternative to plying barge on just ballast, it's recommended that fly ash be transported instead. The cargo is in extensive demand among cement manufacturers outside the country via Haldia, and TPP produces this cargo in surplus or less utilised. Also, since there is no current movement of fly ash along this route, using roadways or railways, end-to-end logistics comparison with the proposed waterway movement is not needed. Fly ash related logistics will be utilized only in evaluating barge turnaround time on return trip.

- **Terminal 6**

Terminal 6 is proposed at Mahewa East near Jamuna Bridge at Prayagraj to handle fertilizer. IFFCO Phulpur is situated at 30 Km from Prayagraj city It will help IFFCO Phulpur plant to distribute the fertilizer in the following Yamuna stretch at Terminal 7 & 8 (multipurpose terminal). At first, fertilizer is transported via roadways to the terminal in Prayagraj and then it is moved via waterways to terminal 7 & 8. Fertiliser as clean cargo can be transported via any clean cargo terminal or multipurpose terminal. The total Urea production from IFFCO Phulpur Complex was 1.6 MMT out of which 0.6 MMT is from Phulpur-I and 0.9 MMT from Phulpur-II in the FY 2016-17.

Fertiliser handling vessel, their dimensions, type, capacity, and speed of vessel to be deployed on River Yamuna should consider optimum cost of operation.

- **Terminal 7**

Terminal 7 is proposed at Madanpur Khadar, near Okhla barrage, in New Delhi. It is proposed as multipurpose cargo terminal to handle clean but multipurpose cargo like Fertiliser, Iron & Steel, Automobiles, Food grains, Sugar etc. Okhla and Tughlakabad (TKD) freight station are within 12 Km from terminal 7. It will provide proper connectivity of railways for cargo transportation to and from Delhi.

- **Terminal 8**

Terminal 8 is proposed at Daulatpur near Kanpur Dehat. It will be multipurpose terminal handling food grains from Punjab/Haryana and Sugar from Muzafarnagar to distribute in internal parts of UP namely Kanpur & nearby region, iron & steel from Odisha, fertilizer distribution from Phulpur plant and etc.Itis situated almost 76.5 Km from the Kanpur city. NH 27 is the main roadway, which passes through the terminal. It connects Jhansi to Kanpur. The nearest railway station Kalpi is just 1.8 Km from proposed Terminal location.

- **Terminal 9, 10 and 11**

Terminal 9/10/11 is proposed for developing tourism and river transportation of tourists from one location to another. The location identified for jetty to handle the proposed tourism traffic from Delhi to Varanasi via Vrindavan, Agra, Kanpur Dehat, Prayagraj and Varanasi.

7.14.2 Design Basis

The classification of vessels described by IWAI requires certain length and certain draft of vessel to be maintained for optimum use. Under this condition, there are other factors thatwill also influence the specific class of vessels that should be deployed on the River to handle traffic to and from Cargo Terminals.

The following flowchart illustrates the decision-making involvedin making the recommendation for the specific classes of vessels IWAI should invest in for Terminal 1 to 8.

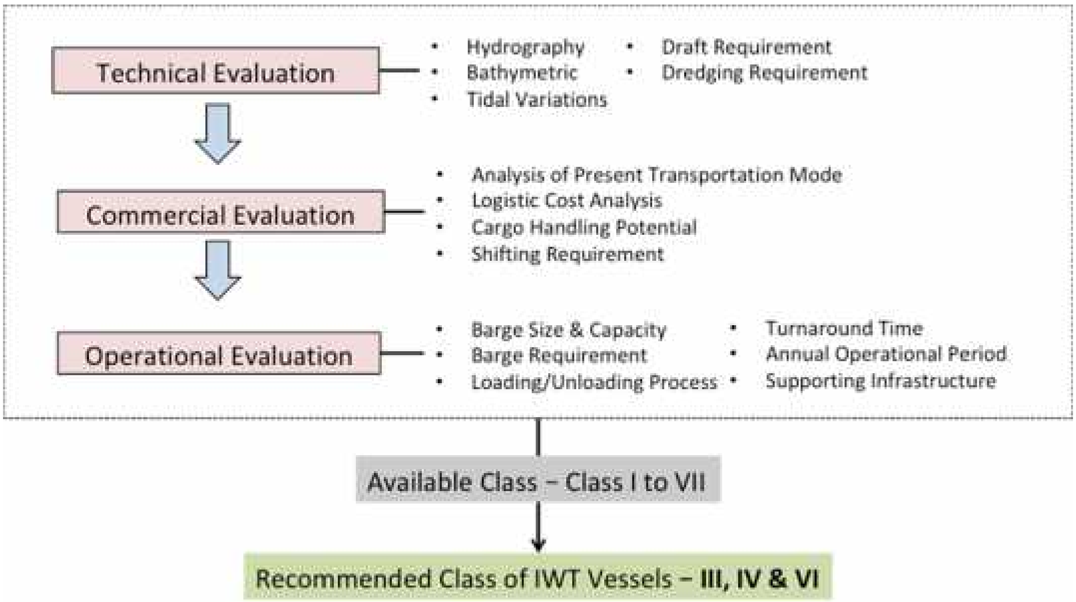


Fig. 7.52 Steps for proposed Vessel design

The technical evaluation acts as the ultimate framework, within which the vessel design selection has to be made. Primarily, hydrographic study, tidal study, draft available and required, together helps evaluate technical conditions that the vessel needs to meet in order to ply on River Yamuna. Next, commercial evaluation involving projected traffic volume for Terminal 1 to 8, and willingness of the potential client (TPP) to shift to waterways further helps narrow down the type of vessels to be recommended. Traffic evaluation makes way for the probable operational conditions under which barges will be operating. This requires knowledge of loading/unloading duration, which will further dictate the turnaround time for barges.

Prevailing maritime conditions on River Yamuna, probable commercial demands that could be met via the proposed waterway, frequency of cargo movement, and total duration for the suggested operation are the overall understanding applied to determine the class of vessels. Vessel from class III, IV, and VI are the options available for IWAI to invest in to cater to the potential traffic at Terminals 1 to 8. Higher the class of vessels, larger the capacity, and lower the logistics cost will be.

7.14.3 Type of Proposed Vessels

The following images depict typical cargo vessels that are used for coal transportation. These are for illustrative purposes only.

Fig. 7.53 Vessel for coal handling

7.14.4 Proposed Vessel Size and Specification

The mentioned vessels in Table 66 are the entire allowed fleet of river-class vessels based on IWAI classifications. Among these, the highlighted ones are the vessels recommended for deployment on River Yamuna.

Table 7.54 Assumption for Vessel Design & Logistics Cost Analysis

Class	Size (m)		Loaded Draft	Capacity (DWT)	Charter Rates - Barge (Rs./Day)	Power (KW)	Consumption		Speed (Knots)
	L	B	(m)				Fuel	Ltr/Hr.	
I	32	5	1.0	100	18,000	-	DO	50	06-07
II	45	8	1.2	300	30,000	337	DO	90	06-07
III	58	9	1.5	500	60,000	-	DO	110	06-07
IV	70	12	1.8	1,000	80,000	432	DO	122	06-07
V	70	12	1.8	1,000	80,000	432	DO	122	06-07
VI	86	14	2.5	2,000	1,10,000	597	DO	177	06-07
VII	86	14	2.9	4,000	1,30,000	-	DO	250	06-07

Source: IWAI

Class III, IV, and VI are recommended for cargo movement for river Yamuna, primarily because the river has enough draft to accommodate all of these vessels. Even Class V vessels are a good contender, as their specifications are identical to Class IV vessels. Also, these are all self-propelled type vessel. Detailed Specification of Passenger boat is mentioned in below table.

Table 7.55 Specification of Indicative Passenger ferry

Passenger Ferry	Class I	Class II	Class III	Class IV	Class V	Class VI	Class VII
	Damen Ferry 1806	Fast Ferry	Dalmau Eco Slim	VST 10	NB 33 Catamaran	NB43 Double Ended	BLT 2003
Length (m)	18	14	24	36.4	39	41.2	43
Beam (m)	5.6	3.2	10.5	11.3	11.6	10	8.9

Passenger Ferry	Class I	Class II	Class III	Class IV	Class V	Class VI	Class VII
	Damen Ferry 1806	Fast Ferry	Dalmau Eco Slim	VST 10	NB 33 Catamaran	NB43 Double Ended	BLT 2003
Draft (m)	1.8	1.2	1.5	1.7	1.7	1.9	2.8
Passenger Capacity (PAX)	130	45	150	330	426	700	500
Speed (Km/h)	8.5	25.0	12.0	45.0	18.0	13.0	17.0

7.14.5 Turnaround Time

The table below shows the computed turnaround time required per barge for every class of vessels classified by IWAI. The entire waterway logistic analysis computed herein is based on the assumption that only daytime navigation will be allowed:

- Terminal 1 – Total Turnaround Time

Table 7.56 Terminal 1 – Badarpur TPP Total turnaround time

Description	Fy22	Fy 27	Fy 37	Fy 47
Loading time - Hours	5	5	5	5
Sailing Time - Loaded (Sahibganj to Badarpur Plant) Hr.	170	170	170	170
Discharge time @ Madanpur Khadar Jetty - Hours	5	5	5	5
Sailing Time - Ballast (Badarpur Plant to Sahibganj) Hr.	114	114	114	114
Total Time (Hours)	293	293	293	293

Table 7.57 Terminal 1 – Dadri TPP Total turnaround time

Description	Fy22	Fy 27	Fy 37	Fy 47
Loading time - Hours	5	5	5	5
Sailing Time - Loaded (Patna Ghat to Dadri Plant) Hr.	151	151	151	151
Discharge time @ Madanpur Khadar Jetty - Hours	5	5	5	5
Sailing Time - Ballast (Dadri Plant to Patna Ghat) Hr.	101	101	101	101
Total Time (Hours)	261	261	261	261

- Terminal 2 – Total Turnaround Time

Table 7.58 Terminal 2 – Harduaganj TPP Total turnaround time

Description	Fy22	Fy 27	Fy 37	Fy 47
Loading time - Hours	5	5	5	5
Sailing Time - Loaded (Sahibganj to Harduaganj Plant) Hr	151	151	151	151
Discharge time @ Samogar Mustkil Jetty - Hours	5	5	5	5
Sailing Time - Ballast (Harduaganj Plant to Sahibganj) Hr	103	103	103	103
Total Time (Hours)	263	263	263	263

Table 7.59 Terminal 2 – Jawaharpur TPP Total turnaround time

Description	Fy22	Fy 27	Fy 37	Fy 47
Loading time - Hours	5	5	5	5
Sailing Time - Loaded (Varanasi to Jawaharpur Plant) Hr	96	96	96	96
Discharge time @ Samogar Mustkil Jetty - Hours	5	5	5	5

Description	Fy22	Fy 27	Fy 37	Fy 47
Sailing Time - Ballast (Jawaharpur Plant to Varanasi Ghat) Hr	67	67	67	67
Total Time (Hours)	172	172	172	172

- Terminal 3 – Total Turnaround Time

Table 7.60 Terminal 3 –Tanda TPP Total turnaround time

Description	Fy22	Fy 27	Fy 37	Fy 47
Loading time - Hours	5	5	5	5
Sailing Time - Loaded (Sahibganj to Tanda Plant) Hr.	84	84	84	84
Discharge time @ Mehwa Khachhar - Hours	5	5	5	5
Sailing Time - Ballast (Tanda Plant to Sahibganj) Hr.	56	56	56	56
Total Time (Hours)	150	150	150	150

Table 7.61 Terminal 3 –Unchahar TPP Total turnaround time

Description	Fy22	Fy 27	Fy 37	Fy 47
Loading time - Hours	5	5	5	5
Sailing Time - Loaded (Sahibganj to Unchahar Plant) Hr.	84	84	84	84
Discharge time @ Mahewa Khachhar Jetty - Hours	5	5	5	5
Sailing Time - Ballast (Unchahar Plant to Sahibganj Terminal) Hr.	56	56	56	56
Total Time (Hours)	150	150	150	150

- Terminal 4 – Total Turnaround Time

Table 7.62 Terminal 4 – Panki TPP Total turnaround time

Description	Fy22	Fy 27	Fy 37	Fy 47
Loading time - Hours	5	5	5	5
Sailing Time - Loaded (Sahibganj to Panki Plant) Hr.	107	107	107	107
Discharge time @ Dilauliya Kachhar Jetty - Hours	5	5	5	5
Sailing Time - Ballast (Panki Plant to Sahibganj Terminal) Hr.	71	71	71	71
Total Time (Hours)	187	187	187	187

Table 7.63 Terminal 4 – Parichha TPP Total turnaround time

Description	Fy22	Fy 27	Fy 37	Fy 47
Loading time - Hours	5	5	5	5
Sailing Time - Loaded (Sahibganj to Parichha Plant) Hr.	107	107	107	107
Discharge time @ Dilauliya Kachhar Jetty - Hours	5	5	5	5
Sailing Time - Ballast (Parichha Plant to Sahibganj Terminal) Hr.	71	71	71	71
Total Time (Hours)	187	187	187	187

- Terminal 5 – Total Turnaround Time

Table 7.64 Terminal 5 – Bara TPP Total turnaround time

Description	Fy22	Fy 27	Fy 37	Fy 47
Loading time - Hours	5	5	5	5
Sailing Time - Loaded (Varanasi to Bara Plant) Hr.	107	107	107	107
Discharge time @ Naini Bridge, Arail - Hours	5	5	5	5
Sailing Time - Ballast (Bara Plant to Varanasi Terminal) Hr.	71	71	71	71
Total Time (Hours)	187	187	187	187

Table 7.65 Terminal 5 – Meja TPP Total turnaround time

Description	Fy22	Fy 27	Fy 37	Fy 47
Loading time - Hours	5	5	5	5
Sailing Time - Loaded (Varanasi to Meja Plant) Hr.	20	20	20	20
Discharge time @ Naini Bridge, Arail - Hours	5	5	5	5
Sailing Time - Ballast (Meja Plant to Varanasi Terminal) Hr.	14	14	14	14
Total Time (Hours)	43	43	43	43

7.14.6 Number of Vessels Required

- **Cargo Terminal – 1 to 5**

The following table gives an estimate of the total barges IWAI may have to invest in. These requirements will differ based on the class of vessels that is ultimately chosen to move cargo on River Yamuna.

Table 7.66 Barge Capacity & Parcel Size in Class III, IV & VI

Description	Class III		Class IV		Class VI	
	Fy 22	Fy 47	Fy 22	Fy 47	Fy 22	Fy 47
Barge Capacity (DWT)	500	500	1,000	1,000	2,000	2,000
Barge Parcel Size	450	450	900	900	1,800	1,800

Table 7.67 Terminal 1 - Number of barges/vessels required

Description	Class III		Class IV		Class VI	
	Fy22	Fy 47	Fy22	Fy 47	Fy22	Fy 47
Terminal 1 - Badarpur						
Total Traffic (mn Tonnes)	0.4	1.0	0.4	1.0	0.4	1.0
Turnaround of Barges - (Days)	13	13	13	13	13	13
Number of trips in an year	24	24	24	24	24	24
Total Transportation Per Year Per Barge (Tonnes)	10,800	10,800	21,600	21,600	43,200	43,200
Number of Barges	37	90	19	45	10	23
Terminal 1Dadri						
Total Traffic (mn Tonnes)	1.2	2.9	1.2	2.9	1.2	2.9
Turnaround of Barges - (Days)	11	11	11	11	11	11
Number of trips in an year	28	28	28	28	28	28
Total Transportation Per Year Per Barge (Tonnes)	12,600	12,600	25,200	25,200	50,400	50,400
Number of Barges	95	230	48	115	24	58

Table 7.68 Terminal 2 - Number of barges/vessels required

Description	Class III		Class IV		Class VI	
	Fy22	Fy 47	Fy22	Fy 47	Fy22	Fy 47
Terminal 2 - Harduaganj						
Total Traffic (mn Tonnes)	0.4	1.1	0.4	1.1	0.4	1.1
Turnaround of Barges - (Days)	11	11	11	11	11	11
Number of trips in an year	28	28	28	28	28	28
Total Transportation Per Year Per Barge (Tonnes)	12,600	12,600	25,200	25,200	50,400	50,400
Number of Barges	35	85	18	43	9	22

Description	Class III		Class IV		Class VI	
	Fy22	Fy 47	Fy22	Fy 47	Fy22	Fy 47
Terminal 2 - Jawaharpur						
Total Traffic (mn Tonnes)	0.5	1.2	0.5	1.2	0.5	1.2
Turnaround of Barges - Day & No Ballast (Days)	8	8	8	8	8	8
Number of trips in an year	38	38	38	38	38	38
Total Transportation Per Year Per Barge (Tonnes)]	17,100	17,100	34,200	34,200	68,400	68,400
Number of Barges - Class III	30	71	15	36	8	18

Table 7.69 Terminal 3 - Number of barges/vessels required

Description	Class III		Class IV		Class VI	
	Fy22	Fy 47	Fy22	Fy 47	Fy22	Fy 47
Terminal 3 - Tanda						
Total Traffic (mn Tonnes)	0.4	0.9	0.4	0.9	0.4	0.9
Turnaround of Barges - (Days)	7	7	7	7	7	7
Number of trips in an year	43	43	43	43	43	43
Total Transportation Per Year Per Barge (Tonnes)	19,350	19,350	38,700	38,700	77,400	77,400
Number of Barges	19	46	10	23	5	12
Terminal 3 - Unchahar						
Total Traffic (mn Tonnes)	0.7	1.8	0.7	1.8	0.7	1.8
Turnaround of Barges - (Days)	7	7	7	7	7	7
Number of trips in an year	43	43	43	43	43	43
Total Transportation Per Year Per Barge (Tonnes)]	19,350	19,350	38,700	38,700	77,400	77,400
Number of Barges	39	92	20	46	10	23

Table 7.70 Terminal 4 - Number of barges/vessels required

Description	Class III		Class IV		Class VI	
	Fy22	Fy 47	Fy22	Fy 47	Fy22	Fy 47
Terminal 4 - Panki						
Total Traffic (mn Tonnes)	0.1	0.3	0.1	0.3	0.1	0.3
Turnaround of Barges - (Days)	8	8	8	8	8	8
Number of trips in an year	38	38	38	38	38	38
Total Transportation Per Year Per Barge (Tonnes)	17,100	17,100	34,200	34,200	68,400	68,400
Number of Barges	8	20	4	10	2	5
Terminal 4 - Parichha						
Total Traffic (mn Tonnes)	0.7	2.0	0.7	2.0	0.7	2.0
Turnaround of Barges - (Days)	8	8	8	8	8	8
Number of trips in an year	38	38	38	38	38	38
Total Transportation Per Year Per Barge (Tonnes)	17,100	17,100	34,200	34,200	68,400	68,400
Number of Barges	42	117	21	59	11	30

Table 7.71 Terminal 5 - Number of barges/vessels required

Description	Class III		Class IV		Class VI	
	Fy22	Fy 47	Fy22	Fy 47	Fy22	Fy 47
Terminal 5 - Meja						
Total Traffic (mn Tonnes)	0.8	2.0	0.8	2.0	0.8	2.0
Turnaround of Barges - (Days)	2	2	2	2	2	2

Description	Class III		Class IV		Class VI	
	Fy22	Fy 47	Fy22	Fy 47	Fy22	Fy 47
Number of trips in an year	150	150	150	150	150	150
Total Transportation Per Year Per Barge (Tonnes)	67,500	67,500	1,35,000	1,35,000	2,70,000	2,70,000
Number of Barges	13	30	7	15	4	8
Terminal 5 - Bara						
Total Traffic (mn Tonnes)	1.2	3.0	1.2	3.0	1.2	3.0
Turnaround of Barges - (Days)	8	8	8	8	8	8
Number of trips in an year	38	38	38	38	38	38
Total Transportation Per Year Per Barge (Tonnes)	17,100	17,100	34,200	34,200	68,400	68,400
Number of Barges	73	176	37	88	19	44

- **Inter-district Tourism Terminal – 9 and 11**

Detailed Estimation of number of passenger ferries to be deployed for accommodation of tourism traffic at Terminal 9 to 11 is discussed. Class wise traffic count per trip is assessed.

Table 7.72 Estimation of number of Passenger Ferries for Terminal 9

Financial Year	2022	2027	2037	2047
Traffic Per Day	652	720	796	879
Class 1 - Damen Ferry 1806				
Passenger Ferry Capacity Per Trip	130	130	130	130
No. of Ferries	2	2	2	2
No. of Trips	3	3	4	4
Class II - 14m Fast Ferry				
Passenger Ferry Capacity Per Trip	45	45	45	45
No. of Ferries	4	4	4	4
No. of Trips	4	4	5	5
Class III - Dalmau Eco Slim				
Passenger Ferry Capacity Per Trip	150	150	150	150
No. of Ferries	2	2	2	2
No. of Trips	3	3	3	3
Class IV - VST 10				
Passenger Ferry Capacity Per Trip	330	330	330	330
No. of Ferries	2	2	2	2
No. of Trips	1	2	2	2
Class V - NB 33 Catamaran (Ozata)				
Passenger Ferry Capacity Per Trip	426	426	426	426
No. of Ferries	2	2	2	2
No. of Trips	1	1	1	2
Class VI - NB 43 Double Ended Passenger Ferry (Goksu)				
Passenger Ferry Capacity Per Trip	700	700	700	700
No. of Ferries	1	1	1	1
No. of Trips	1	1	1	1

Financial Year	2022	2027	2037	2047
Class VII - BLT 2003				
Passenger Ferry Capacity Per Trip	500	500	500	500
No. of Ferries	1	1	1	1
No. of Trips	2	2	2	2

Table 7.73 Estimation of number of Passenger Ferries for Terminal 10

Financial Year	2022	2027	2037	2047
Traffic Per Day	164	172	190	210
Class 1 - Damen Ferry 1806				
Passenger Ferry Capacity Per Trip	130	130	130	130
No. of Ferries	2	2	2	2
No. of Trips	1	1	1	1
Class II - 14m Fast Ferry				
Passenger Ferry Capacity Per Trip	45	45	45	45
No. of Ferries	2	2	3	3
No. of Trips	2	2	2	2
Class III - Dalmau Eco Slim				
Passenger Ferry Capacity Per Trip	150	150	150	150
No. of Ferries	1	1	1	1
No. of Trips	1	1	1	1
Class IV - VST 10				
Passenger Ferry Capacity Per Trip	330	330	330	330
No. of Ferries	1	1	1	1
No. of Trips	1	1	1	1
Class V - NB 33 Catamaran (Ozata)				
Passenger Ferry Capacity Per Trip	426	426	426	426
No. of Ferries	1	1	1	1
No. of Trips	1	1	1	1
Class VI - NB 43 Double Ended Passenger Ferry (Goksu)				
Passenger Ferry Capacity Per Trip	700	700	700	700
No. of Ferries	1	1	1	1
No. of Trips	1	1	1	1
Class VII - BLT 2003				
Passenger Ferry Capacity Per Trip	500	500	500	500
No. of Ferries	1	1	1	1
No. of Trips	1	1	1	1

Table 7.74 Estimation of number of Passenger Ferries for Terminal 11

Financial Year	2022	2027	2037	2047
Traffic Per Day	1,005	1,109	1,226	1,354
Class 1 - Damen Ferry 1806				
Passenger Ferry Capacity Per Trip	130	130	130	130
No. of Ferries	2	3	3	3
No. of Trips	4	3	4	4

Financial Year	2022	2027	2037	2047
Class II - 14m Fast Ferry				
Passenger Ferry Capacity Per Trip	45	45	45	45
No. of Ferries	3	3	4	4
No. of Trips	8	9	7	8
Class III - Dalmau Eco Slim				
Passenger Ferry Capacity Per Trip	150	150	150	150
No. of Ferries	2	2	3	3
No. of Trips	4	4	3	4
Class IV - VST 10				
Passenger Ferry Capacity Per Trip	330	330	330	330
No. of Ferries	2	2	2	2
No. of Trips	2	2	2	3
Class V - NB 33 Catamaran (Ozata)				
Passenger Ferry Capacity Per Trip	426	426	426	426
No. of Ferries	2	2	2	2
No. of Trips	2	2	2	2
Class VI - NB 43 Double Ended Passenger Ferry (Goksu)				
Passenger Ferry Capacity Per Trip	700	700	700	700
No. of Ferries	2	2	2	2
No. of Trips	1	1	1	1
Class VII - BLT 2003				
Passenger Ferry Capacity Per Trip	500	500	500	500
No. of Ferries	2	2	2	2
No. of Trips	2	2	2	2

- **Intra-district Tourism Terminal – 12 and 13**

Detailed Estimation of number of passenger ferries to be deployed for accommodation oftourism traffic at Terminal 12 & 13 is discussed. Class wise traffic count per trip is assessed.

Table 7.75 Estimation of number of Passenger Ferries for Terminal 12 (A, B, and C)

Financial Year	2022	2027	2037	2047
Traffic Per Day	388	408	451	498
Class 1 - Damen Ferry 1806				
Passenger Ferry Capacity Per Trip	130	130	130	130
No. of Ferries	2	2	2	2
No. of Trips	1	2	2	2
Class II - 14m Fast Ferry				
Passenger Ferry Capacity Per Trip	45	45	45	45
No. of Ferries	1	1	1	1
No. of Trips	9	9	10	11
Class III - Dalmau Eco Slim				
Passenger Ferry Capacity Per Trip	150	150	150	150

Financial Year	2022	2027	2037	2047
No. of Ferries	1	1	1	1
No. of Trips	3	3	3	3
Class IV - VST 10				
Passenger Ferry Capacity Per Trip	330	330	330	330
No. of Ferries	1	1	1	1
No. of Trips	1	1	1	2
Class V - NB 33 Catamaran (Ozata)				
Passenger Ferry Capacity Per Trip	426	426	426	426
No. of Ferries	1	1	1	1
No. of Trips	1	1	1	1
Class VI - NB 43 Double Ended Passenger Ferry (Goksu)				
Traffic Per Day	388	408	451	498
Passenger Ferry Capacity Per Trip	700	700	700	700
No. of Ferries	1	1	1	1
No. of Trips	1	1	1	1
Class VII - BLT 2003				
Passenger Ferry Capacity Per Trip	500	500	500	500
No. of Ferries	1	1	1	1
No. of Trips	1	1	1	1

Table 7.76 Estimation of number of Passenger Ferries for Terminal 13 (A, B, C and D)

Financial Year	2022	2027	2037	2047
Traffic Per Day	16,092	16,912	18,682	20,637
Class 1 - Damen Ferry 1806				
Passenger Ferry Capacity Per Trip	130	130	130	130
No. of Ferries	8	8	10	10
No. of Trips	16	17	15	16
Class II - 14m Fast Ferry				
Passenger Ferry Capacity Per Trip	45	45	45	45
No. of Ferries	10	10	12	12
No. of Trips	36	38	35	39
Class III - Dalmau Eco Slim				
Passenger Ferry Capacity Per Trip	150	150	150	150
No. of Ferries	10	10	12	12
No. of Trips	11	12	11	12
Class IV - VST 10				
Passenger Ferry Capacity Per Trip	330	330	330	330
No. of Ferries	4	4	5	5
No. of Trips	13	13	12	13
Class V - NB 33 Catamaran (Ozata)				
Passenger Ferry Capacity Per Trip	426	426	426	426
No. of Ferries	4	4	5	5
No. of Trips	10	10	9	10
Class VI - NB 43 Double Ended Passenger Ferry (Goksu)				
Passenger Ferry Capacity Per Trip	700	700	700	700

Financial Year	2022	2027	2037	2047
No. of Ferries	3	3	4	4
No. of Trips	8	9	7	8
Class VII - BLT 2003				
Passenger Ferry Capacity Per Trip	500	500	500	500
No. of Ferries	3	3	4	4
No. of Trips	11	12	10	11

7.15 Land Acquisition

Khasra map has been collected for each proposed terminal. The summary sheet of the khasra map is presented in below stating the ownership of the land:

Table 7.77 Land Details

Terminal	Location	Total Area (Sqm)	Plot No.	Khasra No.	Area (Sqm)	Ownership Type
1	Near Okhla Barrage	194,400	-			Private
2	District: 146 Agra,Tensile: 00766 Agra, Village: 124674 Samogar Mustkil	194,249	22	00064	10,390	Private
			22	00136	34,010	Private
			22	00153	2,070	Private
			22	00188	10,280	Private
			22	00277	1,900	Private
			23	00216	11,520	Private
			23	00368	7,950	Private
			24	00380	5,420	Private
			25	00092	1,150	Private
			25	00369	5,000	Private
			25	00376	5,030	Private
			26	00373	5,720	Private
			26	00381	5,000	Private
			26	00395	8,300	Private
			27	00092	350	Private
			27	00105	8,520	Private
			31	00092	5,650	Private
			31	00118	6,340	Private
			31	00127	9,010	Private
			31	00140	5,760	Private
			31	00314	11,520	Private
			31	00333	4,840	Private
			31	00357	2,300	Private
			31	00384	6,770	Private
			31	00384	5,190	Private
			31	00395	7,380	Private

Terminal	Location	Total Area (Sqm)	Plot No.	Khasra No.	Area (Sqm)	Ownership Type
			32	00354	4,150	Private
			33	00140	5,760	Private
3	District: 174 Kaushambi, Tensile: 00886 Manjhanpur, Village: 160185 Mahewa Uparhar	271,140	569	00194	2,510	Private
			567	00197	31,160	Private
			568	00584	230	Private
			-	00601	237,240	Government (Blank)
4	District: 163 Kanpur Dehat, Tensile: 00846 Bhognipur, Village: 149630 Dilauliya Kachhar	285,304	137	00063	17,200	Private
			22122	00064	730	Private
			132	00065	4,710	Private
			4,7,15, 17,20, 28,60, 63, 74, 76,97, 98,100 , 102	00066	8,950	Government (Barren)
			138	00067	52,440	Government (Yamuna)
			17,25, 97,104	00068	15,560	Government (Drainage)
			-	00069	96,840	Government (Sand)
			-	-	88,874	Government (Blank)
5	District : 175 Prayagraj, Tensile: 00892 Karchhana, Village: 162185 Mahewa Patti Purab Kachhar	285,304	110	00025	4,600	Private
			113	00030	600	Private
			113	00031	400	Private
			116	00023	500	Private
			119	00038	1,700	Private
			124	00029	4,700	Private
			125	00029	4,800	Private
			126	00037	2,000	Private
			84	-	-	Government (Blank)
			85	-	-	Government (Blank)
			86	-	-	Government (Blank)
			87	-	-	Government (Blank)
			88	-	-	Government

Terminal	Location	Total Area (Sqm)	Plot No.	Khasra No.	Area (Sqm)	Ownership Type
						(Blank)
			89	-	-	Government (Blank)
			90	-	-	Government (Blank)
			91	-	-	Government (Blank)
			92	-	-	Government (Blank)
			94	-	-	Government (Blank)
			95	-	-	Government (Blank)
			96	-	-	Government (Blank)
			97	-	-	Government (Blank)
			98	-	-	Government (Blank)
			99	-	-	Government (Blank)
			100	-	-	Government (Blank)
			101	-	-	Government (Blank)
			102	-	-	Government (Blank)
			103	-	-	Government (Blank)
			104	-	-	Government (Blank)
			105	-	-	Government (Blank)
			107	-	-	Government (Blank)
			108	-	-	Government (Blank)
			109	-	-	Government (Blank)
			111	-	-	Government (Blank)
			112	-	-	Government (Blank)
			114	-	-	Government (Blank)
			115	-	-	Government (Blank)

Terminal	Location	Total Area (Sqm)	Plot No.	Khasra No.	Area (Sqm)	Ownership Type
			117	-	-	Government (Blank)
			118	-	-	Government (Blank)
			120	-	-	Government (Blank)
			121	-	-	Government (Blank)
			122	-	-	Government (Blank)
			123	-	-	Government (Blank)
			127	-	-	Government (Blank)
			128	-	-	Government (Blank)
			129	-	-	Government (Blank)
			130	-	-	Government (Blank)
			131	-	-	Government (Blank)
6	District : 175 Prayagraj, Tensile: 00892 Karchhana, Village: 162185 Mahewa Patti Purab Kachhar	125,048	52	00030	300	Private
			52	0019	1,200	Private
			52	00002	2,800	Private
			52	00024	1,800	Private
			52	00035	1,500	Private
			52	00025	1,400	Private
			52	00025	1,400	Private
			52	00022	1,300	Private
			52	00012	4,600	Private
			52	00028	1,500	Private
			52	00029	9,500	Private
			52	00015	6,600	Private
			52	00005	2,900	Private
			52	00016	4,100	Private
			52	00027	2,000	Private
			52	00020	1,700	Private
			52	00031	7,300	Private
			52	00030	1,100	Private
			52	00032	1,100	Private
			52	00026	2,400	Private
			52	00009	4,000	Private
			54	00009	4,000	Private

Terminal	Location	Total Area (Sqm)	Plot No.	Khasra No.	Area (Sqm)	Ownership Type
			55	00035	2,600	Private
			56	00036	2,500	Private
			57	00021	3,400	Private
			58	00021	600	Private
			59	00021	3,600	Private
			60	00019	3,800	Private
			61	00025	4,200	Private
			62	00025	500	Private
			63	-	-	Government (Blank)
			64	-	-	Government (Blank)
			65	-	-	Government (Blank)
			66	-	-	Government (Blank)
			67	-	-	Government (Blank)
			68	-	-	Government (Blank)
			69	-	-	Government (Blank)
			70	-	-	Government (Blank)
			71	-	-	Government (Blank)
			73	-	-	Government (Blank)
			74	-	-	Government (Blank)
			75	-	-	Government (Blank)
			76	-	-	Government (Blank)
			77	-	-	Government (Blank)
			78	-	-	Government (Blank)
			79	-	-	Government (Blank)
			80	-	-	Government (Blank)
			81	-	-	Government (Blank)
7	Madanpur Khadar	380,000	-	-	-	Private

Terminal	Location	Total Area (Sqm)	Plot No.	Khasra No.	Area (Sqm)	Ownership Type
8	District: 163 Kanpur Dehat, Tensile : 00846 Bhognipur, Village : 149629 Daulatpur	182,109	-	00405	60,400	Fertile land
			-	00406	88,700	Government
			-	00409	6,450	Government(Drainage)
			-	00410	1,169,820	Government (Yamuna)
			-	00411	556,490	Government (Sand)
			-	00416	85,090	Government (PWD - Jhansi Kanpur Marg)
9	Madanpur Khadar	10,500	-	-	-	Private
10	Tajganj	10,500	-	-	-	Government (Blank)
11	District: 145 Mathura, Tensile: 00762 Mat, Village: 123996 Panigaon Banger	9,105	172/3	00513	9,320	Private
12A	Sonia Vihar	5,000			-	Private
12B	Jagatpur	7,916			-	Private
12C	District: Ghaziabad, Tensile: Loni, Village: 119695 Ilaichipur	5,310	357	00001	10,370	Government Land
			536		8,210	Government Land
			523		2,500	Government Land
13A	District: 175 Prayagraj, Tensile: 00891 Bara, Village: 162137 Devari Beni	10,117	492	00075	3,200	Private
				00131	6,850	Private
			491	00003	3,990	Private
				00075	230	Private
			489	00038	5,930	Private
13B	District: Prayagraj, Tensile : Sadar, Location: Saraswati Ghat	4,452	-	-	-	Government (Already a establishmen t)

Terminal	Location	Total Area (Sqm)	Plot No.	Khasra No.	Area (Sqm)	Ownership Type
13C	District: Prayagraj, Tensile : Sadar, Village: Kydganj	4,452	-	-	-	Government (Already a establishmen t)
13D	District : 175 Prayagraj, Tensile: 00892 Karchhana, Village: 162185 Mahewa Patti Purab Kachhar	4,452	83	-	-	Government (Blank)
14	District: 175 Prayagraj, Tensile: 00890 Sadar, Village: 161829 Bakshi Moda	14,164	-	00591	50,540	Barren Government Land

Note: The Khasra maps are given Annexure 6.3

CHAPTER – 8

MODEL STUDY

8.1 Preamble

WAPCOS have entrusted mathematical model studies for proposed navigation channel to Central Water and Power Research Station, Pune. Necessary river cross sections and details of various hydraulic structures across RiverYamuna in 1089 km reach from Allahabad to Delhi. The gauge –discharge data analysis for 13 gauging stations in this 1089 km reach presented in chapter 3 indicated that the minimum flow in Yamuna river during lean season (February to May) varies from 10 m^3/s to 20 m^3/s from Delhi to Agra and further up to Etawah. From Auraiya to Naini minimum flow is 30 m^3/s to 60 m^3/s. The average 10 daily flow (based on 10 to 25 year data) during lean season is 20 m^3/s to 40 m^3/s from Agra to Auraiya and about 80 to 300 m^3/s between Auraiya to Naini.

As per IWAI norms for waterway to be feasible for class I to V water depths should be 1.2 m to 2.0 m for 330 days in a year. In order to assess water depth in the natural irregular/non-uniform shape river cross sections of river mathematical model is most appropriate tool. The interventions/measures (such as dredging, barrages) required toimprove water depths could also be studied with the helpof mathematical model. In order to decide safe grade elevation for cargo and passenger terminals, high flood level for 100 return period floods could also be predicted from the model.

8.2 About Modelling Software HEC-RAS

These mathematical model studies for predicting water levels along Yamuna river reach under consideration were carried out on HEC-RAS model developed by Hydrologic Engineering Centre (HEC) of U. S. Army Corps of Engineers. HECRAS is software for River System analysis and is capable of simulating steady and unsteady flows and mobile bed changes in river channel network with different types of boundary conditions.

The basic computational procedure is based on the solution of Energy equation and momentum equations. This model is used worldwide to study flood plain management, to evaluate effects of encroachments in flood plain, to assess changes in water surface profiles due to channel modifications and construction of levees etc. The model is also capable of simulating various hydraulic structures along river reach such as bridges, culverts, dams, weirs. Model needs appropriate topographical data of river channels and flood plains for topography simulation in the model and hydrological and hydraulic data for model calibration and for generating boundary conditions required to simulate upstream and downstream boundary conditions for the model runs.

In steady flow analysis the model computes water surface profiles using energy equation withiterative standard step procedure. The basic energy equation is:

$$Z_2 + Y_2 + \frac{\alpha_2 V_2^2}{2g} = Z_1 + Y_1 + \frac{\alpha_1 V_1^2}{2g} + h_i$$

Z_1, Z_2 = elevation of main channel inverts

Y_1, Y_2 = depth of water at cross sections

V_1, V_2 = average velocities

h_i = energy head loss and

α_1, α_2 = weighted velocity coefficients

In case of unsteady flow analysis the model computes water surface profiles by solving set of partial differential equations representing mass and momentum conservations at the controlvolume. The governing equations i.e. continuity and momentum equations are listed below:

$$\frac{\partial A}{\partial t} + \frac{\partial Q}{\partial X} - Q_L = 0$$

$$\frac{\partial Q}{\partial t} + \frac{\partial QV}{\partial X} + gA\left(\frac{\partial Z}{\partial X} + S_f\right) = 0$$

Q_L = Lateral flow per unit length

S_f = Friction slope

A = Total Flow Area

8.3 Data Used For Studies

The following data has been used for model studies

Topography/bathymetry data

The river cross sections extending to high bank levels/HFLs were used for Yamuna river reach of 1081 km under consideration. Model topography wasreproduced using these data

Details of Hydraulic structures

The data of existing bridges/weirs were incorporated in the model.

Gauge discharge data

The G-Q data for the period of 25 year (1991 to 2015) was procured by WAPCOS from CWC. Data for 13 CWC gauge stations in 1081 km reach from Delhi to Allahabad (namely Delhi railway bridge, Mohana, Mathura, Agra, Etawah, Auraiya, Kalpi, Hamirpur, Chillaghat, Rajapur, Pratappur and Naini) and its analysis including gauge-discharge curves, monthly/yearly maximum/minimum, 10 daily flows etc.were included for model calibration and validation studies.

8.4 Boundary Conditions for Model Runs

Model runs were taken for low flows during lean season (Feb- May) as well as 50/100 year return period flood discharges estimated and presented in chapter 3 on data analysis.

It is essential to estimate the flow depths during lean season under existing conditions to ensure required depths for the class of waterway intended to be developed.

Based on above data the model runs for lean season were planned for discharges 20 m^3/s, 30 m^3/s, 50 m^3/s, 100 m^3/s and 200 m^3/s at upstream boundary. Subsequently model runs with proposed measures (Barrages) were made for range of discharges to study efficacy of suggested measures.

For predicting high flood levels, 100 year return floods as mentioned in table below were used at respective gauging stations. For the reach Delhi to Agra reported highest flood discharge of 3466 m^3/s was used.

Table 8.1 Discharges for different return periods at gauging stations

Gauge Stations	Return Period Discharge (Cumecs)		
	50 Yr	100 Yr	500 Yr
Delhi Railway Bridge(1068km)	4846	5439	6811
Mohana(Ch992km)	7534	8717	11449
Agra(Ch.752 km)	3435	3840	4777
Etawah(Ch.531.84 km)	4287	4820	6050
Auraiya(Ch.417.51 km)	33119	37408	47320
Kalpi(Ch.349.60 km)	34236	38802	49355
Hamirpur (Ch.280.53 km)	44666	50535	64097

Near downstream boundary nearest gauging station is at Naini. But at Naini only water level data is available. Hence no G-Q relationship couldbe developed which can be used for givingdownstream boundary condition in the model. The minimum water level at Naini varies between 71.39 m to 72.05 m during the lean season over the period of data. The lowest water level could beused as downstream condition for lean season flows. However it must be kept in mind that water level at Naini is influenced by the flow from Ganga at Sangam.

Therefore, normal depth was considered as downstream boundary condition. This is rather conservative conditions as far as lean season flows are considered. This reflects in rather low depths in lower reach of about 50 km (as compared to minimum observed depth asboundary condition) as indicated by some trial runs. But water levels in remaining upstream reach are unaffected. So, Normal depth was used as downstream boundary condition.

8.5 Modeling Procedure

The bathymetry and topographic survey data of Yamuna river network provided by Survey Teams are used in setting up HEC-RAS model. The model is set up for entire river network from 6km U/S of Wazirabad Barrage to Allahabad Sangam with cross sections along the reach.

The existing barrages (Delhi and Mathura) and new structures (barrages with navigational locks) are incorporated in the model at different locations of the river. The roughness coefficients used at bed and bank are computed from grain size analysis and field observation study.

Other boundary conditions like initial flow distribution, bed slope are incorporated for complete model preparation. The calibrated model is then used for performing steady and unsteady flow analysis to simulate the effect of proposed weirs/barrages in the river network. The hydraulic parameters like flow depth, width and effect of weir along the reach are analysed.

The model setups are also simulated for 30 years flood to study the impact of flooding and its effect on existing embankments. Yamuna River is distributed to downstream reaches based on flow bifurcation ratio and steady simulation is carried out. The maximum water level for 30 years flood at tidal pole locations is compared with embankment levels and accordingly revision in existing height and/or raising new embankments along the route.

8.6 Model Calibration and Validation

Model calibration and validation using observed G-Q data is the most essential step before making any prediction runs. The Manning's roughness values are tuned during calibration process. In the present studies lot of data available was used to calibrate the model for long reach of 1081 km.

The data for discharges varying from 10 to 200 m^3/s was used for calibration in different reaches. The Manning's roughness values used were in the range 0.022 to 0.025. Then using another independent set of data with discharges in the range 200 m^3/s to 1100 m^3/s and above, the model was validated by comparing predicted and observed water levels at gauging stations in the reach under consideration.

8.7 Development of Model for River Yamuna

The CWPRS, Pune had conducted mathematical model study for routing the flood in river Yamuna and based the field survey data and Gauge-Discharge data available at CWC sites. The model was set up with inclusion of bridges, weir, barrages, etc.

The mathematical model covering the reach starting from upstream boundary point of 6km upstream of Wazirabad Barrage at Delhi to downstream boundary at Sangam, Prayagraj project was developed. Complete stretch of 1089km is divided in zone 43 and 44.

1) From Sangam at Prayagraj (CH 0km) to Agra (CH 755km) Zone 44
2) From Agra(CH 755km) to Delhi (CH 1089km) Zone 43

8.8 Model Runs for Existing Condition

The model runs under existing conditions were carried out by incorporation of all existing hydraulic structures (mainly bridges and barrages/weirs) for which relevant data was collected and supplied by WAPCOS. These runs were made for range of discharges varying from 20 to 1100 m^3/s and further for 50/100 year return period flood. The predicted water levels and available depths along the reach for range of discharges are presented in a combined statement vide Calibration table show water surface profiles for range of discharges for existing conditions. In general for the range of lean season discharges the water depths in the reach from 0km to about 370 km were of the order of 2 m in major part of the reach except for some small stretches where bed levels were higher. However, for remaining reach from 370 km to 1052 km (up to Okhla barrage) water depths for low discharges up to 50 m^3/s were in the range 0.5 m to 1.5 m except for some stretches with deep pools. Even with discharges of 100 and 200 m^3/s there was marginal improvement in depth. This is due to fact that with increase in discharge water will spread on more width with negligible rise in water levels.

Fig. 8.1 to Fig. 8.10 show results of some calibration/validation runs for reach 0 to 754 km. Fig. 8.11 to Fig. 8.20 show results for reach 755 km to 1081 km.

It could be seen therefrom that the observed and predicted water levels are in close agreement for range of discharges. The calibrated/validated model was then used to make prediction runs for existing condition and for runs with proposed measures for improvement of navigability.

The detailed computation of Water Depths for Different discharges in River Yamuna reach from Prayagraj to Agra with Normal Depth condition at downstream boundary are presented at Annexure 8.1 and Agra to Delhi Annexure 8.2.

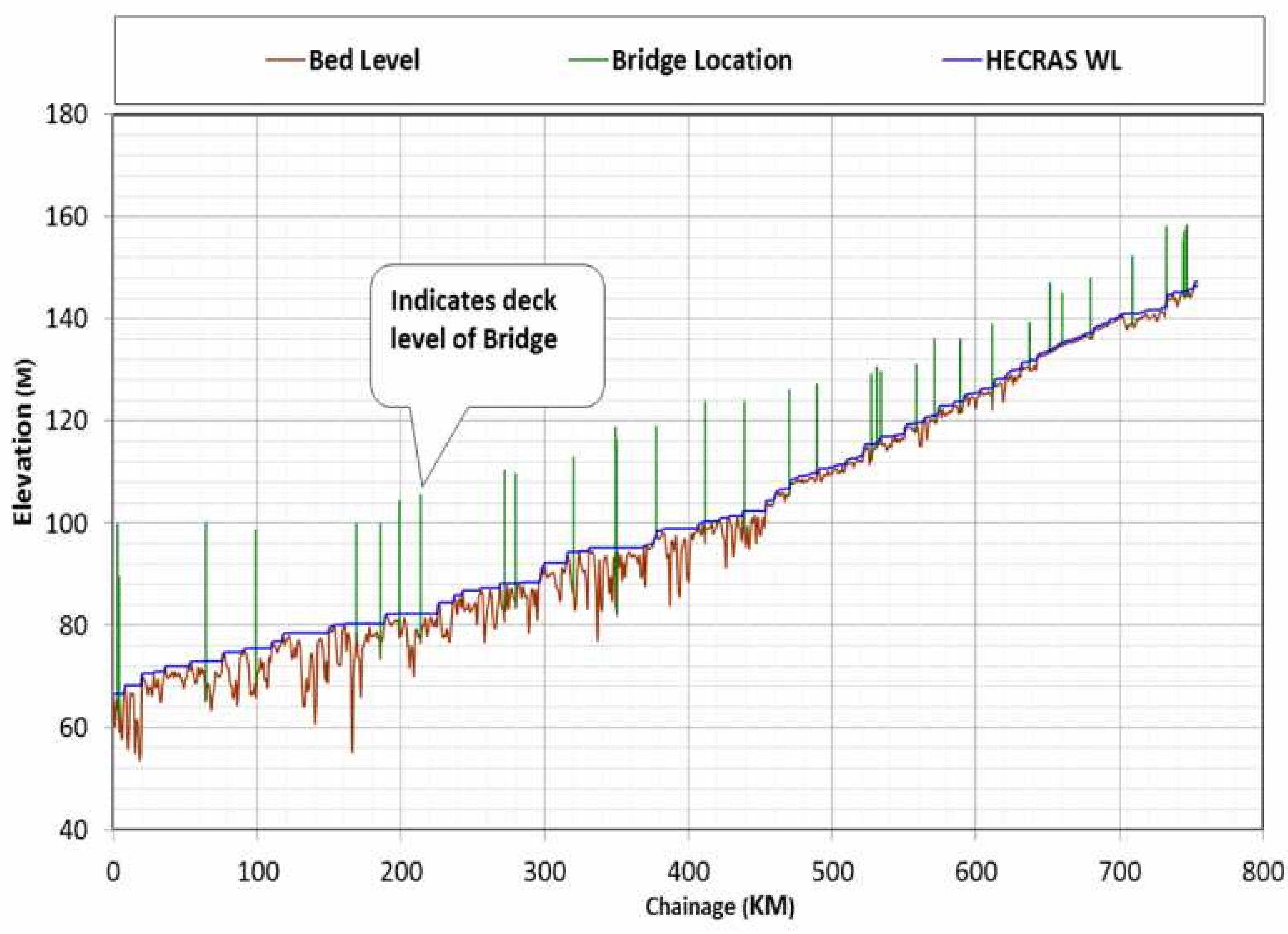


Fig. 8.1 Water Surface Profile of HECRAS Model for 20 cumec discharge in Yamuna River from Prayagraj to Agra

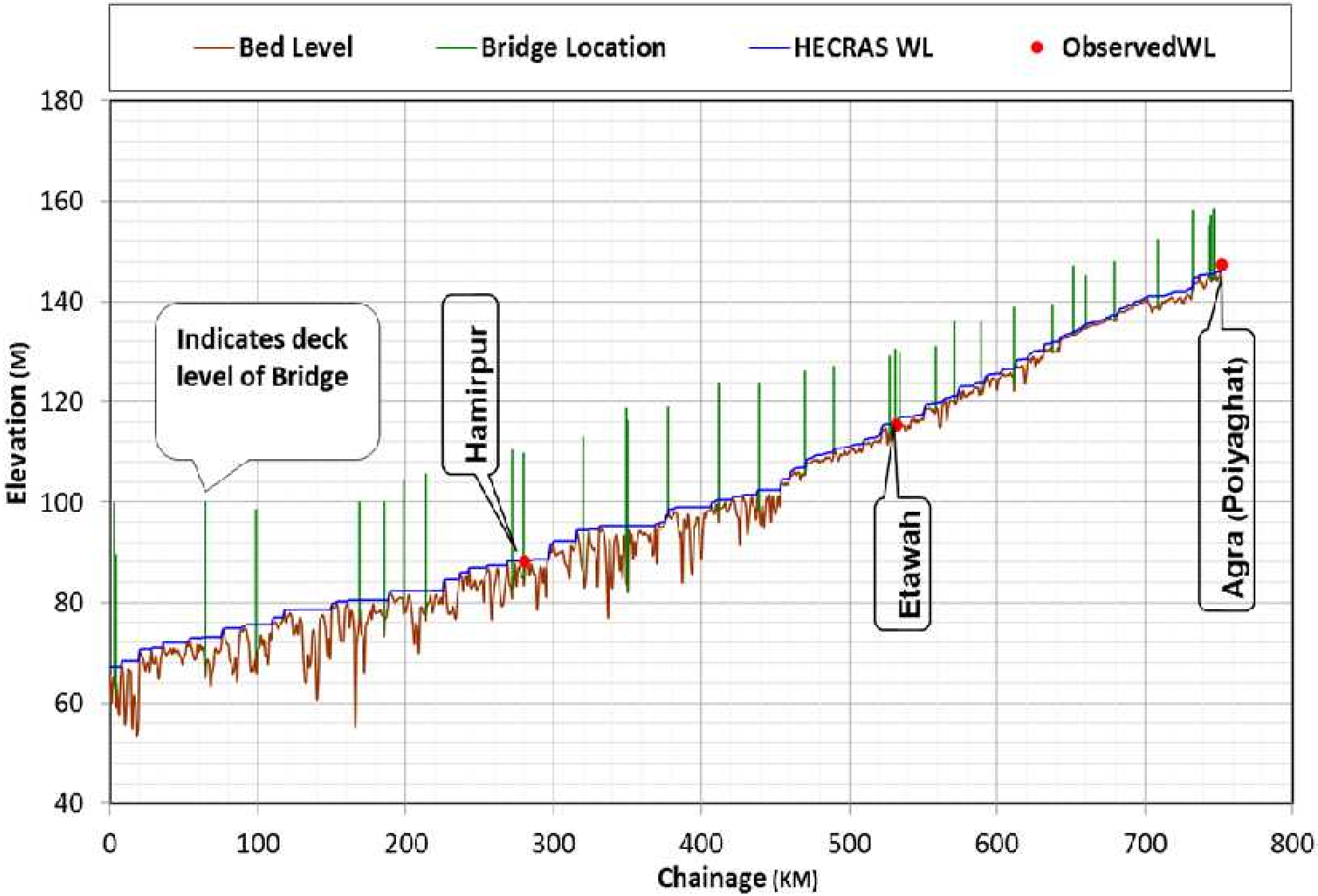


Fig. 8.2 Calibration of HECRAS Model for 30 cumec discharge in Yamuna river reach from Prayagraj to Agra with Observed Water levels from GQ data

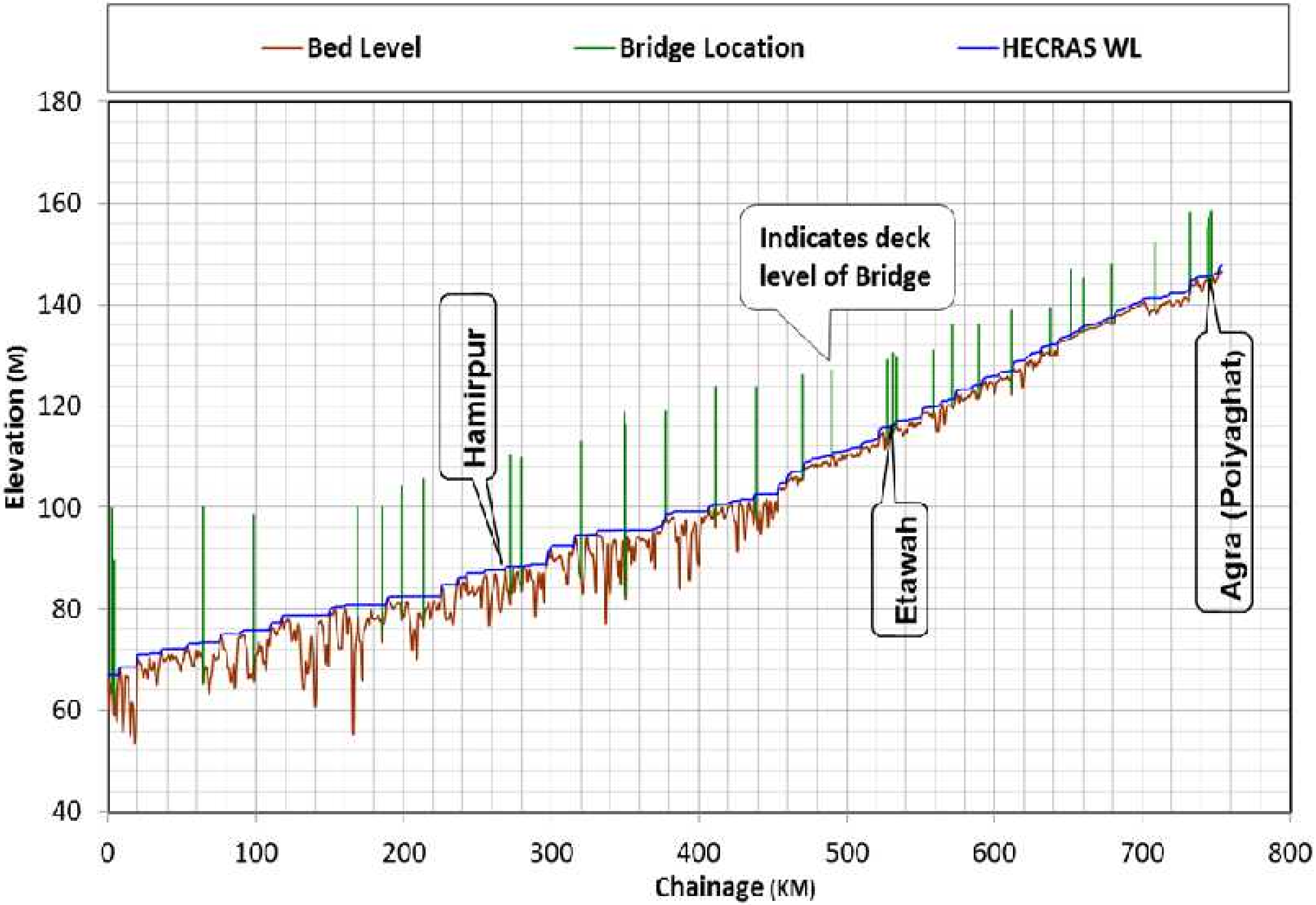


Fig. 8.3 Water Surface Profile from HECRAS Model for 50 cumec discharge in Yamuna river reach from Prayagraj to Agra

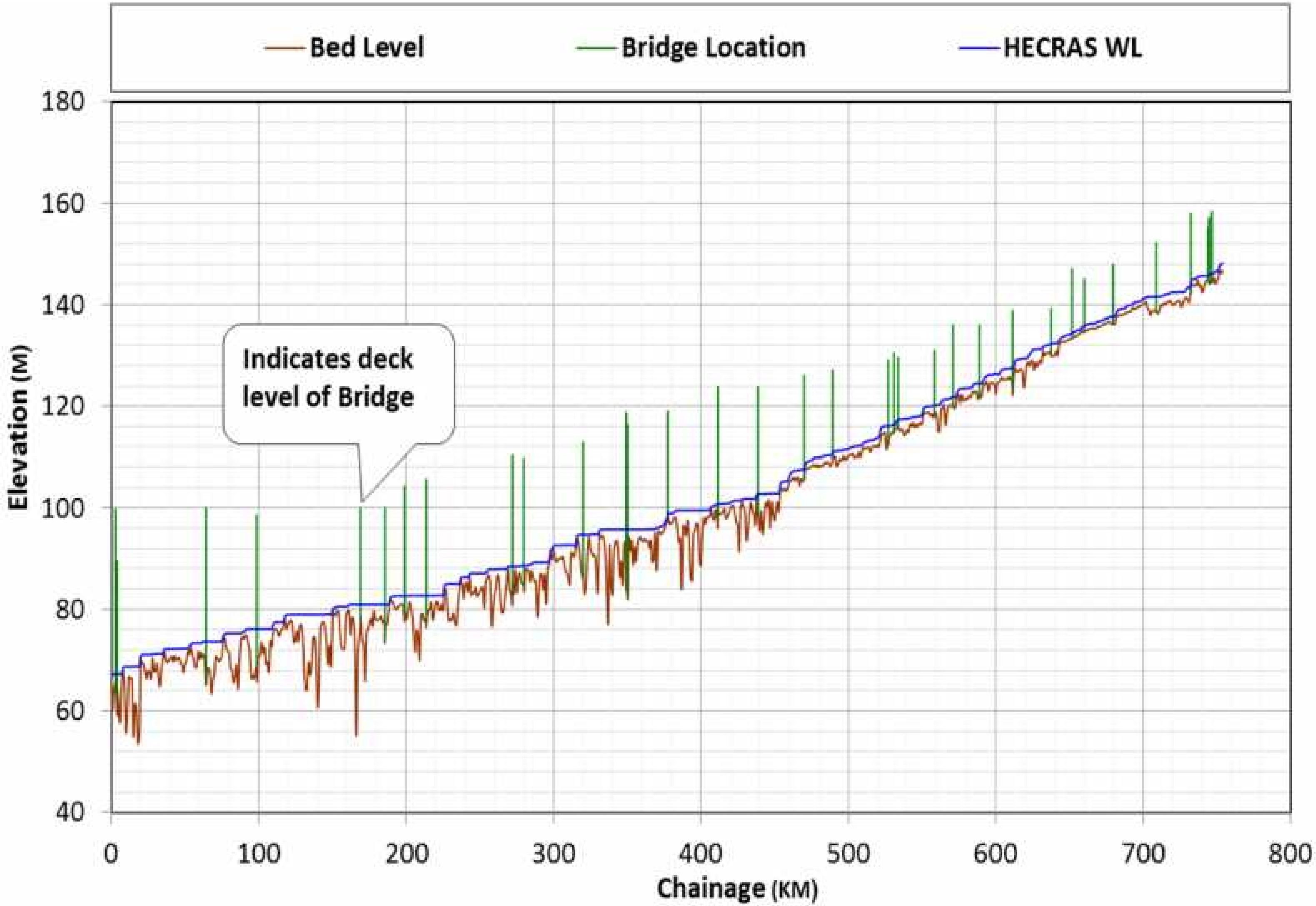


Fig. 8.4 Water Surface Profile of HECRAS Model for 100 cumec discharge in Yamuna river reach from Prayagraj to Agra with Observed Water levels from GQ data

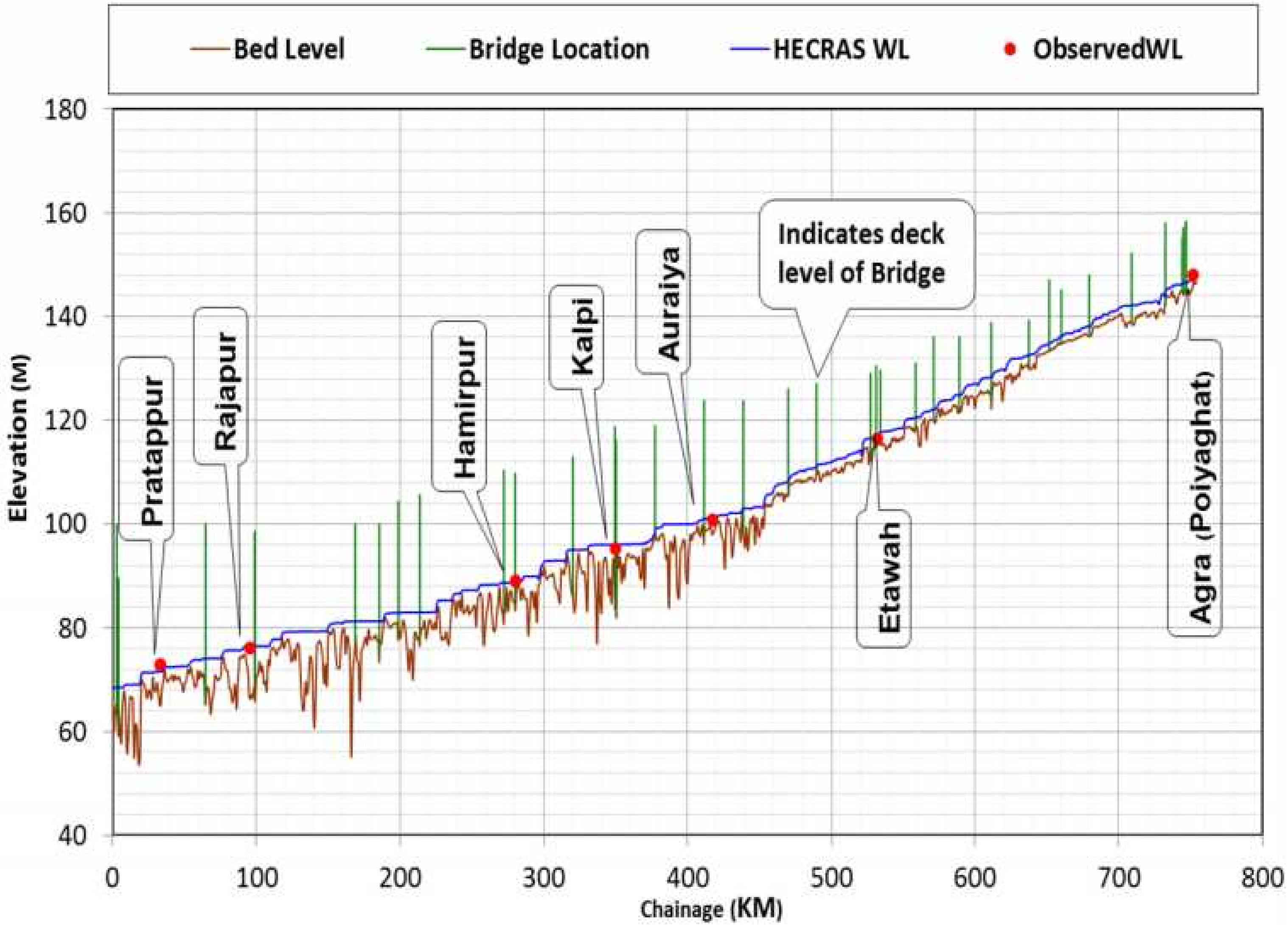


Fig. 8.5 Calibration of HECRAS Model for 200 cumec discharge in Yamuna river reach from Prayagraj to Agra with Observed Water levels from GQ Data

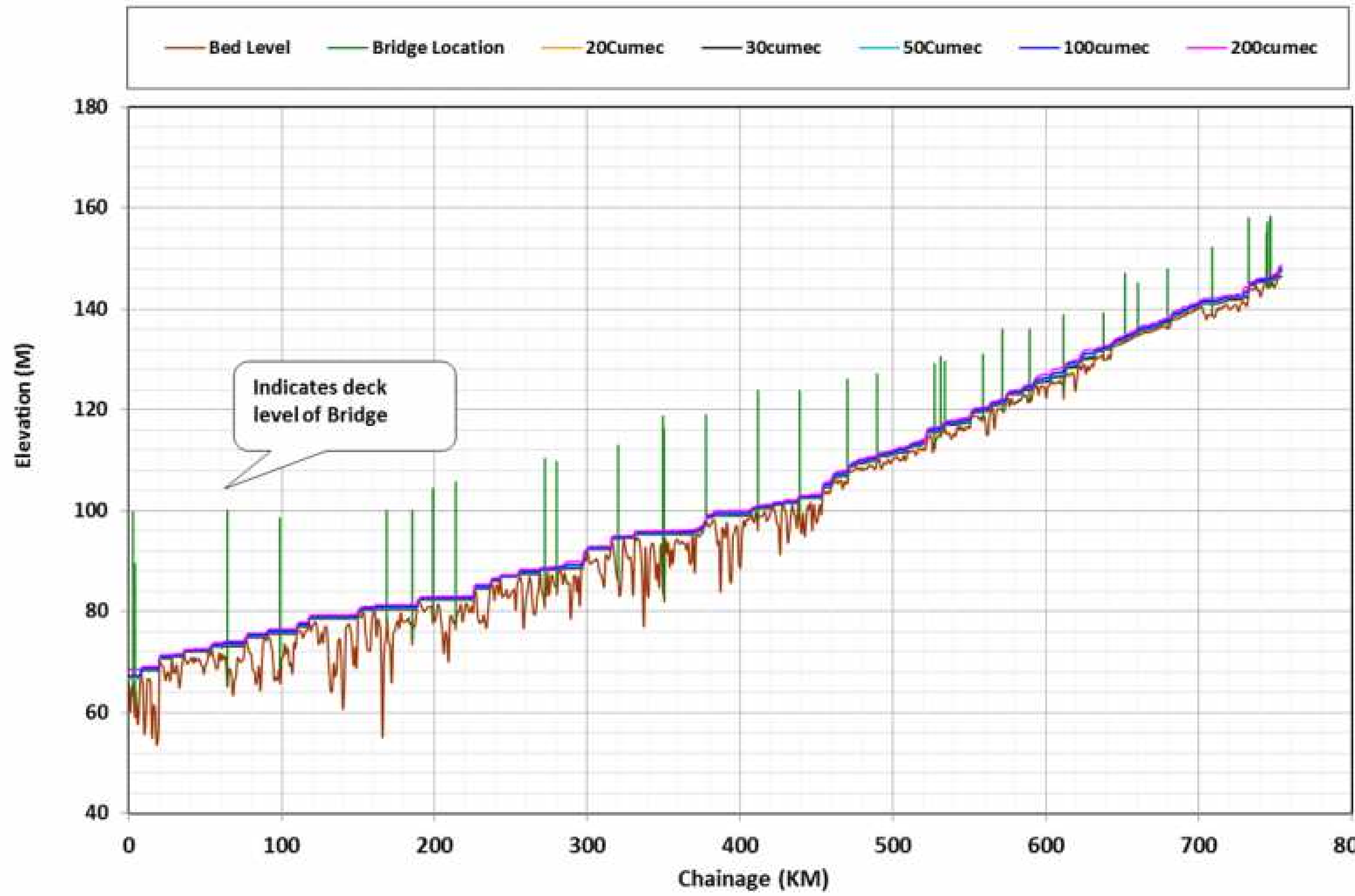


Fig. 8.6 Water surface profiles for different discharges in Yamuna River reach from Prayagraj to Agra

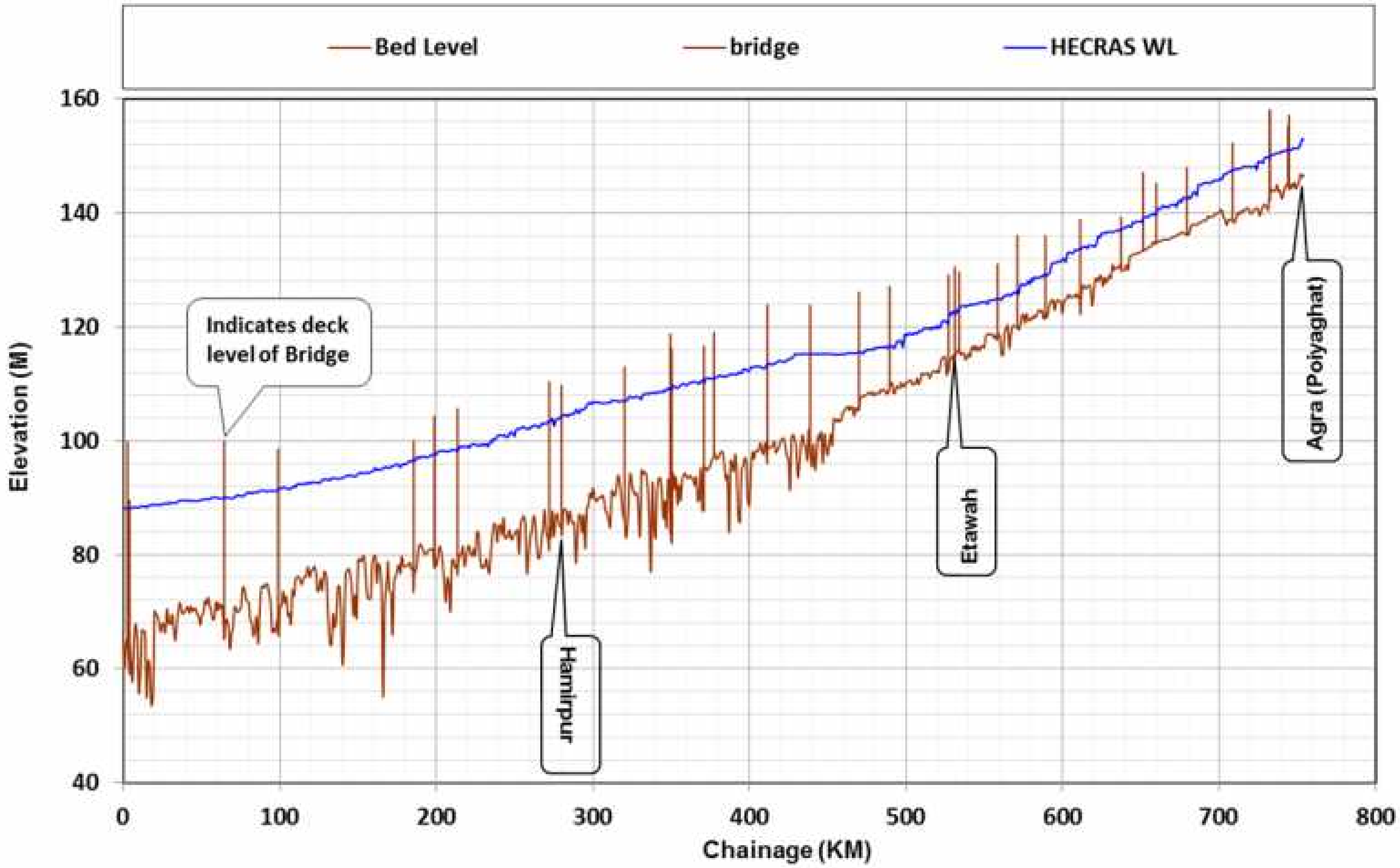


Fig. 8.7 Water Surface Profile of HECRAS Model for Design Discharge of 50 year return period in Yamuna river reach from Prayagraj to Agra for existing condition

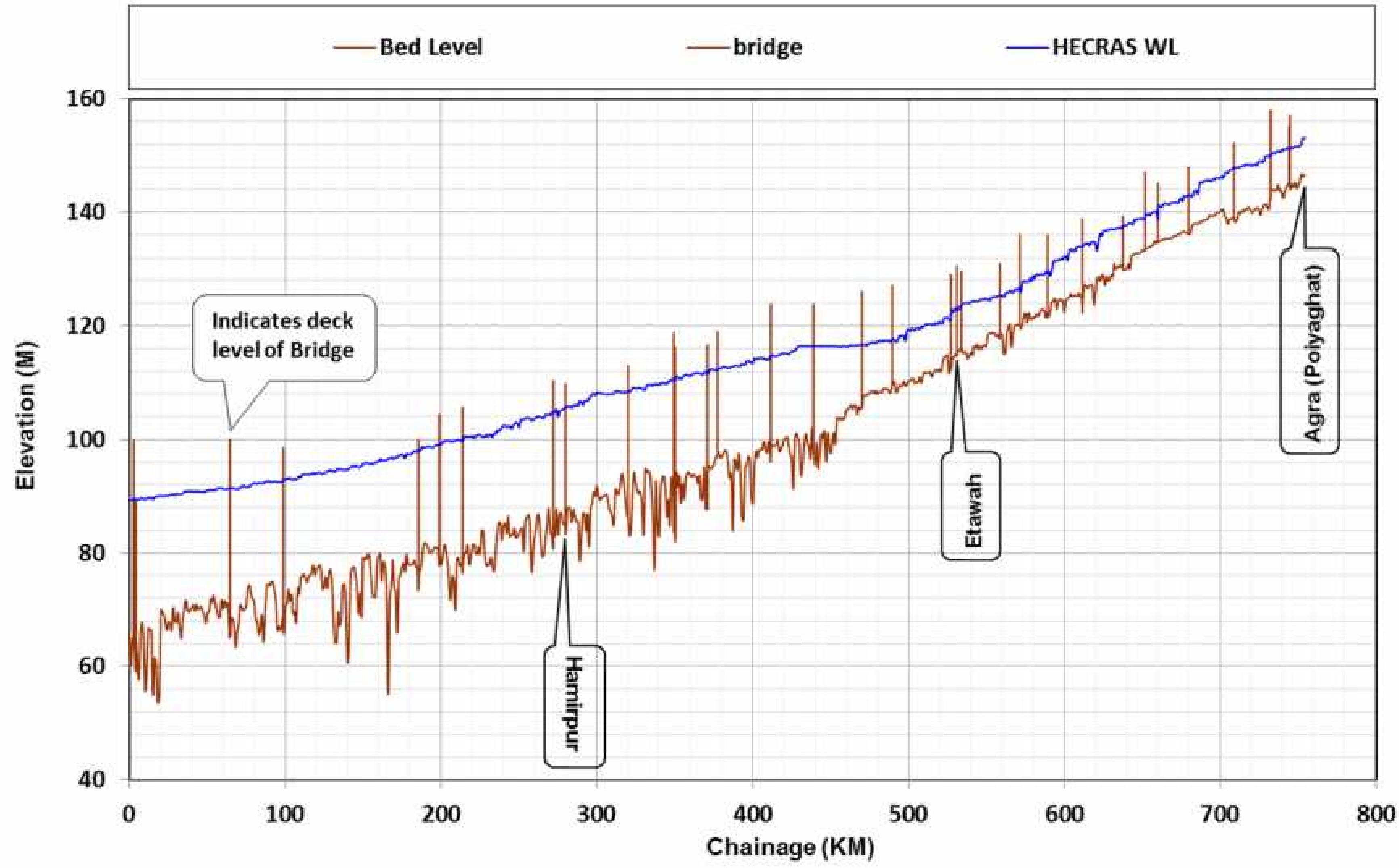


Fig. 8.8 Water Surface Profile of HECRAS Model for Design Discharge of 100 year return period in Yamuna river reach from Prayagraj to Agra for existing condition

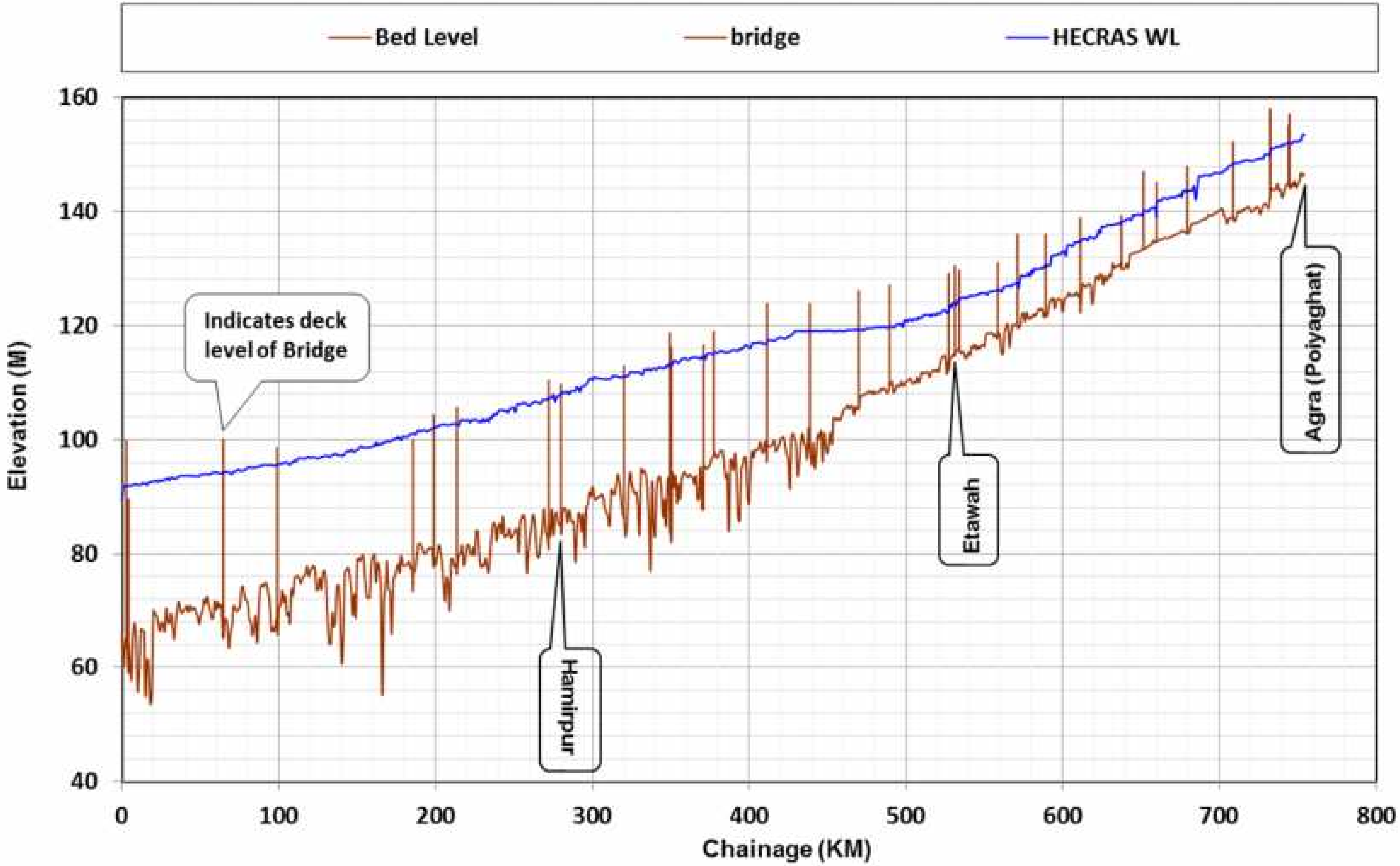


Fig. 8.9 Water Surface Profile of HECRAS Model for Design Discharge of 500 year return period in Yamuna river reach from Prayagraj to Agra for existing condition

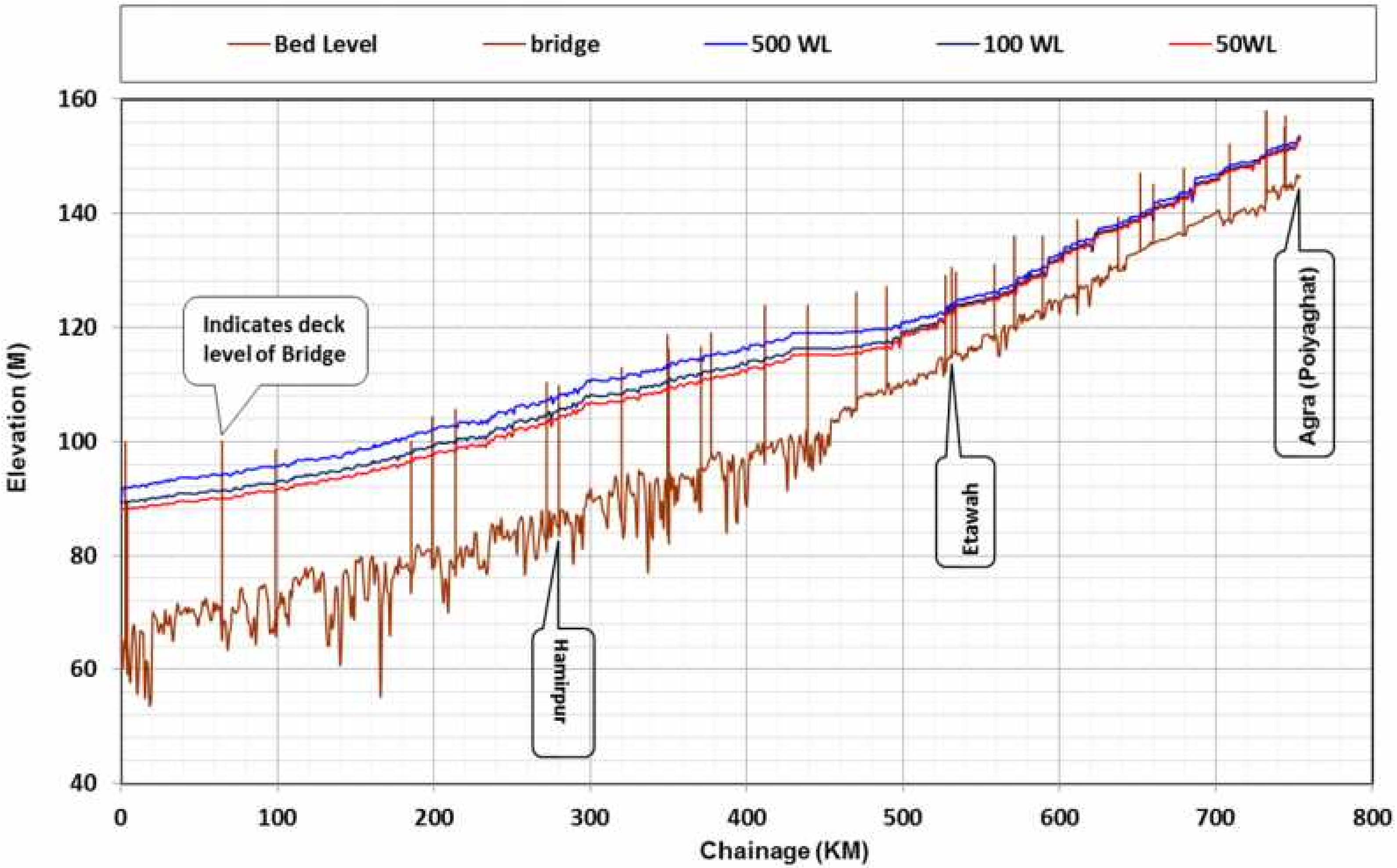


Fig. 8.10 Water Surface Profiles of HECRAS Model for different floods for 50,100, 500 year return period in Yamuna River reach from Prayagraj to Agra for existing condition

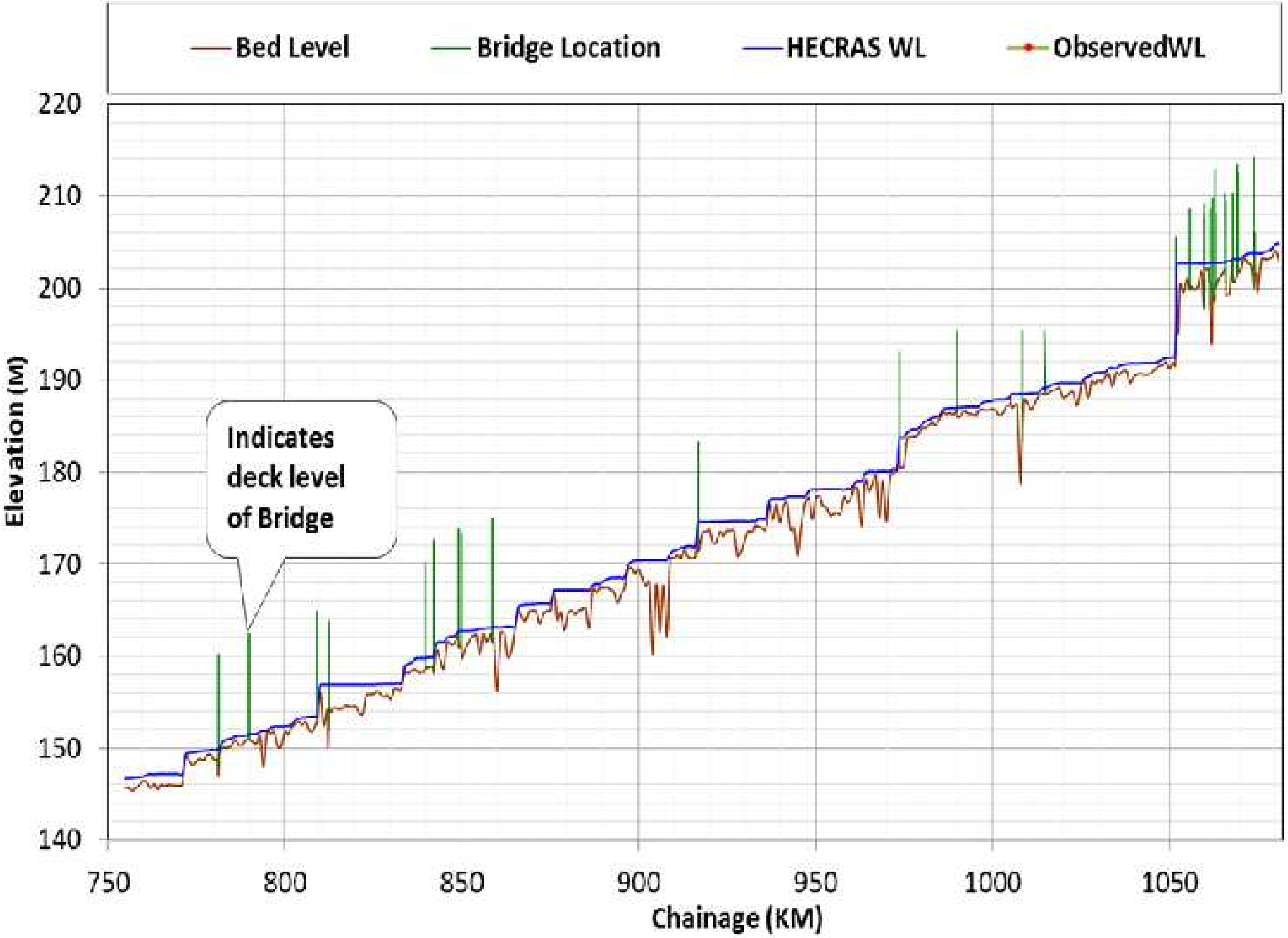


Fig. 8.11 Water Surface Profile from HECRAS Model for 20 cumec discharge in Yamuna river reach from Agra to Delhi

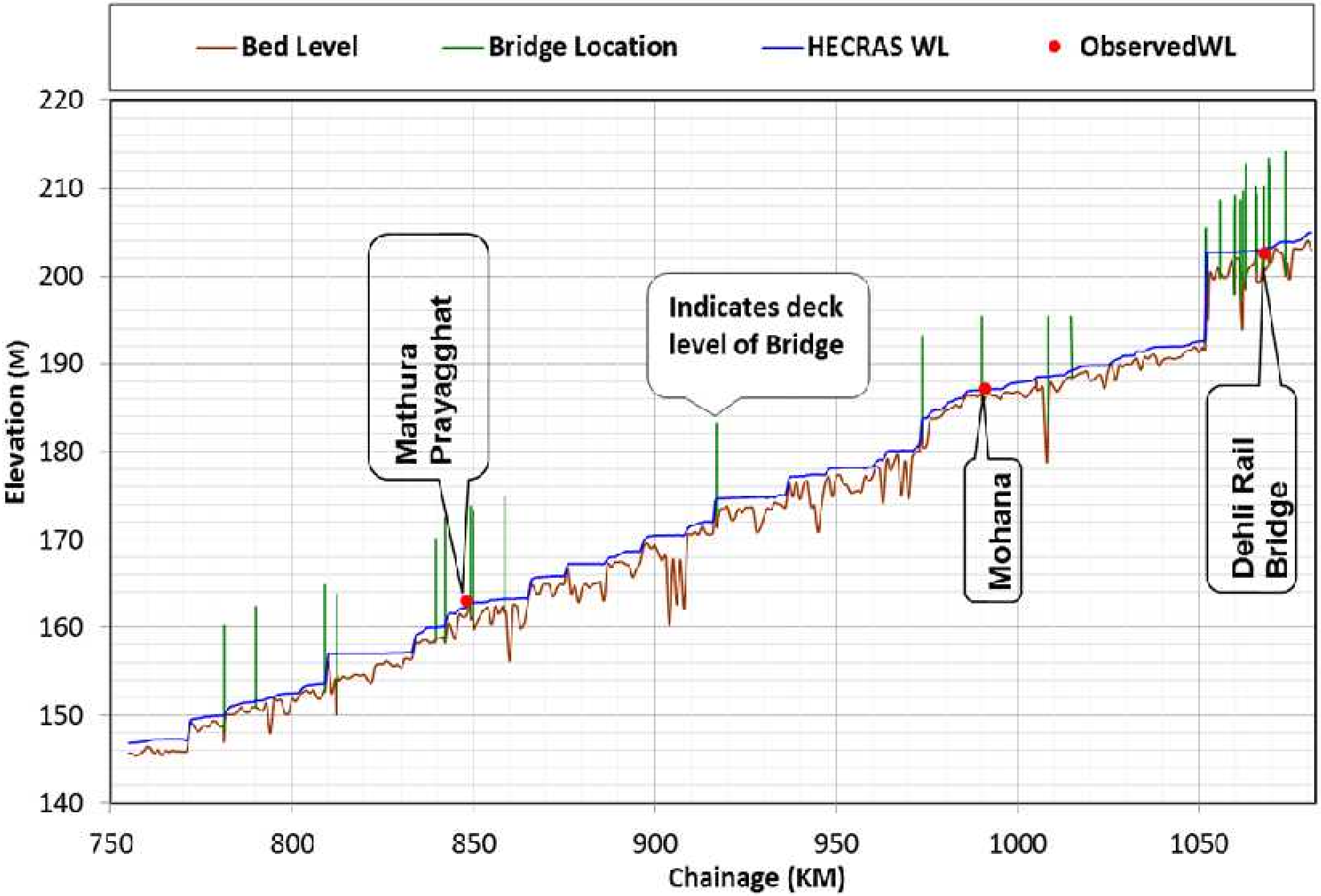


Fig. 8.12 Calibration of HECRAS Model for 30 cumec discharge in Yamuna river reach from Agra to Delhi with Observed Water levels from GQ data

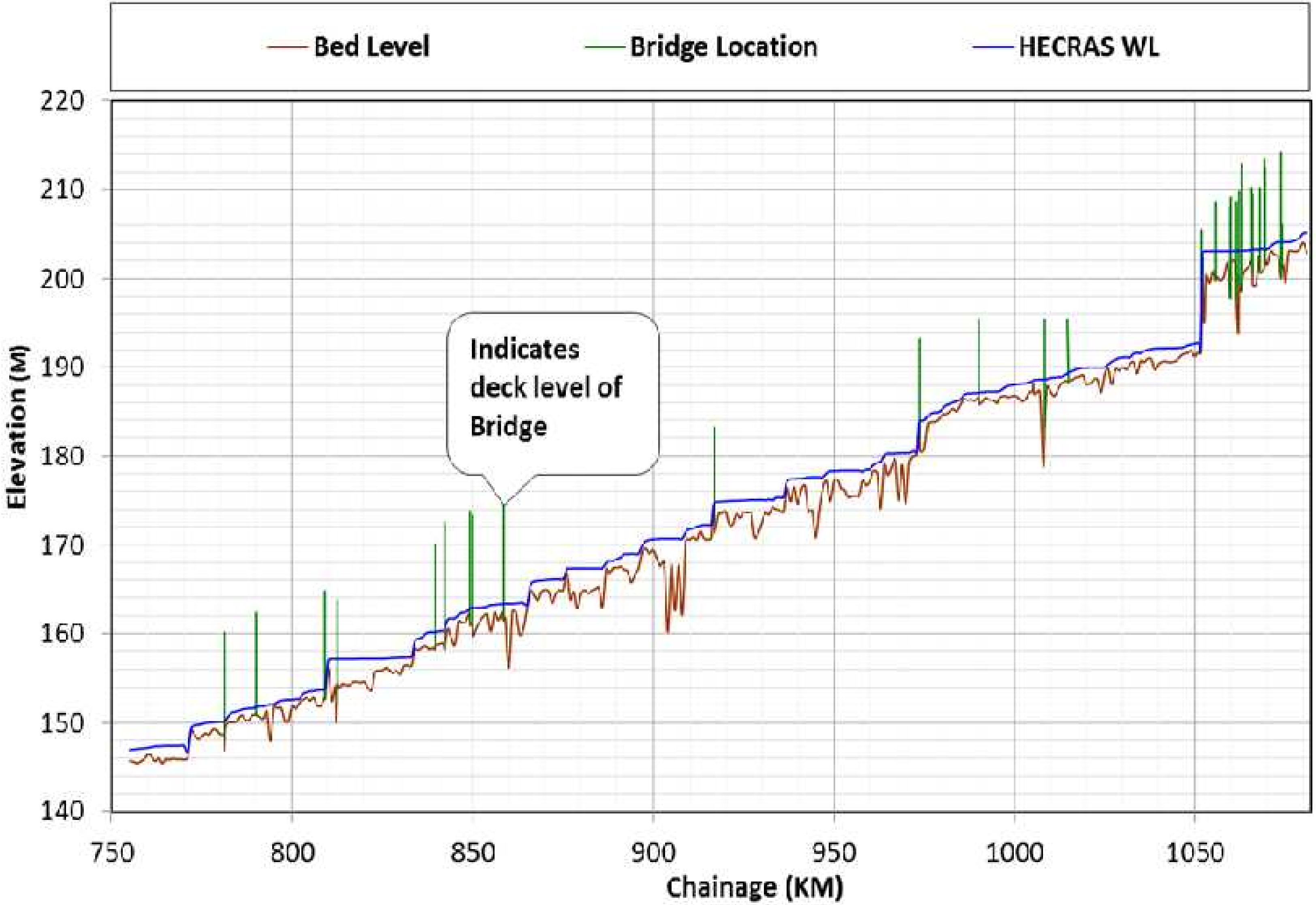


Fig. 8.13 Water Surface Profile from HECRAS Model for 50 cumec discharge in Yamuna river reach from Agra to Delhi

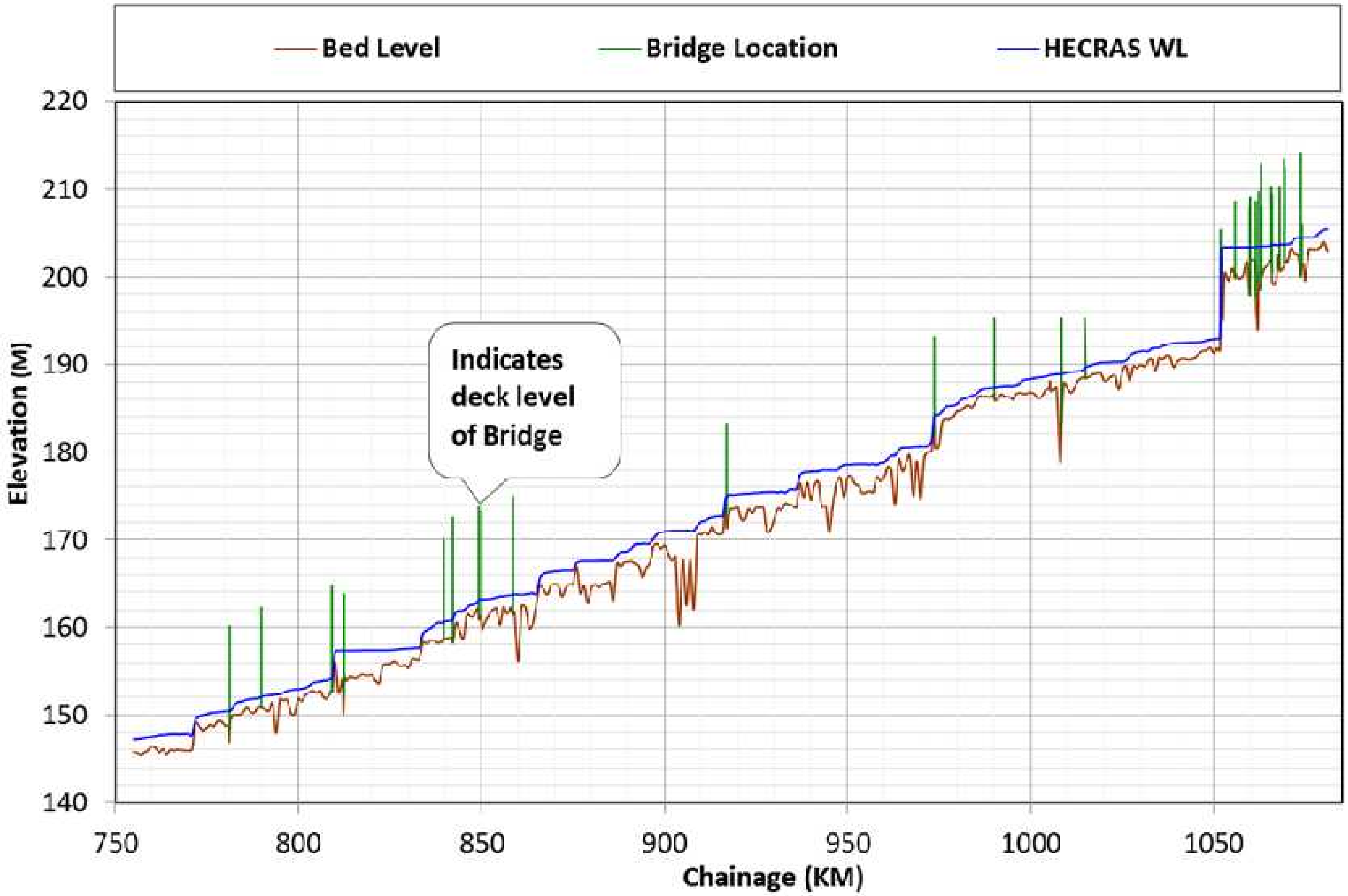


Fig. 8.14 Water Surface Profile for HECRAS Model for 100 cumec discharge in Yamuna river reach from Agra to Delhi

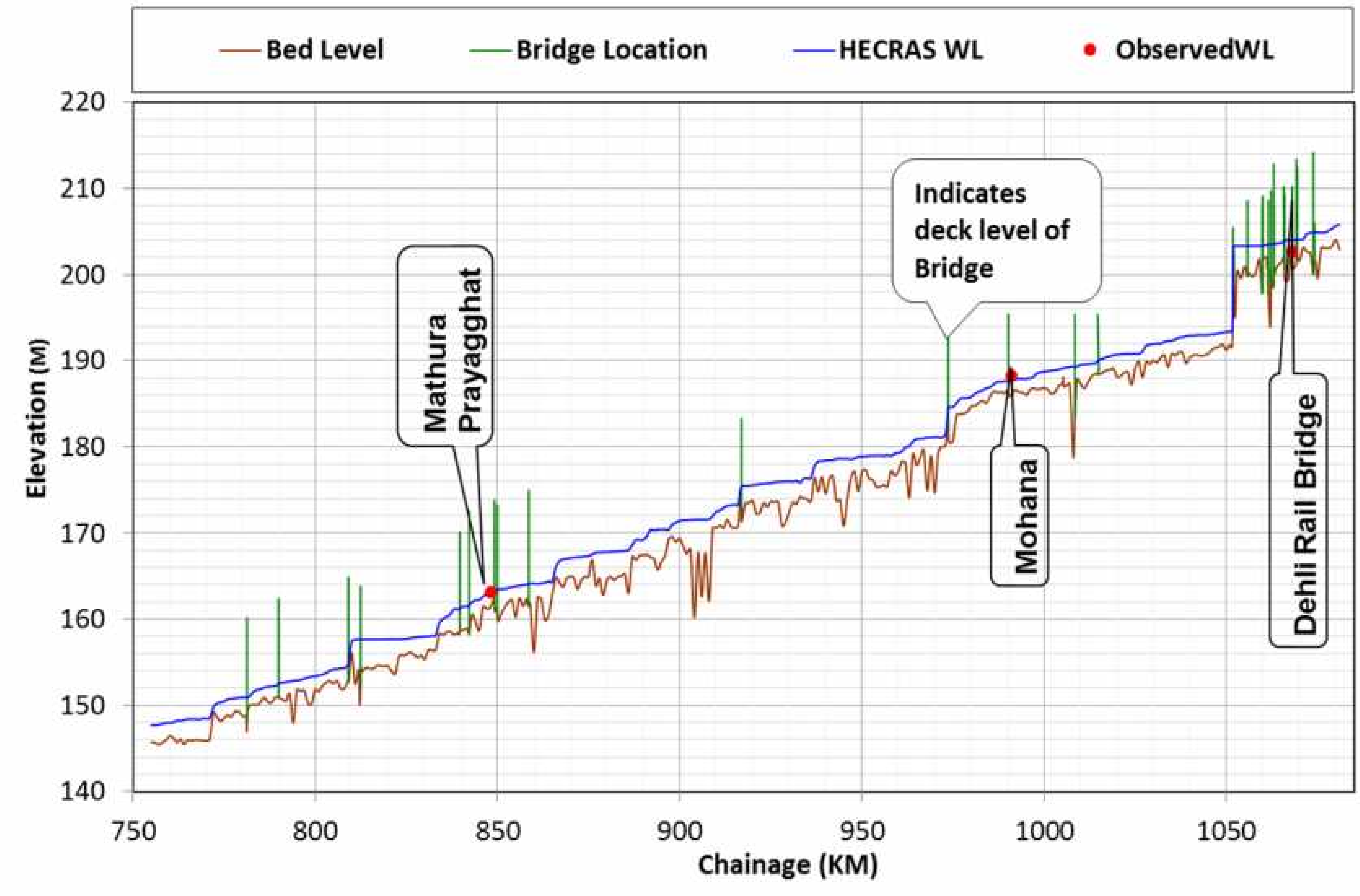


Fig. 8.15 Validation of HECRAS Model for 200 cumec discharge in Yamuna river reach from Agra to Delhi with Observed Water levels from GQ data

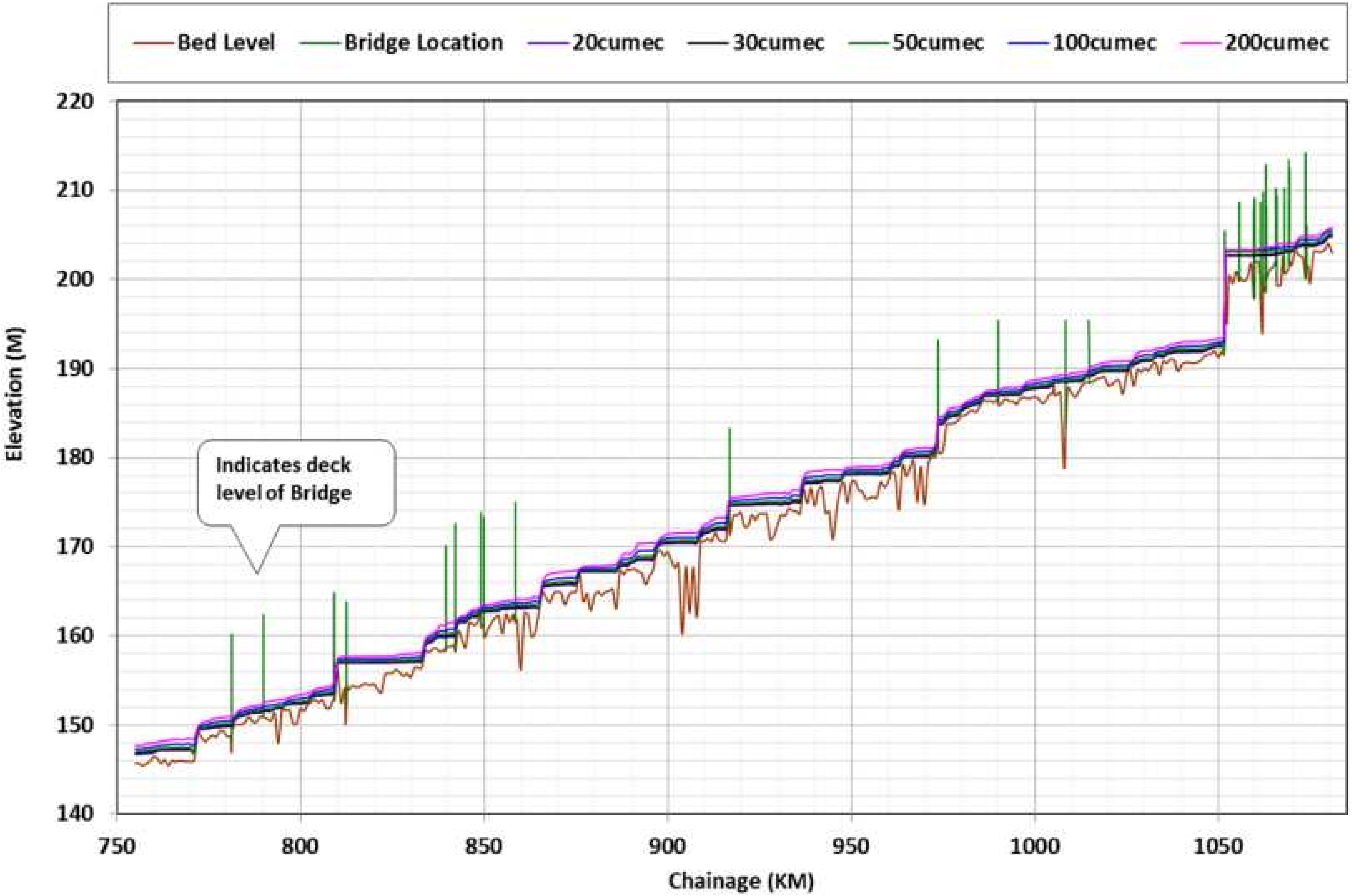


Fig. 8.16 Water surface profiles for different discharges in Yamuna River reach from Agra to Delhi

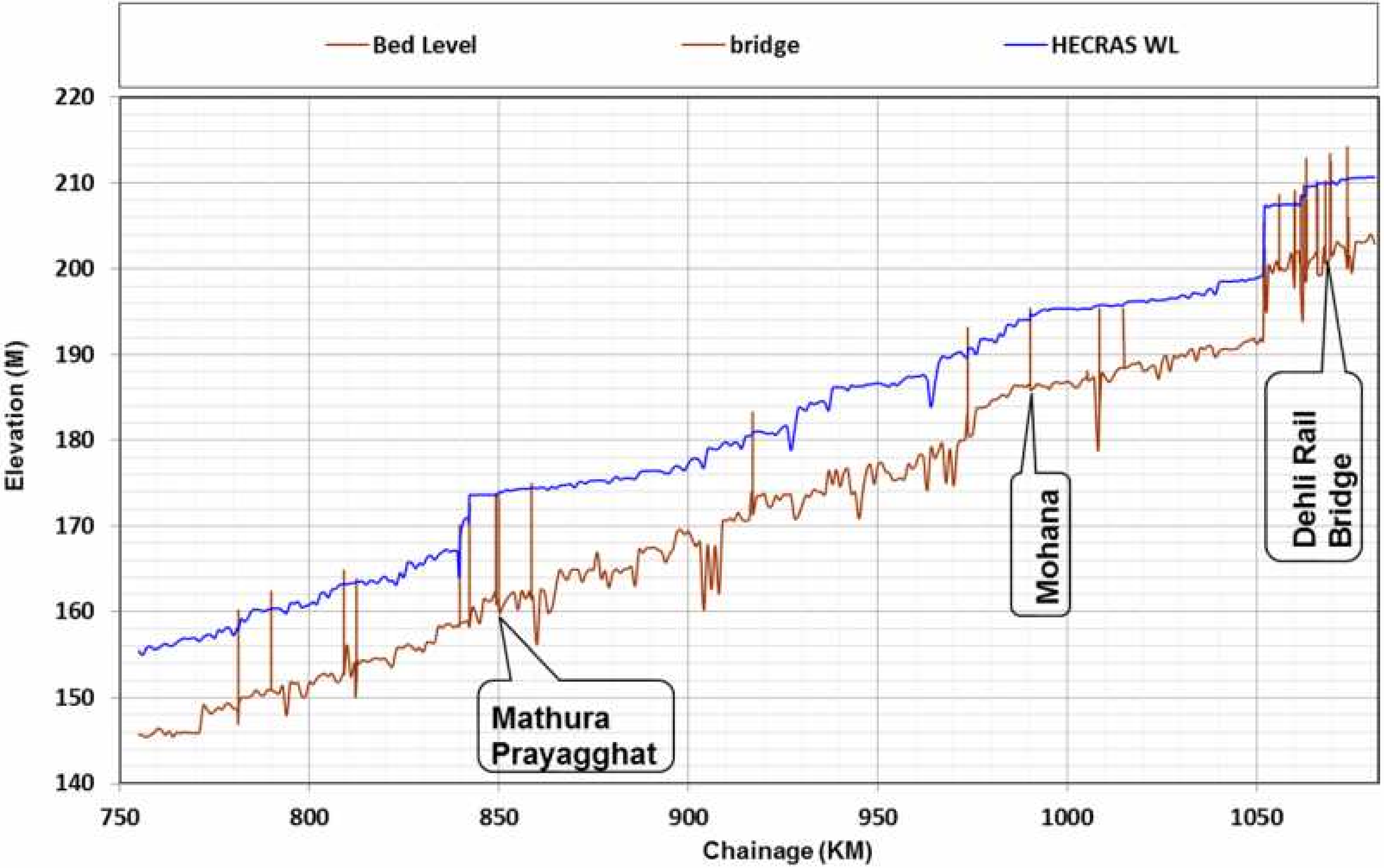


Fig. 8.17 Water Surface Profile from HECRAS Model for 50 year return period discharge in Yamuna river reach from Agra to Delhi

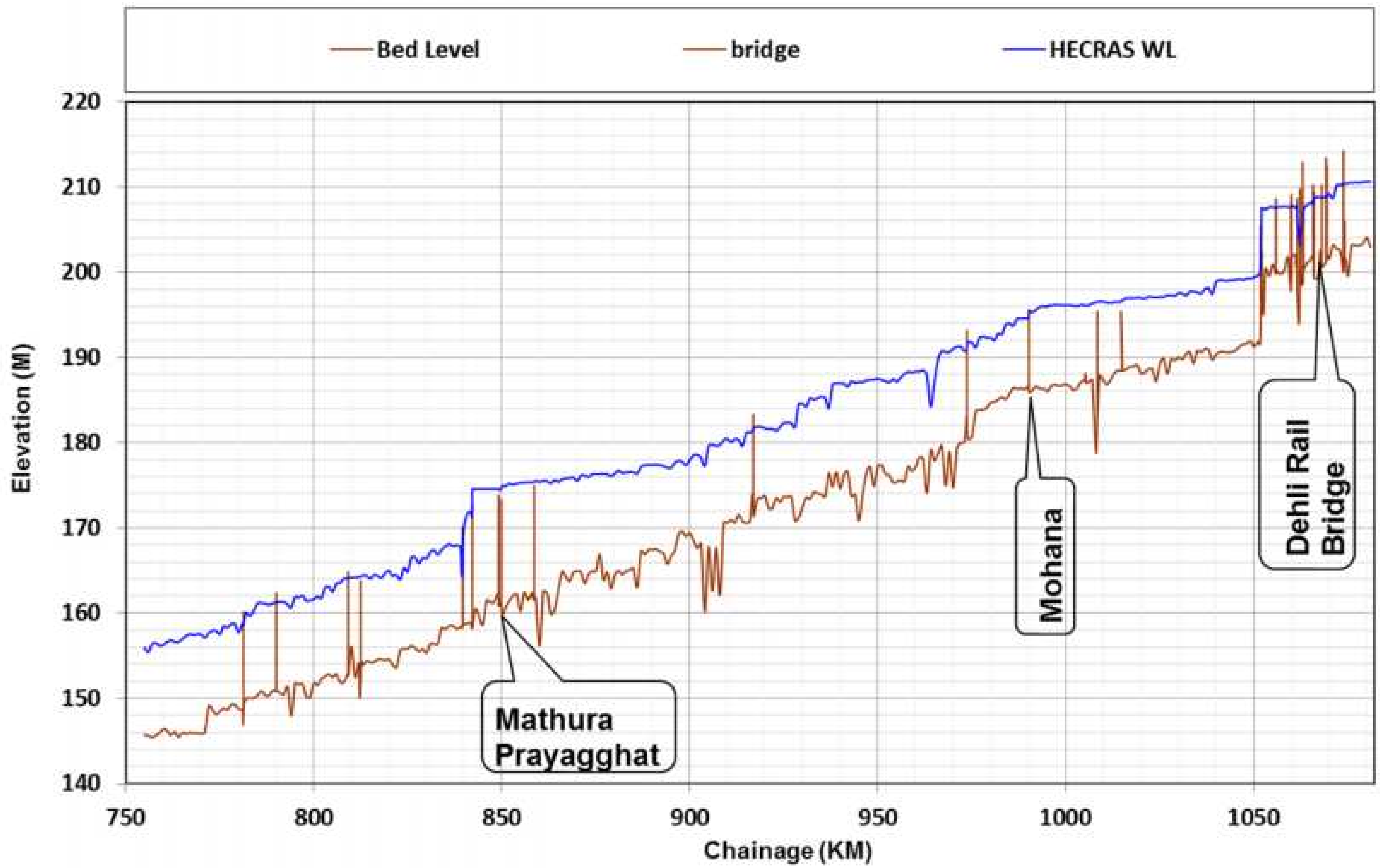


Fig. 8.18 Water Surface Profile from HECRAS Model for 100 year return period discharge in Yamuna river reach from Agra to Delhi

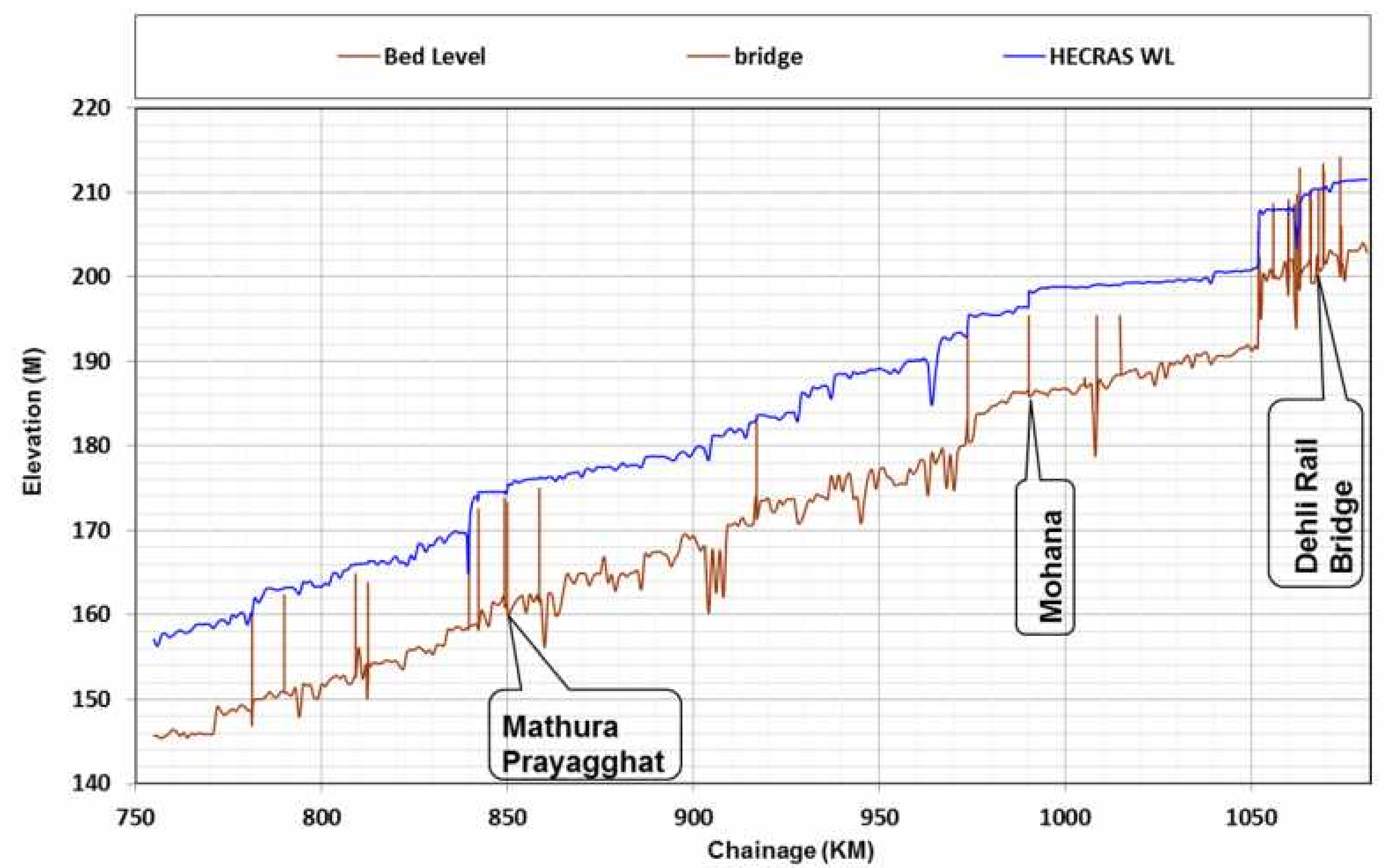


Fig. 8.19 Water Surface Profile from HECRAS Model for 500 year return period discharge in Yamuna river reach from Agra to Delhi

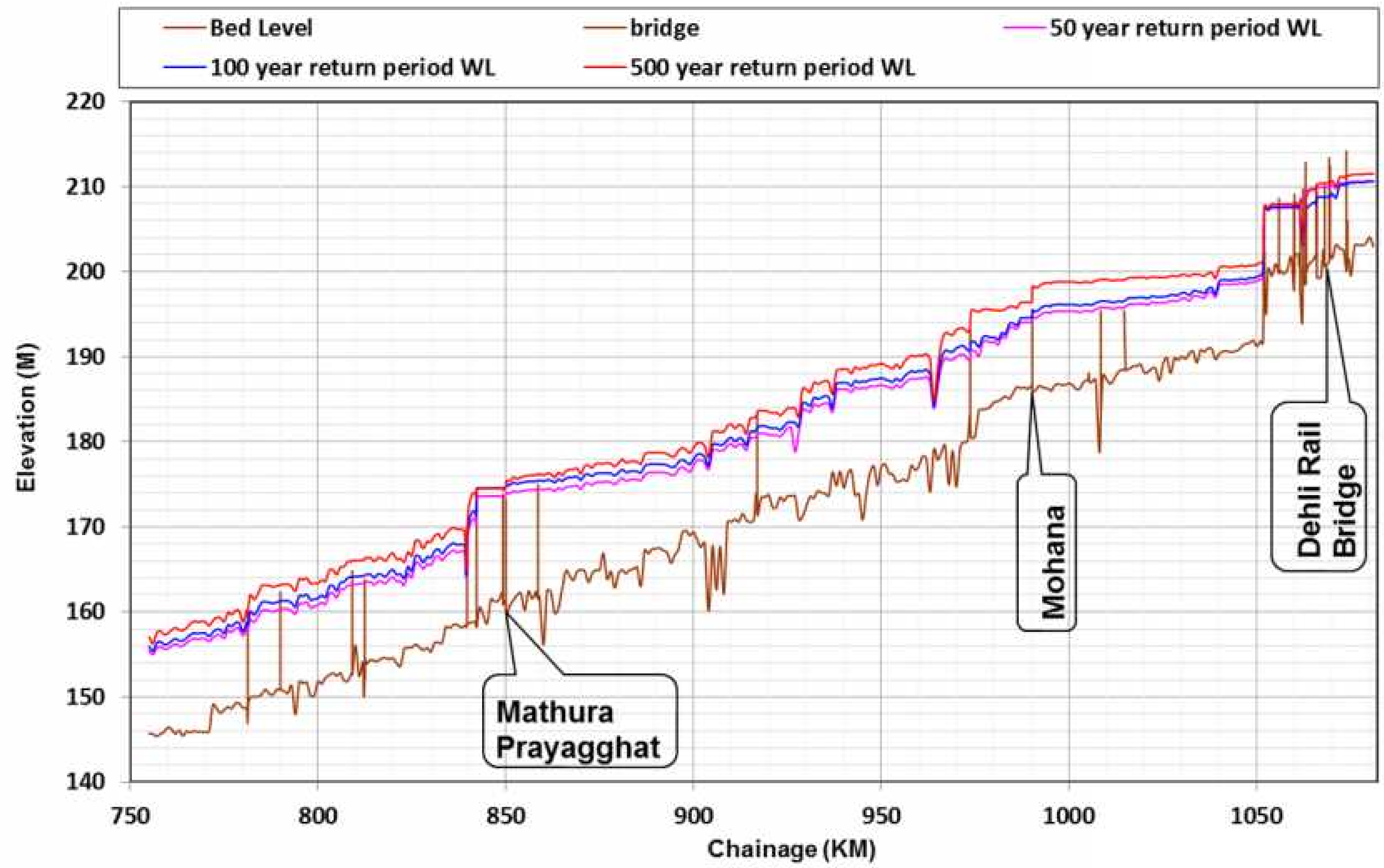


Fig. 8.20 Water Surface Profiles for different year return period discharges in Yamuna river reach from Agra to Delhi

8.9 Model Runs With Proposed Barrages

Model runs under existing condition indicated depths in the range 0.5 m to 1.5 m in the reach on upstream of 370/400 km (Kalpi/Auraiya) even for discharges of 100 m^3/s and more. The lean season minimum flow from Rajapur (95 km) to Auraiya (417 km) is about 40 to 56 m^3/s and average 10 daily flows are still better (80 to 134 m^3/s) as shown in table shown earlier. This is because rivers Chambal, Sind, Betwa and Ken join Yamuna in this reach. But on upstream of Auraiya till Okhla barrage, the minimum lean season flow is in the range 10 to 20 m^3/s and 10 daily average flows also reduce to 18 to 20 m^3/s. Also this reach upstream of Auraiya till Okhla barrage has steeper slope (1/5900) as compared to reach downstream of Auraiya till Naini (slope- 1/14250). Due to these two reasons water depths available during lean season in the reach upstream of Auraiya are in the range 0.5 to 1 m in most of reach except some reaches with deep pools as could be seen from results presented in Annexure . Dredging in this long reach may not be economically feasible and may not be helpful due to wide river bed and steeper slopes. Provision of bunds on both side of deep channel to restrict channel bed width and increase depth will not be a permanent solution. Such bunds will get washed during floods.

Therefore, providing Barrages with ponding up to 5 m appears to be possible solution in this reach. Based on bathymetry study and hydrological data analysis, WAPCOS has proposed 20 barrages at an interval of about 30 km at locations given in Table below. These barrages will only be for raising of water levels along river reaches. The gates will be fully open during flood period so that there will not be an increase in flood levels. Barrage crest levels will be close to the river bed levels. Barrages were simulated in the model as internal boundary with respective design pond level/FRL for lean season discharges. For simulation of 100 floods all gates open condition was applied so that there was no water level control.

Table 8.2 Location of Proposed Barrages

Sl. No.	Stretch	Chainage (Km)	Co-Ordinates	Locations			
				Nearby Landmarks	Tehsil	District	State
1.	River Betwa Mouth To River Chambal Mouth	371	**26°13'24.31"N/ 79°38'33.47"E**	Dahelkhand Dewara Village	Kalpi	Jalaun	Uttar Pradesh
2.		431	**26°25'10.07"N/ 79°18'19.42"E**	Pura	Madhogarh (Mangadpura)	Jalaun	Uttar Pradesh
3.	River Chambal Mouth To Agra	471	**26°32'22.38"N/ 79°13'55.54"E**	Garha Kasda Village	Chakarnagar	Etawah	Uttar Pradesh
4.		501	**26°37'34.01"N/ 79° 04'15.14"E**	Bilahati Village	Chakarnagar	Etawah	Uttar Pradesh
5		531	**26°44'38.55"N/ 78°59'20.65"E**	Bhind-Etawah Bridge (Nh92)	Etawah	Etawah	Uttar Pradesh
6.		561	**26°52'10.30"N/ 78°48'42.96"E**	Guraiya Village	Jaswantnagar	Etawah	Uttar Pradesh

Sl. No.	Stretch	Chainage (Km)	Co-Ordinates	Locations			
				Nearby Landmarks	Tehsil	District	State
7.		591	26°52'47.40"N/ 78°39'6.15"E	Kachhora Bridge	Bah	Agra	Uttar Pradesh
8.		621	26°58'17.31"N/ 78°30'53.24"E	Budhera Village	Shikohabad	Firozabad	Uttar Pradesh
9.		651	27°2'3.50"N/ 78°26'13.9"E	Luhari Fatehabad Bridge (Near Yamuna Exp. Way)	Fatehabad	Agra	Uttar Pradesh
10.		681	27° 7'29.24"N/ 78°21'53.68"E	Indon Village	Firozabad	Firozabad	Uttar Pradesh
11.		711	27° 5'1.40"N/ 78°13'31.58"E	Mewali Kalan Village (Near Yamuna Exp.Way)	Fatehabad	Agra	Uttar Pradesh
12.		751	27°14'22.71"N/ 78° 1'50.37"E	Manoharpur	Agra	Agra	Uttar Pradesh
13.		781	27°14'19.33"N/ 77°56'10.35"E	District Road Bridge	Agra	Agra	Uttar Pradesh
14.		811	27°17'55.42"N/ 77°49'10.03"E	Bhadaya Village	Mathura	Mathura	Uttar Pradesh
15.		872	27°37'5.30"N/ 77°42'34.42"E	Dangoli Khader	Mat	Mathura	Uttar Pradesh
16.		902	27°47'59.05"N/ 77°42'5.70"E	Sultanpur Khadar	Mat	Mathura	Uttar Pradesh
17.	Agra To Delhi	932	27°51'4.02"N/ 77°36'7.24"E	Firozpur Banger/ Inayatgarh Village	Mat	Mathura	Uttar Pradesh
18.		962	28° 1'12.83"N/ 77°31'53.91"E	Sherpur Village / Tappal Town	Khair	Aligarh	Uttar Pradesh
19.		992	28°14'9.43"N/ 77°27'18.40"E	Mohna Town	Ballabgarh	Faridabad	Haryana
20.		1022	28°24'20.69"N/ 77°28'1.19"E	Sector-150, Noida	Gautam Buddha Nagar	Faridabad-Gautam Buddha Nagar	Haryana-Uttar Pradesh

The detailed computation of Water Depths for Different discharges in River Yamuna reach from Prayagraj to Agra with proposed structures and maintaining pond level are presented at Annexure 8.3 and Agra to Delhi Annexure 8.4.

Fig 8.21 to Fig. 8.30 shows water surface profiles for different discharges with proposed barrages for the reach 0 to 754 km.

Fig 8.31 to 8.40 show water surface profiles for different discharges with proposed barrages for the reach 755 km to 1054 km.

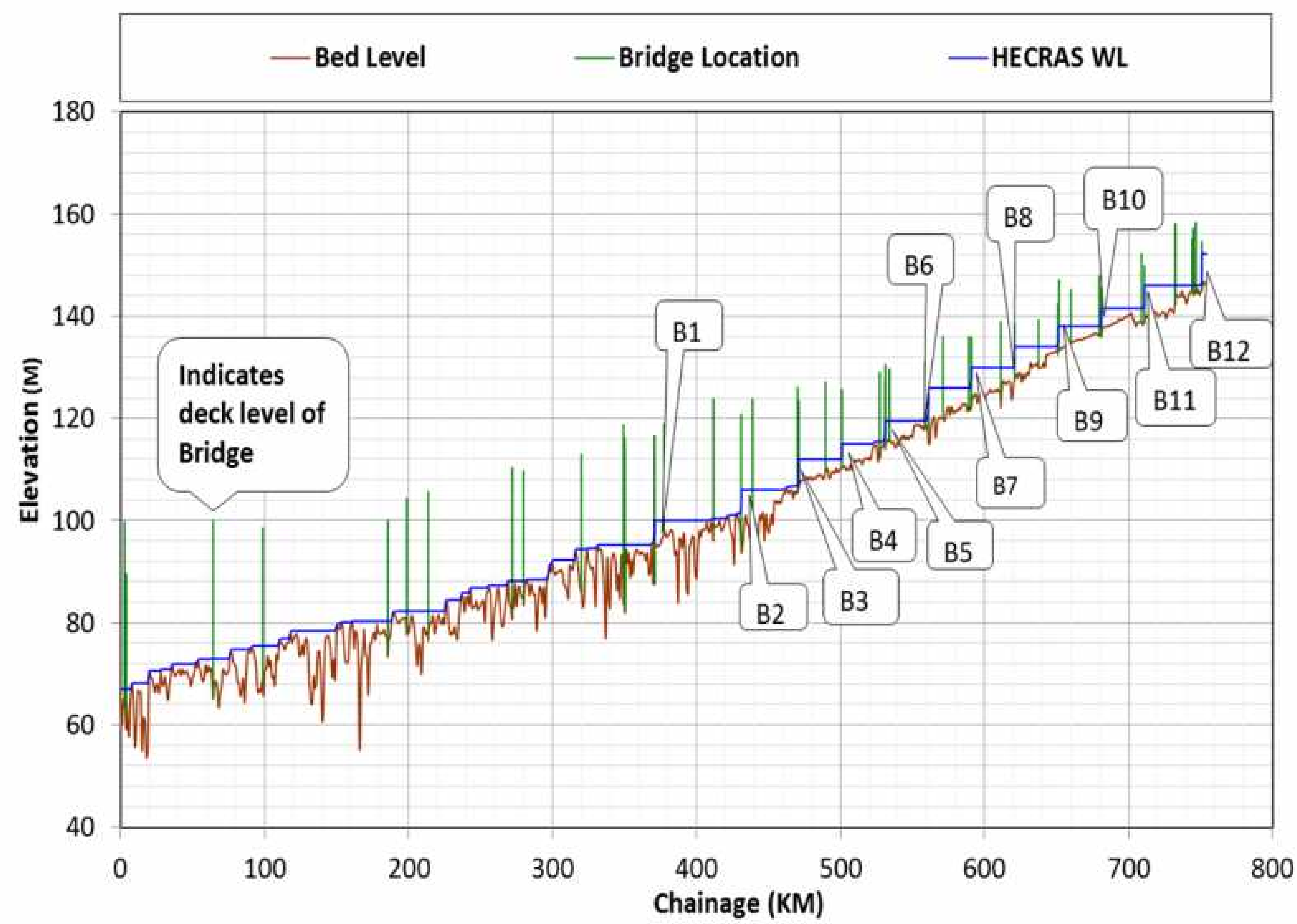


Fig. 8.21 Water Surface Profile of HECRAS Model for 20 cumec discharge in Yamuna river reach from Prayagraj to Agra with proposed Barrages

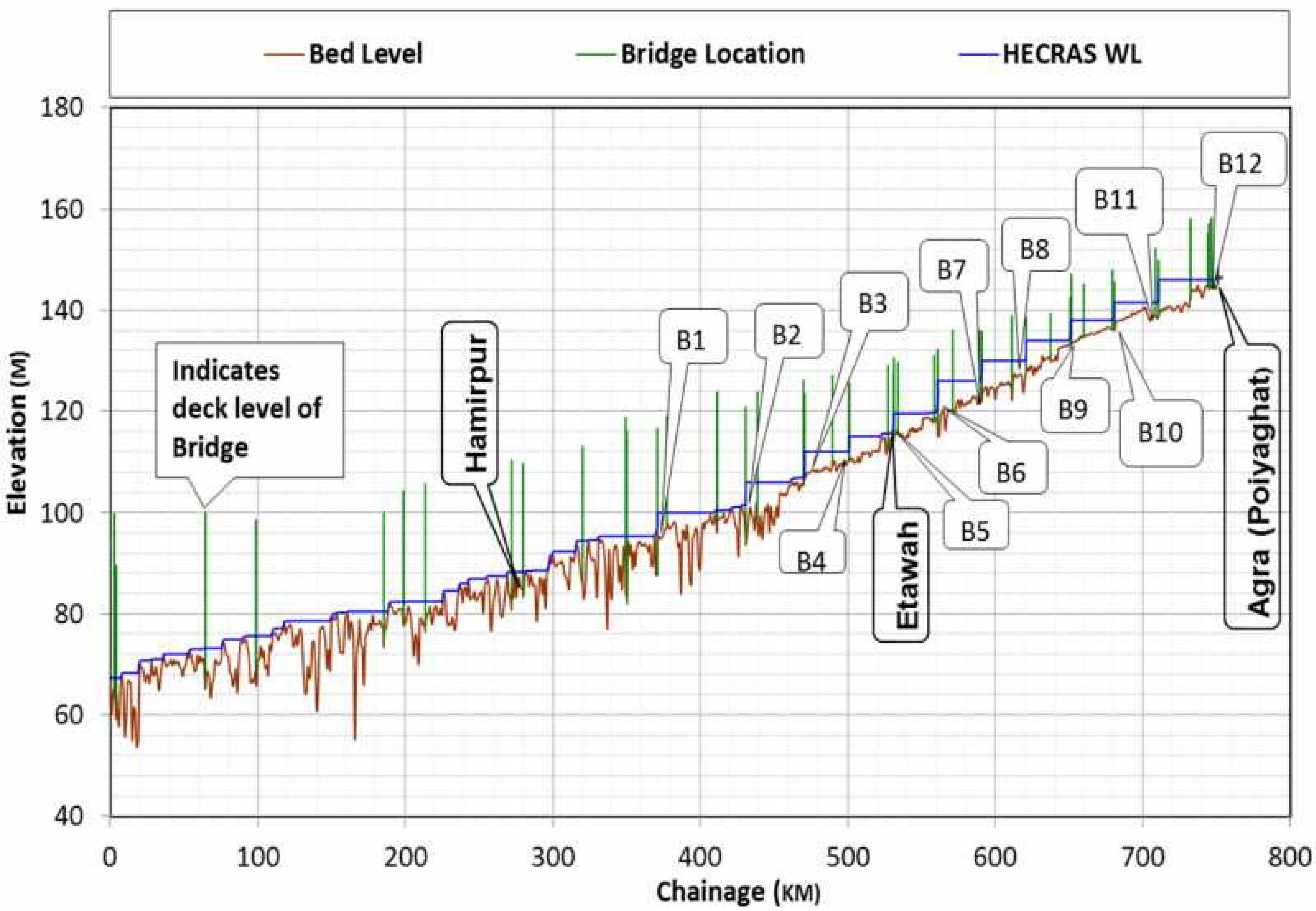


Fig. 8.22 Water Surface Profile of HECRAS Model for 30 cumec discharge in Yamuna river reach from Prayagraj to Agra with proposed Barrages

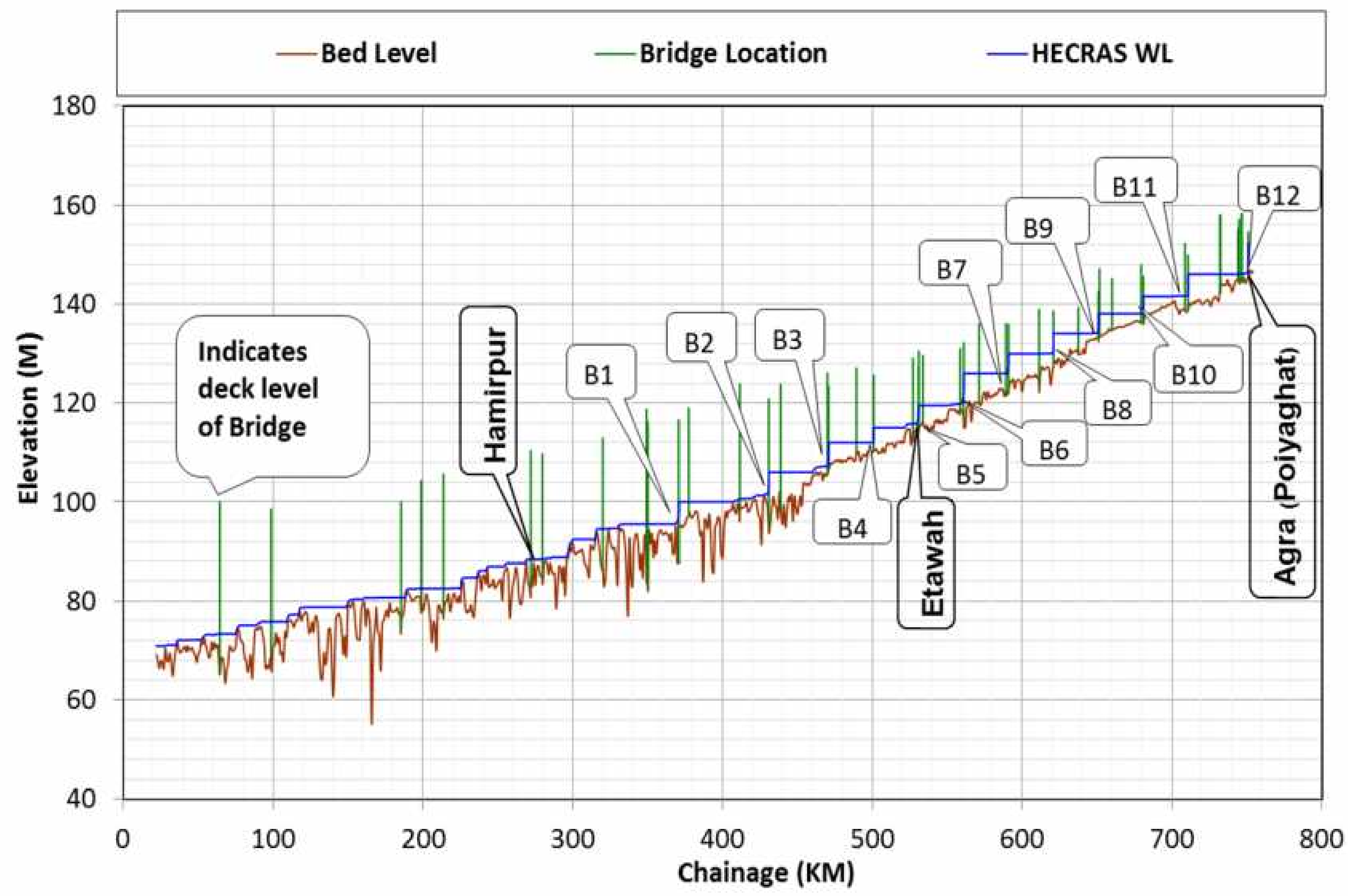


Fig. 8.23 Water Surface Profile from HECRAS Model for 50 cumec discharge in Yamuna river reach from Prayagraj to Agra with proposed Barrages

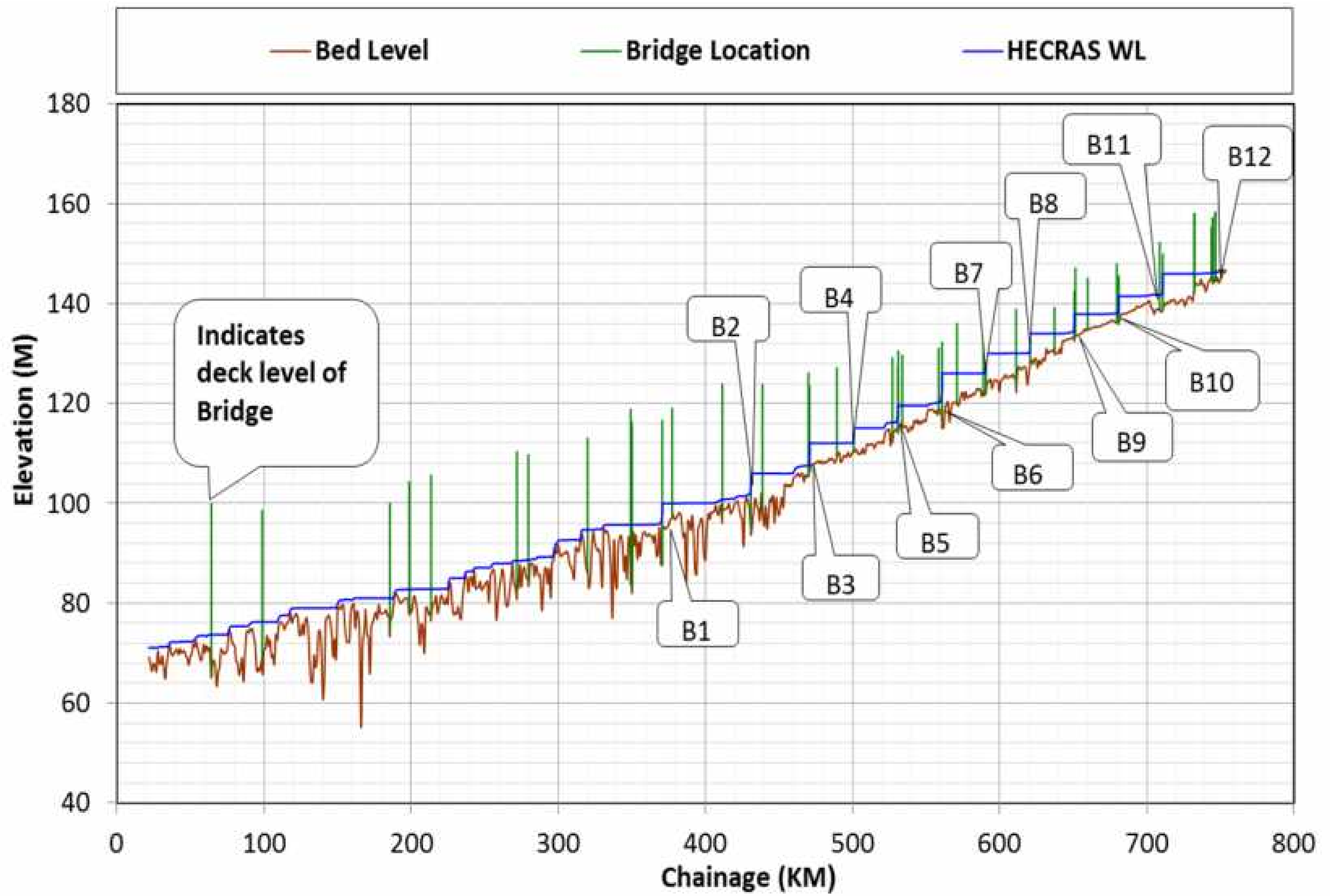


Fig. 8.24 Water Surface Profile of HECRAS Model for 100 cumec discharge in Yamuna river reach from Prayagraj to Agra with proposed Barrages

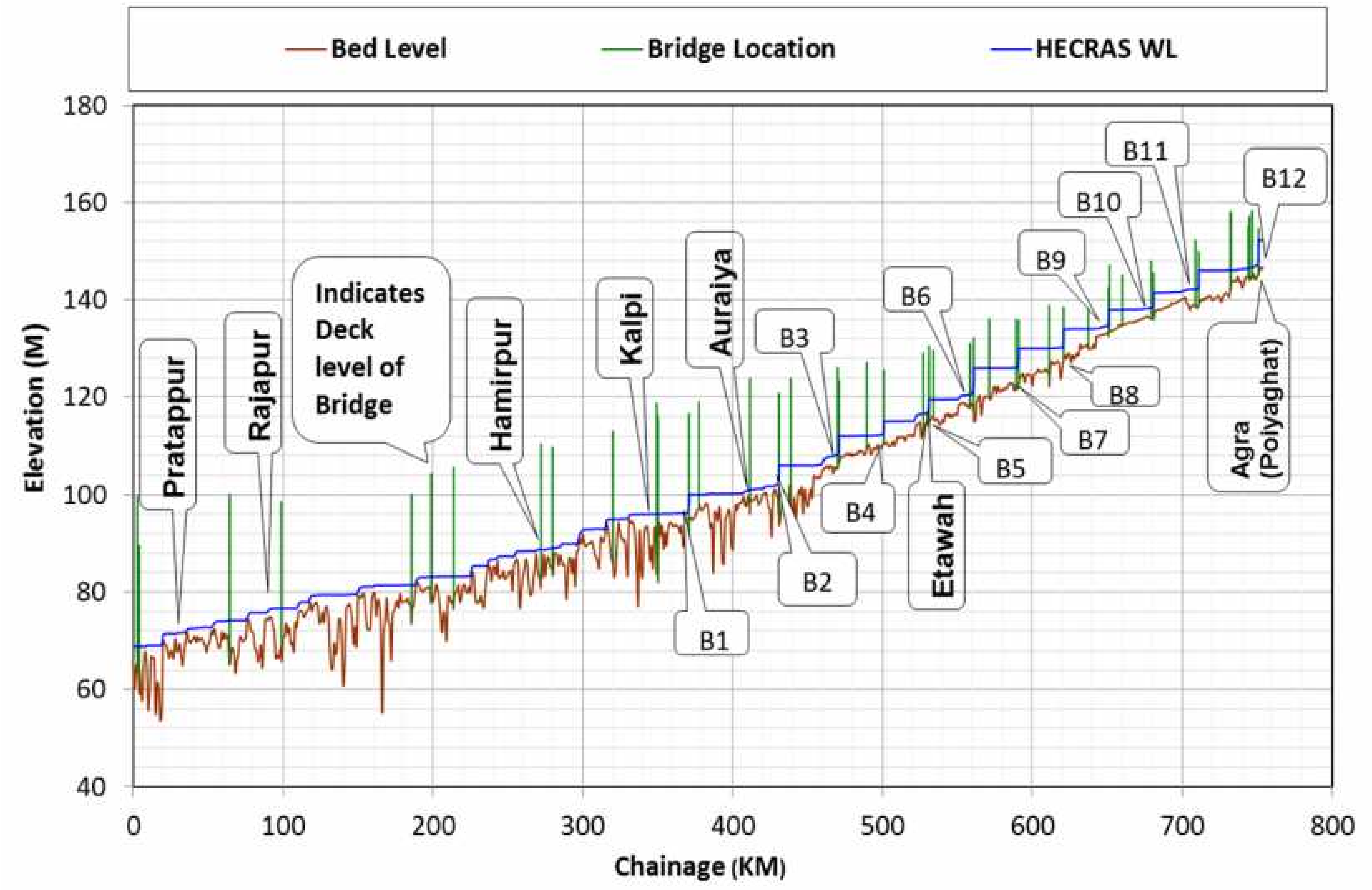


Fig. 8.25 Water Surface Profile from HECRAS Model for 200 cumec discharge in Yamuna river reach from Prayagraj to Agra with proposed Barrages

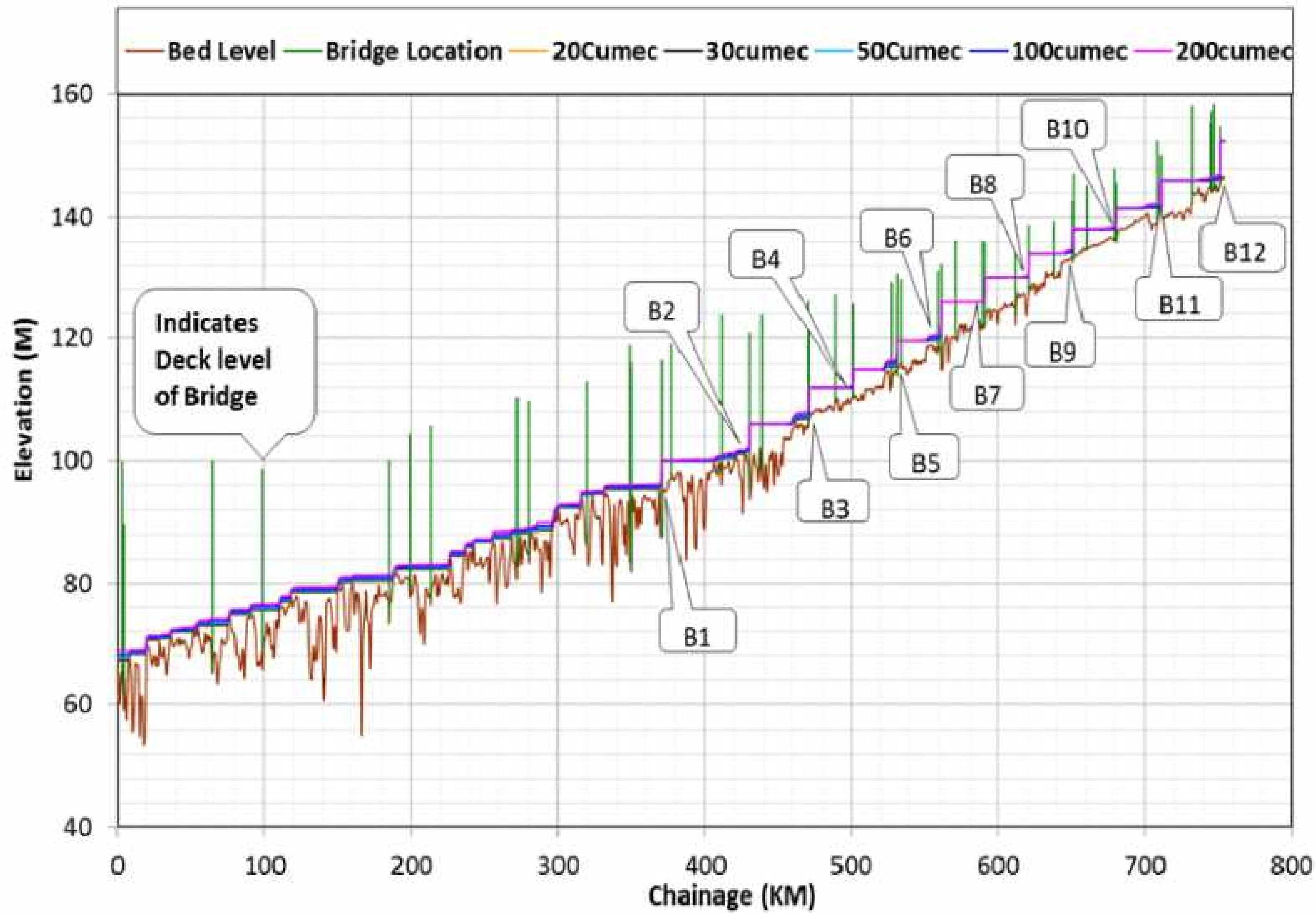


Fig. 8.26 Water surface profiles for different discharges in Yamuna River reach from Prayagraj to Agra with proposed Barrages

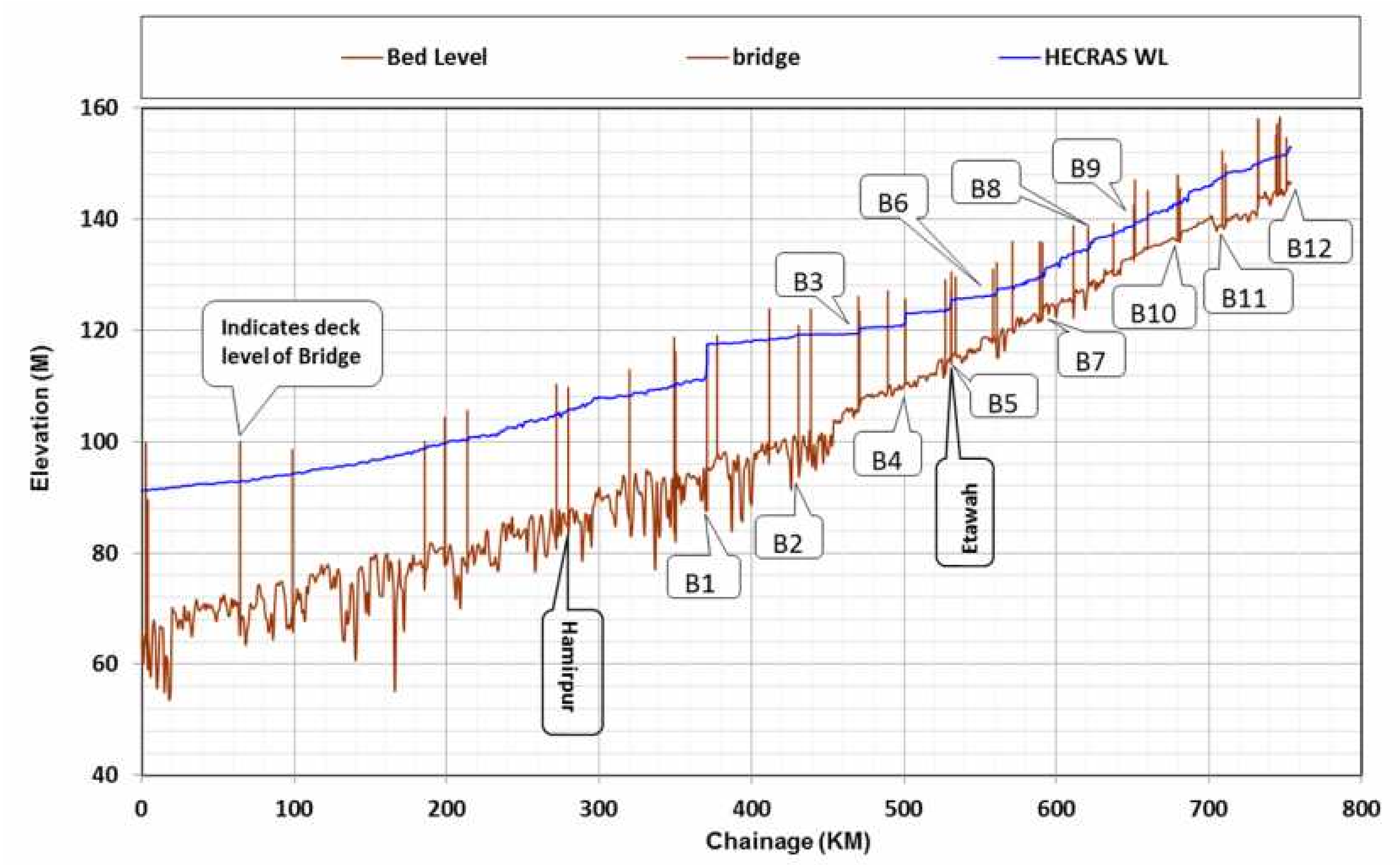


Fig. 8.27 Water Surface Profile of HECRAS Model for Design Discharge of 50 year return period in Yamuna river reach from Prayagraj to Agra

Water Surface Profile of HECRAS Model for Design Discharge of 50 year return period in Yamuna river reach from Prayagraj to Agra

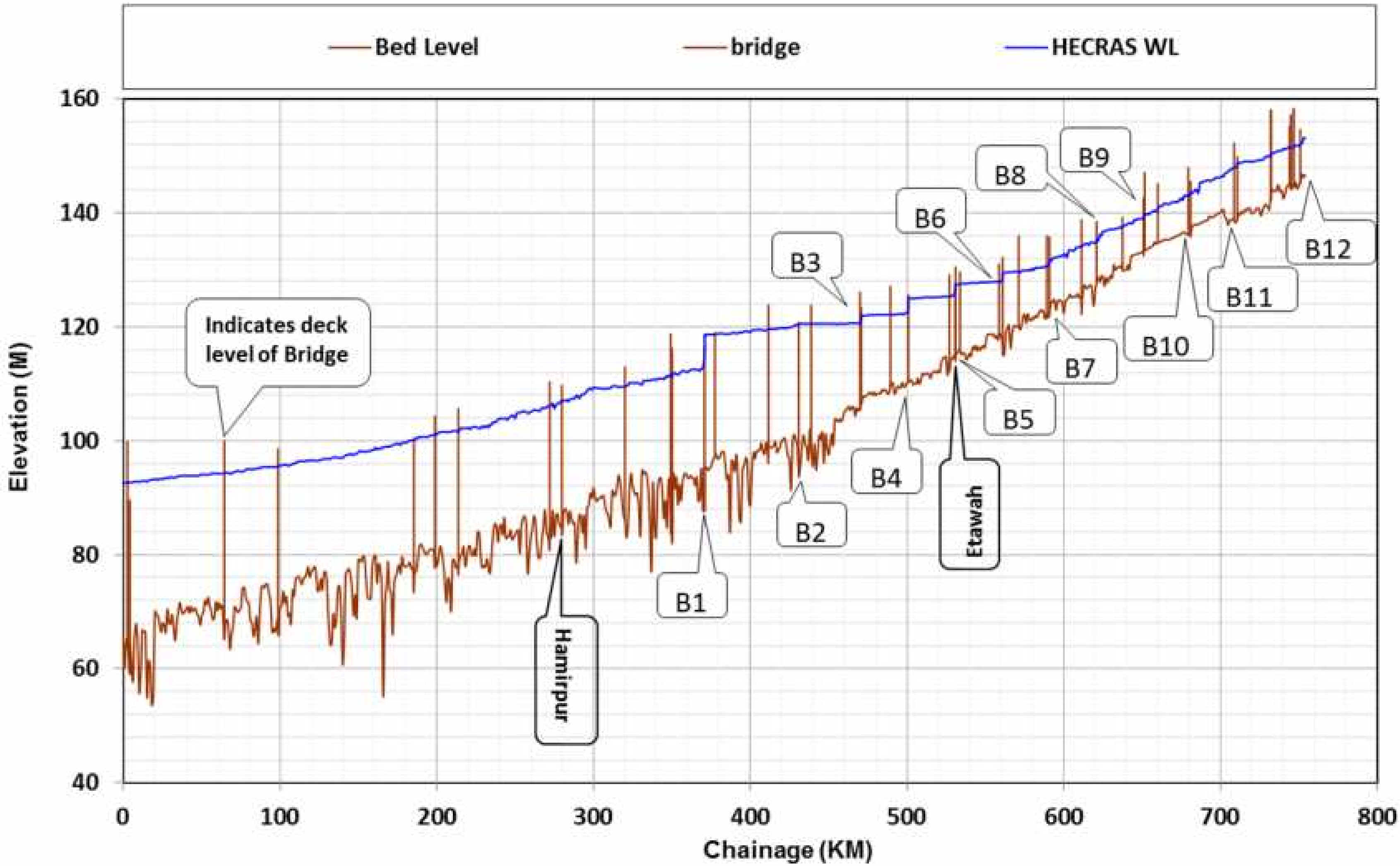


Fig. 8.28 Water Surface Profile of HECRAS Model for Design Discharge of 100 year return period in Yamuna river reach from Prayagraj to Agra

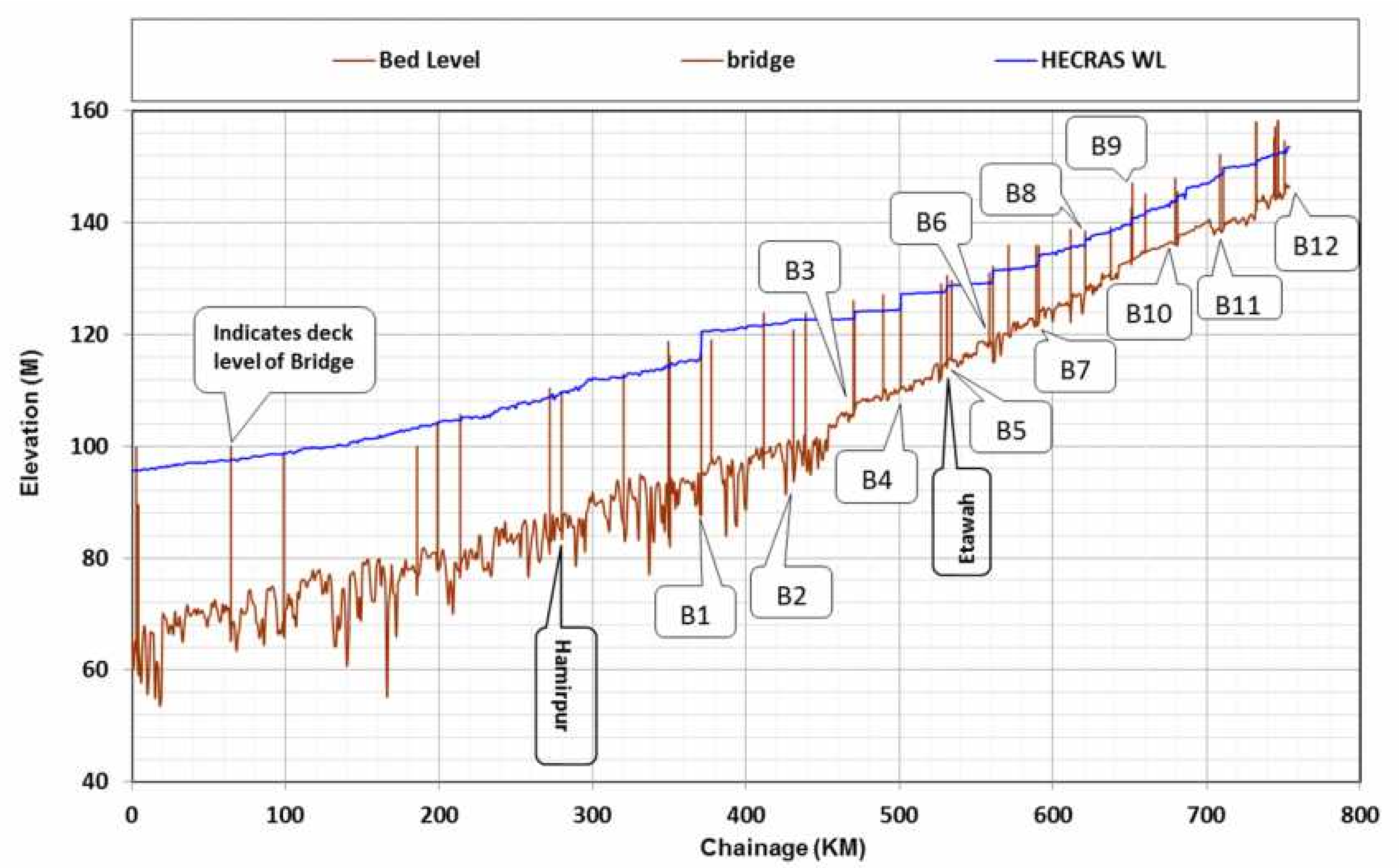


Fig. 8.29 Water Surface Profile of HECRAS Model for Design Discharge of 500 year return period in Yamuna river reach from Prayagraj to Agra

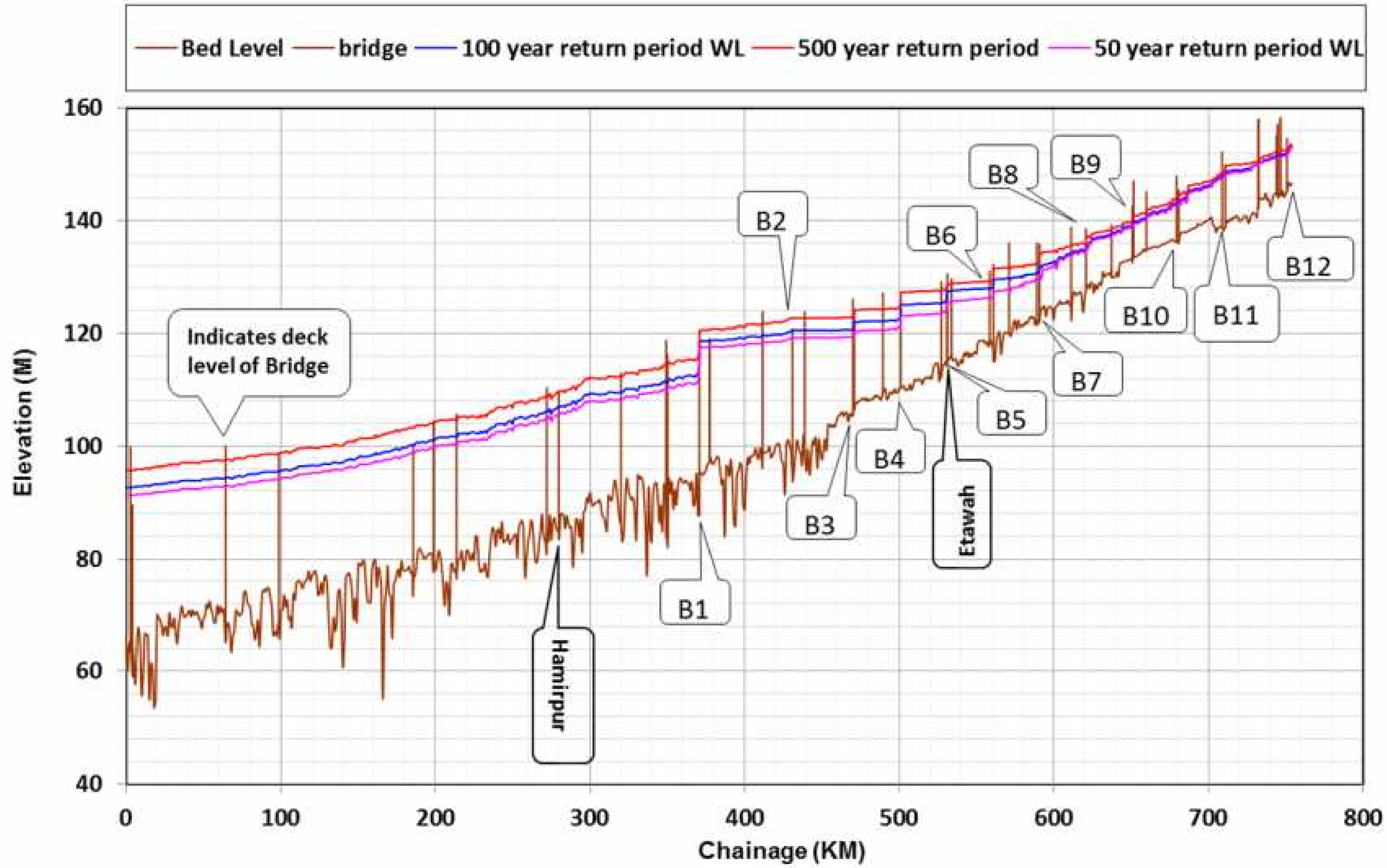


Fig. 8.30 Water Surface Profile of HECRAS Model for different year return period in Yamuna river reach from Prayagraj to Agra

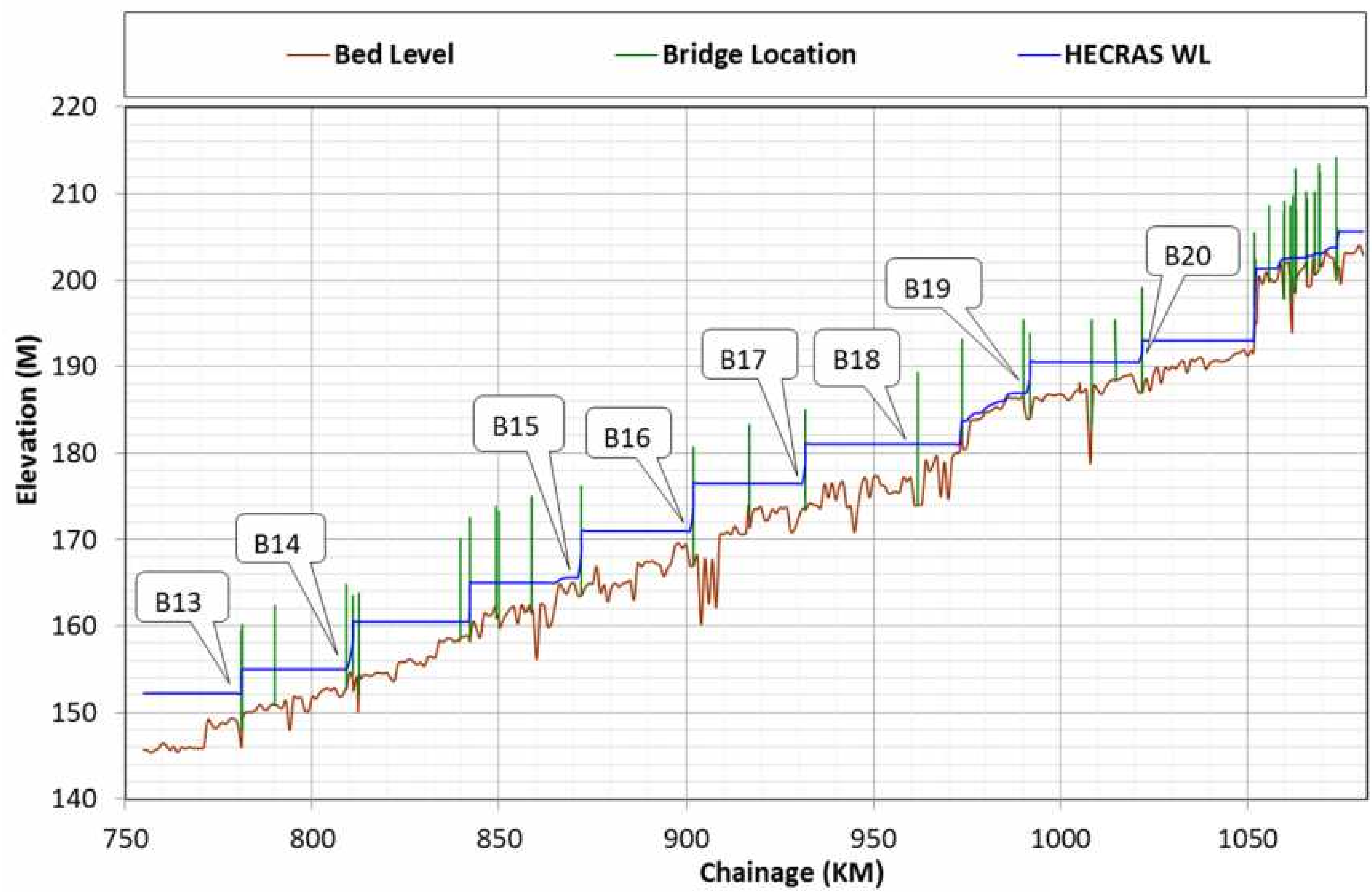


Fig. 8.31 Water Surface Profile from HECRAS Model for 20 cumec discharge in Yamuna river reach from Agra to Delhi with proposed structures and maintaining pond level

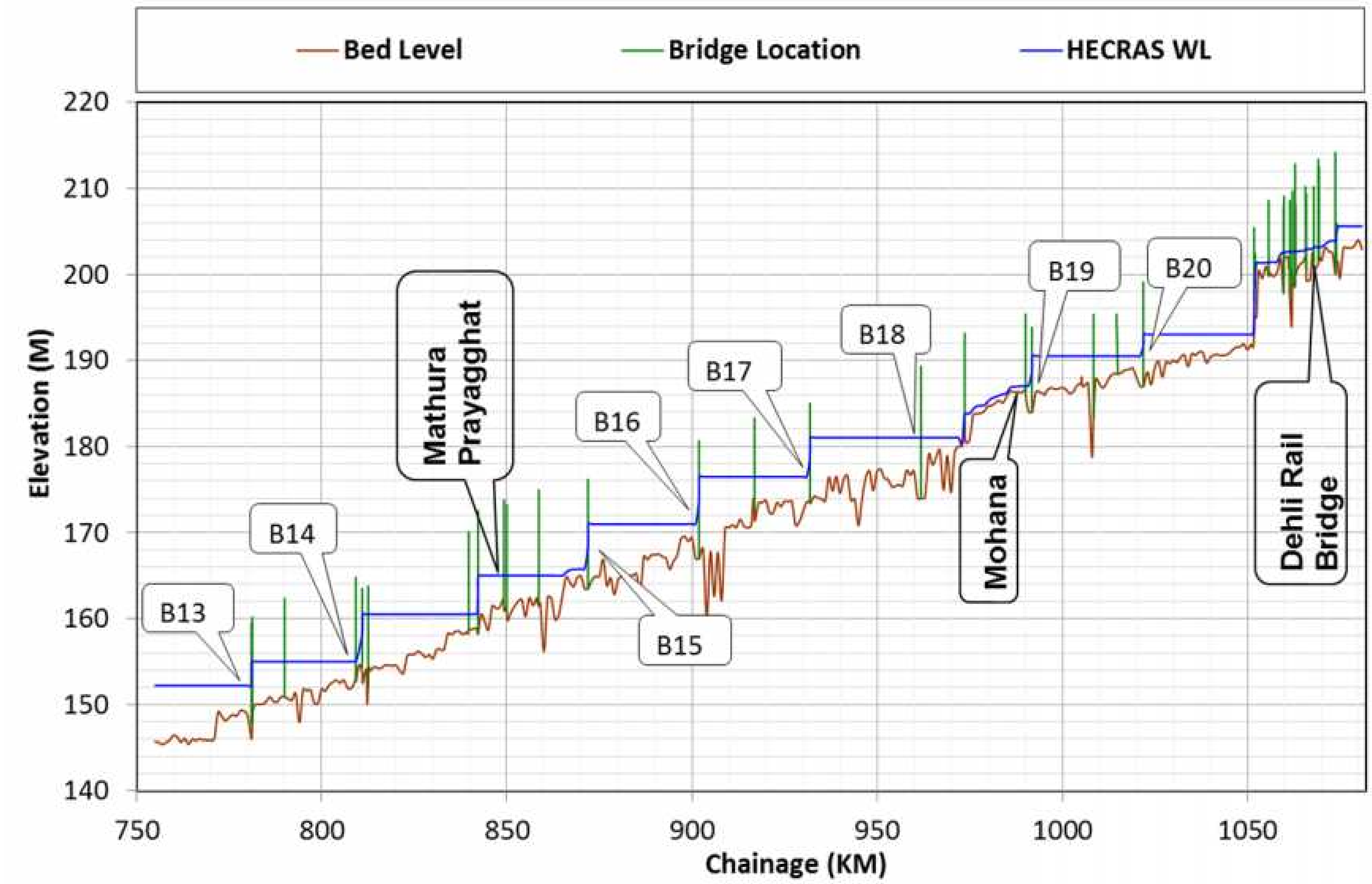


Fig. 8.32 Water Surface Profile from HECRAS Model for 30 cumec discharge in Yamuna river reach from Agra to Delhi with proposed structures and maintaining pond level

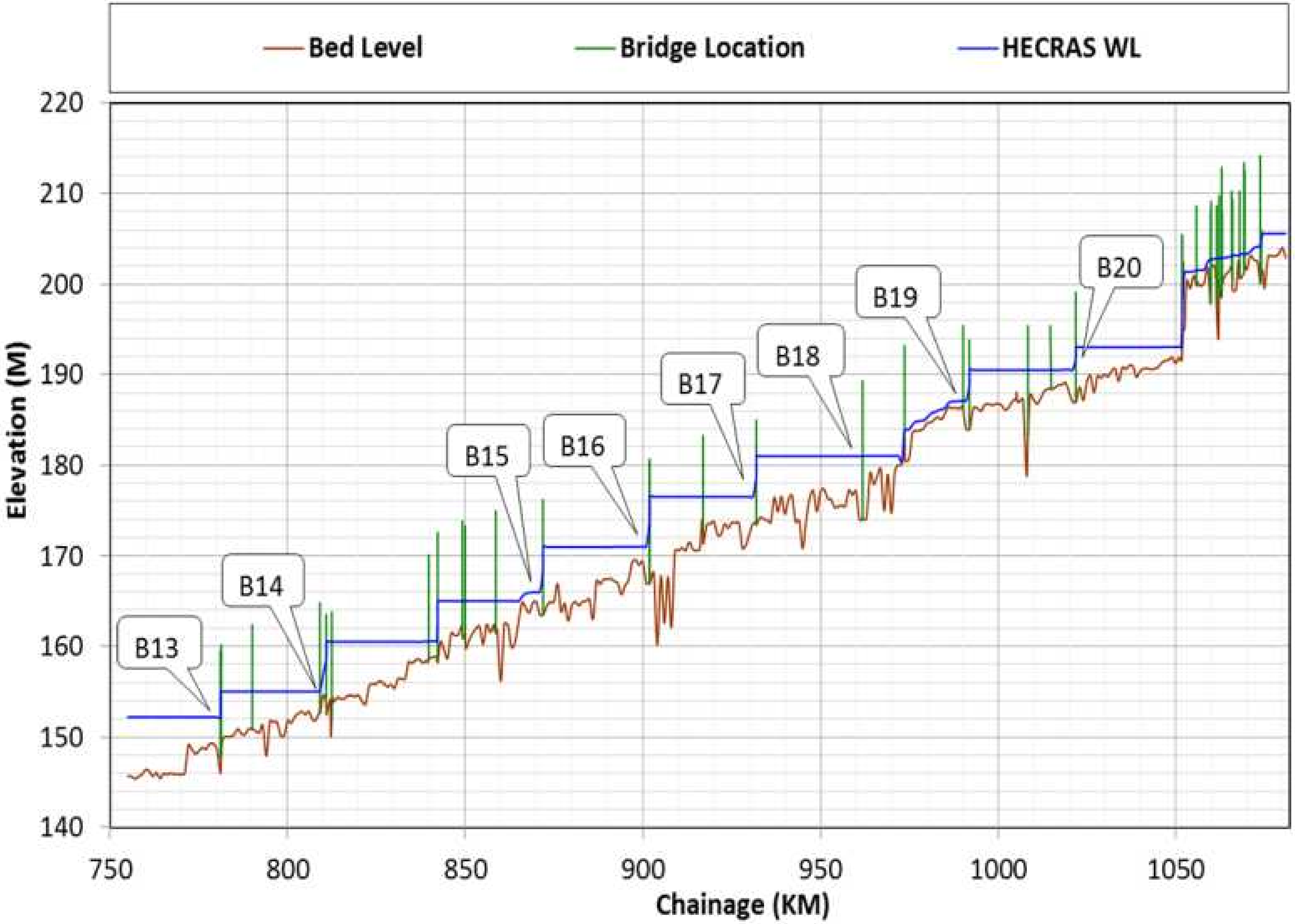


Fig. 8.33 Water Surface Profile from HECRAS Model for 50 cumec discharge in Yamuna river reach from Agra to Delhi with proposed structures and maintaining pond level

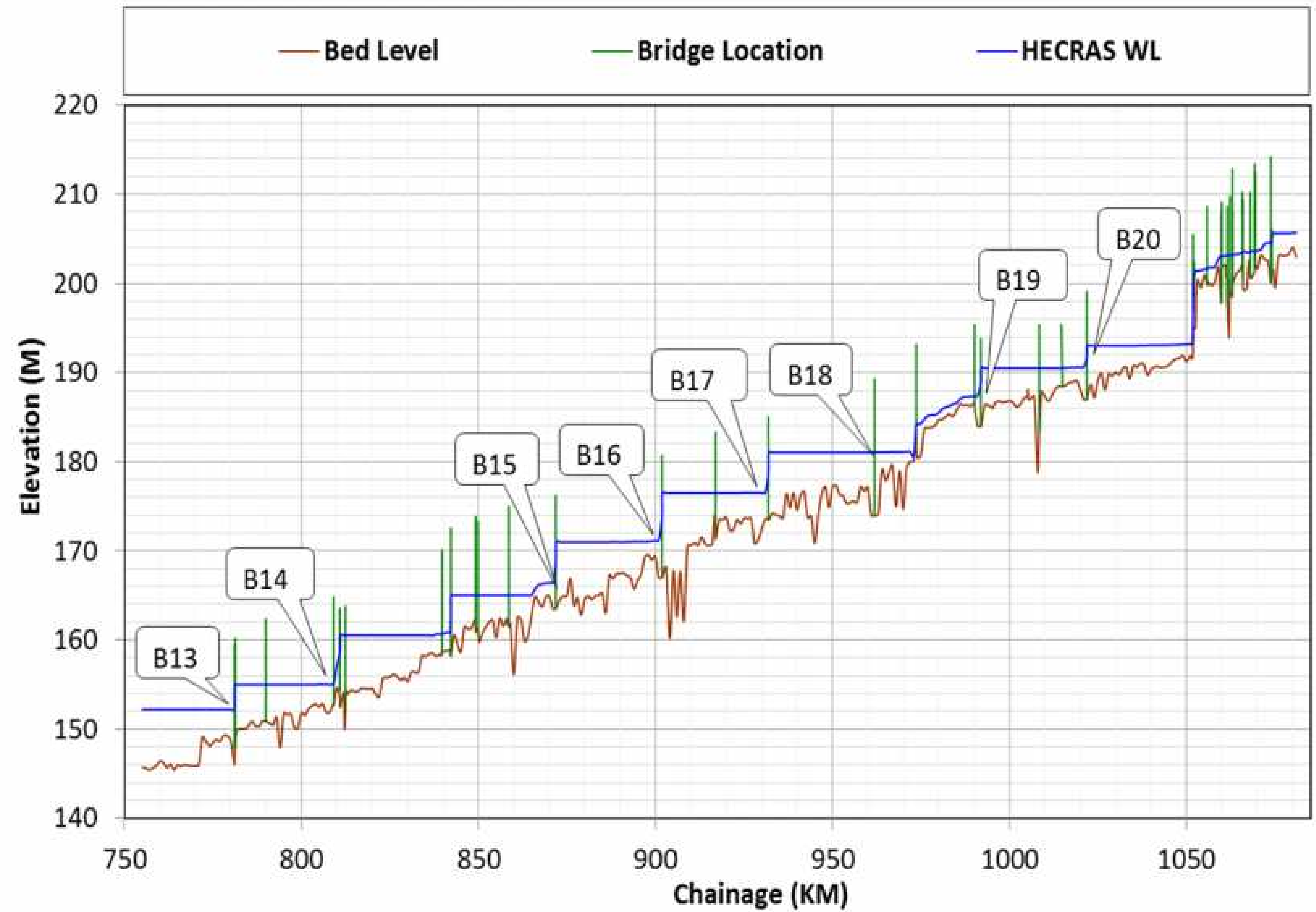


Fig. 8.34 Water Surface Profile from HECRAS Model for 100 cumec discharge in Yamuna river reach from Agra to Delhi with proposed structures and maintaining pond level

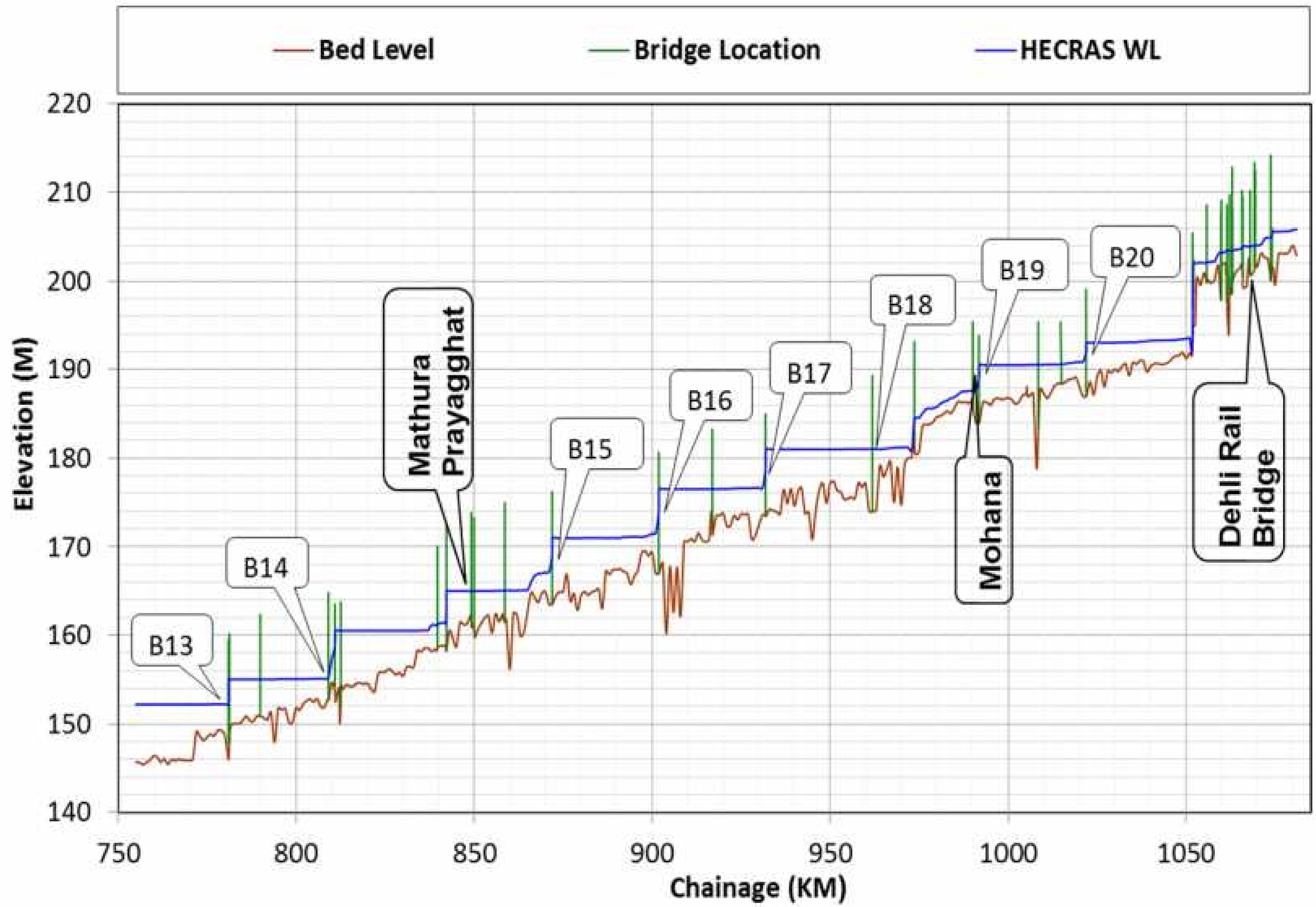


Fig. 8.35 Water Surface Profile from HECRAS Model for 200 cumec discharge in Yamuna river reach from Agra to Delhi with proposed structures and maintaining pond level

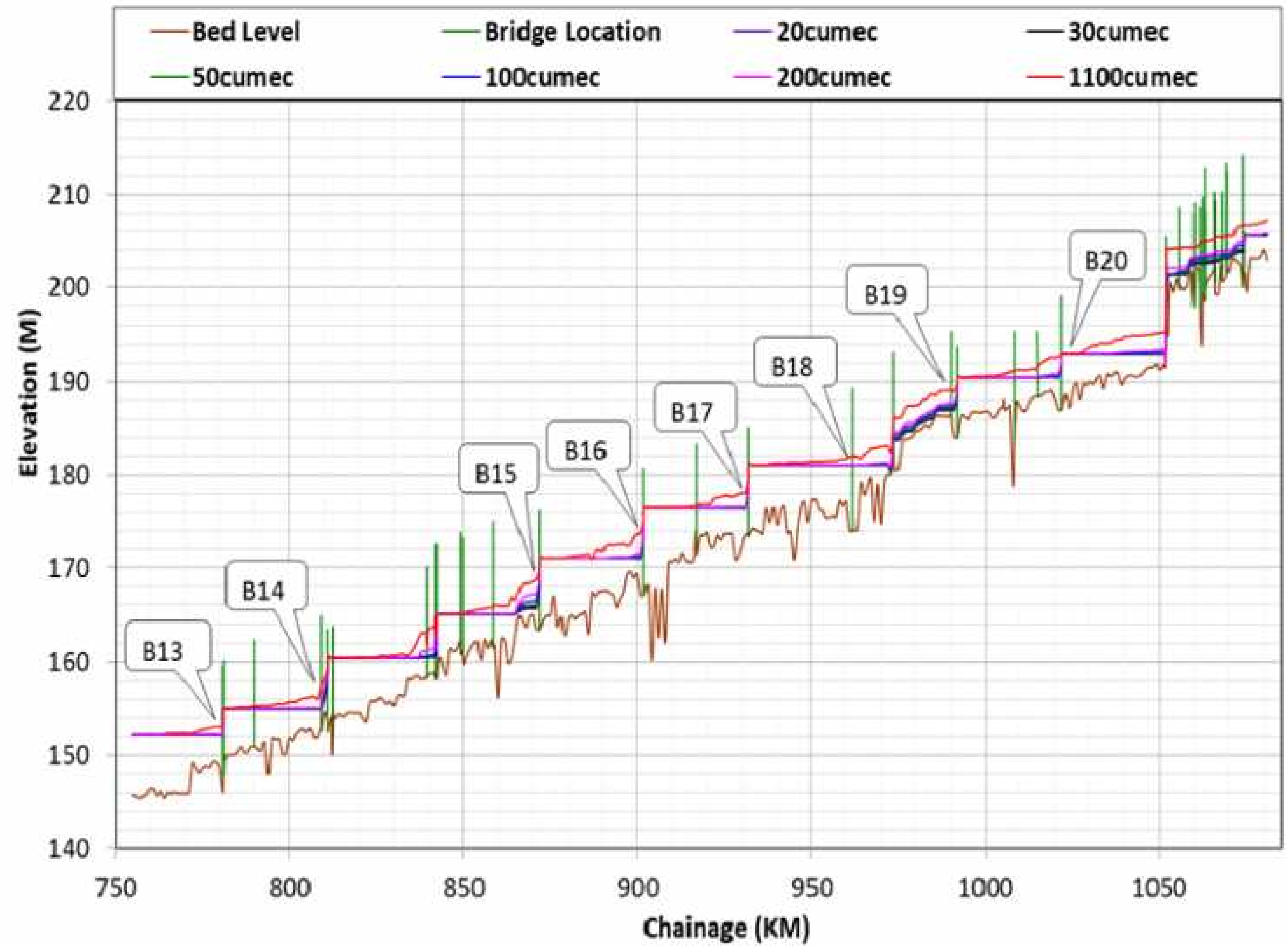


Fig. 8.36 Water surface profiles for different discharges in Yamuna River reach from Agra to Delhi with proposed structures and maintaining pond level

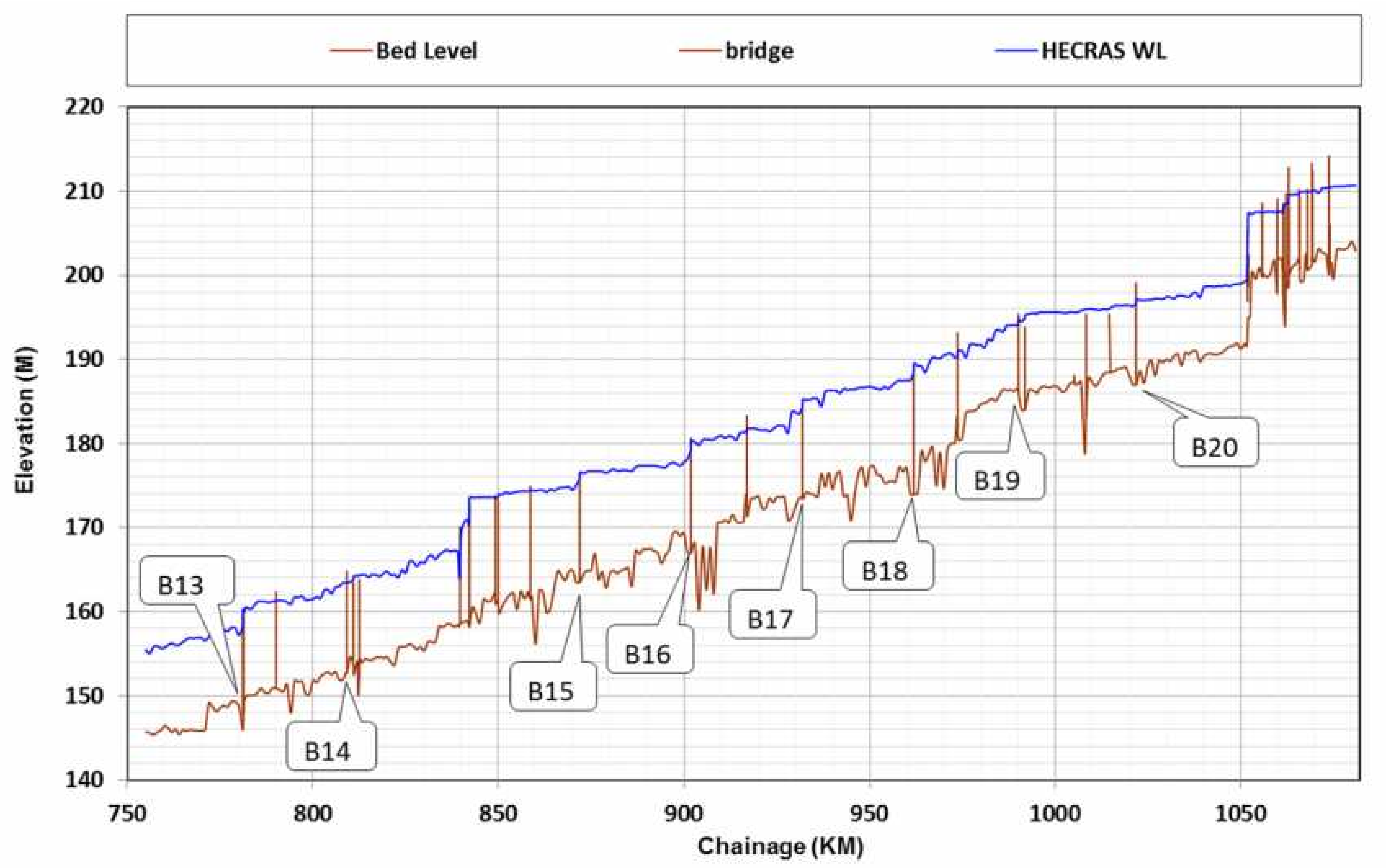


Fig. 8.37 Water Surface Profile from HECRAS Model for 50 year return period discharge in Yamuna river reach from Agra to Delhi with proposed structures

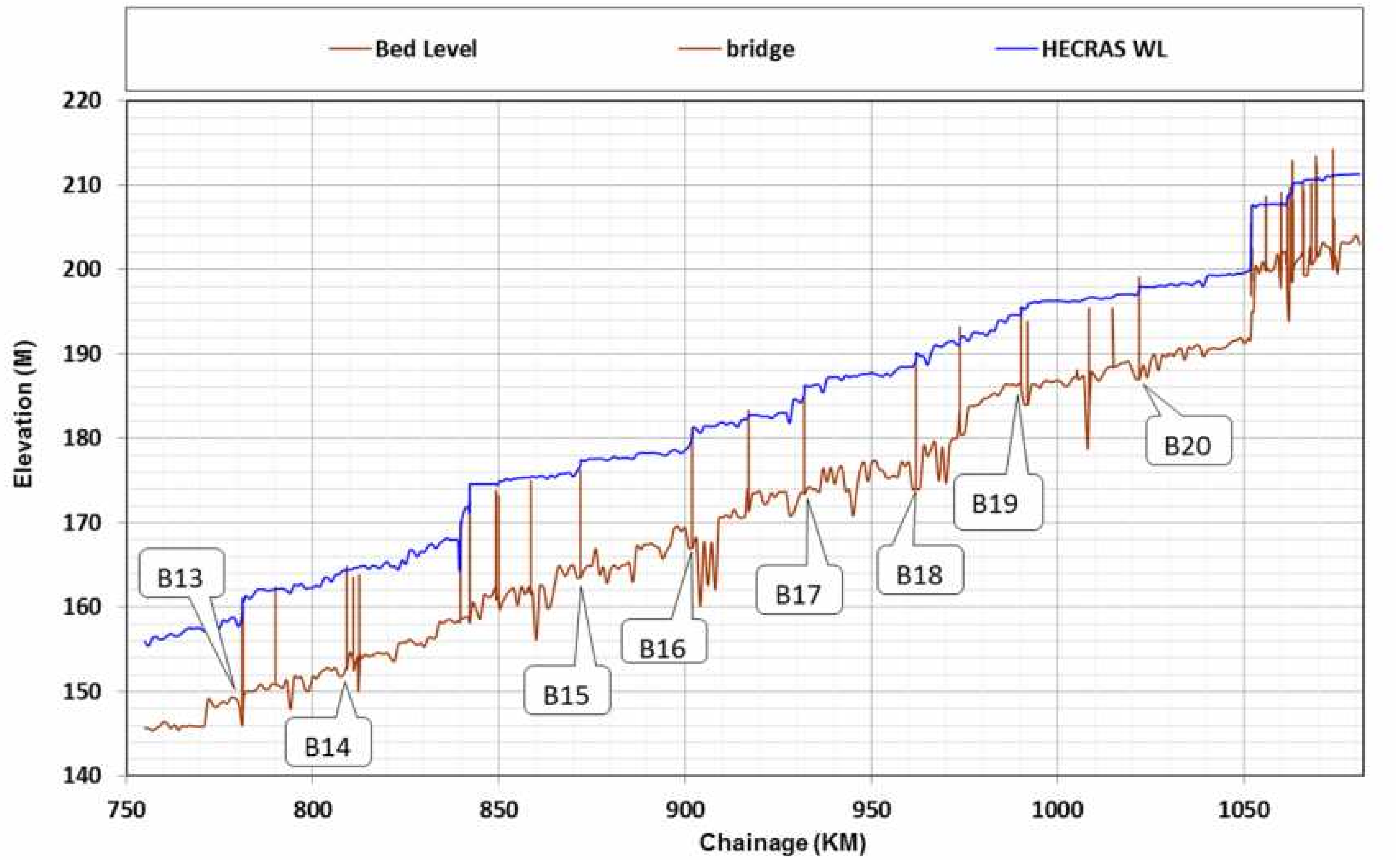


Fig. 8.38 Water Surface Profile from HECRAS Model for 100 year return period discharge in Yamuna river reach from Agra to Delhi with proposed structures

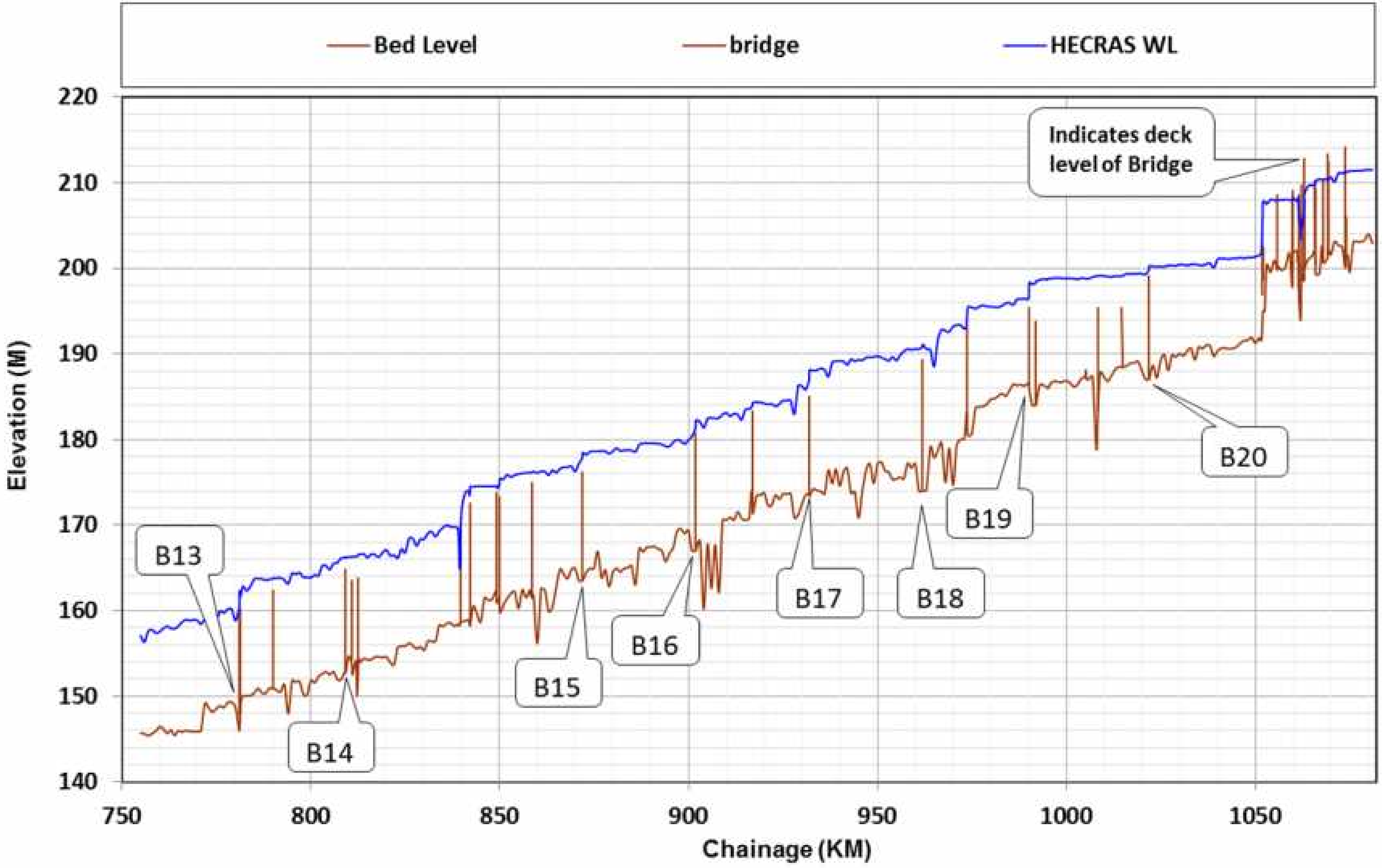


Fig. 8.39 Water Surface Profile from HECRAS Model for 500 year return period discharge in Yamuna river reach from Agra to Delhi with proposed structures

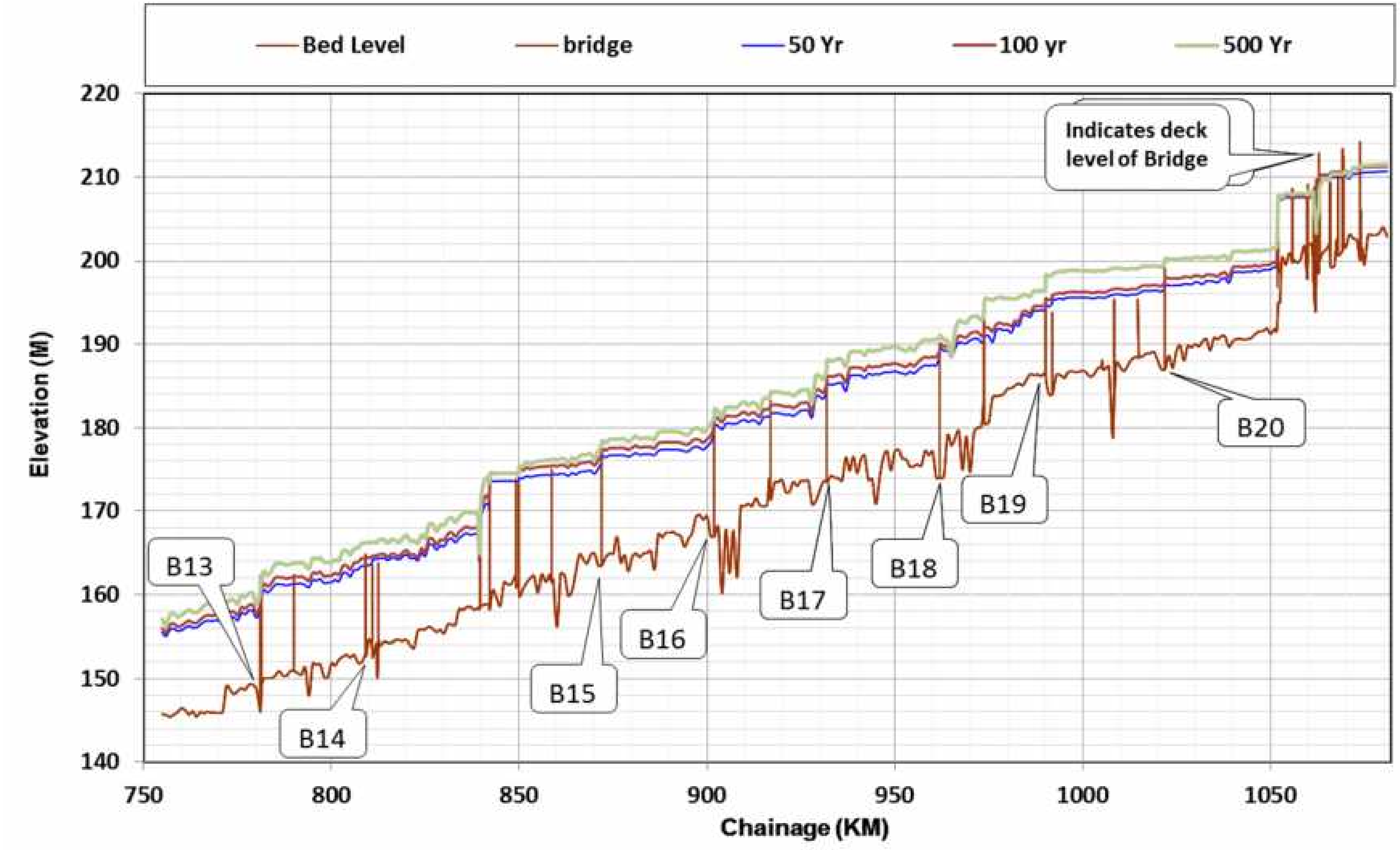


Fig. 8.40 Water Surface Profile from HECRAS Model for different year return period discharge in Yamuna river reach from Agra to Delhi with proposed structures

From results it could be seen that with provision of barrages water depths have improved to about 2 m and above in major reach except for small stretches where bed levels are higher and depths are of the order of 1.0 m to 1.8m The capital dredging requirement will be reduced considerably. Only in small stretches with higher bed levels marginal dredging of 0.5 m to 1 m may be necessary.

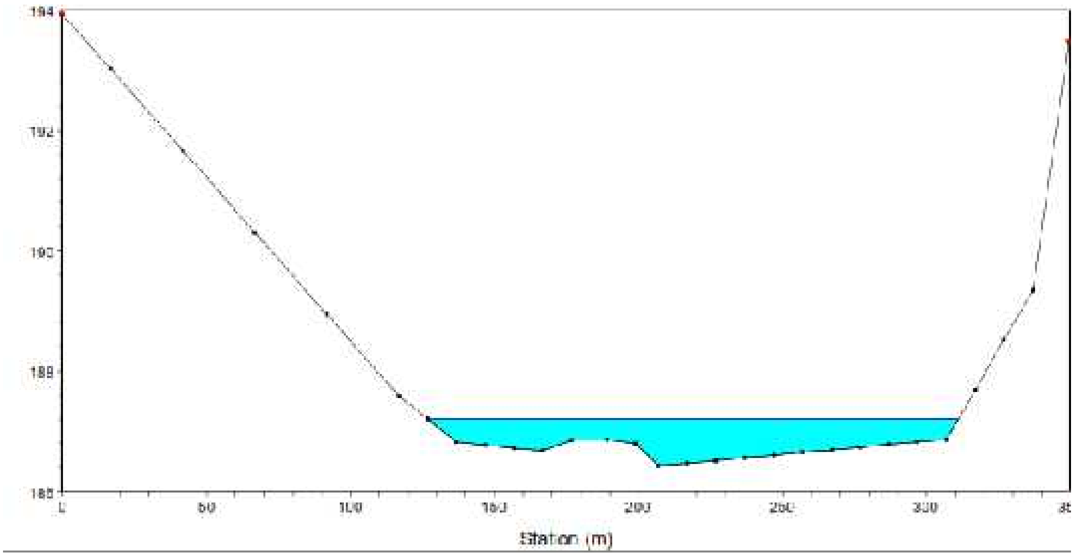


Fig. 8.41 Cross section No. 986 showing water level for Q=200 with existing condition

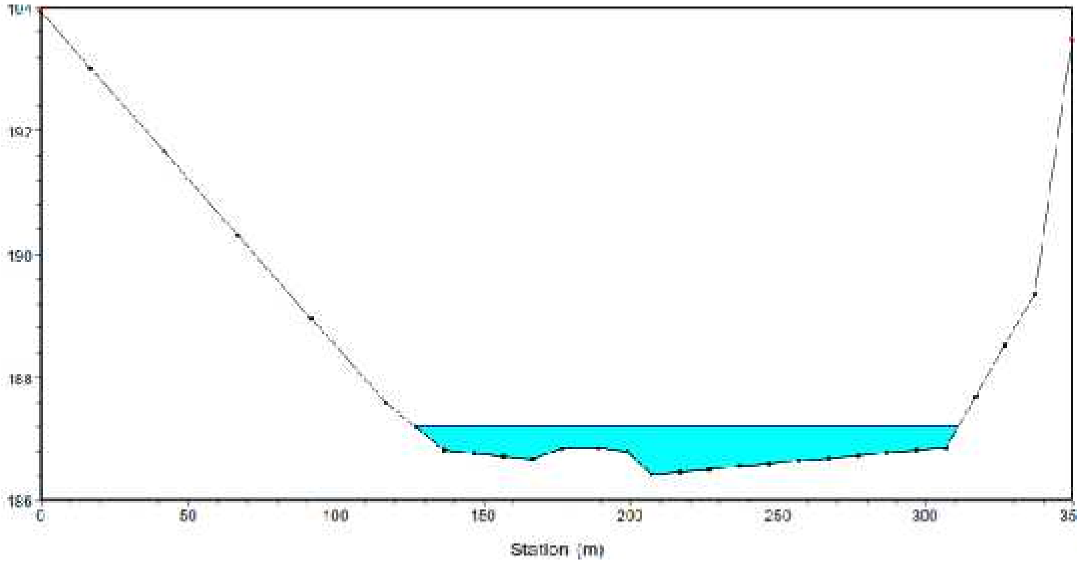


Fig. 8.42 Cross section No. 986 showing water level for Q=200 with Proposed barrage

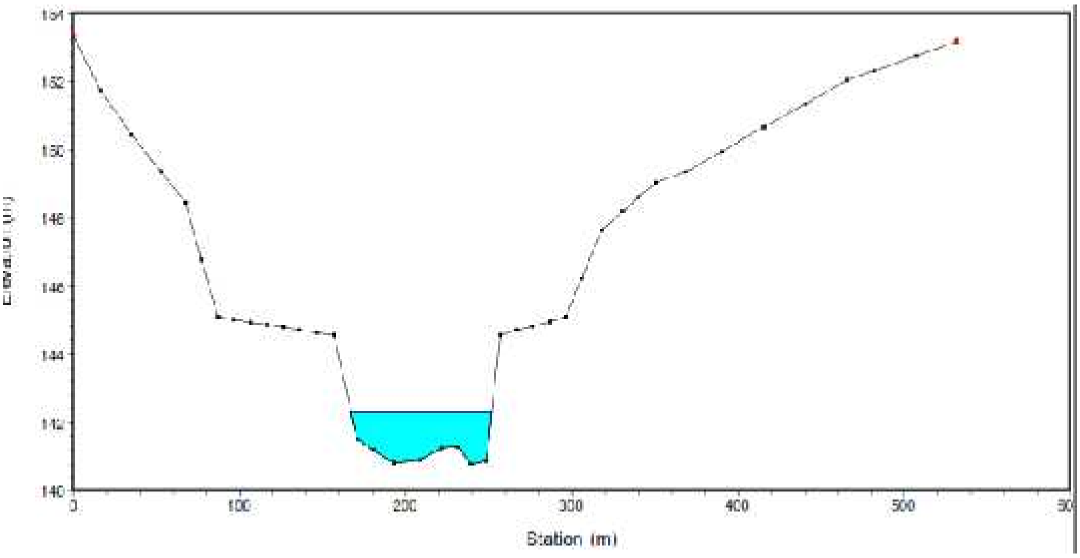


Fig. 8.43 Cross section No. 731 showing water level for Q=20 with existing condition

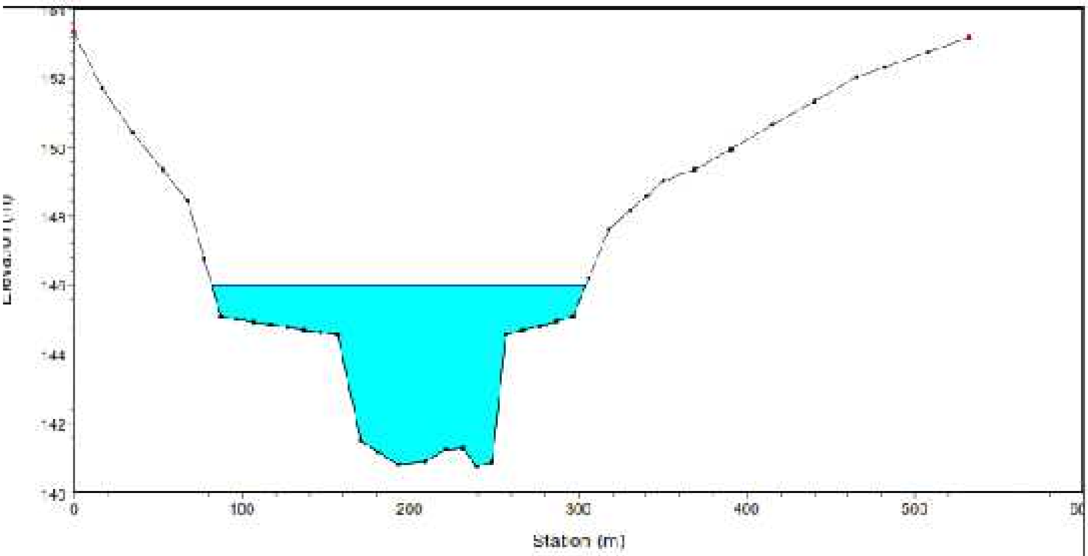


Fig. 8.44 Cross section No .731 showing water level for Q=20 with proposed barrage

8.10 Analysis of Model Results and Conclusions

Analysis of results of model studies are presented in Tables and figures referred above. It could be seen that model was adequately calibrated and validated with different/independent data sets. For simulation of lean flows discharges ranging from 20 m^3/s to 200 m^3/s were run. For high flood simulation some observed high flows and 100 year return period discharges were used. The emphasis of study was on Water depths available along proposed navigation reach under existing conditions and measures for improvement of navigability. Analysis of model G-Q data, bathymetry data, and model results indicate following conclusions

1. Lean season minimum flows available from Delhi to Etawah are in the range of 5 to 20 m^3/s and average of 10 daily flows during lean season is in the range 20 to 40 m^3/s. As compared to this minimum lean season flows in downstream

reach from Auraiya to Naini are 60 to 180 m^3/s and average ten daily flows are 120 to 400 m^3/s. The inflows from different tributaries viz. Chambal, Sind, Betwa and Ken improves flow in this lower reach. The baseline Understanding and presentation of baseline flow at different segments 50 km length each of the main river is presented in Fig. below

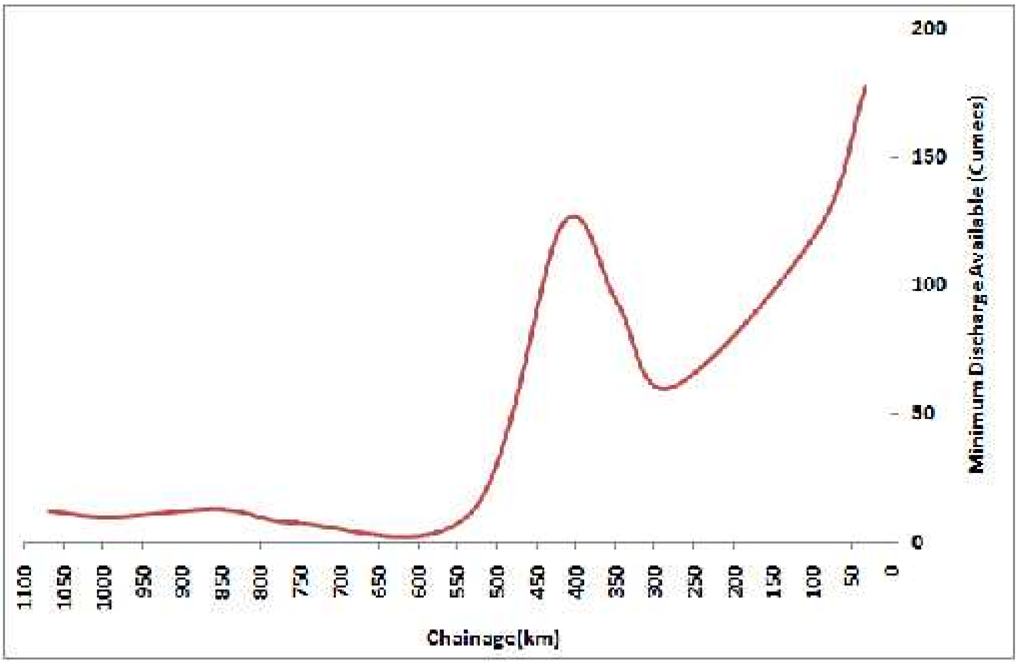


Fig. 8.45 Presentation of baseline flow at different segments

The needed flow for each 50 Km length has been computed to maintained 2.5 m draft for a waterway of 60m and 120m width and the available lean season flow are presented in the table given below:

Table 8.3 Needed flow and Available flow

Chainage (Km)	Targeted Depth (m)	Discharge Required (Cumec)		Available Lean Season flow (Cumec)
		60 m Channel Width	120 m Channel Width	
0 - 50	2.5	78.48	156.95	177.50
50 - 100	2.5	109.86	219.73	132.00
100 - 150	2.5	87.34	174.69	107.50
150 - 200	2.5	47.29	94.58	90.00
200 - 250	2.5	116.01	232.02	72.50
250 - 300	2.5	70.14	140.28	60.00
300 - 350	2.5	100.97	201.93	75.00
350 - 400	2.5	93.98	187.95	115.00
400 - 450	2.5	82.94	165.87	120.00
450 - 500	2.5	148.30	296.59	57.50
500 - 550	2.5	85.26	170.52	15.00
550 - 600	2.5	113.25	226.50	5.00

Chainage (Km)	Targeted Depth (m)	Discharge Required (Cumec)		Available Lean Season flow (Cumec)
		60 m Channel Width	120 m Channel Width	
600 - 650	2.5	132.88	265.77	2.50
650 - 700	2.5	119.80	239.61	5.00
700 - 750	2.5	114.16	228.31	7.50
750 - 800	2.5	99.86	199.73	9.00
800 - 850	2.5	143.81	287.62	12.50
850 - 900	2.5	127.68	255.35	13.00
900 - 950	2.5	126.58	253.17	11.50
950 - 1000	2.5	128.74	257.48	10.00
1000 - 1050	2.5	130.01	260.02	10.00
1050 - 1081	2.5	406.65	813.29	12.50

The table above reveals that the available lean season flow is not enough with river bed and profile remaining as it is and is very low as compared to high requirement of discharge except in first 50 km of river stretch for 120m wide channel while the available lean season flow is enough to meet targeted draft of 2.5m up to chainage 370 Km for 60m wide channel. The remaining portion of the NW 110 above Ch. 371 up to New Delhi at Ch. 1081 Km for 60m wide channel the available flow is not sufficient to meet targeted draft of 2.5m.

Yamuna river bed slope in reach from Okhla to Auraiya is about 1/5900 and is much steeper than the slope of lower reach from Auraiya to Naini (1/14250). The lower reach has undulating river bed with relatively mild average slope resulting in formation of many deep pools along the reach.

2. The model results for the lower reach from 0 to 370 km with lean season flows mentioned above indicate that in most of the reach water depths will be above 2.5 m except for some intermittent reaches where bed levels are high. Even in these intermittent reaches water depths for minimum lean season flow of 50 m^3/s and 100 m^3/s will be in the range 0.6 m to 1.5 m and 0.8 m to 1.8 m respectively. Thus, the existing flow is enough with channelization of the river including dredging of the order of 1.0 m to 1.9 m in these stretches minimum water depths water depth of 2.5 m could be created in the entire stretch of 370 km. Considering minimum water level of 71.39 m at Naini (during period 1999- 2016) no dredging will be required in the reach 0 km to about 50 km. This reach of 370 km can provide navigable stretch with 2 m depth round the year after carrying out suggested dredging.

3. Analysis of results for remaining reach from 370 to 1081 km up to Delhi/Palla for lean season minimum flows mentioned above indicate following

- Depths in this entire stretch will be in the range 0.5 m to 1.5 except for some deep pools and about 7 km reach on upstream of Okhla barrage where depth more than 2.5 m prevail.
- Reasons for low water depths are low lean season flows, steeper slope of reach and larger river bed width
- Even with increase in discharge to 50 and 100 m^3/s the rise in depth was very marginal due to steeper bed slope and wide river bed.
- Dredging river bed 1.0 m to 2.0 m over such long reach will not be economical and it may not serve purpose due to inadequate flow in lean season.
- Provision of barrage at an interval of about 30 km with pond depth of 5 m to 6 m at each barrage is the only possible measure.

4. Analysis of result for model runs with proposed 20 barrages in reach from 370 km to 1052 km (Okhla barrage) and maintaining design pond levels indicate following :

- With proposed 20 barrages in this 680 km reach and lean season flow of 20 to 30 m^3/s flow , water depths of 2 m and above will be created in about 560 km reach. In remaining 120 km reach depths will be less than 2 m.
- About 6 to 10 km reach on downstream of each barrage will have water depths 0.5 to 1.8 m.
- Major portion of 120 km reach identified with water depths less than 2 m will have depths in the range 0.8 m to 1.5 m. Thus , dredging depths will be in the range 0.50 m to 1.2m.
- The dredging requirement in 120 km reach can be reduced further by raising design pond level by about 1 to 1.5 m after studying implications in case of each Barrage

- ***With proposed barrages depths of 2.5 m will be available so that class IV waterway could be developed.***

The existing flood flow storage in upstream tributaries would definitely provide for the intended needed flow in downstream stretch fully when required.

The stretch wise development details based on Mathematical Model Study is given below:

Table 8.4 Proposed Development Options

Sr. No.	Stretch	Development Options	Reason	Class of Waterway Recommended
1.	Prayagraj to River Betwa Mouth (Ch. 0 to 272 km)	Dredging Only	Model Study Analysis shows that this stretch having sufficient water depth except some portion of river in patches, by dredging only it could be possible to get 2.5 m draft	Class IV
2.	River Betwa Mouth to River Chambal Mouth (Ch.272 to 453 km)	Dredging along with Barrage with Navigational Lock	From Chainage 272 to 380 km it could be possible to get sufficient water depth by dredging and from Ch. 371 to 453 km water can be stored by constructing a barrages to get required water depth	Class IV
3.	River Chambal Mouth to Agra (Ch.453 to 743 km)	Dredging along with Barrage with Navigational Lock	Model Study Analysis for these stretched shows that min. water depth available in these stretches varies from 0.39m to 0.92 m and also the water is not sufficient round the year to maintain the 2.5 m depth. Therefore, it is necessary to construct barrages in these stretches along with navigational lock to make stretches feasible for navigation throughout the year.	Class IV
4.	Agra to Delhi (Ch.743 to Ch.1081 km)	Dredging along with Barrage with Navigational Lock		

CHAPTER – 9

PRELIMINARY ENGINEERING DESIGNS

9.1 General

9.1.1 A channel may be navigable by vessels of certain dimensions i.e. length, beam (width), draft, air-draft etc. and not by larger vessels. Therefore, in ascertaining navigability of any channel, the first thing that needs to be determined is the size of the `design' vessel or the largest vessel to ply on the channel.

9.1.2 There are other sets of considerations which have a strong influence on dimensions of design vessels and thus on the entire issue of navigation. These considerations are related to the type and volume of traffic to be carried along the channel. Determination of typical parcel or shipment sizes will enable estimation of the typical pay-load (deadweight) which in turn will facilitate the design of a suitable vessel or vessels and the volume of traffic (number of voyages etc.).

9.1.3 Therefore, the approach taken is first to consider the size of the vessels that could ply in the channel with the navigational facilities. Simultaneously, the traffic survey and projections made in the previous chapter would be utilised to examine adequacy of the size and number of vessels arrived.

9.2 Navigation Channel

9.2.1 In the present context the design vessel may be taken as the largest - in terms of pay load - vessel that can safely ply in the river in the required numbers. Since design condition of maintaining least available depth (LAD) of 2.5 m all –round the year in the River Yamuna for development of Inland Water Transport is stipulated in the TOR, the design vessel and consequent effects on the adequacy of size and number of vessels are dealt.

9.2.2 The largest sized vessel that can ply on the river would depend on whether 1-way or 2-way navigation is to be catered to, the river width, depth and lock dimensions. There are several guidelines which have been evolved by various countries and authorities about the relationship between the dimensions of any restricted waterway and the vessels that may ply in it. However, the recommendations may vary widely from country to country or waterway to waterway. Normally, for inland and well sheltered (restricted) waterways, a vessel between 1/5 to 1/8ththe (bottom) width of the channel is considered to be safe for permitting 2 way navigation. A waterway, which is only 5 times the width of the largest vessel, is considered particularly narrow. This is based on provisions for `lanes' for bank clearance, for each vessel maneuvering and clearance between two vessels. It will be seen that channel which is just 5B wide provides only 1B for each of the lanes - an obvious bare minimum. Anything less would carry a high degree of risk of collision between approaching vessels and a tendency to go aground on/near the bank particularly if prevalent wind and current are across the river and strong. However, keeping in view the possible increase in cost of widening the channel, the soft nature of the river bed and banks, the relatively low speeds at which vessels could or would ply in the canal, the ratio of 1:5 between beam of design vessel and bottom width of canal is provisionally used for calculations. On this basis vessels with beam of 10 m would be the largest that could be accommodated in 50 m wide river channel with 2-way navigation

9.2.3 Vessels with a draft (when underway) which is somewhat less than the depth of waterway can navigate through it. Obviously, therefore, vessels having a draft of less than 2.5 m could navigate. The question of how much less than the water depth the max. vessel draft (loaded) should be, depends on various considerations. The difference between water depth and the max. Permissible draft in any channel is termed the Under Keel Clearance (UKC). UKC depends mainly on waterway conditions i.e. turbulence of the water course and other environmental forces. In open water, vessels are inclined to pitch, roll and heave to a greater or lesser degree depending on the degree of disturbance and vessel size. A further factor to be considered is `Squat' which is the extra settlement of a vessel's stern when moving at operating speed, thereby increasing its maximum draft (which is generally of the stern end in any case). In the instant case if the above standards were to be applied maximum vessel draft would have to be between2.25 m (10% UKC) and 2.00 m (20% UKC) for the 2.5m deep fairway. However, considering the realities of the situation in the channel viz. that there can be no natural wave action in the river; that the vessels are unlikely to have any squat due to their shape and low - speed and also the soft nature of river bed and banks, UKC is not going to be required for the usual reasons. Of course some clearance between bed and keel is absolutely essential.

9.2.4 There is yet another important parameter, which will have a telling effect on permissible vessel dimensions. When a vessel is navigating in a very narrow and shallow channel its maneuverability as well as speed suffer due to a kind of drag that is imposed on the moving hull by the relative lack of water around it. This is especially true in artificially dug canals. The guidelines developed for this aspect is that the `n' factor should be as large as possible, preferably around 10 or above. The `n' factor is defined by:

Cross sectional wetted area of the channel

Largest cross section of the vessel

In the instant case the wetted cross sectional area of the channel will be 120 m^2. The cross section of the design vessel (usually in its mid-ship portion) would be 21.6m^2 for the waterway. In other words, the `n’ factor for the waterway would be 5.6. An `n' factor of 5.5 to 6 is about the lowest tolerable by most standards/guidelines and it would therefore be prudent to limit the maximum draft for the design vessel to 1.8 for the 50 m wide channel.

9.2.5 Having thus arrived at the beam and draft of the design vessel, the length and dead weight of the vessel may be worked out. Typically, the length of an inland vessel is between 4 to 8 times the vessel's beam, the longer vessels tending to yield a faster speed for a given horse-powered engine. It is, however, important to note one limitation on vessel length viz. that the vessel's length on water-line (LWL) should be somewhat less than the width of the channel. If the length is kept the same or more than this it would become virtually impossible for a vessel to be turned around even in an emergency. This, in along/narrow waterway would be an unacceptable condition for obvious reason, unless special turning areas are excavated at relatively short intervals. It may also be possible to turn vessels around in rivers through which the route passes. Therefore, the largest vessel should not be longer than - say -45 m at water line for the 50 m wide channel. In this manner the following dimensions of the largest vessel may be arrived at:

LWL 45 m
B 12 m
D 1.8 m

Another pertinent consideration that remains to be taken into account is the compatibility of the selected vessel sizes to the lock dimensions; obviously, vessels cannot be longer than the locks through which they must pass. In this connection the further para may please be referred where the lock gate is dealt with. It may be seen from there that width of vessel that can pass the lock would be 14 m.

9.2.7 Further, from market assessment, two types of vessels are considered for NW 110; vessels, which are currently available in market and IWAI's designed vessels. First category contains vessels presently operating in Indian waters. Second category consists of IWAI's specially designed vessels customized to Indian Rivers. IWAI had commissioned a European Consultant for designing cost effective vessels to be deployed in inland waterways of India. As per the Terms of Reference (ToR) of the project the primary task is to maintaining least available depth (LAD) of 2.5 m all –round the year in the River Yamuna for development of Inland Water Transport. Considering above the vessel sizes is given below:

Table 9.1 Vessel Size

Category	DWT (t)	Length (L) (m)	Beam (B) (m)	Draft (D) (m)
Vessel I	1000	70	12	1.8
Vessel II	1300	110	12	1.5

9.2.8 Dimensions of waterway principally include the width and depth. Dimensioning or designing of waterway is of critical importance for safety and efficiency of barge operations in the waterway. The design parameters are depth, breadth and alignment. Cross sections of waterway may be expected to satisfy following requirements

- The waterway must be deep enough to prevent vessels from running a ground or being difficult to steer
- The waterway must be sufficiently wide to enable the standard traffic flow to pass safely and speedily
- Vessels must be able to reach a reasonable speed to keep down the cost of transport
- The cross current must not be too large and therefore uneconomical

In the present context, the vessels and their dimensions as given in Table 9.1 above are taken for functional planning/designing of waterway. The waterway is planned to follow an alignment along the deepest portion waterway, as it is ideal for the particular waterway. The alignment is based on the hydrographic survey analysis and historic changes to river courses (based on satellite imageries of two seasons for the past 10 years). The alignment is shown below:

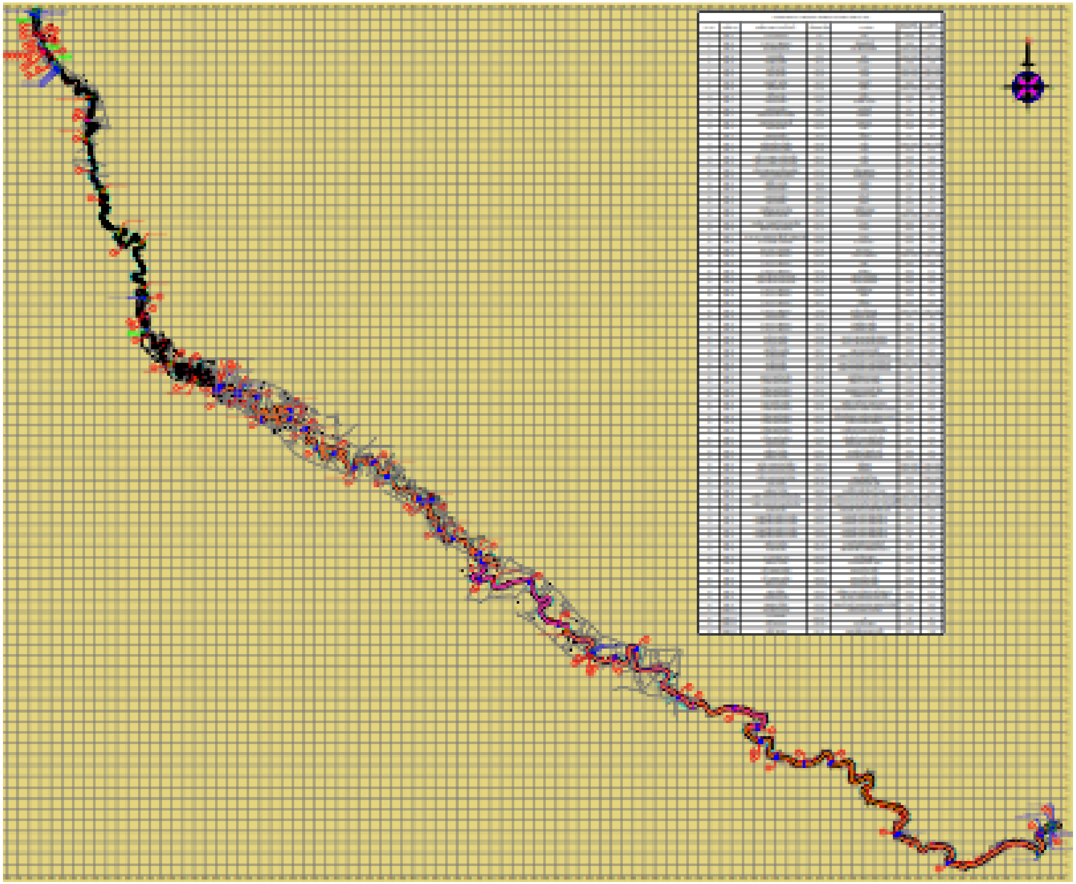


Fig. 9.1 Waterway Channel Alignment Master Plan

The waterway width for range of vessels would be as follows:

Table 9.2 Waterway Width

Category	DWT (t)	Length (L) (m)	Beam (B) (m)	Draft (D) (m)	Waterway Width (W) (m)
Vessel I	1000	70	12	1.8	60
Vessel II	1300	110	12	1.5	60

A vessel occupies a greater width on bend than on straight waterway consequently on bends a width allowance as square of length of vessel divided by bend radius has to be added.

The difference between water depth and the maximum permissible drafting any channel is termed the Under Keel Clearance (UKC). In the instant case vessel draft with 10% UKC for range of vessels would be as follows

Table 9.3 Waterway Depth

Category	DWT (t)	Length (L) (m)	Beam (B) (m)	Draft (D) (m)	UKC (10% of Draft)	Waterway Depth (d) (m)
Vessel I	1000	70	12	1.8	0.18	1.98 ~ 2.00
Vessel II	1300	110	12	1.5	0.15	1.65

The cross sectional area ratio for range of vessels would be as follows

Table 9.4 Sectional Area Ratio of waterway

Category	DWT (t)	Length (L) (m)	Beam (B) (m)	Draft (D) (m)	Cross section waterway (m^2)	Cross section vessel (m^2)	n
Vessel I	1000	70	12	1.8	140.00	21.6	6.48
Vessel II	1300	110	12	1.5	112.60	18.0	6.26

It is important to note a limitation on vessel length that the vessel's length on waterline (LWL) should be somewhat less than the width of the channel. If the length is kept the same or more than width of channel it would become virtually impossible for a vessel to be turned around even in an emergency. This, in a long/narrow waterway would be an unacceptable condition for obvious reason, unless special turning areas are dredged at relatively short intervals.

In the present case, in IWAI's classification of waterways for river, no classification has been given for 2.5m minimum depth of water. Class IV and Class V is having minimum water depth of 2.0m while Class VI is having minimum water depth of 2.75m. Considering this and following IWAI's classification of Waterways in River, the waterway dimensions for River Yamuna NW 110 are as follows

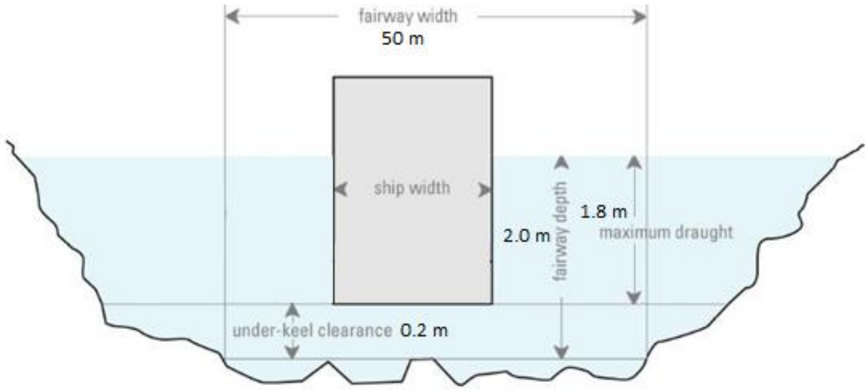


Fig. 9.2 Section of fairway channel

The cross sectional area ratio for adopted waterway would be 5.6 which are above the lowest tolerable by most standards/guidelines.

The size and/or diameter of the turning basin would depend on the geometry of water area available and berth arrangement. The diameter of the turning circle where vessels turn by free interplay of the propeller and rudder assisted by tugs should be 1.7 times the length of the design vessel to be turned, 70m, in present case. Hence, with a margin of safety, turning circle of diameter 120m is proposed at terminal sites.

Depth of Navigation Channel

With the above discussions, it is planned to maintain depth of 2.5m all along the stretch from Prayagraj to Delhi but to optimize the cost and minimize the environmental damage, it is planned to maintain depth of 2.0 m from Prayagraj to River Chambal mouth and1.7 m from River Chambal mouth to Delhi at present

Width of Navigation Channel

It is planned to provide two-way cargo movements in the navigation channel and maintaining the width of channel between 60-120 m. However, at present it is planned to maintain the channel width of 50 m and side slopes of 1:5 from section Prayagraj to Delhi as per class-IV.

Size of the Vessel/Ships

As per IWAI planning, vessels of maximum length 110 m, beam 11.4 m, draught 2.5 m - 2.8m and air draught to 9m will ply in NW-1 waterway and the same vessels will travel to NW 110. However, the vessel size will vary in different stretched as per the available LAD and type and quantity of cargo to be transported. Vessels of size 1000-2000 DWT are expected to ply in the waterway.

9.3 Specification of Barges/Vessels

9.3.1 General Specification

The general specifications of barges are as follows;

- The Vessel shall be built to operate in Yamuna River, and with 1000 DWT cargo carrying capacity per Barge.
- The Vessel to be designed for carrying Bulk, Break bulk, Containers & Vehicles up to 1000 DWT
- Design to Carry Bulk Cargos as well as Containers and to be Strengthened Aft for Pushing.
- Vessel built according to Rules and Regulations for the Construction and Classification of Inland Waterways Ships by the Indian Register of Shipping, or to corresponding regulations of internationally approved classification society.

9.3.2 Main Particulars

Length overall	-	70.0 m
Breadth Moulded	-	12.0 m
Loaded Draft	-	1.8 m

9.3.3 Dead Weight

Cargo - 1000 t

9.3.4 Performance

The ships, with freshly painted hull, at a mean draft in smooth deep waters, also have a speed of 5.00 Knots.

9.3.5 Materials

- All steel plates & sections used for construction of the vessel's hull shall be of shipbuilding quality i.e. Grade A. Class approved type.
- All wood used in the vessel is to be well-seasoned (dry), free from sap shakes warps and other defects and is to be reasonably free from knots.
- All smith work or fabricated fittings to be of neat design, strong, smooth and free from defects and to be galvanized where required by the specifications.
- All castings to be of good quality close grained and free from cracks, blow holes and other defects, to be manufactured to the Classification requirements.
- All electrical cables, fastenings, shackles, rigging and light fittings shall be of reputed make of good quality and of Classification/approved type where required.

- All machinery foundation bolts of high tensile steel & all other fasteners to be of mild steel galvanized, all fasteners to be of metric standards.

9.3.6 Workmanship

Workmanship is to be of good quality and in every respect and in accordance with best shipbuilding practice.

Following table describes specification of vessels as per classification of waterways.

Table 9.5 Proposed Vessel Design based on Market Standards

Class	Size (m)		Loaded Draft (m)	Capacity (DWT)	Consumption Ltr/Hr.	Speed (Knots)
	Length	Breadth				
I	32	5	1.0	100	50	6-7
II	45	8	1.2	300	90	6-7
III	58	9	1.5	500	110	6-7
IV	70	12	1.8	1,000	122	6-7
V	70	12	1.8	1,000	122	6-7
VI	86	14	2.5	2,000	177	6-7
VII	86	14	2.9	4,000	250	6-7

Second category consists of IWAI's specially designed vessels customized to Indian Rivers. IWAI had commissioned a European Consultant for designing cost effective vessels to be deployed in inland waterways of India. Following table describes the principal particulars of all the vessels designed by IWAI.

Table 9.6 IWAI designed Vessels Specifications

Type of Vessel	L (m)	B (m)	Depth (m)	Draught (m)	Power (Kw)	DWT
Bulk Carrier B1	110	12.0	3.7	2.8	1,000	2,500
Bulk Carrier B2	110	12.0	4.3	2.8	1,000	2,500
Bulk Carrier B3	92	12.0	3.7	2.8	1,000	2,100
Car Carrier	90	14.5	3.1	1.8	1,000	840
Container CO2	110	12.0	4.3	2.6	1,000	2,100
Container CO1	110	12.0	3.7	2.5	1,000	2,100
Dumb Barge	42	8.0	2.8	2.5	1,000	580
Ro-Ro	70	15.0	2.8	1.7	1,000	750
Liquid Bulk T1	110	12.0	3.7	2.8	1,000	2,400
Liquid Bulk T2	110	12.0	3.7	2.8	1,000	2,400

Source: IWAI

These designed vessels do not fit in any existing vessel class defined by IWAI. Detailed Specification of Passenger boat is mentioned in below:

Table 9.7 Specification of Indicative Passenger ferry

Passenger Ferry	Class I	Class II	Class III	Class IV	Class V	Class VI	Class VII
	Damen Ferry 1806	Fast Ferry	Dalmau Eco Slim	VST 10	NB 33 Catamaran	NB43 Double Ended	BLT 2003
Length (m)	18	14	24	36.4	39	41.2	43
Beam (m)	5.6	3.2	10.5	11.3	11.6	10	8.9
Draft (m)	1.8	1.2	1.5	1.7	1.7	1.9	2.8
Passenger Capacity (PAX)	130	45	150	330	426	700	500
Speed (Km/h)	8.5	25.0	12.0	45.0	18.0	13.0	17.0

9.4 Preliminary Engineering of Barrages

For maintaining 2.5 meter water depth in the channel from Delhi to Allahabad 20 nos. of barrages have been proposed. Typical preliminary engineering design of the barrages at chainage 751kmand chainage371is given below:

BARRAGE ON RIVER YAMUNA AT CHAINAGE 751km

Parameters Adopted

Maximum design discharge = 11000 cumec

(50 year return period discharge is 3435 cumec. The design discharge for Taj Barrage is taken as 11000 cumec by Irrigation Department U.P. in their "Taj Barrage Project" submitted to Govt. Accordingly we have also considered the same design discharge being near to the proposed barrage.)

H.F.L = 153.60 m

(Adopted from Gauge discharge curve plotted from Agra (PG) gauge discharge site)

Pond level = 152.20 m
Bed level of river = 145.70 m
Width of River = 340.00 m

Salient Features

Waterway between two abutments = 329 m
Divide wall = 1 No. of 3.0 m thick
Top of Bund = 153.6+ 1.8 = 155.4 m
Bridge = 7.50 m clear road width (As per M.O.T)
Navigation Lock chamber width = 2 No. 18 m each

Under Sluices		Weir	
No. of span	= 3 nos.	No. of span	= 10 nos.
Width of span	= 20m	Width of span	= 20m
Thickness of divide wall	= 3.0m	Thickness of pier	= 2 m
Thickness of Abutment	= 2 m at top & 3.5 m at base	Thickness of Abutment	= 2 m at top & 3.5 m at base

Pond level = EL 152.2
Bed level = EL 145.7 m
Lacey's waterway = 4.83 $\sqrt{11000}$
= 506 m as per BIS 6966 – 1989 Part I

Provide 10 nos. weir bays of 20 m each + 3 nos. under sluices of 20 m each + 2 nos. locks of 18 m each.
Pier thickness = 2 m
1 nos. divide wall thickness = 3 m

Total Waterway
(Between two abutments) =10 x 20 + 3 x 20 + (2x18+2.5x2+3) + 9 x 2+ 2 x 2+3
=200 + 60 + 44 + 18 + 4+3 = 329 m

Looseness factor = 329/506
= 0.65 O.K.
Weir bays = 10 nos. of 20 m each
Under Sluices bays = 3 nos. of 20 m each

Q1 = Discharge through Weir Portion

It will act as sharp crested weir hence the value of C = 1.84

Q1 = $1.84 (L – 0.1nH) H^{3/2}$

Where n = end correction

H = Upstream TEL-Crest Level
= 154.86-146.7
= 8.16m

L = 10*20 = 200m

Q1 = $1.84(200-0.1*2*10*8.16)*8.16^{3/2}$
= 7882cumecs

Q2 = Discharge passing through under sluices bays

Crest has been kept at bed = 145.7 m

H	=	154.86 – 145.7 = 9.16 m
Where C	=	1.70 for broad crested weir
L	=	3*20 = 60m
Q2	=	1.7 (L – 0.1 nH) $H^{3/2}$
	=	1.7 (60 – 0.1*2*3*9.16)*$9.16^{3/2}$
	=	2570cumecs
Q3	**=**	**Discharge passing through lock**
	=	1.7 (2*18*$9.16^{3/2}$)
	=	1697 cumec

Total Discharge passing through barrage	=	Q1 + Q2 + Q3
	=	7882+2570+1697
	=	12149cumec

Hence O.K.

<u>Section through Sharp Crested Weir</u>

CISTERN

U/S HFL	=	153.6m
U/S TEL	=	153.6+1+.0.26
	=	154.86m
D/S HFL	=	153.6 – 1 = 152.6m
D/S TEL	=	152.6+1+.26
	=	153.86m
Q	=	7882cumecs through weir bays
Head over the crest (H)	=	U/S TEL – Crest Level
	=	154.86 – 146.7 = 9.16
	=	8.16m
Crest length	=	2.59 H including Curves
	=	2.59 x 8.16
	=	21.1 m Provided 25 m
B_t(Clear Waterway in Weir Portion)	=	200 m

$q = \frac{Q}{B_t} = \frac{7882}{200}$ = 39.4cumecs/width

Assume retrogression on d/s	=	1 m
Diff. in water level between u/s & d/s	=	1 m
From Blanch curve between q and HL		
q	=	39.4
H_L	=	1 m

$\therefore Ef_2$ = 9.1 d1 = 4.0

Cistern level required (i) = d/s water level – Ef_2
= 152.6 – 9.1
= 143.5
(ii) = 1 m below the d/s bed
(Where bed = 145.7)
= 145.7 – 1 = 144.7 m

By comparing (i) and (ii)
The cistern level has been kept at EL 143.5 m

Ef_1 = Ef_2 + H_L
= 9.1 + 1 = 10.1
From Blench curve

Value of depth d2 w.r.t q = 39.4 and Ef_1 = 10.1
d2 = 9.0
Cistern length = 5 (d2 – d1)
= 5 (9.0 – 4.0)
= 25 m
Provided 35m

Curtain Walls

Q = 11000 Cumec

River Width B = 340 m

q = Q/B = 11000/340

= 32.35 cumec/m

Scour depth = R = $1.35(q^2/f)^{1/3}$, Where f = silt factor

f = $1.76\sqrt{M_r}$

M_r Grain size of particle in mm (d_{50}) = 0.24 mm

(From Grain Size Analysis)

= $1.76\sqrt{.24}$

= 0.86

R = $1.35\,(q^2/f)^{1/3}$
= $1.35\,(32.35^2/0.86)^{1/3}$
= 14.5 Say 15.0m

As per BIS Codes 6966 – 1989 Part I

Depth of u/s curtain wall	=	1.0 R
	=	15.0 m
Depth of d/s curtain wall	=	1.25 R
	=	1.25x15.0
	=	18.75 m
Below level of u/s C/wall	=	HFL – 1.0 R
	=	153.6 – 15.0
	=	138.6
Below bed	=	145.7 – 138.6
	=	7.1 m below bed
		Provided 8 m below bed
Bottom level of d/s C/wall	=	HFL – 1.25 R
	=	152.6 – 18.75 = 133.85
Below d/s bed	=	144.7-133.85
	=	10.85 m
	=	Provided 12.0 m

Check at Exit

H = u/s ponded level – d/s retrogressed level
152.2 – 144.7 = 7.5m

D/s curtain wall depth = 12.0 m

d_{eff} = 12.0 – 2.0 = 10.0 m

$$G_E = \frac{H}{\pi \, x \sqrt{\lambda} x d_{eff}}$$

Where,

α = b/d
= 100/12.0
= 8.3

Where b = Length between u/s and d/s c/walls = 100 m

λ = (1 + 8.3)/2
= 9.3/2
= 4.65

$\sqrt{\lambda}$ = 2.1

$$G_E = \frac{7.5}{\pi \, x \, 2.1 \, x \, 10.0}$$

= 0.11 <1/6for such soils
< 0.167, hence safe O.K.

Calculation of Uplift Pressure

U/s Pile No. 1

b	=	100
d	=	8
1/α	=	d/b
		0.08
ϕ_D	=	17.6
ϕ_E	=	25.1
ϕ_{C1}	=	100-ϕ_E
		74.9
ϕ_{D1}	=	100-ϕ_D
		82.4

D/s Pile No. 2

b	=	100
d	=	12
1/α	=	d/b
		0.12
ϕ_D	=	21.2
ϕ_E	=	30.6
ϕ_{C2}	=	0
$\phi_{E2} = \phi_E$	=	30.6
$\phi_{D2} = \phi_D$	=	21.2

Let us correct these pressures

ϕ_{C1}	=	74.9
ϕ_{E2}	=	30.6

Correction to ϕ_{C1}

(i) Effect of sheet pile no. (2) on pile No. (1) of depth d

Correction = 19*√(D/b')*(d+D)/b

d	=	6
D	=	10
b'	=	98
b	=	100

Correction = 0.97

(ii) Correction for depth of floor = 3

Corrected ϕ_{C1} = 78.87

Correction to ϕ_{E2}

(i) Effect of sheet pile no. (1) on pile No. (2) of depth d

Correction = 19*√(D/b')*(d+D)/b

d = 10

D = 6

b' = 98

b = 100

Correction = 0.75

(ii) Correction for depth of floor = 1.88

Corrected ϕ_{E2} = 27.97

Table 9.8 Hydraulic Gradient Line profile calculation

Condition of flow	U/S WL	D/S WL	Head (m)	U/S Curtain Wall			D/S Curtain Wall		
				ϕ_{E1}	ϕ_{D1}	ϕ_{C1}	ϕ_{E2}	ϕ_{D2}	ϕ_{C2}
				100	82.4	78.87	27.97	21.2	0
No Flow, Maximum Static Head	152.20	143.5	8.7	8.7	7.2	5.65	1.58	0.34	0
		Dry Condition		152.20	150.7	149.15	145.08	143.84	143.50

U/s HGL = 149.15

D/s HGL = 145.10

Difference in HGL in a length of 100m 149.15-145.10 = 4.05m

Slope per meter = 4.05/100 = .04

Table 9.9 Calculation of Floor Thickness

S. No.	Distance from d/s end of c/wall	Rise in HGL @ 0.04 per m	HGL at point = d/s HGL+ Col.(3)	Floor Level	Pressure head Col.(4)-Col.(5)	Floor Thickness Col.(6)/ 1.31	Floor Thickness to be provided including wearing coat of 75mm
Col. (1)	Col. (2)	Col. (3)	Col. (4)	Col. (5)	Col. (6)	Col. (7)	Col. (8)
1.	5	0.20	144.88	144	0.88	0.67	2.0
2.	15	0.61	145.29	144	1.29	0.99	2.0
3.	20	0.81	145.49	143	2.49	1.90	3.0
4.	30	1.22	145.90	143	2.90	2.22	3.5
5.	40	1.63	146.31	143	3.31	2.53	3.5
6.	55	2.24	146.92	143	3.92	2.99	4.0
7.	60	2.44	147.12	145.7	1.42	1.09	2.5

S. No.	Distance from d/s end of c/wall	Rise in HGL @ 0.04 per m	HGL at point = d/s HGL+ Col.(3)	Floor Level	Pressure head Col.(4)- Col.(5)	Floor Thickness Col.(6)/ 1.31	Floor Thickness to be provided including wearing coat of 75mm
8.	70	2.85	147.53	145.7	1.83	1.40	2.5
9.	80	3.26	147.94	145.7	2.24	1.71	3.0
10.	100	4.07	148.75	145.7	3.05	2.33	3.5

SECTION THROUGH UNDER SLUICES BAYS

Head over the crest = U/S TEL – Crest Level

= 154.86 – 145.7 = 9.16

H = 9.16m

As length of crest is sufficient as such it will act as broad crested weir.

Crest length = 2.59 H including Curves

= 2.59 x 9.16

= 23.72 m

Provided 25 m

Q = through under sluices bays

= 2570cumecs

B_t = 60 m (Clear Waterway for under sluices)

$q = \frac{2570}{60}$ = 42.8cumecs/m width

Due to retrogression diff. in water level between u/s & d/s = 1 m

From Blench curve between q and H_L

Where

q = 42.8

H_L = 1 m

$\therefore Ef_2$ = 9.3 d_1 = 4.2m

Cistern level required = d/s water level - Ef_2

(i) = 152.6 – 9.3

= 143.3

(ii) =1 m below the d/s bed (where bed = EL145.7)

= EL 144.7

By comparing (i) and (ii)

The cistern level has been kept at EL 143.0 m

$Ef_1 = Ef_2 + H_L$

$= 9.3 + 1 = 10.3$

From Blench curve w.r.t. q = 42.8 and Ef_1 = 10.3

	d_2	=	9.0 m
Cistern length		=	$5 (d_2 - d_1)$
		=	5 (9.0 – 4.2)
		=	24 m
Kept the cistern length		=	35 m

Curtain Walls

R	=	already calculated under weir bays
	=	15.0

As per BIS Codes 6966 – 1989 Part I

Depth of u/s curtain wall	=	1.0 R = 15.0 m
Depth of d/s curtain wall	=	1.25 R = 1.25x15.0= 18.75 m
Below level of u/s C/wall	=	HFL – 1.0 R
	=	153.6 – 15.0
	=	138.6
Below bed	=	145.7 – 138.6
	=	7.1 m below bed
		Provided 8 m below bed
Bottom level of d/s C/wall	=	HFL – 1.25 R
	=	152.6 – 18.75 = 133.85
Below d/s bed	=	144.7-133.85
	=	10.85 m Provided 12.0 m

Check at Exit

H = u/s ponded level – d/s retrogressed level

152.2 – 144.7 = 7.5m

D/s curtain wall depth = 12.0 m

d_{eff} = 12.0 – 2.0 = 10.0 m

G_E = $\frac{H}{\pi\ x \sqrt{\lambda} x d_{eff}}$

Where,

α = b/d

= 100/12.0

= 8.3

where b = Length between u/s and d/s c/walls = 100 m

λ = (1 + 8.3)/2

= 9.3/2

= 4.65

$\sqrt{\lambda}$ = 2.1

G_E = $\frac{7.5}{\pi\ x\ 2.1\ x\ 10.0}$

= 0.11 <1/6for such soil

< 0.167, Hence safe O.K.

Calculation of Uplift Pressure

U/s Pile No. 1

b	=	100
d	=	8
1/α	=	d/b
		0.08
ϕ_D	=	17.6
ϕ_E	=	25.1
ϕ_{E1}	=	100
ϕ_{C1}	=	100-ϕ_E
		74.9
ϕ_{D1}	=	100-ϕ_D
		82.4

D/s Pile No. 2

b	=	100
d	=	12
1/α	=	d/b
		0.12
ϕ_D	=	21.2
ϕ_E	=	30.6
ϕ_{C2}	=	0
$\phi_{E2} = \phi_E$	=	30.6
$\phi_{D2} = \phi_D$	=	21.2

Let us correct these pressures

ϕ_{C1} = 74.9

ϕ_{E2} = 30.6

Correction to ϕ_{C1}

(i) Effect of sheet pile no. (2) on pile No. (1) of depth d

Correction = 19*√(D/b')*(d+D)/b

d = 6

D = 10

b' = 98

b = 100

Correction = 0.97

(ii) Correction for depth of floor = 3

Corrected ϕ_{C1} = 78.87

Correction to ϕ_{E2}

(i) Effect of sheet pile no. (1) on pile No. (2) of depth d

Correction = 19*√(D/b')*(d+D)/b

d = 10

D = 6

b' = 98

b = 100

Correction = 0.75

(ii) Correction for depth of floor = 1.88

Corrected ϕ_{E2} = 27.97

Table.9.10 Hydraulic Gradient Line profile calculation

Condition of flow	U/S WL	D/S WL	Head(m)	U/S Curtain Wall			D/S Curtain Wall		
				ϕ_{E1}	ϕ_{D1}	ϕ_{C1}	ϕ_{E2}	ϕ_{D2}	ϕ_{C2}
				100	82.4	78.87	27.97	21.2	0
No Flow, Maximum Static Head	152.20	143	9.20	9.2	7.6	5.98	1.67	0.35	0
				152.2	150.6	148.98	144.67	143.35	143.0

U/s HGL = 148.98
D/s HGL = 144.67

Difference in HGL in a length of 100m 148.98-144.67 = 4.31m

Slope per meter = 4.31/100 = .04

Table 9.11 Calculation of Floor Thickness

S. No.	Distance from d/s end of c/wall	Rise in HGL @ 0.04per m	HGL at point = d/s HGL+ Col.(3)	Floor Level (m)	Pressure head Col.(4)-Col.(5)	Floor Thickness Col.(6)/ 1.31	Floor Thickness to be provided including wearing coat of 75mm
Col. (1)	Col. (2)	Col. (3)	Col. (4)	Col. (5)	Col. (6)	Col. (7)	Col. (8)
1.	5	0.22	144.90	144.00	0.90	0.68	2.0
2.	15	0.65	145.33	144.00	1.33	1.01	2.0
3.	20	0.86	145.54	143.00	2.54	1.94	3.0
4.	30	1.29	145.97	143.00	2.97	2.27	3.5
5.	40	1.72	146.40	143.00	3.40	2.60	3.5
6.	55	2.37	147.05	143.00	4.05	3.09	4.0
7.	60	2.58	147.26	145.70	1.56	1.19	2.5
8.	70	3.01	147.69	145.70	1.99	1.52	2.5
9.	80	3.45	148.13	145.70	2.43	1.85	3.0
10.	100	4.31	148.99	145.70	3.29	2.51	3.5

Salient Features

Under sluice Bays

3 nos. gates size = 20m x 6.8 m
Crest level = at El 145.7
Gate height = 6.8 m above crest
Cistern level = El 143.0
Floor length between two C/walls = 100 m

Weir Bays

10 nos. gates size = 20m x 5.8 m
Crest level = at El 146.7
Gate height = 5.8 m above crest
Cistern level = El 143.5
Floor length between two C/walls = 100 m

C/walls (Under sluice Bays)

U/s C/wall = 8 m below bed
D/s C/wall = 12m below bed

C/walls (Weir Bays)

U/s C/wall = 8 m below bed
D/s C/wall = 12 m below bed

U/S & D/S Protection Works beyond C/walls

Upstream Protection works

(i) Upstream Protection works

Normal Scour depth R = 15.0m

D = 1.5R-y
= 1.5*15.0-(153.6-145.7)
= 14.6m

Provide a launching apron of thickness 1.5m in a length = (2.25*14.6)/1.5
= 21.9 say 22m

(ii) Downstream Protection works

Normal Scour depth R = 15.0m
D = 2.0R-y
= 2*15.0-(152.6-145.7)
= 23.1m

Provide a launching apron of thickness 1.5m in a length 1.5D
= 1.5*23.1
= 34.65 say 35m

Beyond u/s c/walls, cement concrete blocks of 1600 x 1600 x 1000 mm are provided. A toe wall of 1 m deep provided and thereafter stone protection are being provided. Beyond d/s c/wall friction blocks of size 1600 x 1600x1000 mm are provided and 30 cm thick inverted filter is being provided. Between friction blocks, jharris comprising of bajri of 100 mm thick provided to release any upward pressure. Thereafter loose stones have been provided in length of 15m by keeping the thickness as 1.5m.

Design of Guide Bund for Barrage

Guide bunds are provided on both sides of the barrage to protect against flood and then joined with the existing banks of the rivers.

HFL at this work site = 153.6
Free Board = 1.8 m
Top Level of Guide bund = 153.6 + 1.8 = 155.4
Height of bund = Top of bund – bed of river
= 155.4 – 145.7
= 9.7m

Length of guide bund (As per BIS Code)

Waterway at barrage site = 329 m (L)

Length of u/s guide bund = 1.25 L
= 1.25 x329
= 411.25 m
Provided 415m

Length of d/s guide bund = 0.25 L
= 0.25 x 329
= 82.25 m Provided 90 m

Radius of curved head (u/s portion)
= 0.45 L
= 0.45 x 329
= 148.05 m

The curved portion be kept between 120^o to 145^{o}Say 130^o with a radius of 148 m

<u>Section of Bund</u>

Keep top width of Bund = 6 m
Side slopes = 2:1

Thickness of pitching T = 0.06 $(Q)^{1/3}$
= 0.06 $(11000)^{1/3}$
= 0.06 x 22.24
= 1.33 m Say 1.5 m

Thickness of Apron = 1.9 T
= 1.9 x 1.5 = 2.85 Say 3.0 m

Where Y = Depth of water above river bed
= 153.6 – 145.7
= 7.9 m

R = 15.0 m

D = 1.25 R-Y
= 1.25 x 15.0– 7.9
= 10.85m

Length of Apron = 1.5 D
= 1.5 x 10.85
= 16.275 m Say 18 m

<u>For Curvilinear Transition Portion of Guide Bund</u>

D = 1.5 R-Y
= 1.5 x 15.0 – 7.9
= 14.6 m

Hence length of Apron in curved portion = 1.5 D
= 1.5 x 14.6
= 21.9 m Say 24 m

Pitching is provided on water side and grass turfing may be provided on other side of guide bund. The length of apron at noses shall be increased 1.5 D

Where D	=	2.24 R-Y
	=	2.24 x 15.0 – 7.9
	=	25.7
Length of apron at noses	=	1.5 x 25.7 = 38.55
		Provided 40 m

Note: The d/s cistern shall always remain full and such no necessity to check under running conditions

Bridge

A bridge of 7.50 m clear road width has been provided over the barrage with regulation platform of width 1.2 m.

Slab thickness of 1.6 m thick and reinforcement has been provided as per MoRTH.

Invert level of bridge	=	152.2+8.0m clearance for class-IV
	=	160.2m

Road Level	=	160.2 + 1.6+.075 m
	=	161.87 m

Approach road of 180m on both sides is provided to connect the ground level at EL 156.0m with road level. Ramps are provided on both sides of bridge to join with the guide bunds at EL 155.00. Detailed Typical barrage drawings are shown in Volume 2 Drawings (Drawing No. 3).

BARRAGE ON RIVER YAMUNA AT CHAINAGE 371km

PARAMETERS ADOPTED

Maximum design discharge	=	36000cumecs (As per Kalpi CWC Site)
H.F.L	=	El 109.5
Bed level of river	=	El 94.0
Pond level	=	El 100.0
Width of River	=	620m

SALIENT FEATURES

Waterway between two abatement	=	571 m
Divide wall	=	1 no. of 3.0 m thick
Top of Bund	=	109.5 + 1.50 = 111.0 m

Bridge = 7.5 m clear road width
Navigation Lock = 18 m each

Under Sluices		**Weir**	
No. of span	= 6 nos.	No. of span	= 18 nos.
Width of span	= 20m	Width of span	= 20m
Thickness of divide wall	= 3.0m	Thickness of pier	= 2 m
Thickness of Abutment	= 2 m at top & 3.5 m at base	Thickness of Abutment	= 2 m at top & 3.5 m at base

Design of Barrage at chainage371 km of River Yamuna

Discharge = 36000cumecs
HFL = 109.5 m
Q = 36000 cumec
Bed level = EL 94.0 m
Pond level = River bed + 6.0= 94.0 + 6.0 = EL 100.0

Lacey's waterway = 4.83 √36000
= 916 m as per BIS 6966 – 1989 Part I

Provide 18 nos. weir bays of 20 m each + 6 nos. under sluices of 20 m each + 2 nos. lock bays of 18 m

Pier width = 2 m
1 nos. divide wall = 3 m
Total Waterway
(Between two abutments) = 6 x 20 + 18 x 20 + (2x18+2.5x2+3) + 5 x 2+ 17 x 2+3
= 120 + 360 + 44 + 10 + 34+3 = 571m

Looseness factor provided = 571/916
= 0.62

Provided Weir bays = 18 nos. of 20 m each
Under Sluices bays = 6 nos. of 20 m each
Where C = 1.84

Q_1 = Discharge through Weir Portion

It will act as sharp crested weir as head over the crest is 1.5 times of width of weir. Width of the crest has been kept as 2.0m

$Q_1 = 1.84 (L – 0.1nH) H^{3/2}$

Where n	=	end correction
H	=	Upstream TEL-Crest Level
	=	110.94-96.5
	=	14.44m
L	=	18*20 = 360m
Q_1	=	$1.84(200-0.1*2*18*14.44)*14.44^{3/2}$
	=	31110cumecs
Q_2	=	Discharge passing through under sluices bays

Crest has been kept at bed = 94.0 m

H	=	110.94 – 94.0 = 16.94 m
Where C	=	1.70 for broad crested weir
L	=	6*20 = 120m
Q_2	=	$1.7\ (L - 0.1\ nH)\ H^{3/2}$
	=	$1.7\ (120 - 0.1*2*6*16.94)*16.94^{3/2}$
	=	11817cumecs
Q_3	=	Discharge passing through lock
	=	$1.7\ (2*18*16.94^{3/2})$
	=	4268 cumec
Total Discharge passing through barrage	=	Q1 + Q2 + Q3
	=	31110+11817+4268
	=	47195cumecs

<u>SECTION THROUGH SHARP CRESTED WEIR</u>

CISTERN

U/S HFL	=	109.5m
U/S TEL	=	109.5+1+.0.44
	=	110.94m
D/S HFL	=	109.5 – 1 = 108.5m
D/S TEL	=	108.5+1+.44
	=	109.44m
Q	=	31110cumecs through weir bays
B_t(Clear Waterway in Weir Portion)	=	360 m

q = $\frac{Q}{B_t} = \frac{31110}{360}$ = 86.4cumecs/width

Assume retrogression on d/s = 1 m

Diff. in water level between u/s & d/s = 1 m

From Blanch curve between q and HL

q = 86.4
HL = 1 m
$\therefore Ef_2$ = 11 d1 = 6.0

Cistern floor level required (i) = d/s water level – Ef_2
= 108.5 – 11
= 97.5
(ii) = 1 m below the d/s bed (where bed = 94.0)
= 94.0 – 1 = 93.0 m

By comparing (i) and (ii)

The cistern level has been kept at EL 93.0

$Ef_1 = Ef_2 + H_L$
= 11 + 1 = 12

From Blench curve

Value of depth d2 w.r.t q = 86.4 and Ef_1 = 12
d2 = 9.5

Cistern length = 5 (d2 – d1)
= 5 (9.5 – 6.0)
= 17.5 m
Provided 25m

Curtain Walls

Q = 36000 Cumec

River Width B = 620 m

q = Q/B = 36000/620

= 58.06 cumec/m

Scour depth = R = $1.35(q^2/f)^{1/3}$, Where f = silt factor f = $1.76\sqrt{M_r}$

M_r Grain size of particle in mm = .32 mm (From Soil sample analysis) = $1.76\sqrt{.32}$ = 1.00

R = $1.35\,(q^2/f)^{1/3}$

= $1.35\,(58.06^2/1.0)^{1/3}$ = 14.99

Say 15.0m

As per BIS Codes 6966 – 1989 Part I

Depth of u/s curtain wall = 1.0 R

= 15.0 m

Depth of d/s curtain wall = 1.25 R

= 1.25x15.0

= 18.75 m

Below level of u/s C/wall = HFL – 1.0 R

= 109.5 – 15.0

= 94.5

Scour level in u/s is above RBL hence curtain wall will be provided D/3+1 below bed level. Where D = upstream depth = 15.5m

Provided 6.5 m below bed

Bottom level of d/s C/wall = HFL – 1.25 R

= 109.5 – 18.75 = 90.75

Below d/s bed = 94.0-90.75

= 3.25 m

Provided 8 m

Check at Exit

H = u/s ponded level – d/s retrogressed level

100.0 – 93.0 = 7.0m

D/s curtain wall depth = 8.0m

d_{eff} = 8.0 – 2.0 = 6.0 m

$$G_E = \frac{H}{\pi \, x \sqrt{\lambda} x d_{eff}}$$

Where,

α	=	b/d
	=	105/6
	=	17.5
Where b =		Length between u/s and d/s c/walls = 70 m
λ	=	(1 + 17.5)/2
	=	9.25
$\sqrt{\lambda}$	=	3.04
G_E	=	$\frac{7}{\pi\ x\ 2.51\ x\ 6}$
	=	0.122 <1/6for such soil

< 0.167, hence safe O.K.

Calculation of Uplift Pressure

U/s Pile No. 1

b	=	105
d	=	4.5
1/α	=	d/b
		0.043
ϕ_D	=	15.8
ϕ_E	=	22.5
ϕ_{C1}	=	100-ϕ_E
		77.5
ϕ_{D1}	=	100-ϕ_D
		84.2

D/s Pile No. 2

b	=	70
d	=	6
1/α	=	d/b
		0.086
ϕ_D	=	18.1
ϕ_E	=	26
ϕ_{C2}	=	0
ϕ_{E2} =ϕ_E	=	26
ϕ_{D2}=ϕ_D	=	18.1

Let us correct these pressures

ϕ_{C1} = 77.5

ϕ_{E2} = 26

Correction to ϕ_{C1}

(i) Effect of sheet pile no. (2) on pile No. (1) of depth d

Correction = 19*√(D/b')*(d+D)/b

d = 4.5

D = 6

b' = 68

b = 70

Correction = 0.85

(ii) Correction for depth of floor = 2.68

Corrected ϕ_{C1} = 81.03

Correction to ϕ_{E2}

(i) Effect of sheet pile no. (1) on pile No. (2) of depth d

Correction = 19*√(D/b')*(d+D)/b

d = 6

D = 4.5

b' = 68

b = 70

Correction = 0.73

(ii) Correction for depth of floor = 1.58

Corrected ϕ_{E2} = 23.69

Table 9.12 Hydraulic Gradient Line profile calculation

Condition of flow	**U/S WL**	**D/S WL**	**Head**	**U/S Pile**			**D/S Pile**		
				ϕ_{E1}	ϕ_{D1}	ϕ_{C1}	ϕ_{E2}	ϕ_{D2}	ϕ_{C2}
				100	84.2	81.03	23.69	18.1	0
No Flow, Maximum Static Head	100.00	93	7	7	5.9	4.78	1.13	0.20	0
		Dry Condition		100.00	98.9	97.78	94.13	93.20	93.00

U/s HGL = 97.78

D/s HGL = 94.13

Difference in HGL in a length of 70m = 97.78-94.13 = 3.65m

Slope per meter = 3.65/105 = .04

Table 9.13 Calculation of Floor Thickness

S. No.	Distance from d/s end of c/wall	Rise in HGL @ 0.04per m	HGL at point = d/s HGL+ Col.(3)	Floor Level	Pressure head Col.(4)-Col.(5)	Floor Thickness Col.(6)/ 1.31	Floor Thickness to be provided including wearing coat of 75mm
Col. (1)	Col. (2)	Col. (3)	Col. (4)	Col. (5)	Col. (6)	Col. (7)	Col. (8)
1	5	0.18	94.18	94	0.18	0.14	2
2	10	0.36	94.36	94	0.36	0.28	2
3	15	0.55	93.55	93	0.55	0.42	2
4	20	0.73	93.73	93	0.73	0.56	2
5	30	1.09	94.09	93	1.09	0.83	2.5
6	40	1.46	94.46	93	1.46	1.11	2.5
7	47	1.71	98.21	96.5	1.71	1.31	2.5
8	52	1.90	98.40	96.5	1.90	1.45	3
9	60	2.19	98.69	96.5	2.19	1.67	3
10	75	2.73	99.23	96.5	2.73	2.09	3.5
11	90	3.28	99.78	96.5	3.28	2.50	4
12	105	3.83	97.83	94	3.83	2.92	4

SECTION THROUGH UNDER SLUICES BAYS

Head over the crest = U/S TEL – Crest Level

= 110.94 – 94.0 = 16.94

H = 16.94m

As length of crest is sufficient as such it will act as broad crested weir.

Q = through under sluices bays

= 11817 cumec

B_t = 120m(Clear Waterway for under sluices)

$q = \frac{11817}{120}$ = 98.47 cumec/m width

Due to retrogression diff. in water level between u/s & d/s = 1 m

From Blench curve between q and H_L

Where

q = 98.47

H_L		=	1 m
$\therefore Ef_2$		=	11
d_1 = 6.0m			
Cistern floor level required		=	d/s water level - Ef_2
	(i)	=	108.5 – 11
		=	97.0
	(ii)	=	1 m below the d/s bed (where bed = EL94.0)
		=	EL 93.0

By comparing (i) and (ii)

The cistern level has been kept at EL 93.0 m

Ef_1 = $Ef_2 + H_L$

= 11 + 1 = 12

From Blench curve w.r.t.	q	=	98.47 and Ef_1 = 12	
	d_2	=	9.0 m	
Cistern length		=	5 ($d_2 - d_1$)	
		=	5 (11.0 – 9.0)	
		=	10 m	
Kept the cistern length		=	25 m	

Curtain Walls

R	=	already calculated under weir bays
	=	15.0

As per BIS Codes 6966 – 1989 Part I

Depth of u/s curtain wall	=	1.0 R = 15.0 m
Depth of d/s curtain wall	=	1.25 R = 1.25x15.0= 18.75 m
Below level of u/s C/wall	=	HFL – 1.0 R
	=	110.5 – 15.0
	=	95.5

Scour level in u/s is above RBL hence curtain wall will be provided D/3+1 below bed level. Where D = upstream depth = 15.5m

Provided 6.5 m below bed

Bottom level of d/s C/wall = HFL – 1.25 R

= 110.5 – 18.75 = 91.75

Below d/s bed = 94.0-91.75

= 2.25m

Provided 8 m

Check at Exit

H = u/s ponded level – d/s retrogressed level

100.0 – 93.0 = 7.0m

D/s curtain wall depth = 8 m

d_{eff} = 8 – 2 = 6 m

$$G_E = \frac{H}{\pi \, x \sqrt{\lambda} x d_{eff}}$$

Where,

α = b/d = 70/6

= 11.67

Where b = Length between u/s and d/s c/walls = 70 m

λ = (1 + 11.67)/2

= 12.67/2

= 6.335

$\sqrt{\lambda}$ = 2.51

$$G_E = \frac{7}{\pi \, x \, 2.51 \, x \, 6}$$

= 0.147 <1/6for such soils

< 0.167, Hence safe O.K.

Calculation of Uplift Pressure

U/s Pile No. 1

b = 105

d = 4.5

1/α = d/b

		0.043
ϕ_D	=	15.8
ϕ_E	=	22.5
ϕ_{E1}	=	100
ϕ_{C1}	=	100-ϕ_E
		77.5
ϕ_{D1}	=	100-ϕ_D
		84.2

D/s Pile No. 2

b	=	70
d	=	6
1/α	=	d/b
		0.086
ϕ_D	=	18.1
ϕ_E	=	26
ϕ_{C2}	=	0
ϕ_{E2} =ϕ_E	=	26
ϕ_{D2}=ϕ_D	=	18.1

Let us correct these pressures

ϕ_{C1}	=	77.5
ϕ_{E2}	=	26

Correction to ϕ_{C1}

(i) Effect of sheet pile no. (2) on pile No. (1) of depth d

Correction = 19*√(D/b')*(d+D)/b

d	=	4.5
D	=	6
b'	=	68
b	=	70
Correction	=	0.85

(ii) Correction for depth of floor = 2.68

Corrected ϕ_{C1} = 81.03

Correction to ϕ_{E2}

(i) Effect of sheet pile no. (1) on pile No. (2) of depth d

Correction = 19*√(D/b')*(d+D)/b

d = 6
D = 4.5
b' = 68
b = 70

Correction = 0.73

(ii) Correction for depth of floor = 1.58

Corrected ϕ_{E2} = 23.69

Table 9.14 Hydraulic Gradient Line profile calculation

Condition of flow	U/S WL	D/S WL	Head	U/S Pile			D/S Pile		
				ϕ_{E1}	ϕ_{D1}	ϕ_{C1}	ϕ_{E2}	ϕ_{D2}	ϕ_{C2}
				100	84.2	81.03	23.69	18.1	0
No Flow, Maximum Static Head	100.00	93	7	7	5.9	4.78	1.13	0.20	0
		Dry Condition		100.00	98.9	97.78	94.13	93.20	93.00

U/s HGL = 97.78

D/s HGL = 94.13

Difference in HGL in a length of 70m = 97.78-94.13 = 3.65m

Slope per meter = 3.65/105 = .04

Table 9.15 Calculation of Floor Thickness

S. No.	Distance from d/s end of c/wall	Rise in HGL @ 0.04per m	HGL at point = d/s HGL+ Col.(3)	Floor Level	Pressure head Col.(4)-Col.(5)	Floor Thickness Col.(6)/1.31	Floor Thickness to be provided including wearing coat of 75mm
Col. (1)	Col. (2)	Col. (3)	Col. (4)	Col. (5)	Col. (6)	Col. (7)	Col. (8)
1.	5	0.18	94.18	94	0.18	0.14	2
2.	10	0.36	94.36	94	0.36	0.28	2
3.	15	0.55	93.55	93	0.55	0.42	2
4.	20	0.73	93.73	93	0.73	0.56	2
5.	30	1.09	94.09	93	1.09	0.83	2.5

S. No.	Distance from d/s end of c/wall	Rise in HGL @ 0.04per m	HGL at point = d/s HGL+ Col.(3)	Floor Level	Pressure head Col.(4)-Col.(5)	Floor Thickness Col.(6)/1.31	Floor Thickness to be provided including wearing coat of 75mm
6.	40	1.46	94.46	93	1.46	1.11	2.5
7.	42	1.53	95.53	94	1.53	1.17	2.5
8.	50	1.82	95.82	94	1.82	1.39	3
9.	60	2.19	96.19	94	2.19	1.67	3
10.	75	2.73	96.73	94	2.73	2.09	3.5
11.	90	3.28	97.28	94	3.28	2.50	4
12.	105	3.83	97.83	94	3.83	2.92	4

SALIENT FEATURES

Under sluice Bays

6 nos. gates size = 20m x 6.3 m

Crest level = at El 94

Gate height = 6.3 m above crest

Cistern level = El 93.0

Floor length between

two C/walls = 105 m

C/walls

U/s C/wall = 6.5 m below bed

D/s C/wall = 8.0m below bed

Weir Bays

18 nos. gates size = 20m x 3.8 m

Crest level = at El 96.5

Gate height = 3.8 m above crest

Cistern level = El 93.0

Floor length between

two C/walls = 105 m

C/walls

U/s C/wall = 6.5 m below bed

D/s C/wall = 8.0 m below bed

U/S & D/S Protection Works beyond C/walls

Upstream Protection works

(i) Upstream Protection works

Normal Scour depth R = 15.0m

D = 1.5R-y
= 1.5*15.0-(109.5-94.0)
= 7.0m

Provide a launching apron of thickness 1.5m in a length = (2.25*7.0)/1.5
= 10.5 say 12m

(ii) Downstream Protection works

Normal Scour depth R = 15.0m

D = 2.0R-y
= 2*15.0-(109.5-94.0)
= 14.5m

Provide a launching apron of thickness 1.5m in a length 1.5D
= 1.5*14.5
= 21.75 say 23m

Beyond u/s c/walls, cement concrete blocks of 1600 x 1600 x 1000 mm are provided. A toe wall of 1 m deep provided and thereafter stone protection are being provided. Beyond d/s c/wall friction blocks of size 1600 x 1600x1000 mm are provided and 30 cm thick inverted filter is being provided. Between friction blocks, jharris comprising of bajri of 100 mm thick provided to release any upward pressure. Thereafter loose stones have been provided in length of 15m by keeping the thickness as 1.5m.

DESIGN OF GUIDE BUND

Guide bunds are provided on both sides of the barrage to protect against flood and after that they are joined with the existing banks of the rivers.

HFL at this work site	=	109.5		
Free Board	=	1.50 m		
Top Level of Guide bund	=	109.5 + 1.5	=	111.00
Height of bund	=	Top of bund – bed of river		
	=	111.0 – 94.0		
	=	17.0m		

Length of guide bund (As per BIS Code)

Waterway at barrage site = 571 m (L)

Length of u/s guide bund	=	1.25 L	
	=	1.25 x571	
	=	713.75 m	
`		Provided 715 m	
Length of d/s guide bund	=	0.25 L	
	=	0.25 x 571	
	=	142.75 m	Provided 145 m

Radius of curved head (u/s portion)

	=	0.45 L
	=	0.45 x 571
	=	256.95 m

The curved portion be kept between 120^o to 145^o

Say 130^o with a radius of 257 m

Section of Bund

Keep top width of Bund	=	6 m
Side slopes	=	2:1
Thickness of pitching T	=	$0.06 (Q)^{1/3}$
	=	$0.06 (36000)^{1/3}$
	=	0.06 x 33.01
= 1.98 m		
Say	=	2.0 m
Thickness of Apron	=	1.9 T
	=	1.9 x 2.0 = 3.8m
Where Y	=	Depth of water above river bed
	=	109.5 – 94.0
	=	15.5 m
R	=	15.0 m
D	=	1.25 R-Y
	=	1.25 x 15.0– 15.5
	=	3.25m
Length of Apron	=	1.5 D
	=	1.5 x 3.25
	=	4.875 m
		Say 7 m

For Curvilinear Transition Portion of Guide Bund

D	=	1.5 R-Y
	=	1.5 x 15.0 – 15.5
	=	7.0 m
Hence length of Apron in curved portion	=	1.5 D
	=	1.5 x 7.0
	=	10.5 m

Pitching is provided on water side and grass turfing may be provided on other side of guide bund.

The length of apron at noses shall be increased 1.5 D

Where D = 2.24 R-Y
= 2.24 x 15.0 – 15.5
= 18.6
Provided 19 m

Bridge

A bridge of 7.50 m clear road width has been provided over the barrage with regulation platform of width 1.2 m
Slab thickness of 1.6 m thick and reinforcement has been provided as per MoRTH.

Invert level of bridge = 100.0+8.0m clearance for class-IV
= 108.0m
Road Level = 108.0 + 1.6+.075 m
= 109.67 m

Approach road of 100m on both sides is provided to connect the ground level with road level. Ramps are provided on both sides of bridge to join with the guide bunds at EL 111.00. Detailed typical barrage drawings are shown in Volume 2 Drawings (Drawing No. 3).

The design parameters of all the proposed barrages has been given in Annexure 9.1

9.5 Preliminary Engineering of Cross-Regulator

For maintaining 2.5 meter water depth in the navigational channel in two regulators, one each at River Betwa Mouth and River Chambal Mouth has been proposed. Preliminary engineering design of the regulator at River Betwa confluence with River Yamuna is given below:

Cross-Regulatoron River Betwa at Yamuna Confluence

PARAMETERS ADOPTED

Maximum design discharge at	=	20000 cumec (As per CWC gauge site Shahijina Site on River Betwa)
H.F.L	=	El 106.7
FSL	=	El 97.5
Bed level of river	=	El 88.5

SALIENT FEATURES

Waterway between two abatement	=	442 m
Top of Bund	=	106.5 + 1.8 = 108.3 m
Regulation Platform	=	1.2m width

Navigation Lock	=	2 nos. 18 m each

Regulator Bays

No. of span	=	20 nos.
Width of span	=	18m
Thickness of Abutment	=	2 m at top & 3.5 m at base

Design of Cross-Regulator at Betwa Confluence

Design Discharge = 20000 cumec as per CWC gauge site at Shahijina

HFL	=	106.7 m
Q	=	20000 cumec
FSL	=	EL 97.5m
Bed level	=	EL 88.5 m

Provide 20 nos. regulator bays of 18 m each + 2 nos. lock of 18 m

Pier thickness	=	2 m
Total Waterway		
(Between two abutments)	=	20x 18 + 2x 19 + (2x18+2.5x2+3)
	=	360 + 38 + 44 = 442 m

Section through Regulator Bays

Head over the crest	=	FSL – 88.5
H	=	97.5 – 88.5 = 9.0m

As length of crest is sufficient as such it will act as broad crested weir.

Crest length	=	2.59 H including curves
	=	2.59 x 9.0
	=	23.31 m
		Provided 30 m

$$q = \frac{20000}{442} = 45.25 \text{cumecs/m width}$$

Due to retrogression diff. in water level between u/s & d/s = 0.5m

From Blanch curve between q and H_L

Where

q	=	45.25			
H_L	=	0.5 m			
$\therefore Ef_2$	=	9.5	d_1	=	4.3m

Cistern level required = d/s water level - Ef_2

(i) = 96.7 – 9.5 = 87.2

(ii) =1 m below the d/s bed (where bed = EL88.5m)

= EL 87.5

By comparing (i) and (ii)

The cistern level has been kept at EL 87.0m

Ef_1 = Ef_2 + H_L

= 9.5 + 0.5 = 10.0

From Blench curve w.r.t. q = 45.25 and Ef_1 = 10.0

d_2 = 8.2 m

Cistern length = 5 (d_2 – d_1)

= 5 (8.2 – 4.3)

= 19.5 m

Kept the cistern length 25 m

<u>Curtain Walls</u>

q = 45.25cumecs/m

Scour depth = R = $1.35(q^2/f)^{1/3}$, Where f = silt factor

f = $1.76\sqrt{M_r}$

M_r Grain size of particle in mm = 0.24 mm

= $1.76\sqrt{.24}$

= 0.86

R = $1.35 (q^2/f)^{1/3}$

= $1.35 (45.25^2/0.86)^{1/3}$

= 18.02

As per BIS Codes 6966 – 1989 Part I

Depth of u/s curtain wall = 1.0 R = 18.02 m

Depth of d/s curtain wall = 1.25 R = 1.25x18.02= 22.52 m

Below level of u/s curtain wall = HFL – 1.0 R

= 106.7 – 18.02

= 88.68

As below level of u/s curtain wall is above River bed level, Provided depth of u/s and d/s curtain wall is D/3+1 and D/2+1 respectively.

Where D = water depth
= FSL – River Bed Level = 97.5-88.5= 9.0

(i) depth of u/s curtain wall = D/3+1
= 9/3 +1
= 4.0 m

Provided 5.0 m

(ii) Depth of d/s curtain wall = D/2+1
= 9/2 +1
= 5.5 m

Bottom level of d/s C/wall = HFL – 1.25 R
= 106.7 – 1.25x18.02 = 84.18

(iii) Depth of d/s curtain wall = 88.5-84.18
= 4.32 m

Provided 11.0m (Considering safety against exit gradient)

Salient Features

20 nos. gates size = 18m x 9.5 m
Crest level = at El 88.5
Gate height = 9.5 m above crest
Cistern level = El 87.0
Floor length between two C/walls = 85 m

C/walls
U/s C/wall = 5 m below bed
D/s C/wall = 11.0 m below bed

<u>Check at Exit</u>

H = u/s ponded level – d/s retrogressed level
97.5 – 88.0 = 9.5m
D/s curtain wall depth = 11.0 m
d_{eff} = 11.0 – 2.0 = 9.0m

$$G_E = \frac{H}{\pi \, x \sqrt{\lambda} x d_{eff}}$$

Where,
α = b/d
= 85/10.0
= 8.5

Where b = Length between u/s and d/s c/walls = 85 m

λ = (1 +8.5)/2

= 4.75

$\sqrt{\lambda}$ = 2.18

$$G_E = \frac{9.5}{\pi \; x \; 2.18 \; x 9.0}$$

= 0.15 $<1/6$for such soil

< 0.167, hence safe O.K.

Calculation of Uplift Pressure

U/s Pile No. 1

b	=	85
d	=	5
$1/\alpha$	=	d/b
		0.059
ϕ_D	=	16
ϕ_E	=	22
ϕ_{E1}	=	100
ϕ_{C1}	=	$100-\phi_E$
		78
ϕ_{D1}	=	$100-\phi_D$
		84

D/s Pile No. 2

b	=	85
d	=	10
$1/\alpha$	=	d/b
		0.118
ϕ_D	=	21
ϕ_E	=	31
ϕ_{C2}	=	0
$\phi_{E2} = \phi_E$	=	31
$\phi_{D2} = \phi_D$	=	21

Let us correct these pressures

ϕ_{C1}	=	78
ϕ_{E2}	=	31

Correction to ϕ_{C1}

(i) Effect of sheet pile no. (2) on pile No. (1) of depth d

Correction = 19*√(D/b')*(d+D)/b

d	=	3
D	=	8
b'	=	83
b	=	85
Correction	=	0.76

(ii) Correction for depth of floor = 2.4

Corrected ϕ_{C1} = 81.16

Correction to ϕ_{E2}

(i) Effect of sheet pile no. (1) on pile No. (2) of depth d

Correction = 19*√(D/b')*(d+D)/b

d	=	8
D	=	3
b'	=	83
b	=	85
Correction	=	0.47

(ii) Correction for depth of floor = 2

Corrected ϕ_{E2} = 28.53

Table 9.16 Hydraulic Gradient Line profile calculation

Condition of flow	**U/S WL**	**D/S WL**	**Head**	**U/S Curtain wall**			**D/S Curtain wall**		
				ϕ_{E1}	ϕ_{D1}	ϕ_{C1}	ϕ_{E2}	ϕ_{D2}	ϕ_{C2}
				100	84	81.1	28.53	21	0
No Flow, Maximum Static Head	97.5	88.5	9.00	9	7.6	6.14	1.75	0.37	0
				97.50	96.1	94.6	90.25	88.87	88.50

U/s HGL = 94.6
D/s HGL = 90.2

Difference in HGL in a length of 85m = 94.6-90.2 = 4.4m

Slope per meter = 4.4/85 = 0.052

Table 9.17 Calculation of Floor Thickness

S. No.	Distance from d/s end of c/wall	Rise in HGL @ 0.052per m	HGL at point = d/s HGL+ Col.(3)	Floor Level	Pressure head Col.(4)-Col.(5)	Floor Thickness Col.(6)/1.31	Floor Thickness to be provided including wearing coat of 75mm
Col. (1)	**Col. (2)**	**Col. (3)**	**Col. (4)**	**Col. (5)**	**Col. (6)**	**Col. (7)**	**Col. (8)**
1	5	0.26	90.51	88.5	2.01	1.53	2.5
2	12	0.624	90.87	88.5	2.37	1.81	2.5
3	17	0.884	91.13	87	4.13	3.16	4
4	25	1.3	91.55	87	4.55	3.47	4.5
5	35	1.82	92.07	87	5.07	3.87	4.5
6	42	2.184	92.43	87	5.43	4.15	5
7	45	2.34	92.59	88.5	4.09	3.12	4
8	50	2.6	92.85	88.5	4.35	3.32	4
9	70	3.64	93.89	88.5	5.39	4.12	5
10	85	4.42	94.67	88.5	6.17	4.71	5.5

U/s& d/s Protection Works beyond C/walls

Upstream Protection works

Normal Scour depth R = 18.02m

D = 1.5R-y
= 1.5*18.02-(106.7-88.5)
= 8.83m

Provide a launching apron of thickness 1.5m in a length
= (2.25*8.83)/1.5
= 13.2 say 16m

(iii) Downstream Protection works

Normal Scour depth R = 18.02

D = 2.0R-y
= 2*18.02-(106.7-88.5)
= 17.84 m

Provide a launching apron of thickness 1.5m in a length 1.5D

= 1.5*18.02

= 27.03 say 30m

Beyond u/s c/walls, cement concrete blocks of 1600 x 1600 x 1000 mm are provided. A toe wall of 1 m deep provided and thereafter stone protection are being provided. Beyond d/s c/wall friction blocks of size 1600 x 1600x1000 mm are provided and 30 cm thick inverted filter is being provided. Between friction blocks, jharris comprising of bajri of 100 mm thick provided to release any upward pressure. Thereafter loose stones have been provided in length of 15m by keeping the thickness as 1.5m.

Design of Guide Bund for Regulator

Guide bunds are provided on both sides of the regulator to protect against flood and after that they are joined with the existing banks of the rivers.

HFL at this work site	=	106.7		
Free Board	=	1.8 m		
Top Level of Guide bund	=	106.7 + 1.8	=	108.5
Height of bund	=	Top of bund – bed of river		
	=	108.5 – 88.5	=	El 20.0

Length of guide bund (As per BIS Code)

Waterway at regulator site = 442 m (L)

Length of u/s guide bund = 1.25 L

= 1.25 x442

= 552.5 m

` Provided 560 m

Length of d/s guide bund = 0.25 L

= 0.25 x 442

= 110.5 m

Provided 120m

Radius of curved head (u/s portion)

= 0.45 L

= 0.45 x 442

= 199 m

The curved portion be kept between 120^{o} to 145^{o}

Say 130^{o} with a radius of 199 m

Section of Bund

Keep top width of Bund	=	6 m
Side slopes	=	2:1
Thickness of pitching T	=	0.06 $(Q)^{1/3}$
	=	0.06 $(20000)^{1/3}$
	=	0.06 x 27.14
	=	1.63 m Say 1.7 m
Thickness of Apron	=	1.9 T
	=	1.9 x 1.7 = 3.23
	=	Say 3.25 m
Where Y	=	Depth of water above river bed
	=	106.7 – 88.5
	=	18.2 m
R	=	18.02 m
D	=	1.25 R-Y
	=	1.25 x 18.02 – 18.2
	=	4.32m
Length of Apron	=	1.5 D
	=	1.5 x 4.32
	=	6.48 m Say 10 m

For Curvilinear Transition Portion of Guide Bund

D	=	1.5 R-Y
	=	1.5 x 18.02 – 18.2
	=	8.83 m Say 10 m
Hence length of Apron in curved portion	=	1.5 D
	=	1.5 x 10
	=	15 m

Pitching is provided on water side and grass turfing may be provided on other side of guide bund.

The length of apron at noses shall be increased 1.5 D

Where D	=	2.24 R-Y	
	=	2.24 x 18.02 – 18.2	
	=	22.16	Provided 25 m

Detailed typical regulator drawings are shown in Volume 2 Drawings (Drawing No. 4).

9.6 Navigation Lock

The functional requirements of a lock are mainly intended for navigation. The most important general functional requirement is that vessels have to be able to pass as rapidly and safely as is deemed socially (macro-economically) acceptable. Speed expressed as passing time is used to indicate the extra time required by a vessel participating as part of a fleet (with a particular number and composition) to progress from one side of the lock to the other, compared to the situation if the lock would not have been there. In this sense, the word lock is understood to mean a coherent whole of the lock approaches, lock heads and chamber(s) as well as the lay out and facilities provided in this. The passing time is determined by the time necessary for waiting, sailing in and out, mooring and unmooring and the operational time (closing and opening the gates and levelling out the chamber). This time largely depends on the amount of traffic (being the lock load or the relation between the intensity and capacity of the lock).Safe passage through the lock complex is determined by the degree of certainty in which navigation traffic can be dealt with (smoothly), without danger and/or damage to people, material and the environment and still guarantee quality of life in the direct vicinity. The main parts of locks are mentioned below:

- The lock chamber;
- Lock approach structures;
- Filling/emptying systems;
- Lock gates;
- Mechanical and electrical equipment;
- Control systems,
- Instrumentation (including water level and flow monitoring equipment),
- Power supplies;
- Communications systems;
- Mooring equipment;
- Lighting and signaling equipment;
- Safety equipment;
- Stocks of spares;
- Maintenance equipment;

Lock Chamber

The necessary chamber dimensions mainly depend on:

- The dimensions of the largest vessel;
- The volume and pattern of navigation;
- Optimal chamber filling with several vessels;
- The inland or recreational navigation purpose.

Methods for determining chamber dimensions of a capacity lock

It starts with an assumption of preliminary chamber dimensions and number of chambers.For the provisionally chosen lock complex and a normative volume of navigation, one of the modelsused to determine the value of characteristic parameters to test the design at hand on:

- the average passing through time (particularly important to the captain because of costing,
- the permitted intensity;
- the necessary waiting space (-length),
- the locking time cost for navigation, per week (possibly converted to cost per annum).

Lock approach structures

The lock approach is the navigation area between the connecting waterway and the lock complex, where approaching vessels have the opportunity to decrease speed and moor to a guiding structure if necessary (mooring is usually not an option for large vessels; they keep their position, whether or not with tugboats). With this, sufficient view and overview should be ensured both by day and by night. The lock approach should therefore be free of obstacles and not be situated in a bend. In addition, transverse and longitudinal currents in the lock approach should be avoided as much as possible, in view of the reduced manoeuvrability of the vessel when reducing speed and stopping. The lock approach is functionally divided into:

The line-up area

This area has to be equipped with proper mooring facilities and be situated as such that moored vessels are not an obstruction to departing vessels. This area is intended for vessels that will be locking through in the next locking process. From the mooring area, vessels should be able to enter the chamber quickly via the leading jetties. A mooring area is required per chamber and per side. The size of the mooring area corresponds with a completely filled chamber. A general guideline is a length of 1.2 or 1.3 times the chamber length.

The waiting area

This area is also equipped with mooring facilities. This area is only created at locks where the expected navigation intensity will be such that, on busy days, the mooring area will be too small for all the waiting vessels. This area is intended for vessels that will not be able to lock through at the next locking process after arrival. For a lock with one chamber, one waiting area per side is necessary or a communal area for a lock complex with several chambers.

Free area

Meant to provide vessels with the opportunity to decrease speed and start manoeuvres to moor in the line-up or waiting area. Furthermore, the free area provides the opportunity to, where necessary; adjust the profile of the waterway to the profile of the lock approach. For stopping and mooring, the following length should be available; an indication of inland navigation is approximately 2.5 times the normative vessel length.

Chamber and heads

The number of important parts of the primary function of the locking process takes place in the chamber and the heads, namely

- The sailing in and tying up of one or several vessels,
- The untying and sailing out of one or several vessels,
- The closing and opening of gates and
- The levelling of the water level in the chamber.

Cables and mains

In general, we strive for an integration of crossing cables and mains (the small infrastructure) in the lock and/or lock approaches, as long as this does not result in unnecessary risks for the locking process. During construction, existing cables and mains will have to be moved temporarily if necessary or other facilities could be necessary in order to disrupt the performance as little as possible. This is executed under instructions of the authorities in charge of small infrastructure. Often, these authorities will function as customers in relation to the moving or execute the moving under own management. To reduce costs, every effort will be made to consider the definite situation when planning the temporary diversions. In the definite situation, the crossing itself will generally be under the bottom of the lock or the lock approaches. Certain cables and mains of third parties could be housed in cable manholes and tunnels for lock operation, which can be made larger to allow for this. Between the cable manholes, extra lead through pipes can be added to the lock floor for these cables and mains. This is only possible if your operation is not exposed to additional risks or hindrance. Cables and mains that cross a lock and/or lock approaches and the facilities those have to be made or provided for this have to meet the following requirements:

- The cables should not yield unacceptable risk for the lock, lock operation and navigation.
- That which is unacceptable should be substantiated with a risk analysis.
- Gas mains are not included in a lock.
- Navigation must be unable to damage the cables and mains.

- Where visual inspection is impossible (and this will generally be the case) the condition of the cables and mains will have to be established in a different way, certainly in those cases where failure will have serious consequences.
- Cables and mains, with serious failure consequences, must immediately be disconnected or be free of electrical charge when necessary.
- Replacement, expansion or maintenance should take place without prolonged hinder to navigation.

Furthermore, attention has to be paid to possible transmission lines that cross the lock or the lock approaches.

Illumination, signalling and boarding

- Unsafe situations due to dazzling should be avoided. The correct combination of armature, lamp and positioning is of importance.
- The colour of the light is one of the factors in the recognition of boards and signalling. Both white and yellow light can be used. In the lamp choice of illumination, both high-pressure and low-pressure lamps as well as energy saving lamps qualify. In the application of low-pressure (monochromatic) sodium (vapour) light, colour recognition is impossible. If this is the case, separate illumination of traffic signs is recommended.

Safety facilities

Design and management of safety facilities of personnel will be executed in accordance with Health and Safety Regulations, construction regulations, labour regulations and safety regulations. A number of facilities are mentioned below.

Railings are attached to the top of gates. If the lock coping is more than 2.5 m above minimum locking level, fencing is placed behind the bollards. This fencing is always desirable where it concerns recreational navigation and where tourists are allowed on the lock coping.

Steel ladders should not be in regular use. Straight stairs, a spiral staircase or step ladders should be installed.

Basement chambers that could possibly flood (for instance those of operating mechanisms of mitre gates) have to be provided with an exit that can be opened from the inside. In addition, sufficient natural ventilation will be required as well as plunger pumps.

Usable length of Chamber = 1.1*L (Where L is the length of reference vessel)

= 1.1*110m

= 121m

Provide 125m

Width of Chamber = 1.1*B (Where B is the beam of reference vessel)
= 1.1*15m
= 16.5m

Plus 0.2 m wide fender on either side of the ship while it is moored up
= 16.5+.4
= 16.9m
Provide 18m

Sill depth in the Chamber = Maximum draught of reference vessel + keel clearance; an extra increment may need to be introduced for translation waves
= 2.9+.3+.3
=3.5m
Provide 3.5m

Discharging capacity of lock chamber = $1.7*18*7.96^{3/2}$
= 688 cumec

Volume of Chamber = 125*18*3.5
= $7875m^3$

Time to fill the lock chamber = 6300/688
= 11.45 sec say 12 sec.

This is too fast; therefore partial gate opening may be done to fill the chamber up to desired level.

Navigational lock of 175m X 44m has been proposed at every barrage and regulator locations having two chambers separately for upstream and downstream vessels.

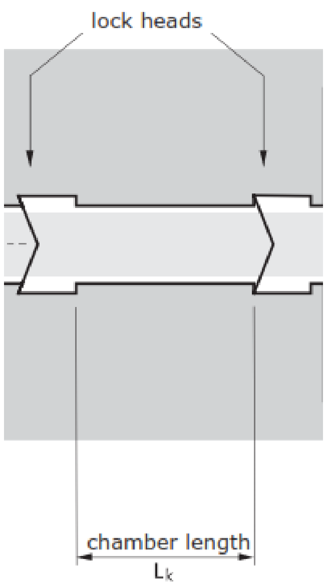


Fig. 9.3 Schematic representation of a navigational lock

9.7 Preliminary Engineering of Bridge

Existing bridges falling in the stretch of Yamuna River are not having requisite horizontal and vertical clearance as per IWAI guidelines and needs to be reconstructed. Details of one such bridge crossing Yamuna river at Mohna Baghpur Road are given below:

Table 9.18 Details of Existing Bridge at CH 990km

Structure Name and for road / rail	Chainage (km)	Type of Structure (RCC / Iron / Wooden)	Location	Length (m)	Width (m)	Horizontal clearance (clear distance Between piers) (m)	Vertical clearance w.r.t. HFL / MHWS (m)
Highway bridge	990.2	RCC	On Mohna baghpur Road	340.0	7.0	39.5	4.6

Preliminary design of the new bridge with required horizontal and vertical clearance i.e. 50m horizontal clearance and 8m vertical clearance above HFL for class-IV waterway as per IWAI criteria at CH 990 km is given below:

Parameters Adopted

Maximum discharge = 10000 cumec (As per CWC Site Mohana)

Catchment area = 27670 sq. km

H.F.L = El 193.13m (in September 1978)
= El 192.26m (in September 2010)
Bed level of river = El 184.75m (After dredging)
New Invert level at bridge = 193.13 + 8.0 =201.13

River Bank level = El192.20m

River width = 365m

Soil type = Alluvial soil

Discharge and Depth of Scour for Foundation Design

As per IRC: 78-2014 Cl. 703.1.1 for the catchment area of 27670 sq. km increase over design discharge is 20% to provide adequate margin of safety

Now design discharge for foundation = 12000Cumecs

Mean depth of scour

$R = 1.34(q^2/f)^{1/3}$

Where q = design discharge per meter width of waterway. Waterway provided is 365m same as river width
q = 12000/600 = 32.87 cumec per meter width

Where f = silt factor

As per IRC: 78-2014 Cl. 703.2.2.1
For coarse sand weighted mean diameter d_m is 0.75mm and Silt factor f is 1.5
$f = 1.76\sqrt{d_m}$
$= 1.76\sqrt{0.75} = 1.5$

R = $1.34*(32.87^2/1.5)^{1/3}$
= 12.00m

Scour depth including Rankin's depth = 2.67R
= 2.67*12.00
= 32.04m

Foundation level below HFL = 193.13-32.04
= 161.09 Say El 161.0m

Below HFL = 184.75-161.0
= 23.75m Say 24m

Substructure:

Well foundation is proposed for the piers.

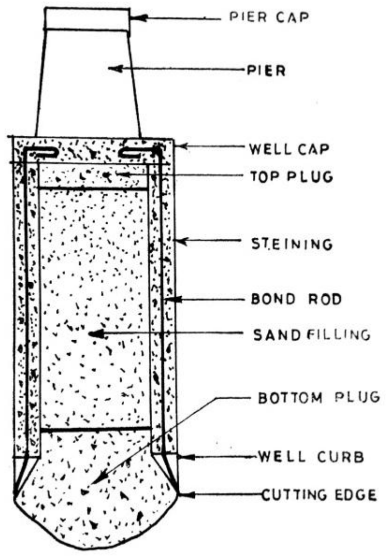


Fig. 9.4 Typical section of a well foundation

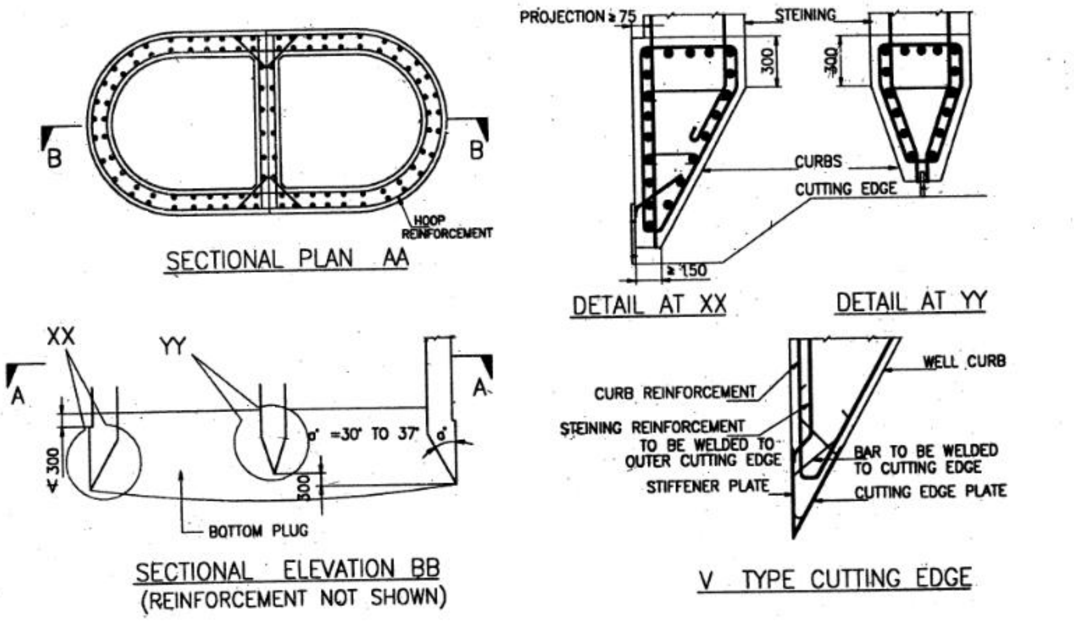


Fig. 9.5 Details of Typical well foundation

Superstructure:

Considering the length of span as 50m Pre-stressed RCC girder slab span is proposed for the proposed bridge.

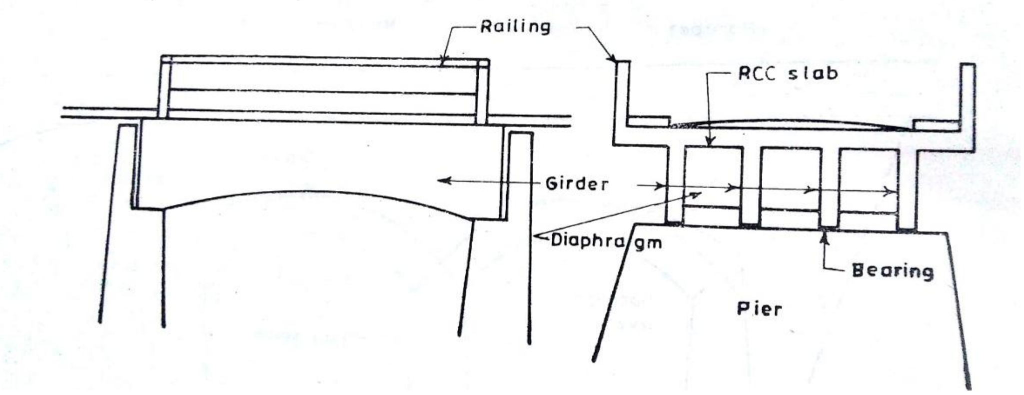


Fig. 9.6 Typical section of Girder and Slab Bridge

Total waterway	=	365m
Length of span	=	50m
No. of span	=	7
No. of piers	=	6
No. of abutments	=	2
Circular Pier of Diameter	=	2.5m

Approach Road to bridge is provided with a gradient of 1 in 30 for a length of 270m on both sides to meet the ground level with the road level.

Details of new bridge are as per table given below:

Table 9.19 Details of proposed new bridge

Structure Name and for road / rail	Chainage (km)	Type of Structure (RCC / Iron / Wooden)	Location	Length (m)	Width (m)	Horizontal clearance (clear distance Between piers) (m)	Vertical clearance w.r.t. HFL / MHWS (m)
Highway bridge	990.5	RCC	On Mohna Baghpur Road	365.0	7.0	50.0	8.0

Typical drawing of proposed bridges is shown in Volume 2 Drawings (Drawing No. 5).

9.8 Cargo Terminals and River Ports

9.8.1 Design Codes and Standards

All works shall satisfy the requirement of the latest relevant codes and standards. Generally Indian Standards shall be followed. Wherever, the details for part of works are not defined adequately in Indian standards, the relevant acceptable International Standards shall be adopted. The List of codes and standards covering the major part of the works to be followed is listed below:

Table 9.20 List of Codes and Standards

IS: 456	Code of practice for Plain and Reinforced Concrete
IS: 875	Code of practice for Design Loads for Buildings & Structures
IS: 1893	Criteria for Earthquake Resistant Design of Structures
IS: 4326	Earthquake resistant design and construction of Buildings – Code of practice
IS: 4651	Code of practice for Planning and Design of Ports and Harbours
IS: 9527	Code of practice for Design and Construction of Port and Harbour Structures
BS 6349-part 2	Code of practice for Marine structure quay, Wharves, jetties & Dolphins
IS: 800	Code of practice for General Construction in Steel
IS: 1786	Specification for High Strength Deformed Steel bars and wires for Concrete Reinforcement
IS: 13920	Ductile detailing of Reinforced Concrete Structures subjected to Seismic Forces - Code of Practice
IS: 2911	Code of practice for Design and Construction of Pile Foundations
IS: 1904	Code of practice for Design and Construction of Foundations in Soils : General Requirements

SP: 7	National Building Code of India
SP: 16	Design aids for Reinforced Concrete to IS: 456
SP: 34	Hand book on Concrete Reinforcement and Detailing
IRC : 21	Standard Specifications and Code of Practice for Road Bridges Section III
IRC : 6	Standard Specifications and Code of Practice for Road Bridges Section II

9.8.2 Details of Terminals

Total 19 nos. of terminal have been identified including 8 Cargo terminals, 10 Passenger terminals and one Ro-Ro terminal.

Table 9.21 Proposed Terminals

Terminal No.	Terminal Location	Chainage (km)
Cargo Terminals		
T1	Raipur Khader, Delhi	1051.3
T2	Near Samogar Mustkil, Agra	916.8
T3	MahewaKhachhar, Kaushambi	98.7
T4	Dilauliya Kachhar, Kanpur Dehat	349.2
T5	Near Naini Bridge, Allahabad	3.0
T6	Near Yamuna Bridge, Allahabad	4.2
T7	MadanpurKhadar, Delhi	1051.3
T8	Daulatpur, Jalaun	349.8
Passenger Terminals		
T9	MadanpurKhader, Delhi	1051.7
T10	Near TajMahal, Agra	742.4
T11	PanigaonKhader, Mathura	858.5
T12(a)	SoniyaVihar, Delhi	1077.5
T12(b)	Jagatpur, Delhi	1079.0
T12(c)	Tronica City, Delhi	1082.0
T13(a)	SujawanGhat, Prayagraj	19.5
T13(b)	SaraswatiGhat, Prayagraj	3.4
T13(c)	Near Boat Club, Prayagraj	4.0
T13(d)	Hanuman Ghat, Prayagraj	2.0
Ro-Ro Terminal		
T14	BaksiModa, Prayagraj	8.5

Type of jetty

Cargo Terminal T1 to T8 are RCC Piled jetty and Passenger Terminal T9 to T13 (d) are Floating Pontoons. Preliminary engineering design of one terminal is given below:

Terminal 5 (Near Naini Bridge, Prayagraj)

Terminal 5 is proposed beside Naini Bridge (New Yamuna Bridge) in Allahabad. It is a cable bridge and is part of NH 30. There is another bridge near the terminal on the river, i.e. Old Naini Bridge (Old Yamuna Bridge). The terminal has good connectivity. The terminal is proposed for handling coal requirement of Meja Thermal Power Station and Bara Thermal Power Station. This terminal would also be used for transporting fly ash from these plants to Haldia Port for exporting to Singapore and Bangladesh. Terminal is proposed to have a berth of 125m length and 25m width.

Fig. 9.7 Location of proposed Terminal-5

9.8.3 Design of Terminals

Structural System of Berthing Jetty

The proposed jetty is required to handle Self-propelled barges, carrying capacity 1000 DWT, Size (70m X 12m), loaded draft 1.8m (Class-IV) or IWAI designed vessel of size (110m X 12m) The jetty is planned as a berthing structure proposed to be on piles, which provide least resistance to natural equilibrium and ease of extension/addition of facilities at a later date. The berthing structure is of length 125 m and width 25m. Details of typical drawings of proposed jetty are shown in Volume 2 Drawings (Drawing No. 6).

The thickness of the deck slab of jetty is 0.65 m. The slab at deck level is supported on Cross beams of 1.0m x 1.0m in the lateral direction. The Cross beams rest on the pile caps / pile muffs. The 1200 mm diameter bored cast in situ piles with 6mm thick liner are fixed to the pile caps at the top and fixed into the ground at the bottom. The important design levels taken into consideration are discussed as follows:

Table 9.22 Design Parameters for Terminal 5 (Near Naini Bridge, Prayagraj)

Top Level of Jetty (Deck slab)	+87.20 m
Top level of Piles	+84.95m
Diameter of piles (D)	0.5m
Unit wt. of RCC	25.0 KN/m^3
Unit wt. of water	10.0 KN/m^3
Unit wt. of Steel	78.50 KN/m^3
Founding Level of Piles	-29.00 m below bed Level

Mooring arrangements

Bollards have been proposed at 10m c/c distance along the berthing side of jetty for mooring of vessels.

Fenders

Protective fenders shall be provided at a distance of 10m c/c on berthing side to prevent damage at the interface area.

Analysis of Jetty

STAAD Pro Modeling

The dimension of the jetty is 125m x 25m. The analysis of the structure has been performed in STAAD Pro 2007 for a panel of 45m X 25m as shown in **Fig. 9.8**. In the model the piles are assumed to be fixed at base. The pile length used in analysis is based on fixity length i.e. 11.7m. The cut off level of piles is +84.95m for inner pile.

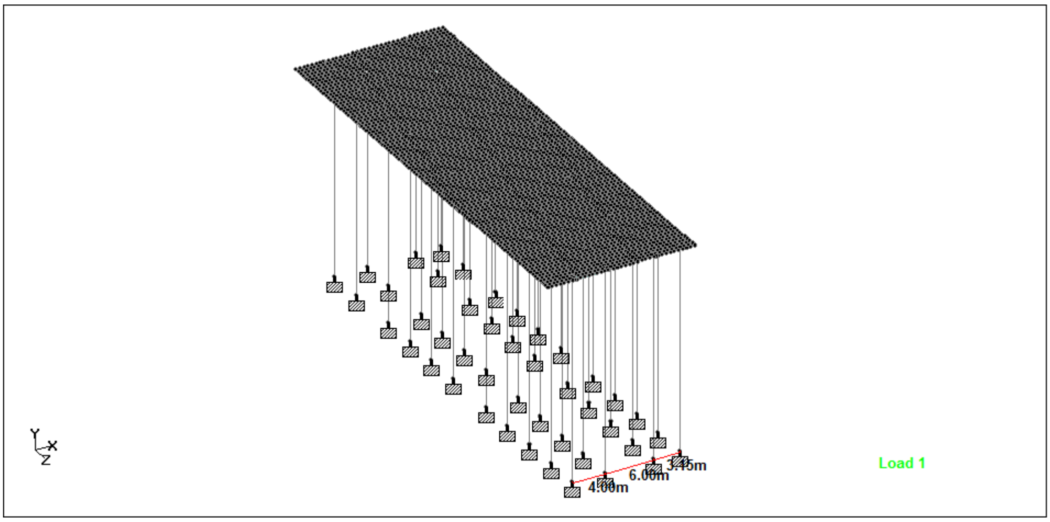


Fig. 9.8 STAAD Panel of the Jetty

Design Loads and Load Combinations

The jetty, approach and bay have been designed considering the following loads:

A. Vertical Loads

a) Dead Load
b) Live Loads
   i) Uniform loading
   ii) Truck loading (IRC Class)

B. Horizontal Loads

c) Berthing load
d) Mooring load
e) Wind load
f) Current load
g) Seismic load

C. Combination of above

The loading has been considered taking into account the guidelines of IS 4651 (Part III): 1974, IRC 6:2000, IS 1893: 2002 (Part 1), IS 875: 1987 (Part 1 and Part 3).

(a) Dead Load

The dead load consists of the weight of the entire structure, including all the permanent attachments such as mooring hardware, light poles, utility booms, brows, platforms, vaults, sheds, and service utility lines. A realistic assessment of all present and future attachments has been made and included. Overestimation of dead loads generally will not adversely affect the cost of the structure. However, overestimation of dead loads would not be conservative for tension or uplift controlled design. Standard unit weights have been used to calculate dead loads. Dead load of the structure can be applied on STAAD MODEL.

Table 9.23 Dead Weight of Slab

Component	Depth of Slab (mm)	Unit Weight (KN/m^3)	Load (KN/m^2)
Jetty	650	25	16.25

Dead weight of Rails

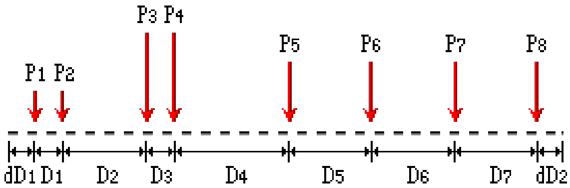
(b) Live Loads

Uniform Live Loads

35 KN/m^2 (As per IS 4561: part-3, Page-5, Cl. 5.1.2)

Truck Loading

IRC Class A truck load has been applied as moving load. The load specification of IRC Class A train of vehicles (with impact factor) is given as under:



P_1 =27 KN	dD_1 = 0.5 m
P_2=27 KN	D_1 = 1.1 m
P_3= 114 KN	D_2 = 3.2 m
P_4= 114 KN	D_3 = 1.2 m
P_5=68 KN	D_4 = 4.3 m
P_6=68 KN	D_5 = 3.0 m
P_7 =68 KN	D_6 = 3.0 m
P_8 =68 KN	D_7 = 3.0 m

(b) Berthing Force

Berthing force is calculated for Self-propelled, carrying capacity 4000 DWT, Size (86m X 14m), loaded draft 2.9m for considering future expansions. According to UFC 4 15202, there are several factors that modify the actual energy to be absorbed by the fender system. The actual kinetic energy E absorbed by the fender system is calculated as per the following:

E_{fender} = Energy to be absorbed by the fender system

$E_{fender} = M_D Vb^2 (C_m C_e C_s C_c) /2$

Where:

W_D	Displacement Tonnage (DT) of the vessel, (t)
V_b	Velocity of vessel in m/s, normal to the berth
C_m	Mass coefficient
C_e	Eccentricity coefficient
C_s	Softness coefficient
C_c	Configurationally Coefficient

Proposed fender

Type of Fender	=	G2 Grade MCS 400 Cell Fender	
Energy Absorption	=	21.60	kN*m
Reaction Force	=	129	kN

Details of above load calculation is shown in Annexure 9.2

(d) Mooring Force

This force is taken according to IS-4561- 1974-Part-III,

(i) Mooring force due to wind

Mooring Force due to wind: $F_w = C_w A_w P$

C_w= Shape Factor
A_w= Windage Area in sqm = 1.175*Lp (D_m-D_L)
P = Wind Speed pressure in N/sqm = 0.6 V_z^2

Vz =V_b *k_1 * k_2* k_3 , where the k_1, k_2 and k_3 are probability factor and terrain height and structure size factor and Topography factor respectively. Values of coefficients are taken from IS-875-Part-III,

k_1 = 1
k_2 = 0.82
k_3 = 1

- The wind speed is considered as 47m/s for Allahabad (IS - 875-III Part 3 1987, cl-5.3& pg-9)
- Shape Factor C_w=1.5 is taken for calculation of Mooring force due to wind.

Calculation summery of mooring force is given below

A_w = 1.175*L_p (D_m-D_L)
= 167.49 m^2

P = 0.6 V_z^2 =0.6*(47*1*0.82*1)^2
= 891.2 N/m^2

F_w = 224T

(ii) Mooring force due to current

Mooring force due to current: $F_c = L_{pp}\ D_r\ P_c$

F_c = Mooring Force due to current in kg
L_{pp}= Length between the perpendiculars in m
D_r = Loaded draft of vessel in m
P_c = Pressure due to current in kg/sq.m

The current velocity is assumed as 3.0 m/s
F_c = L_{pp} * D_r*P_c
= 114.4 T

Assuming that the mooring force due to current and wind act simultaneously in the same direction.

Total Mooring Force (F_T) = F_w + F_c
= 225 t + 114.4 t

Considering at least 4 nos. of bollards per vessel, mooring force at each pile,

F_T= 340/4 = 85 t

Details of above load calculation is shown in Annexure 9.3

(e) Wind Load

The wind loads on the structure has been considered as per IS 875:Part3. The basic wind speed for Allahabad is 47 m /sec. Design Wind Speed can be obtained by the following formula:

Design Wind Speed $V_z = K_1 * K_2 * K_3 * V_b$

Where,
K_1, Risk Coefficient as 1.00
K_2, Terrain (Category 3), Height (10m) and structure size factor (class C) as 0.82
K_3, Topography Factor as 1.0

Accordingly, the design wind pressure, $p_z = 0.6\ V_z^2$

$p_z = 0.6\ V_z^2 = 0.6*(47*1.00*0.82*1)^2$
$= 891\ N/m^2$

(f) Current Force

The current force is given by $\gamma V^2/2g$

Where γ = Unit weight at water = 1.0 t/m^3
V = Current velocity = 3.0 m/sec.
F_C = $\gamma V^2/2g$
= 1.0*0.2^2/(2*9.81)
= 0.46 t

(g) Seismic Force

The seismic force has been calculated as per IS-1893-2002. The design horizontal seismic coefficient A_h for a structure shall be determined by the following expression:

$$A_h = (Z/2)*(I/R)*(S_a/g)$$

Where,

Z = Zone factor given in Table 2, IS-1893-2002. Z at the site has been adopted as 0.16corresponding to Zone III. Map showing the seismic zone from IS 1893-part – I, Allahabad falls in Zone – III.

I = Importance factor =1.5 has been used.

R = Response reduction factor has been taken as 3.0 for RCC Structures as per Table 7 of IS-1893-2002.

S_a/g = Average response acceleration coefficient has been taken as 1.4 as per Figure 2 of IS-1893(Part 1):2002 corresponding to T=0.91 seconds. The earthquake force has been applied in X as well main as Z directions.

(h) Load Combinations as per IS 4651 Part IV 2007

Method of Design: The Berth and its structural components have been designed as per Limit State Method. The partial safety factors for loads in limit state design method has been used. Accordingly, following load combinations have been considered as per IS: 4651-2007

Limit state of serviceability
1.0(DL+LL)
1.0(DL+LL+BF-S)
1.0(DL+LL+BF-(L)
1.0(DL+LL+MF-S)
1.0(DL+LL+MF-L)
1.0(DL+LL+SFX)
1.0(DL+LL+SF-X)

Limit state of collapsibility

1.2(DL+LL) + (CLX)
1.2(DL+LL) + (CL-X)
1.5(DL+LL+BF-S) +1.0CLX
1.5(DL+LL+BF-L) +1.0CLX
1.5(DL+LL+BF-S) +1.0CL-X
1.5(DL+LL+BF-L) +1.0CL-X
1.5(DL+LL+MF-S) +1.0CLX
1.5(DL+LL+MF-L) +1.0CLX
1.5(DL+LL+MF-S) +1.0CL-X
1.5(DL+LL+MF-L) +1.0CL-X
1.2(DL+LL) +1.0CLX
1.2(DL+LL) +1.0CL-X
1.2(DL+LL) +1.0CLX+1.5SFX
1.2(DL+LL) +1.0CL-X+1.5SFX
1.2(DL+LL) +1.0CLX+1.5SF-X
1.2(DL+LL) +1.0CL-X+1.5SF-X
1.2(DL+LL) +1.0CLX+1.5SFZ
1.2(DL+LL) +1.0CL-X+1.5SFZ
1.2(DL+LL) +1.0CLX+1.5SF-Z
1.2(DL+LL) +1.0CL-X+1.5SF-Z
1.2(DL+LL) +1.5SWLX+1.0CLX
1.2(DL+LL) +1.5SWLX+1.0CL-X
1.2(DL+LL) +1.5SWL-X+1.0CLX
1.2(DL+LL) +1.5SWL-X+1.0CL-X
1.2(DL+LL) +1.5SWLZ+1.0CLX
1.2(DL+LL) +1.5SWLZ+1.0CL-X
1.2(DL+LL) +1.5SWL-Z+1.0CLX
1.2(DL+LL) +1.5SWL-Z+1.0CL-X
DL – Dead Load
LL – Live Load
MF-S – Mooring Force River Side
MF-L – Mooring Force Lee Side
BF-S – Berthing Force River Side
BF-L – Berthing Force Lee Side
SF – Earthquake load
CL-Current Load
WL-Wind Load

Other Terminals Design parameters

Table 9.24 Design Parameters for Terminal 1 (Raipur Khader, Delhi)

Top Level of Jetty (Deck slab)	+202.00 m
Top level of Piles	+200.6m
Diameter of piles (D)	1.20 m
Unit wt. of RCC	25.0 KN/m^3

Unit wt. of water	10.0 KN/m^3
Unit wt. of Steel	78.50 KN/m^3

Table 9.25 Design Parameters for Terminal 2 (Near EtmadpurMadra Bridge, Agra)

Top Level of Jetty (Deck slab)	+151.6 m
Top level of Piles	+150.2m
Diameter of piles (D)	1.20 m
Unit wt. of RCC	25.0 KN/m^3
Unit wt. of water	10.0 KN/m^3
Unit wt. of Steel	78.50 KN/m^3

Table 9.26 Design Parameters for Terminal 3 (Maheva Khachar, Kaushambi)

Top Level of Jetty (Deck slab)	+98.00 m
Top level of Piles	+96.6m
Diameter of piles (D)	1.20 m
Unit wt. of RCC	25.0 KN/m^3
Unit wt. of water	10.0 KN/m^3
Unit wt. of Steel	78.50 KN/m^3

Table 9.27 Design Parameters for Terminal 4 (Dilauliya Kachhar, Kanpur Dehat)

Top Level of Jetty (Deck slab)	+113.80 m
Top level of Piles	+112.4m
Diameter of piles (D)	1.20 m
Unit wt. of RCC	25.0 KN/m^3
Unit wt. of water	10.0 KN/m^3
Unit wt. of Steel	78.50 KN/m^3

Table 9.28 Design Parameters for Terminal 6 (Near Yamuna Bridge, Prayagraj)

Top Level of Jetty (Deck slab)	+87.3 m
Top level of Piles	+85.9m
Diameter of piles (D)	1.20 m
Unit wt. of RCC	25.0 KN/m^3
Unit wt. of water	10.0 KN/m^3
Unit wt. of Steel	78.50 KN/m^3

Table 9.29 Design Parameters for Terminal 7 (Madanpur, Delhi)

Top Level of Jetty (Deck slab)	+202.10 m
Top level of Piles	+200.7m
Diameter of piles (D)	1.20 m
Unit wt. of RCC	25.0 KN/m^3
Unit wt. of water	10.0 KN/m^3
Unit wt. of Steel	78.50 KN/m^3

Table 9.30 Design Parameters for Terminal 8 (Kalpi, Jalaun)

Top Level of Jetty (Deck slab)	+113.80 m
Top level of Piles	+112.4m
Diameter of piles (D)	1.20 m
Unit wt. of RCC	25.0 KN/m^3
Unit wt. of water	10.0 KN/m^3
Unit wt. of Steel	78.50 KN/m^3

Table 9.31 Design Parameters for Terminal 14 (Bakshi Moda, Prayagraj)

Top Level of Jetty (Deck slab)	+87.7 m
Top level of Piles	+86.3m
Diameter of piles (D)	1.20 m
Unit wt. of RCC	25.0 KN/m^3
Unit wt. of water	10.0 KN/m^3
Unit wt. of Steel	78.50 KN/m^3

Terminal 9 (Madanpur Khader, Delhi):

Floating Jetty is best possible option & proposed under the project, for embarking & dis-embarking of passengers. To cater to the berthing requirements for easy embarkation/disembarkation to the taxi, a floating jetty of 50m x 20 m is considered suitable. The floating jetty shall be used to facilitate embarking/disembarking of passengers between the terminal and water taxi. It will have sufficient space for accommodating passengers along with their luggage. The floating jetty will have appropriate arrangement to cater to the mooring requirements of the water taxi. The appearance of the jetty will be good and shall have superior finish as per international standards. Floating jetties to be supplied shall meet the following technical specifications:

Table 9.32 Details of Passenger Terminal

Sr. No.	Particulars	Details
A.	JETTY	
1.	Size	50m x 20m
2.	Minimum Free Board	0.5
3.	Material for construction of module/block	Steel
4.	Frames	Steel
5.	Working Life	50 years or more
6.	Handrails	Fabricated out of Stainless Steel, 750 mm high. Reflective stickers to be provided on all the four sides.

Fig. 9.9 Location of proposed Terminal-9

9.9 Protection with Stone Pitching at Terminal Sites

All the permanent structures including terminals will be protected with stone pitching. A typical design of pitching for terminal 5 near Naini Bridge Prayagraj is provided below:

Design of Stone Pitching

Weight of stones/ boulders

Stones/boulders, used in revetment for bank protection, are subjected to hydrodynamic drag and lift forces. These destabilizing forces are expressed in terms of velocity, tractive forces etc. The stabilizing forces acting against these are component of submerged weight of the stones and downward component of force caused by contact of the stones.

$W = 0.02323*S_s/ (S_s-1)^3*V^6$

Where

W = weight of stone in Kg
S_s = Specific gravity of stone
V= mean velocity of water in m/s

Generally, sloping side is pitched with one man stone i.e. a stone which can be lifted by one person –weighing around 40 to 50 kg.

Size of stone/ boulder

Size of stone (D_s in m) may be determined from the following relationship.

$D_s = 0.124*(W/S_s)^{1/3}$

Where

W = weight of stone in Kg
S_s = Specific gravity of stone

Minimum dimension of stone shall be greater than D_s.

Generally, the size of stone should be such that its length, width and thickness are more or less same i.e. stones should be more or less cubical. Round stones or very flat stones having small thickness should be avoided

Thickness of pitching

Minimum thickness of pitching (t) on the river side may be calculated by formula
$t = 0.06*Q^{1/3}$

Where t is the thickness of stone pitching in meter and Q is the Discharge in cumec

Design Parameters

The design flood for pitching may be calculated for 50 years return period using the flood frequency analysis. In certain special cases, where damage potential justifies, maximum observed flood may also be considered for fixing the top level. The design HFL should be obtained from gauge discharge relationship (G-D curve). We have adopted maximum discharge observed at the nearest CWC site i.e. at Pratappur at 33km Chainage.

Maximum discharge observed at the nearest CWC site = 30000 cumec (Pratappur at 33km Chainage)

Design discharge at Naini Bridge site	=	33000 cumec (After adding 10%)
Chainage	=	2.82 km
Bed width	=	660 m
Average Bed level	=	66.5 m
Design HFL	=	85.9
Top of Bank	=	85.9 + 1.3 m free board
	=	87.2 m

DESIGN OF PITCHING

Assume top of pitching = 1 m
Side slope = 2: 1
Thickness of pitching T = $0.06\ Q^{1/3}$
= $0.06\ (33000)^{1/3}$
= 1.92 m
Provided = 1.95 m
Thickness of Apron = 1.9 T
= 1.9 x 1.95 = 3.7
= Provided 3.7 m
Length of Apron = $R = 0.47\ \left(\frac{Q}{f}\right)^{1/3}$
Where f = silt factor = $1.76\ \sqrt{M_r}$
M_r Grain size of particle in mm = 0.16 mm
= $1.76\ \sqrt{.16}$
= 0.70
= $R = 0.473\ \left(\frac{Q}{f}\right)^{1/3}$
= $0.473\ \left(\frac{33000}{0.7}\right)^{1/3}$
= 17.08 m

Where Y = Depth of water
= 85.9 – 66.5
= 19.4 m

D = 1.25 R-Y
= 1.25 x17.08 – 19.4
= 32.68 – 16.27
= 1.95
Say = 2.0 m
Length of Apron = 1.5 D
= 1.5 x 2.0
= 3.0 m
Provided 5.0 m

A typical bank pitching is shown in Figure below:

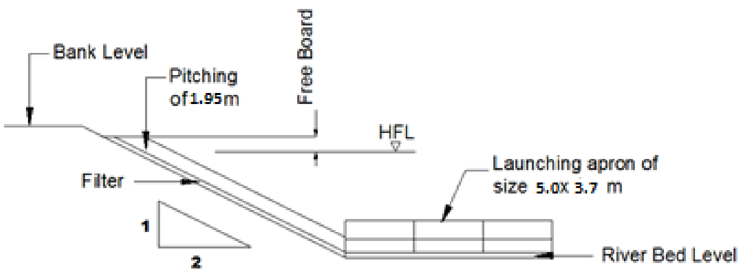


Fig. 9.10 Bank protection with stone pitching

9.10 Shipbuilding & Repair

The Dry dock has been proposed with One Dry-Dock capable of repair and building of ships up to 110 m. The dimension of the Dry Dock would be 120 x 25 x 3 m. This dimension would enable repair yard to repair all vessels, which would operate in NW 110 for handling cargo and passengers.

The layout of the Dry dock is very important as it determines the productivity, overheads, and type of ship the Dry dock can build and the future scope of expansion. The layout of the Dry dock also determines the performance of the Dry dock in terms of number and type of ship the yard can build.

- ✓ Cost minimization
- ✓ The proposed Dry dock layout would have a mix of automation and manual work
- ✓ Transport Minimization (Distance x Time)

The proposed Dry docks would be developed in the plot, adjacent to the identified sites for proposed terminals on the bank of river Yamuna. The Dry dock would be planned with the single line material flow.

The proposed Dry dock is optimised for use of smaller area with all the process integrated at every stage. The Dry dock has been designed for unidirectional flow of material. The storage space, roadways would be designed to optimise the resource and cater to future capacity expansion through productivity improvement.

The design layout of the Dry dock also has the provision for the new building market. The outfit and major workshops have been placed in between the dry docks; this would enable faster turnaround both for outfit during ship repair.

The major issues considered, while developing an initial design for proposed Repair Yard Dry dock are as follows:

- ✓ Market segment
- ✓ Product range
- ✓ Capacity
- ✓ Scope of future expansion
- ✓ Dry dock productivity

The proposed Dry dock would be designed for a mix of automated and manual work process. This would get an advantage of automation for increasing productivity, at the same time involvement low cost labour would enable the Dry dock reduce cost.

The dry docks three in number have been proposed and have a dimension of be 120 x 25 x 3 m, which can accommodate small ships plying in River Yamuna. One dry dock and one slipway of the Dry dock have been planned with outfitting shops around them. This would enable the Dry dock to carryout dry dock repairs of vessels efficiently.

The facility would have an outfit jetty of 120 m. This would have the capacity to carryout outfitting on one ship at any given time. The facility could also utilize infrastructure of the proposed terminal. Details of typical drawings of proposed shipyard are shown in Volume 2 Drawings (Drawing No. 7).

CHAPTER – 10

NAVIGATION & COMMUNICATION SYSTEM

10.1 Navigation Aids

Aids to navigation are required to be provided to identify the fair way for safe navigation. These are various types of marks fixed on river banks, floated on water and moored into the channel bed on both sides of the fairway to guide the master.

In open reaches of River Yamuna NW 110, the marking of the navigational channel by floating buoys is most ideal considering the traffic potential on the waterway, permanent type of lighted buoys are recommended to facilitate round the clock navigation including night navigation. The buoys are to be moored to the bed on either side of the fairway and also at the river confluences of open reaches by means of anchor and chains. The anchor chains need to have sufficient length to facilitate their shortening/lengthening as required during lean and flood periods to suit the prevailing water level. The permanent shore marks are required to be provided on the river banks wherever sharp bends exist so as to align the craft / barge in a straight line along the fairway. Sheets of adhesive scotch lite or luminous paint are required on the shore marks for night navigation.

10.1.1 Proposed aids to navigation system on River Yamuna NW 110

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

- **Lateral Marks**
  To mark the left and right sides of the navigation route to be followed by navigator.

- **Bifurcation Marks**
  To mark the middle grounds between the navigational channel, bifurcated channels and isolated dangers in the middle of the navigational channel.

- **Shore Marks**
  - Bank wise Marks, to indicate the channel at points where it approaches a bank.
  - Crossing Marks, to indicate crossings and alignment of the channel from one bank to another

- **Marks of Prohibited Areas**
  To indicate no permission of entry.

- **Sound Signal Marks**
  To indicate use of horning or other sound signals.

- **Marks for Traffic Control**
  To control up bound or down bound vessels in one-way or sequential passage or to prohibit navigation.

- **Marks on Bridges**
  To indicate the passage through bridges.

The channel marking as per the regulations of Inland Waterways Authority of India (IWAI) under—National Waterway, Safety of Navigation and Shipping Regulations,2002 are come into force after publication in the official Gazette are placed in the **Annexure 10.1** of this report. The channel marks published by IWAI may be provided for the safety of vessels plying in the waterway NW 110.

10.1.2 Estimates of requirements of aids to navigation in proposed waterways

The navigational marks required in the proposed waterways have been worked out. This provision is required for safe and efficient navigation. The numbers of Beacon Stations and buoys have been worked out for the safe and efficient navigation during night along the waterway. The Summary of details of the Navigational Marks and beacon stations required to be provided in the waterway is given as under

Table 10.1 Details of Navigation Aids

S. No.	Location	Type of Navigation aids	Number of navigational aids required in Waterway
1.	At Bridges	Fixed shore Markers	60
2.	At Bends	Fixed shore Markers	104
3.	At Terminal locations, Bifurcations etc.	Fixed shore Markers	19
	Total		183
4.	Navigational Channel Marking	Lighted Beacons/Buoys	524

10.1.3 IALA Buoyage System

Within the IALA Buoyage System there are 5 types of marks which may be used in combination. The mariner can easily distinguish between these marks by readily identifiable characteristics.

Lateral marks differ between Buoyage Regions A and B as described below, whereas the other 4 types of mark are common to both regions.

Lateral Marks

Following the sense of a conventional direction of buoyage, Lateral marks in Region A utilize red and green colours by day and night to denote the port and starboard sides of channels respectively. However Region B these colours are reversed with red to starboard and green to port.

A modified lateral mark may be used at the point where as channel divided to distinguish the preferred channel, that is to say the primary route or channel which is so designated by an authority.

Cardinal Marks

Cardinal marks indicate that the deepest water in the area lies to the named side of the marks. This convention is necessary even though for example, a North mark may have navigable water not only to the North but also east and west of it. The mariner will know he is safe to the North, but must consult his chart for further guidance.

Cardinal marks do not have a distinctive shape but are normally pillar or spar. They are always painted in yellow and black horizontal bands and their distinctive double cone top-marks are always black.

Cardinal marks also have a special system of flashing white lights. The rhythms are basically all “very quick” (VQ) or “quick” (Q) flashing but broken into varying lengths of the flashing phase. “Very quick flashing” is defined as a light flashing at a rate of either 120 or 100 flashes per minutes; “quick flashing” is a light flashing at either 60 or 50 flashes per minutes.

The characters used for Cardinal marks will be seen to be as follows.

North: Continuous very quick flashing or quick flashing
East: Three “very quick” or “quick” flashes followed by darkness
South; Six "very quick" or "quick" flashes followed immediately by a long flash, then darkness
West: Nine "very quick" or "quick" flashes followed by darkness.

The concept of three, six, nine is easily remembered when one associates it with a clock face. The long flash, defined as a light appearance of not less than 2 seconds, is merely a device to ensure that three or nine "very quick" or "quick” flashes cannot be mistaken for six,

It will be observed that two other marks use white lights. Each has a distinctive light rhythm which cannot be confused with the very quick or quick flashing light of the Cardinal marks.

Isolated Danger Mark

The Isolated Danger mark is placed on a danger of small area which has navigable water all around it. Distinctive double black spherical top marks and Group flashing (2) white lights, serve to associate Isolated Danger marks with Cardinal Marks.

Safe Water Marks

The Safe Water mark has navigable water all around it but does rot mark a danger. Safe Water marks can be used, for example, as mid-channel or landfall marks. Safe water marks have an appearance quite different from danger marking buoys. They are spherical, or alternatively pillar or spar with a single red spherical top marks. They are the only type of mark to have vertical stripes (red and white). Their lights, if any, are white using is phase, occulting, one long flash or Morse“ A” rhythms.

Special Marks

Special marks are not primarily intended to assist navigation but are used to indicate a special are or feature whose nature may be apparent from reference to a chart or other nautical document. Special marks are yellow. They may carry a yellow “X” top mark, and any light used is also yellow. To avoid the possibility of confusion between yellow and white in poor visibility, the yellow lights of special marks do not have any of the rhythms used for while lights. Their shape will not conflict with that of navigational marks, this means, for example, that a special buoy located on the port hand side of a channel may be cylindrical, but will not be conical. Special marks may also be lettered or numbered to indicate their purpose.

New Dangers

It should be specially noted that a “new danger” which is one not yet shown in nautical documents, may be indicated be exactly duplicating the normal mark until the information is sufficiently promulgated. A “new danger” mark may carry a Racon coded Morse “D”.

Body	:	ABS Plastic sealed to IP68 Standard.
Lens	:	185 dia moulded UV stabilized Poly- carbonate lens
Color	:	Red, Green, Yellow, White
Range	:	2 to 3 NM at 0.74 ATF (Specify while ordering)
Light Control	:	Automatic on/off by Photo diode
Light Source	:	High Intensity light emitting diodes LEDS with 100, 000 hours of life
Divergence	:	360^0Horiz. X 15^0 Vertical (at 50%) of Peak Intensity
Character	:	Any one character from 256 IALA recommended character can achieved
Input Voltage	:	Nominal 12 VDC
Battery	:	Maintenance free lead-acid fitted with inside Base
Autonomy	:	200 to 300 Hours period
Solar Panel	:	Fitted on the Lantern Dome
Fixing	:	Four – 10 mm dia Hole on 200 PCD
Weight	:	3 Kg approx.

Marine Lantern @ 2km C/C is provided along the proposed waterway. Designed aid is on the basis of light intensity, soil condition and wind direction and velocity

General assembly of proposed buoy is shown in Fig. given below

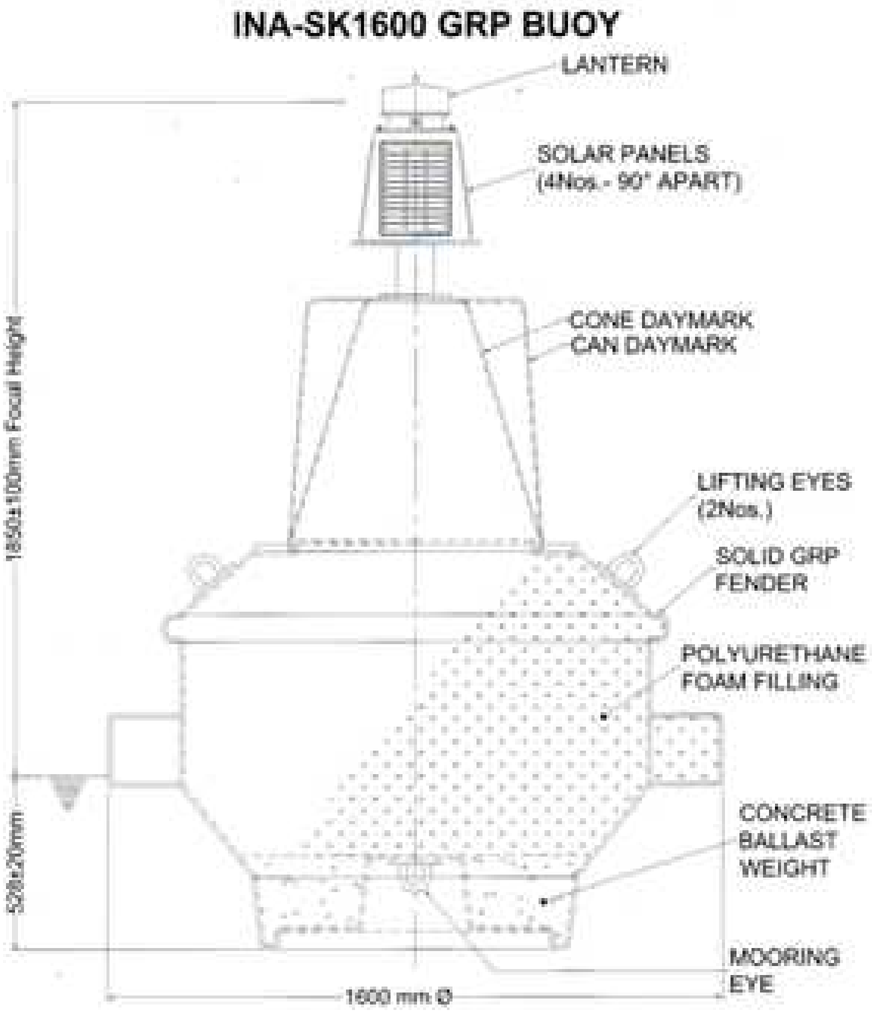


Fig. 10.1 (A) General assembly-partial

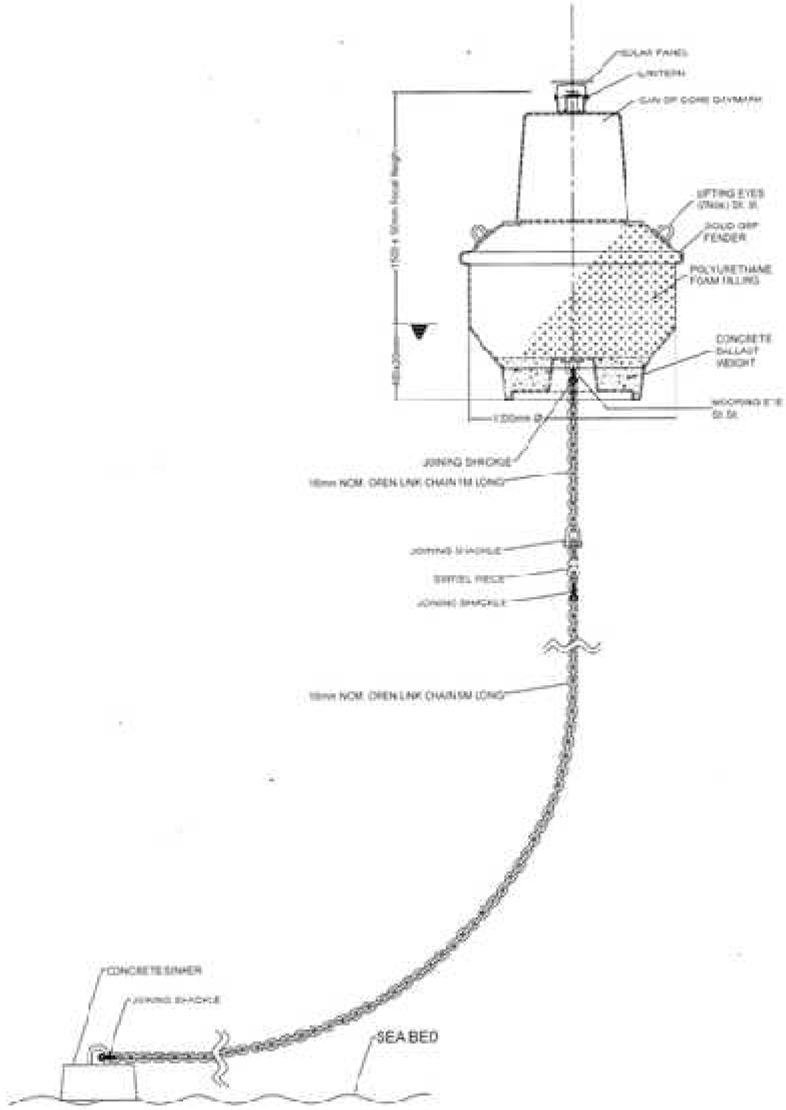


Fig. 10.1 (B) General assembly-Full

Fig. 10.2 Navigational buoys

10.2 Communication Systems

10.2.1 VHF/HF

VHF communication system is a part of VTS/VTMS system i.e. Vessel Traffic system or Vessel Traffic Management System. This navigational system is required when there is heavy traffic at port or terminals. Though there are international standards published by IMO, each Country and each state or province also follows its own standard. It helps to locate exact position for berthing of vessels and decide traffic lane for vessels accordingly. VHF also comes under Marine Communication Systems. VHF Radio also known as very high frequency radio used for communicating between shore & vessels or between two vessels. Depending upon area of operations of various ships activity of VHF system differs. As per nautical miles from shore of vessels, various types of VHF radio frequency system are used for communication. For NW110 vessels could contact terminal Manager via VHF system and would be provided guidance for berthing or for anchorage etc. This system would also help in planning vessels arrival & departure schedule for terminal or port.

10.2.2 Differential Global Positioning System (DGPS)

DGPS is satellite-based system. Generally DGPS system has two reference stations, two integrity monitors, control computer, communication system, marine radio beacons and continuous power supply. All these equipment's are necessary for DGPS system to function. Vessel monitoring & controlling could be done from various DGPS stations or remotely from other control stations. Using DGPS corrections could be made in GPS receiver to increase the accuracy of navigation. It is the advance version of GPS system

10.2.3 RIS/AIS/Radar/VTMS

- **River Information System (RIS)**

  First RIS system has been introduced in India on NW 1 in Fy-16. RIS is a combination of software & hardware equipment used for optimization of traffic & vessels movement in Inland waterways for navigation purposes. RIS is used for electronic data transfer between vessels & shore. Using RIS system many waterway transportation risks like vessels collisions, Vessel – bridge collisions could be avoided. River Yamuna also has many bridges on it. Vessels/barges that would use river could be benefitted by using RIS system and safely navigate in complete stretch of the river.

- **Automatic Identification System (AIS)**

  AIS & RIS system together provides safe navigation for vessels. Both these systems are used simultaneously. Under AIS, vessels that would ply on whole river stretch are monitored. Remote stations/base stations site would be installed/developed for monitoring vessels and identify it. This would further strengthen safe navigation for vessels.

- **Radar**

  Radar is basically used to locate other ships and nearby land area. In radar system there are X frequency & S frequency. X stands for secret & S for small range. Radar screen on ship display each and every object that are in the coverage of particular radar on ship. There is antenna on the top of radar, which continuously rotates, & flashes in order to find out any objects on the navigable path of the ships. It not only identifies objects but also shows its distance from ship. This also helps in avoiding accidents in the waterways. Radar system is also considered as user friendly and economical to install due to less consumption of power & electricity.

- **Vessel Traffic Management System (VTMS)**

  Radar, VHF all are part of VTMS. Together it helps to plan ships arrival & departure, monitor anchorage activities, provide traffic guidance to ships and control traffic in the waterways. In case of emergency or rescue operations would be carried out successfully using VTMS system. Some of the vessels arriving at terminals on River Yamuna would not be complying necessary norms for berthing purposes. In this case anchorage/pilotage or barges need to be used in order to access terminals on River Yamuna. This could be done successfully using VTMS. Overall it helps to have complete control over management of vessels & terminal.

List of Equipment:

Base Station

i) AIS Base Station with Hot stand
ii) Mono pole tower
iii) Porta Cabin 20'X 8'X8'
iv) VHF sets with Antenna
v) Leased Line – Wide Area Network
vi) Metrological Equipment
vii) Gen Set 10 KVA
viii) UPS (UPS APC- SRC6KUXI-6KVA
ix) BSNL Leased line

Control Station Servers

i) Central RIS Operating Processor
ii) Central Monitoring and Storage Processor
iii) Web Server & Time Server
iv) Workstation

v) Operator Display 52” LED Wide Screen + With operator display
vi) RIS Software
vii) Installation, testing, Training and commissioning

O&M

i) Overall Operation & Security of RIS system
ii) Engineer 1no. at 1 stn for 12 months
iii) Operators 1no. at 1 stn for 12 months
iv) Security 1no. at 1 stn for 12 months

10.3 Existing System

No navigable or communication system has been developed on River Yamuna at present.

10.4 Additional requirement

Once the terminals on River Yamuna gets developed, all these basic safety norms need to be installed for safe navigation of vessels and to have complete control on traffic handled at terminals.

CHAPTER – 11

SOCIO ECONOMIC ENVIRONMENTAL ASSESSMENT

11.1 General

Transport has been considered as a primary factor of economic development. Inland waterways transportation is one of the oldest economic and environmental sustainable modes of transportation for passengers and cargo. In some areas, it is the only means of mobility and access to basic services. The sector encompasses various types and sizes of vessels, operating on waterways in major rivers of India. Inland waterways play a vital role in economic development, especially in remote areas. The potential opportunities for IWT sector depends considerably on the specific regional context, such as geographical conditions, level of road development and socio-economic conditions. This section would examine the mechanisms by which the inland waterway transport system in river Yamuna would influence economic growth and development of the hinterland. Developing and maintaining NW 110 is an opportunity to improve sustainable development of this waterway and the hinterland.

Globalization and increase in population put pressure on existing transportation modes to meet increased demand. If towns and cities along the banks of Yamuna fails to keep up with the growing need of transportation and are prone to lack of infrastructural facilities, then it reduces the living standard of people. In such situation, development of NW110 for cargo, passenger and tourism movement would create a brand value to Yamuna's adjoining states. Development of river Yamuna for passenger and cargo movement opens a new door of transportation and would help to ease the burden of existing modes. Waterway is considered as green infrastructure and is environmental friendly and sustainable mode of transportation. Development of IWT route is primarily considered for freight and passenger transportation, but it also offers numerous services and benefits to the society.

The utilization of IWT in river Yamuna is the most important factor that determines the variation in the opportunities of inland waterways on socio-economic development of the districts that fall in the hinterland of the river. Waterways develop economic activities, recreational activities, tourism industry, enhance the socio-economic life of local community and provide sustainable mobility. Inland waterways boost the economic productivity of the hinterland. The proposed waterway NW 110 in river Yamuna would not only offer an alternative mode of transportation for the community but would also generate more new economic activities, like tourism, boat building, sand mining, fishing industry etc.

11.2 Economic Role of Inland Waterway Transport

Inland waterways would open up districts located in the hinterland to economic activities and to land uses that would not otherwise have occurred. The principal role of IWT is to provide access between spatially separated locations, which are located along the river for the industrial and household sectors. For the industrial sector, this involves connections between industries and their input sources and between industries and their markets. For the household sector, it provides people with access to workplaces and education facilities, shops, medical facilities as well as social, recreational and community. Apart from household sector, IWT would also serve tourism sector. Tourists would use inland waterway transport in river Yamuna for enjoying long and short route cruise/ boat rides to enjoy the scenic beauty of the river and the surrounding area.

In India, Inland waterway development is in an infant stage and the majority of the costs of system investment, operations and maintenance need to be taken care by government. Government also needs to promote and subsidise IWT to attract industries and other customers to inland waterways. In the country, existing modes of transportation like roadway and railway are already developed and more funds are allocated every year for development and up gradation of these modes. Industries and passengers prefer roadway and railway as these are already established modes. To compete with these modes of transportation, IWT needs full support from Government. More investment would be required for the development of IWT, so that it could be developed at par with the existing and established modes and could compete with them.

The direct effects of transport investment in IWT are to reduce transport time and costs through increasing volume of cargo, decreasing the operating costs of transport and enhancing access to destinations within the network. These incremental benefits of transport investments may be measured through cost-benefit analysis. Better IWT links and services would lead to lower costs and enhanced accessibility. Increased access and connectivity create increased opportunities for trade, competition and specialisation, which can lead to longer-term productivity gains. These changes are similar to the gains from removing barriers to trade and by expanding opportunities. The potential for IWT is high in future; however waterway development would not accelerate economic development of the region instantly. Due to over utilization of existing modes, It would take time to establish IWT as a preferred mode of transportation for industrial cargo and passengers.

11.3 Impact of IWT improvement of community and the region

The waterway network is indeed an important catalyst to boost the socio-economic activity among the local community. Development of NW 110 will involve development in both physical and human resource development in the region. These types of development will provide more opportunities and benefits to the surrounding communities. This spill-over effect of development has economic as well as social benefits. However, IWT development may result in forced displacement, may be in the form of physical movement of the settlement (migration of people), change in occupation, and change in daily activities and so forth which demands human adaptation from the displacement. Some people may accept this as a new challenge to be faced in their lives, but to some this may disturb their routine; hence may lead to many unforeseen problems. Social changes in the society due to development of NW 110 would be difficult to calculate in financial terms but it is likely to have a positive impact on communities. Some of the positive impacts of IWT on the community and the region are mentioned below.

11.3.1 Employment generation and growth in per head Income

Development of inland waterway would impact development of the hinterland. Inland waterway would generate employment for the population living in the hinterland. Economic growth of the region would certainly facilitate the enhancement of per head income growth.

Inland waterway could facilitate geographic and employment mobility in response to shifting economic activity to the hinterland of the river. The development of the waterway will itself help support employment. After the development of NW 1, it is estimated that around 45,000 direct and 80,000 indirect employments would be generated. Considering this, it could be estimated that NW 110 would generate huge employment opportunities. Employment generation during NW development is a one-time impact. However, once NW 110 gets operational, it would generate more employment for local people as well as other migrants. For example, every proposed terminal would require staffs for handling various tasks, like technical jobs, administration related jobs etc. Hence, NW 110 would benefit the region and community by providing employment opportunities.

Locals residing just near the bank of river Yamuna would be exposed to bigger opportunities compared to those who live far away from the hinterland of Yamuna. This is likely to result in lifting up their social and economic standard. Development of NW 110 could help to decrease unemployment rates in the hinterland especially among group of people who find it hard to get employment because of lack of education for white collared job.

Development of NW 110 on river Yamuna would also encourage business activities, like establishment of shops, hotels, stores selling local products etc. This will provide more money- making activities for the rural community. Waterway development would also result in growth in sand mining industries, vessel/boat making industry, boat rental activity etc. Boat operators, boat builders, boat hire companies, equipment manufacturers, traders and hospitality sector (restaurants, accommodations) would also grow in the hinterland of NW 110. Rural development opportunities have other impacts, like social development and cohesion. It can be a tool to connect the rural and urban communities, and further helps to minimize the economic disparity between the two sectors.

11.3.2 Development of backward areas

Development of NW 110 would help in faster development of backward areas, located on the bank of river Yamuna. This would reduce the gap between rural & urban areas. NW 110 would support small-scale units in rural areas. Waterway tourism is very much important especially in rural areas, as these areas would be developed holistically. Existence of any cultural heritage sites in these areas automatically increases appeal of the waterway. Some of the neglected areas under rural regime that need immediate refurbishment would be largely benefitted from the development of NW 110.

11.3.3 Growth in construction and other sector

Construction companies are other major beneficiaries of waterway development in river Yamuna because of development and maintenance contracts of IWT, like Waterway Channel maintenance work which includes bank protection, dredging, aquatic weed control and de-watering by using environment friendly techniques etc. Apart from waterway development, water transport sector would also provide additional employment opportunities. Arts and cultural based industries would also likely grow along the banks of river, especially in the tourism centric cities like Agra, Mathura, Vrindavan etc., which would further helps to increase the footfalls.

11.3.4 Availability of water for Agriculture

Uttar Pradesh, which covers the largest part of the hinterland of river Yamuna, has agriculture based economy. Due to development of NW 110, the identified stretch of river Yamuna would be wider and deeper, ensuring availability of water in the river throughout the year. Availability of water in the river would positively impact agriculture on the bank of the river, as there would not be shortage of water even during summer season. The development of reliable irrigation has large economic and community benefits. This would intensify farming in the hinterland and result in growth in agriculture production. Improvement in agriculture and higher production would further improve the economy of the region.

11.3.5 Shift from agrarian economy to industrial service sector

In the past, waterways played an important role for the development of industry and welfare of many cities and regions. At present, waterways have a positive impact on regional development. Due to development of IWT sector, the economic potential of the hinterland of NW 110 would increase. Agriculture is the main occupation of people residing on the bank of river Yamuna. Huge parcel of agricultural lands are available on the bank of NW 110. After development of national waterway in the river, more industries would be attracted to NW 110. Usually, industries grow more in coastal areas as compared to land locked areas due to easy access of waterway and port. This facilitates seamless movement of cargo through coastal route. Industries, which are located in the hinterland of NW 110, are dependent on roadway and railway. This restricts the industries from faster and seamless movement of their raw material as well as finished products. Trucks with industrial cargo use the same infrastructure, i.e. railway and roadway, which are used by passengers also. Railway and roadway are overburdened as they serve both cargo and passenger movement. This is not the case with inland waterway. IWT has the advantage over other modes as it provides immense flexibility. IWT could be used for transporting large volume of cargo, without having to compromise on speed. Night navigation facilities would also be added advantage of IWT as cargo could be moved during night also. IWT would not only bring sea cargo to the land locked hinterland, but would also serve as a low-cost marketing channel.

Development of NW 110 would provide industries with an alternate, reliable and seamless mode of transportation. Hence, there is huge potential of development of industries on the bank of NW 110. Development of industries would eventually result in growth of the region and employment generation.

11.3.6 Health and well being of communities

Inland waterway will bring huge potential to intensify recreational activities, like fishing, boating, water sports etc. Waterway recreational activities play an important role in maintaining health of communities. Developing riverside path supports sport activities and indirectly helps to maintain physical & mental fitness of nearby region. Diversity, beauty, history and natural environment of river Yamuna would have positive results to the health and the subjective well-being of the local communities.

11.3.7 Development of Tourism activity

After the development of NW 110, tourism activity on river Yamuna would flourish. Tourism activity has the potential to boost the local economy and bring along additional income from tourist taxes for states located in the hinterland, provided that policies and guidelines are established in ensuring the sustainable developments in NW 110.

From an economic perspective, attracting and retaining foreign tourists and domestic tourists from outside the local area is most advantageous. Iconic structures such as Taj Mahal on the bank of river could provide a substantial boost to economic impact. There is also the potential to link waterway-related developments with the wider visitor economy, for example river cruises on NW 110 would help to attract foreign tourists, thereby increasing range of users.

There are many cities with places of tourism interest located on the bank of river Yamuna, like Agra, Mathura, Vrindavan, and Prayagraj etc. Tourists would use waterway to reach these cities and explore the tourist places. Waterway on river Yamuna would provide attractive opportunities for boat/ cruise tourism. Long route cruise service, which would ply between Delhi to Prayagraj, would be a major attraction. Another attraction would be short distance boat rides between different Ghats of Prayagraj and water taxi in Delhi (Sonia Vihar, Jagatpur and Tronica City). Well-developed passenger terminals would serve tourist traffic for inter and intra district movement on NW 110.Development of other tourism related facilities near the proposed terminals would also contribute in the revenue from tourism related activities on NW 110.

11.3.8 Alternative of Transportation

Inland waterway can be a mechanism for alternative transport in urban and rural areas. NW 110 would offer an alternative for selection of movement for cargo to be moved to/ from the sites of manufacturing, industries and commerce in the hinterland. Inland waterway has the ability to provide sustainable mobility and add some additional alternatives for people to commute or travel to other places especially during local festive seasons. In the absence of inland waterways transport, many remote underprivileged communities would be inaccessible or too costly to service by other means. IWT plays a crucial role in the welfare of these remote rural areas of the inhabitants who are usually among the lowest of low income groups in the region. In some regions, NW 110 could be a main choice of transportation besides road and rail transport.

IWT networks and improved transport technology, through effects on transport costs, access and connectivity would play a crucial role in economic growth and opening up formerly isolated areas to people and economic activity. NW 110 would connect different states and cities. This waterway would be used for various interstate movements for example, between Uttar Pradesh, New Delhi and Haryana. As Uttar Pradesh covers the largest area of the hinterland of river Yamuna; hence NW 110 would be used extensively for intra district movements between Ghats of Prayagraj. IWT system is still an untapped market and an emerging mode of transportation in India; hence after development of IWT system, it is very unlikely that there would be profitability in near future. However, well developed IWT system with proper promotion and awareness, would result in social and environmental gains.

11.4 Economic Benefits of NW 110 Development

Inland waterway in river Yamuna would provide improved access at lower cost and consequently would boost economic growth of the region. Development of river Yamuna as NW 110 would revolutionise industrial growth and passenger movement in urban as well as rural regions, located on the bank of the river.

The links between inland waterway in NW 110 and the economy also tend to become more complex, with transport investment having to meet multiple objectives. These objectives may include mechanism and technologies for cargo handling, freight cost compared to existing modes, improvement in safety, travel conditions, accessibility, environment, integration and social inclusion. An increased proportion of investment may be allocated for infrastructure and other schemes that address multiple objectives rather than solely maximise contributions to economic development.

The economic benefits that will accrue with the development of inland waterway on NW 110 have been classified into following categories:

- Employment Generation
- Fuel savings due to Inland waterway transportation
- Carbon credit earned
- Reduction of congestion on existing modes
- Other benefits such as reduction in accidents, noise etc.
- Less cost of development
- Less land occupancy
- Property Uplift and Regeneration
- Transportation of goods and passengers
- Ecosystem Services

Some of the above mentioned benefits have been analysed in the following sub sections.

11.5 Employment Generation

Construction and operation of Terminals and fairway in NW 110 will lead to direct employment generation. Workforce would increase as per phase wise development of terminals/fairway and their operations in NW 110. This section would discuss in detail capital induced and operation induced employment generation from NW 110.

- **Capital Induced Employment Generation**

  Employment generation during development of terminals and fairway is a one-time impact. Employees in construction phase of terminal and fairway would be employed till the completion of construction of terminal and fairway.

  Fairway development would require employees for maintaining least assured depth (LAD) in the identified stretch of the river, widening bottom channel, bank protection work, provisions of navigation aids and other related activities.

Capital induced employment generation is based on Capital Investment for specific years of construction. Some Terminals, i.e. T1, T7, T9 & T11 would be developed only in one investment phase. Rest of the terminals would be developed in two investment phases.

- **Operation Induced Employment Generation**

Operation induced employment generation would be done throughout operational period of Terminals. After the construction period, terminals would get operational and would result in more employment generation. Employees would be required for working in different departments in Terminals on NW 110. Number of employees would vary on each terminal. For instance, number of employees in Cargo terminals and passenger terminals would be different.

11.5.1 Terminal 1

- **Capital Induced Employment Generation for Terminal 1**

As depicted in the below chart, Investment for construction and development of Terminal 1 would be done in two years, i.e. FY 35 & FY 36.

Employment generation during this construction period would vary in each financial year. Based on the assumptions described above, number of employees is calculated for each investment year. In FY 35, number of employees would be 386, whereas in the following year, i.e. FY 36, number of employees would be 318.

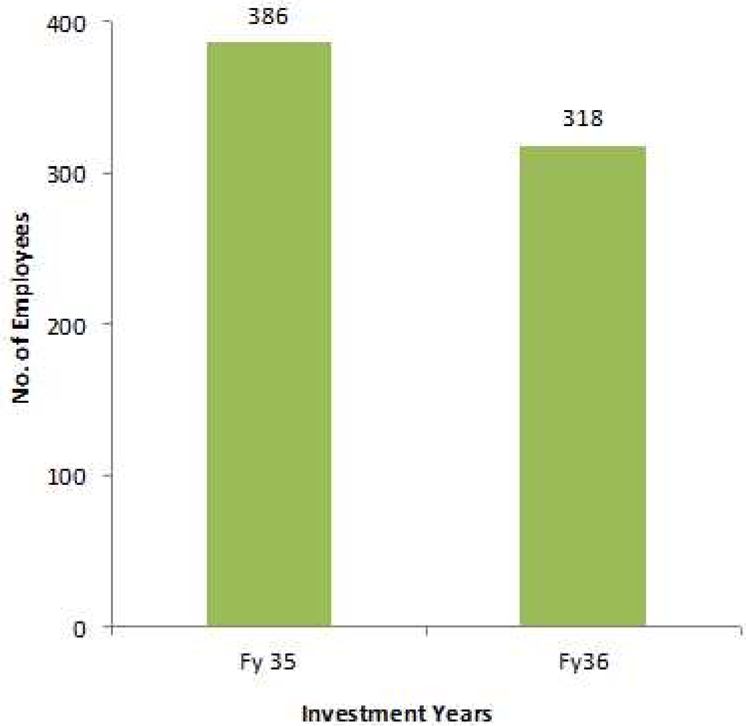


Fig. 11.1 Employment Generation in Development Period at T1

- **Operation Induced Employment Generation for Terminal 1**

Terminal 1 would be operational since FY 37; hence operation induced employment generation would start from FY 37. It has been considered that traffic beyond FY 47 for each terminal would remain constant; hence, number of employees would also remain constant, i.e. 4,035after FY 47.

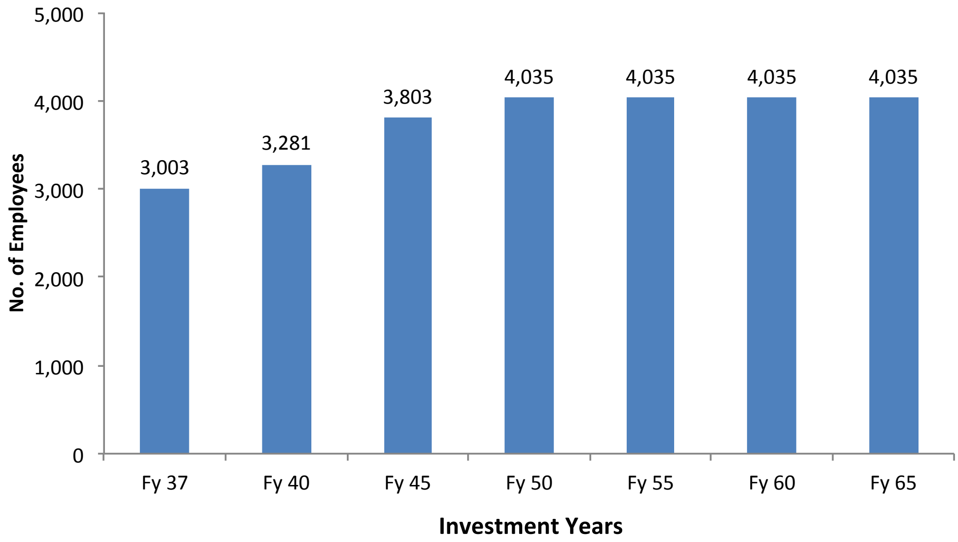


Fig. 11.2 Employment Generation in Operational Period at T1

11.5.2 Terminal 2

- **Capital Induced Employment Generation for Terminal 2**

As indicated in the below chart, Investment for construction and development of Terminal 2 would be done in two years, i.e. FY 30 & FY 31.

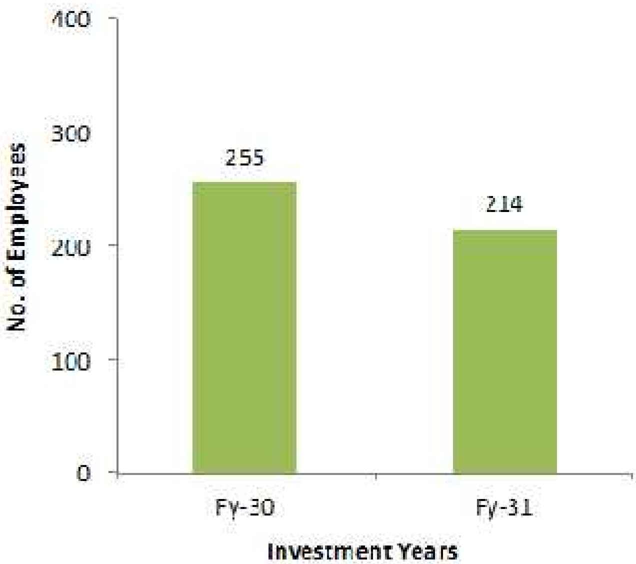


Fig. 11.3 Employment Generation in Development Period at T2

Employment generation during this construction period would vary in each financial year. In the chart below, number of employees is calculated for each investment year. In FY 30, number of employees would be 255, whereas in the following year, i.e. FY 31, number of employees would be 214.

- **Operation Induced Employment Generation for Terminal 2**

For operation induced employment generation, it is assumed that 1 employee would be hired for 0.5 mn T/Km. As Terminal 2 would be operational since FY 32; hence operation induced employment generation would start from FY 32. It has been considered that traffic beyond FY 47 for each terminal would remain constant; hence, number of employees would also remain constant, i.e. 2,114after FY 47.

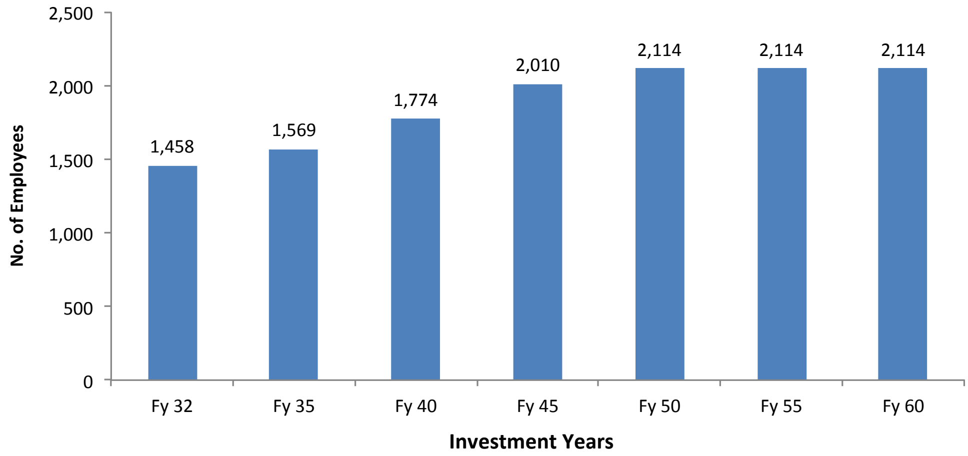


Fig. 11.4 Employment Generation in Operational Period at T2

11.5.3 Terminal 3

- **Capital Induced Employment Generation for Terminal 3**

As depicted in the below chart, Investment for construction and development of Terminal 3 would be done in four years, i.e. FY 24, FY 25, FY 35 and FY 36. Construction Period in Phase 1 (FY 24 & FY 25) is highlighted in blue color, whereas Construction Period in Phase 2 (FY 35 & FY 36) is highlighted in red color. Employment generation during this construction period would vary in each financial year. Based on the assumptions described above, number of employees is calculated for each investment year. In FY 24, number of employees would be 730, whereas in the following year, i.e. FY 25, number of employees would be 523. In FY 35, more employees, i.e. 1,255 would be hired. In FY 36, there would be 898 employees.

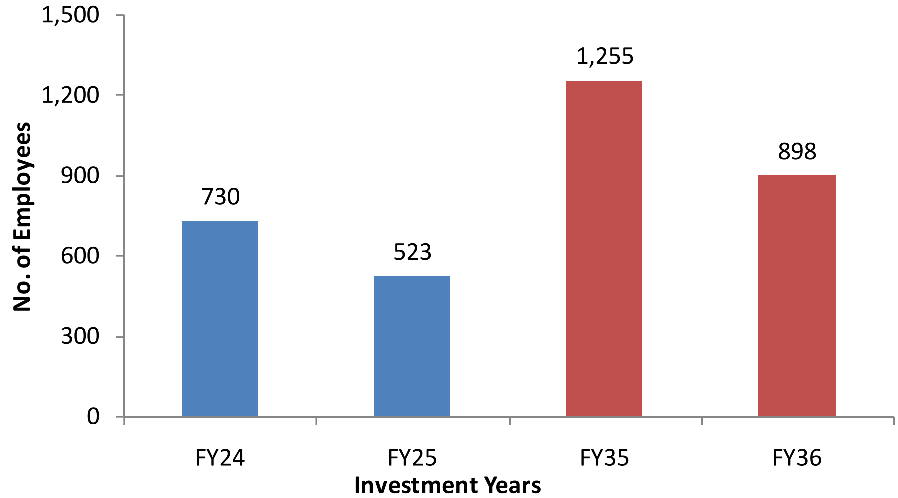


Fig. 11.5 Employment Generation in Development Period at T3

- **Operation Induced Employment Generation for Terminal 3**

Terminal3 would be operational since FY 26; hence operation induced employment generation would start from FY 26. It has been considered that traffic beyond FY 47 for each terminal would remain constant; hence, number of employees would also remain constant, i.e. 300after FY 47.

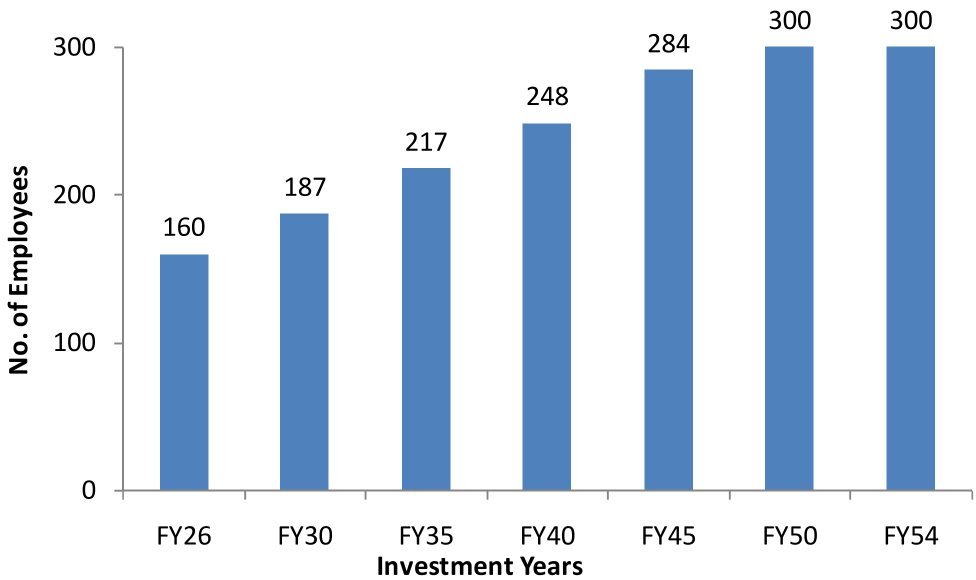


Fig. 11.6 Employment Generation in Operational Period at T3

11.5.4 Terminal 4

- **Capital Induced Employment Generation for Terminal 4**

In the below chart, Investment for construction and development of Terminal 4 would be done in four years, i.e. FY 24, FY 25, FY 35 and FY 36. Construction

Period in Phase 1 (FY 24 & FY 25) is highlighted in blue color, whereas Construction Period in Phase 2 (FY 35 & FY 36) is highlighted in red color.

Employment generation during this construction period would vary in each financial year. Based on the assumptions described above, number of employees is calculated for each investment year. In FY 24, number of employees would be 189, whereas in the following year, i.e. FY 25, number of employees would be 160. In FY 35, more employees, i.e. 252 would be hired. In FY 36, there would be 232 employees.

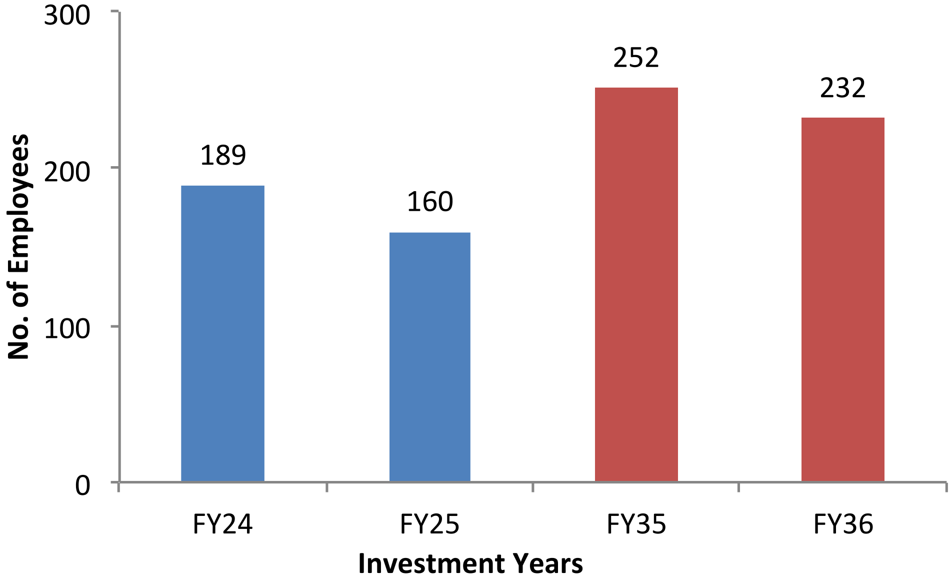


Fig. 11.7 Employment Generation in Development Period at T4

- **Operation Induced Employment Generation for Terminal 4**

As Terminal 4 would be operational since FY 26; hence operation induced employment generation would start from FY 26. The number of employees would also remain constant, i.e. 1,120 after FY 47 as the traffic have been considered constant after FY 47.

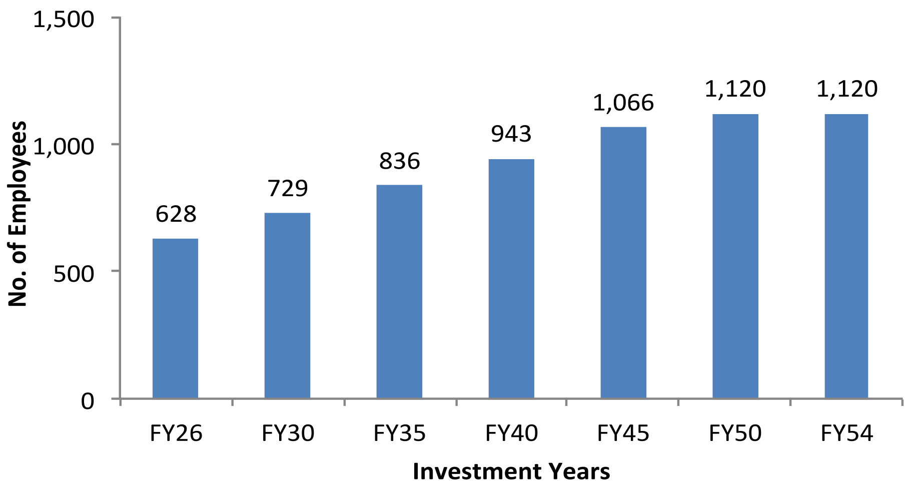


Fig. 11.8 Employment Generation in Operational Period at T4

11.5.5 Terminal 5

- **Capital Induced Employment Generation for Terminal 5**

  The below chart indicated investment for construction and development of Terminal 5. It would be done in four years, i.e. FY 24, FY 25, FY 35 and FY 36. Construction Period in Phase 1 (FY 24 & FY 25) is highlighted in blue color, whereas Construction Period in Phase 2 (FY 35 & FY 36) is highlighted in red color. Based on the assumptions described above, number of employees is calculated for each investment year. In FY 24, number of employees would be 294, whereas in the following year, i.e. FY 25, number of employees would be 246. In FY 35, more employees, i.e. 240 would be hired. In FY 36, there would be 210 employees.

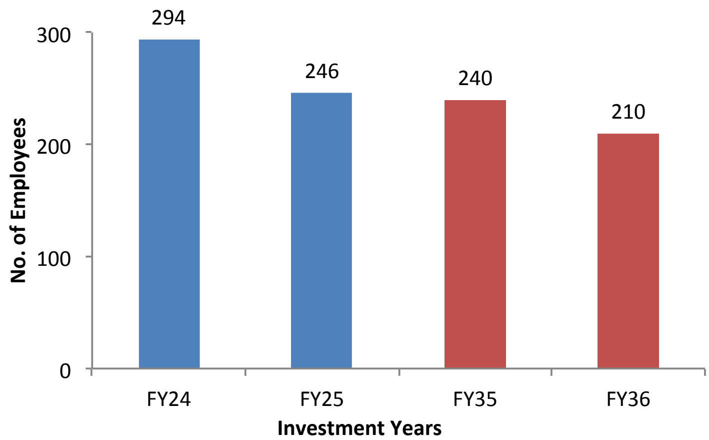


Fig. 11.9 Employment Generation in Development Period at T5

- **Operation Induced Employment Generation for Terminal 5**

  Terminal 5 would be operational since FY 26; hence operation induced employment generation would start from FY 26. The number of employees would also remain constant, i.e. 19 after FY 47 as the traffic have been considered constant after FY 47.

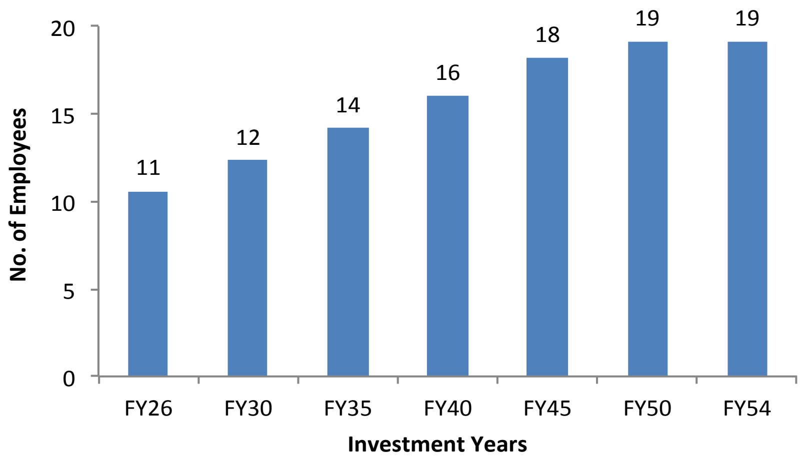


Fig. 11.10 Employment Generation in Operational Period at T5

11.5.6 Terminal 6

- **Capital Induced Employment Generation for Terminal 6**

Investment for construction and development of Terminal 6 would be done in four years, i.e. FY 24, FY 25, FY 35 and FY 36.

Employment generation during this construction period would vary in each financial year. Based on the assumptions described above, number of employees is calculated for each investment year. In FY 24, number of employees would be 198, whereas in the following year, i.e. FY 25, number of employees would be 169. In FY 35 also, number of employees would be169. In FY 36, there would be 237 employees.

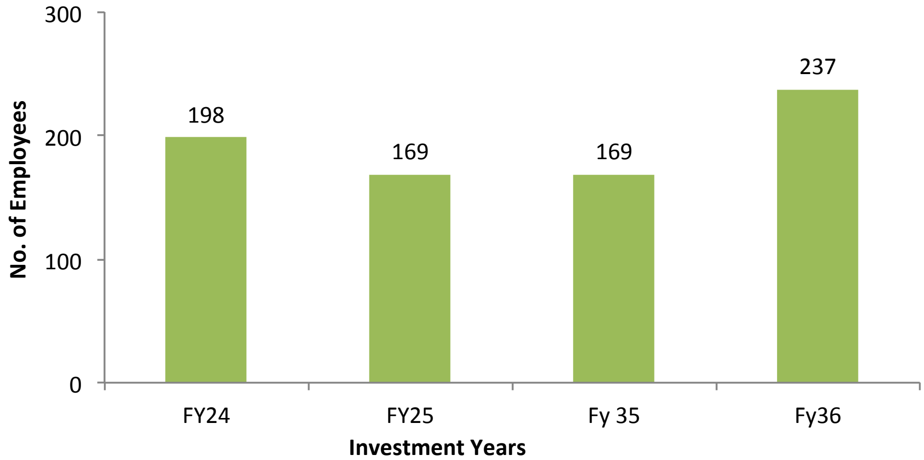


Fig. 11.11 Employment Generation in Development Period at T6

- **Operation Induced Employment Generation for Terminal 6**

As Terminal 6 would be operational since FY 26; hence operation induced employment generation would start from FY 26. The number of employees for FY 26 would be 193; it would be increased to 831 in FY 47 and would remain constant afterwards.

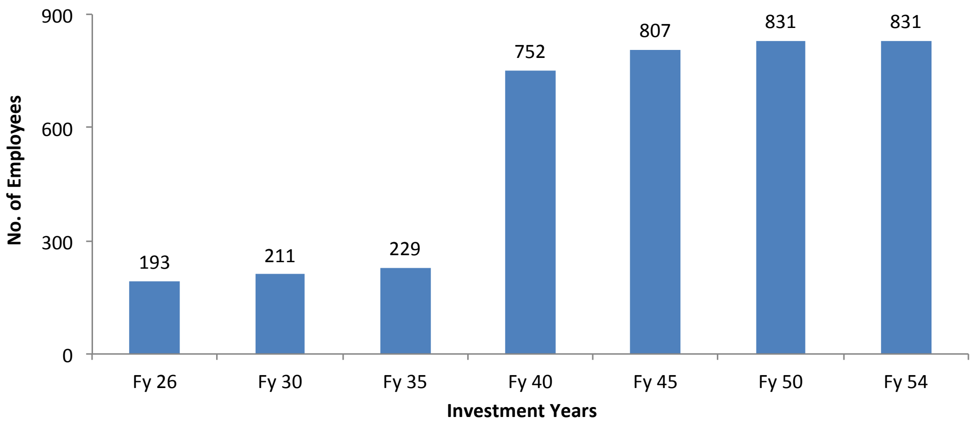


Fig. 11.12 Employment Generation in Operational Period at T6

11.5.7 Terminal 7

- **Capital Induced Employment Generation for Terminal 7**

Terminal 7 would be developed by FY 37. Investment for construction and development of Terminal 7 would be done in two years, i.e. FY 35 and FY 36.

Employment generation during this construction period would vary in each financial year. In FY 35, 923 employees would be hired. In FY 36, number of employees would reduce. There would be 722 employees in FY 36.

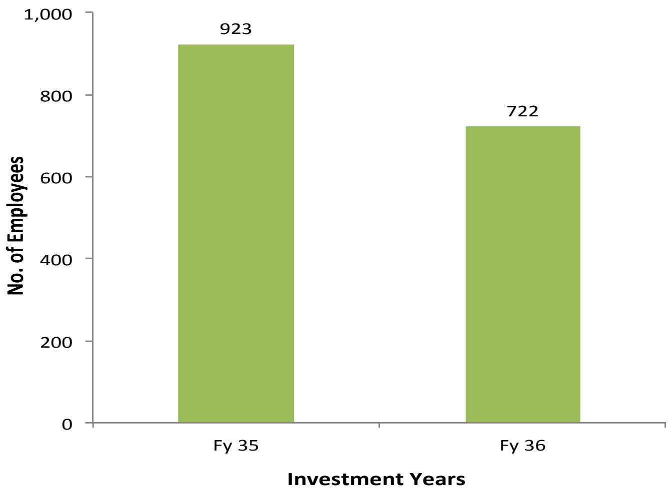


Fig. 11.13 Employment Generation in Development Period at T7

- **Operation Induced Employment Generation for Terminal 7**

Terminal 7 would be operational since FY 37; thus operation induced employment generation would start from FY 37. Due to heavy traffic at Terminal 7, number of employees in FY 37 would be 10,196, which would increase to 12,857 in FY 47. After FY 47, this number would remain constant.

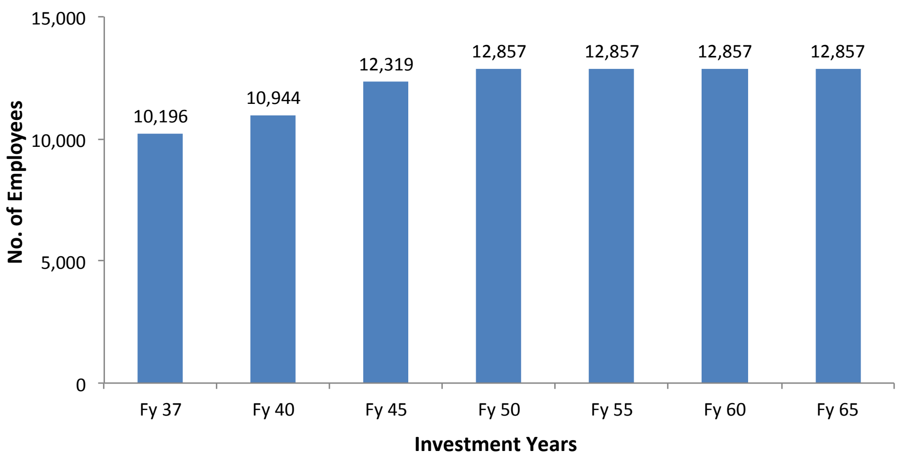


Fig. 11.14 Employment Generation in Operational Period at T7

11.5.8 Terminal 8

- **Capital Induced Employment Generation for Terminal 8**

Investment for construction and development of Terminal 8 would be done in four years, i.e. FY 24, FY 25, FY 35 and FY 36. Employment generation during this construction period would vary in each financial year. Based on the assumptions described above, number of employees is calculated for each investment year. In FY 24, number of employees would be 331, whereas in the following year, i.e. FY 25, number of employees would be 319. In FY 35, number of employees would be143. In FY 36, number of employees would reduce to 95.

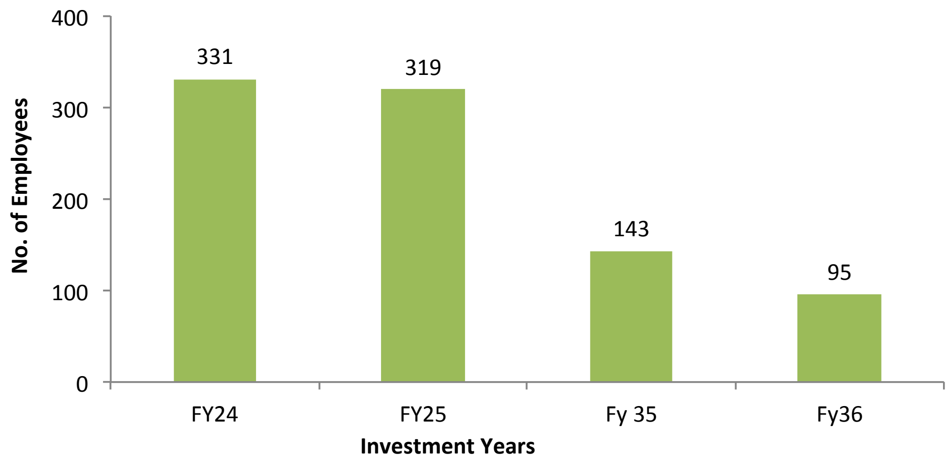


Fig. 11.15 Employment Generation in Development Period at T8

- **Operation Induced Employment Generation for Terminal 8**

Terminal 8 would be operational since FY 26; hence operation induced employment generation would start from FY 26. It has been considered that traffic beyond FY 47 for each terminal would remain constant; hence, number of employees would also remain constant, i.e. 831 after FY 47.

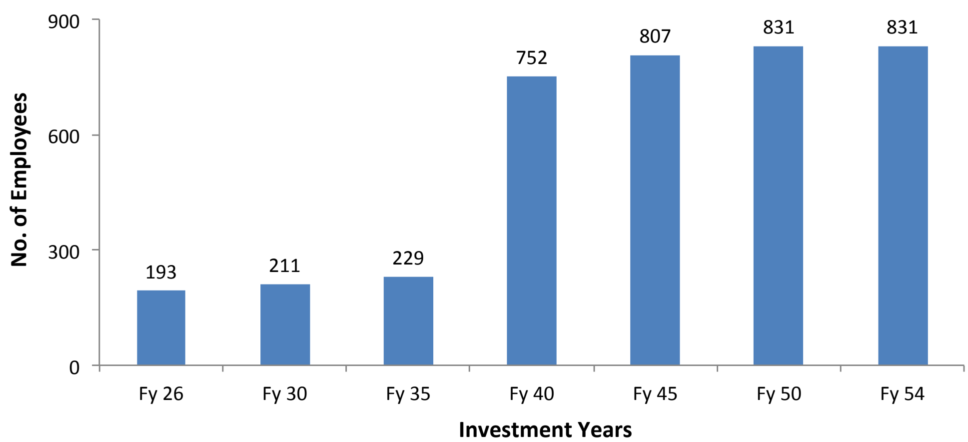


Fig. 11.16 Employment Generation in Operational Period at T8

11.5.9 Fairway

- **Capital Induced Employment Generation for Fairway**

As depicted in the below chart, Investment for construction and development of Fairway would be done in 3 Phases, i.e. FY21-FY25, FY27-31 & FY32-36. Construction Period of terminal in Phase 1 is FY24 & FY25, in Phase 2 is FY30 & FY31 and in Phase 3 is FY35 & FY36.

Employment generation during this construction period would vary in each financial year. Based on the assumptions described above, number of employees is calculated for each investment year. During FY 21-25, number of employees would be 5,468 where as during FY27-FY31 would be 4,382. During FY32-36,6,368 employees would be hired.

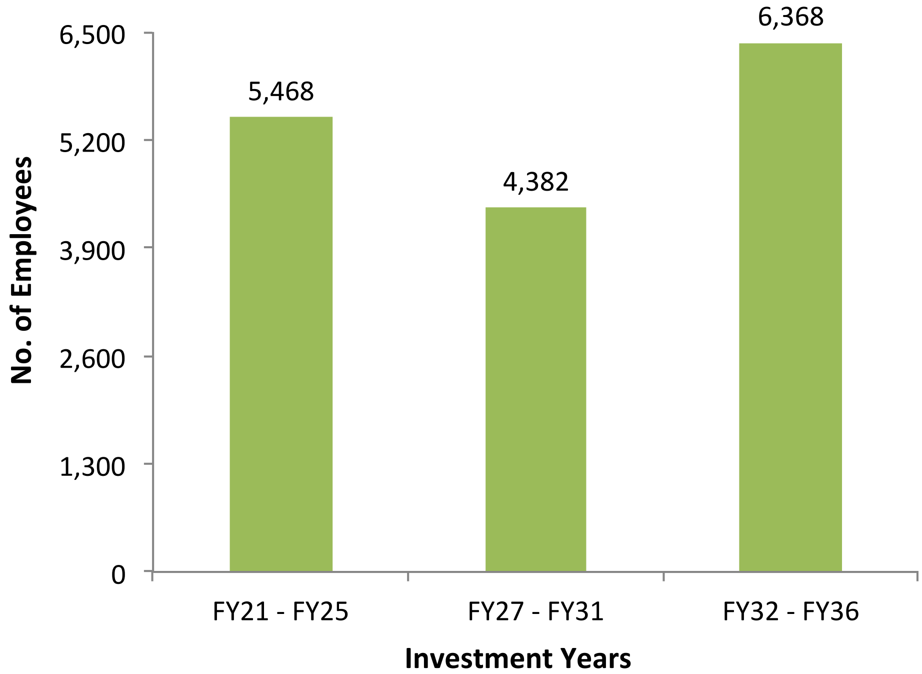


Fig. 11.17 Employment Generation in Development Period -Fairway

- **Operation Induced Employment Generation for Fairway**

Fairway would be operational since FY 26; hence operation induced employment generation would start from FY 26. In FY 26, number of employees for operations of fairway would be 1,155. It has been considered that traffic beyond FY 47 for each terminal would remain constant; hence, number of employees for fairway would also remain constant, i.e. 21,885 after FY 47.

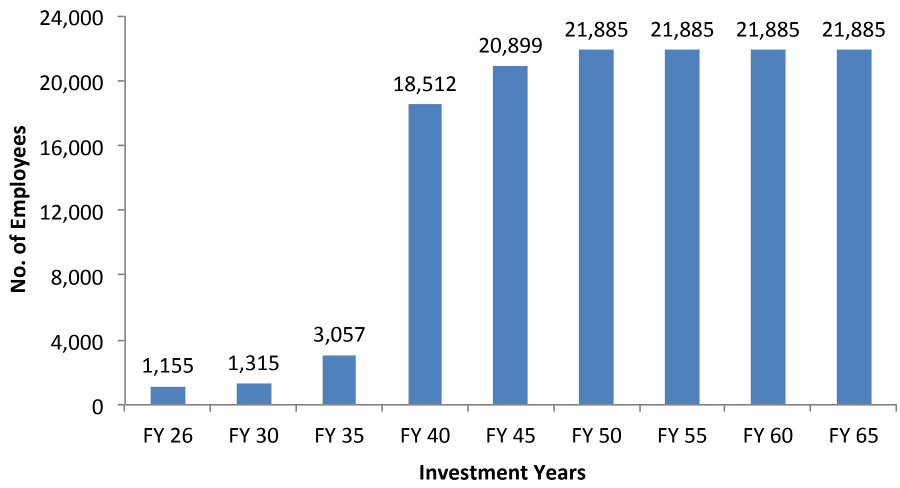


Fig.11.18 Employment Generation in Operational Period - Fairway

11.5.10 Cumulative Fairway & Terminal – Phase 1 Model

- **Capital Induced Employment Generation for Cumulative Fairway & Terminals**

As depicted in the below chart, Investment for construction and development of Fairway & Terminal Phase 1 Model would be done in FY21, FY22, FY23, FY 24, FY 35 and FY 36. Employment generation during this construction period would vary in each financial year. Based on the assumptions described above, number of employees is calculated for each investment year. In FY 21-23, number of employees would be 5,468 each year, whereas in FY 24, number of employees would be 7,172. In FY 25, there would be6,797employees. Number of employees would reduce in FY 35 and FY 36.

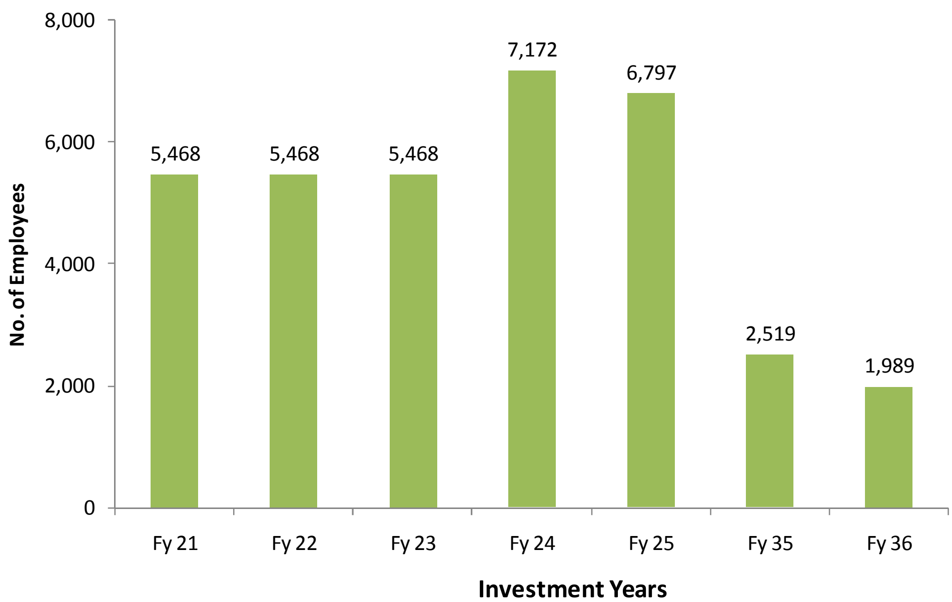


Fig. 11.19 Employment Generation in Development Period at Phase 1 Model

- **Operation Induced Employment Generation for Fairway & Terminals**

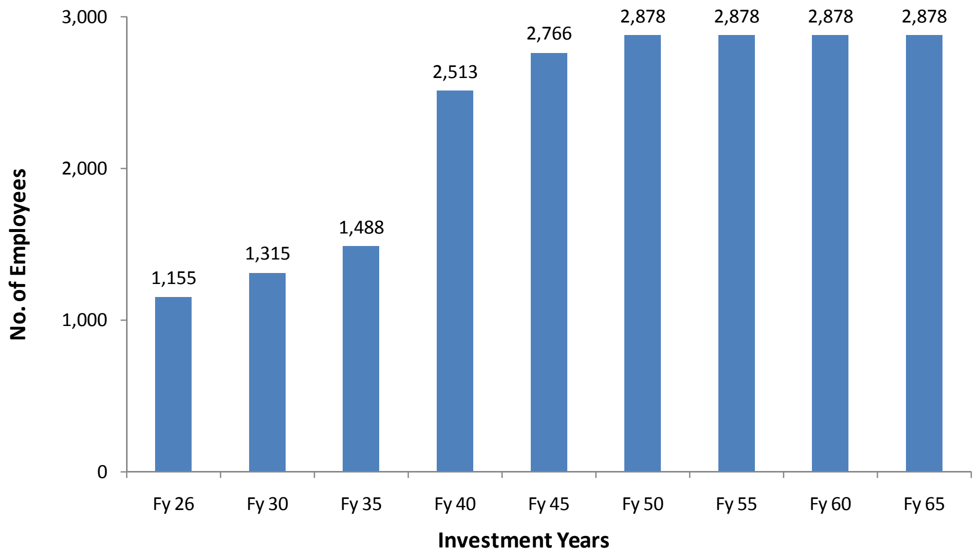


Fig. 11.20 Employment Generation in Operational Period at Phase 1 Model

11.5.11 Cumulative Fairway & Terminal – Phase 2 Model

- **Capital Induced Employment Generation for Cumulative Fairway & Terminals**

Employment generation during this construction period would vary in each financial year. Based on the assumptions described above, number of employees is calculated for each investment year. In FY 27, number of employees would be 4,382, whereas in FY 30, number of employees would be 4,667. In FY 31, 4,616employees would be hired. In FY 35 and FY 36, number of employees would reduce, i.e. 241 and 203 respectively.

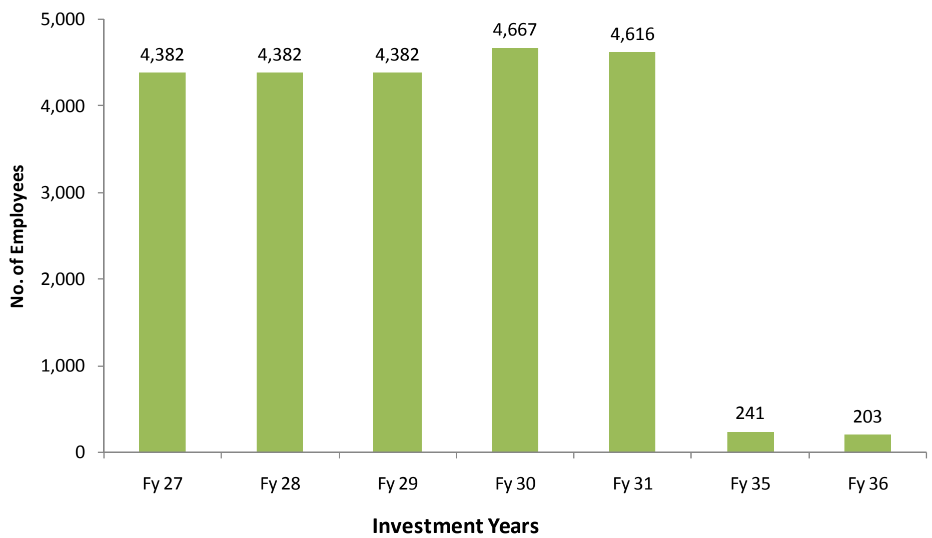


Fig. 11.21 Employment Generation in Development Period at Phase 2 Model

- **Operation Induced Employment Generation for Fairway & Terminals**

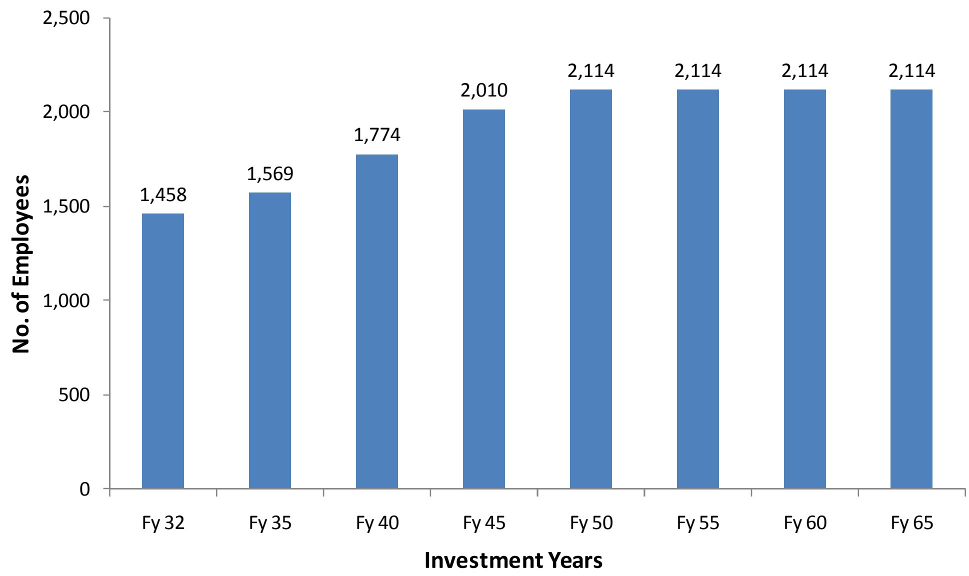


Fig. 11.22 Employment Generation in Operational Period at Phase 2 Model

11.5.12 Cumulative Fairway & Terminal – Phase 3 Model

- **Capital Induced Employment Generation for Cumulative Fairway & Terminals**

  Employment generation during this construction period would vary in each financial year. Based on the assumptions described above, number of employees is calculated for each investment year. In FY 32, number of employees would be 6,368, whereas it would increase to 7,488 in FY 36.

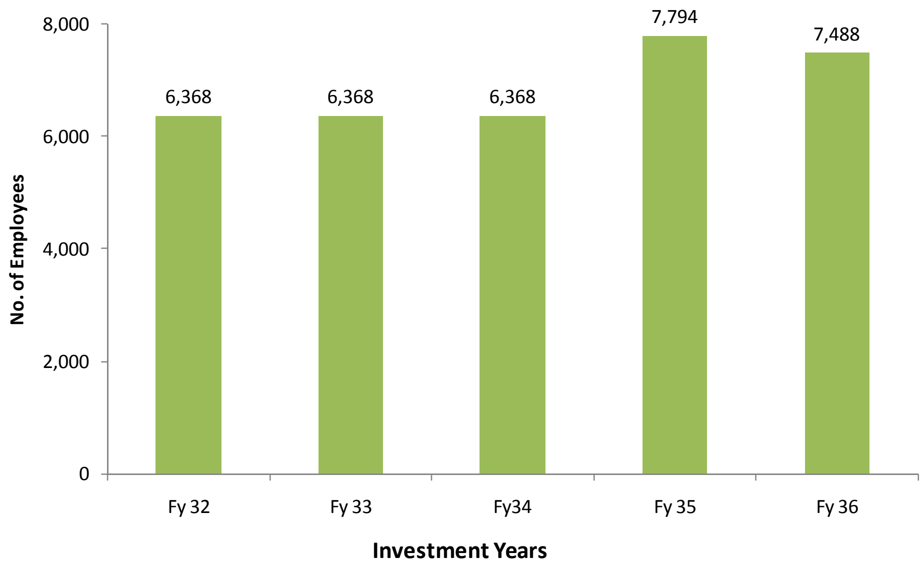


Fig. 11.23 Employment Generation in Development Period at Phase 3 Model

- **Operation Induced Employment Generation for Fairway & Terminals**

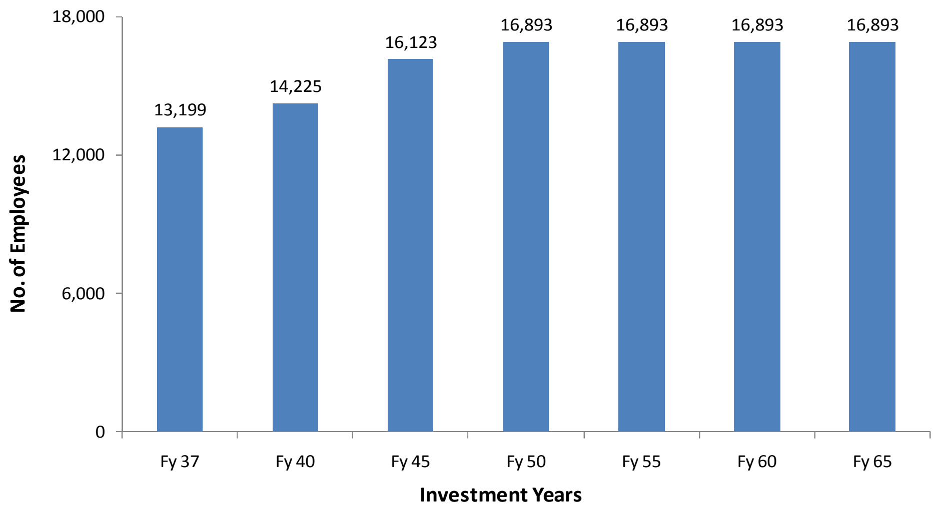


Fig. 11.24 Employment Generation in Operational Period at Phase 3 Model

11.6 Fuel savings due to Inland waterway transportation

IWT, being a fuel efficient mode of transportation, would generate enormous fuel savings compared to the existing modes of road and railway. According to IWAI, following are the fuel consumption details of different modes of transportation.

- Roadway - 0.0313 litre/T-km (for truck with 16 MT carrying capacity)
- Railway - 0.0089 litre/T-km (for rake with 40 wagons, 2,200 MT carrying capacity)
- IWT- 0.0048 litre/T-km (for vessel with 2,000 MT carrying capacity)

As shown above, inland waterway transportation consumes least fuel compared to roadway and railway. Road transport, in particular, depends exclusively on fossil fuels which are not only polluting, but also finite in character. The continued use of such fuel would certainly lead to depletion of existing reserves. IWT is relevant for saving fuel.

11.6.1 Terminal 1

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The below graph depicts fuel saving cost after Terminal 1 becomes operational. For calculating fuel saving cost, it is assumed that 1 Litre of fuel would be used to move 105 Tonne cargo per kilometre (T-Km) by IWT, whereas by railway 85 T-Km could be moved. Roadway is not considered for comparison of fuel consumption because most of the targeted traffic for NW 110 is transported using railway at present. For Calculation, it is considered that fuel price is INR 69.40/ Litre. Fuel saving cost in the below graph is based on the projected traffic, which would be handled at Terminal 1. It has been considered that traffic beyond FY 47 for each terminal would remain constant. Hence, after FY 47, fuel saving cost would also remain constant.

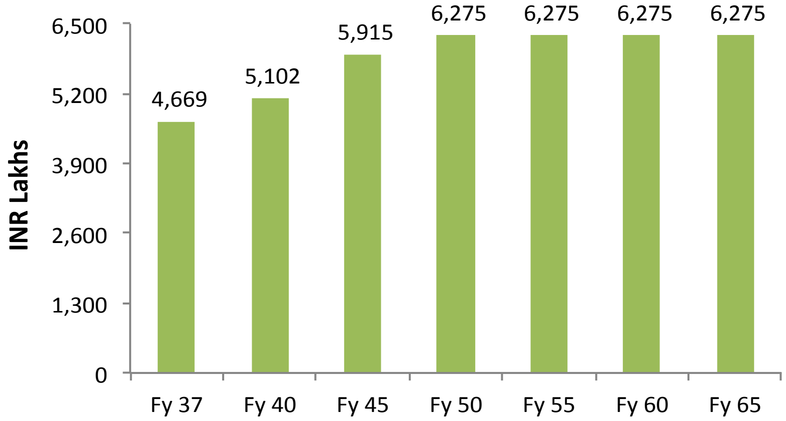


Fig. 11.25 Fuel Saving at T1

11.6.2 Terminal 2

Fuel saving cost in the below graph is based on the projected traffic, which would be handled at Terminal 2. For Calculation, it is considered that fuel price is INR 69.40/ Litre.

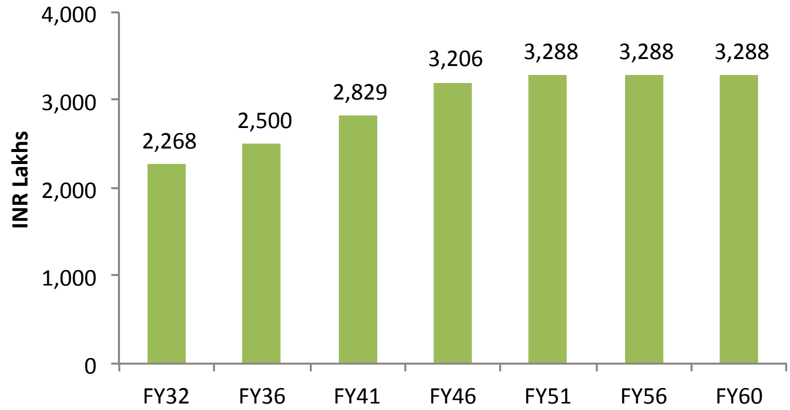


Fig. 11.26 Fuel Saving at T2

11.6.3 Terminal 3

Fuel saving cost in the below graph is based on the projected traffic, which would be handled at Terminal 3. For Calculation, it is considered that fuel price is INR 69.40/ Litre.

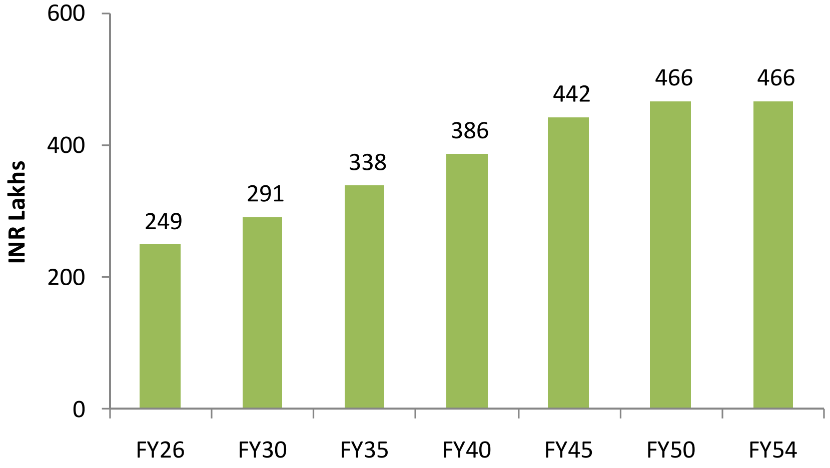


Fig. 11.27 Fuel Saving at T3

11.6.4 Terminal 4

Fuel saving cost in the below graph is based on the projected traffic, which would be handled at Terminal 4. It has been considered that traffic beyond FY 47 for each terminal would remain constant. Hence, after FY 47, fuel saving cost would also remain constant.

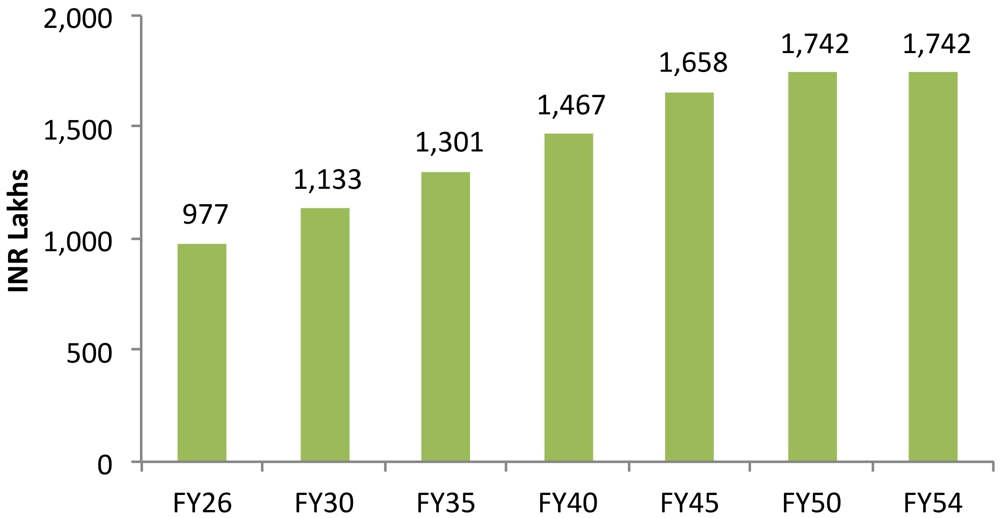


Fig. 11.28 Fuel Saving at T4

11.6.5 Terminal 5

The below chart indicates the fuel saving in terms of cost at Terminal 5.Fuel saving cost in the below graph is based on the projected traffic, which would be handled at Terminal 5.

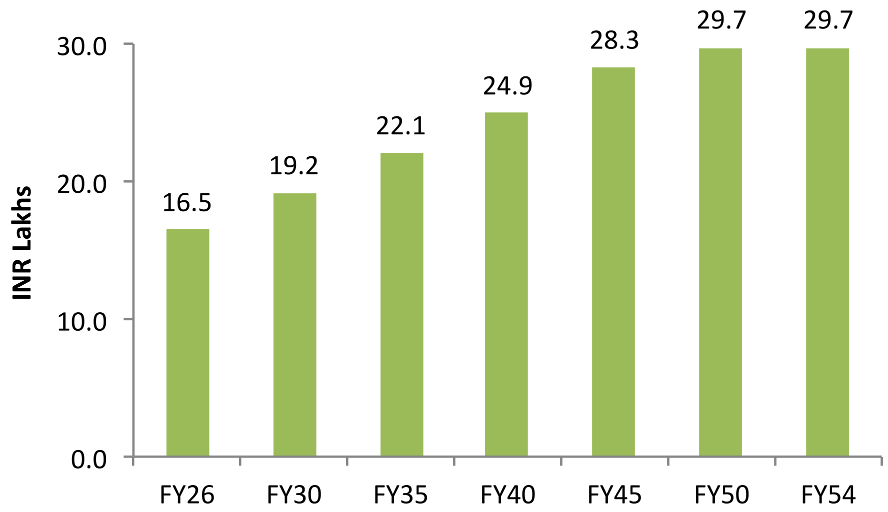


Fig. 11.29 Fuel Saving at T5

11.6.6 Terminal 6

Fuel saving cost in the below graph is based on the projected traffic, which would be handled at Terminal 6. It has been considered that traffic beyond FY 47 for each terminal would remain constant. Hence, after FY 47, fuel saving cost would also remain constant. For Calculation, it is considered that fuel price is INR 69.40/ Litre.

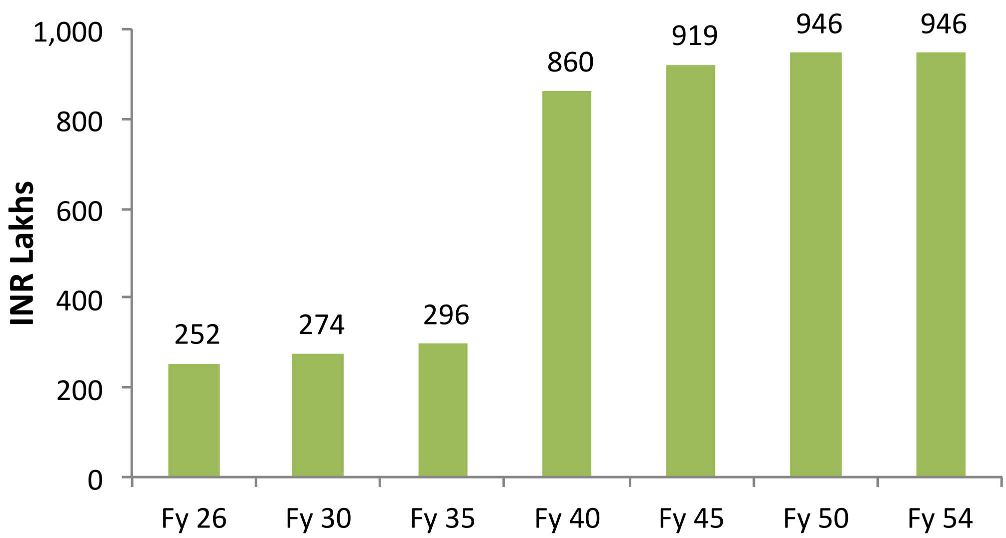


Fig. 11.30 Fuel Saving at T6

11.6.7 Terminal 7

Fuel saving cost in the below graph is based on the projected traffic, which would be handled at Terminal 7. It has been considered that traffic beyond FY 47 for each terminal would remain constant. Hence, after FY 47, fuel saving cost would also remain constant.

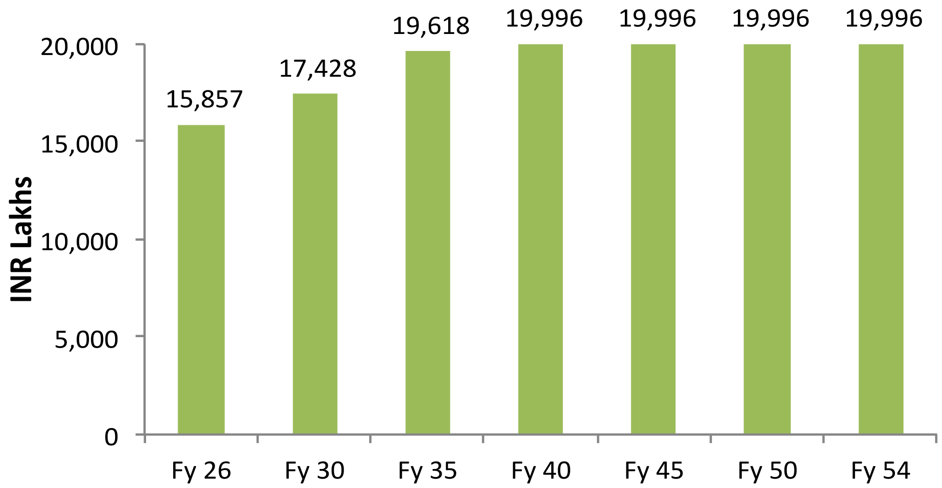


Fig. 11.31 Fuel Saving at T7

11.6.8 Terminal 8

The below graph depicts fuel saving cost after Terminal 8 becomes operational. For calculating fuel saving cost, it is assumed that 1 Litre of fuel would be used to move 105 Tonne cargo per kilometre (T-Km) by IWT, whereas by railway 85 T-Km could be moved. Fuel saving cost in the below graph is based on the projected traffic, which would be handled at Terminal 8. It has been considered that traffic beyond FY 47 for each terminal would remain constant. Hence, after FY 47, fuel saving cost would also remain constant.

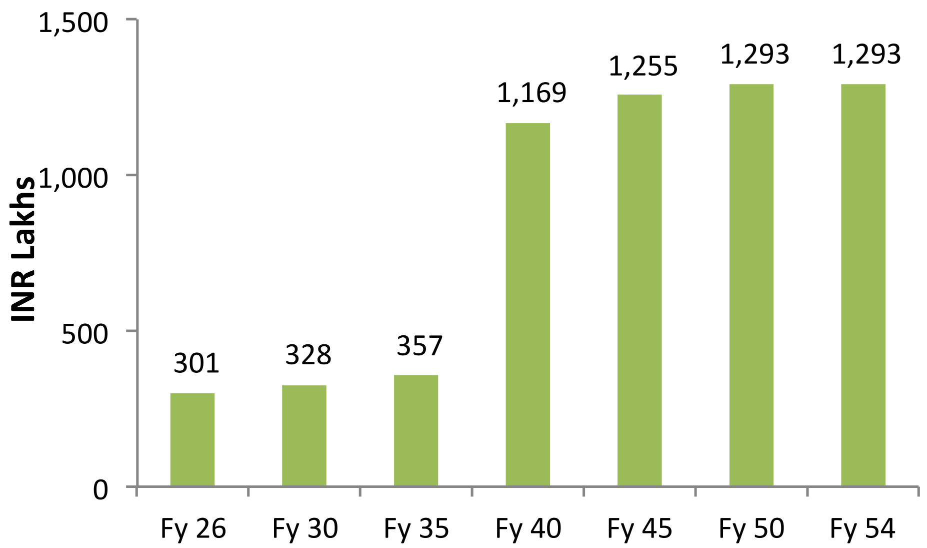


Fig. 11.32 Fuel Saving at T8

11.6.9 Fairway

Fuel saving cost in the below graph is based on the projected traffic, which would be handled at Fairway. It has been considered that traffic beyond FY 47 for each terminal would remain constant; hence, after FY 47, fuel saving cost at fairway would also remain constant.

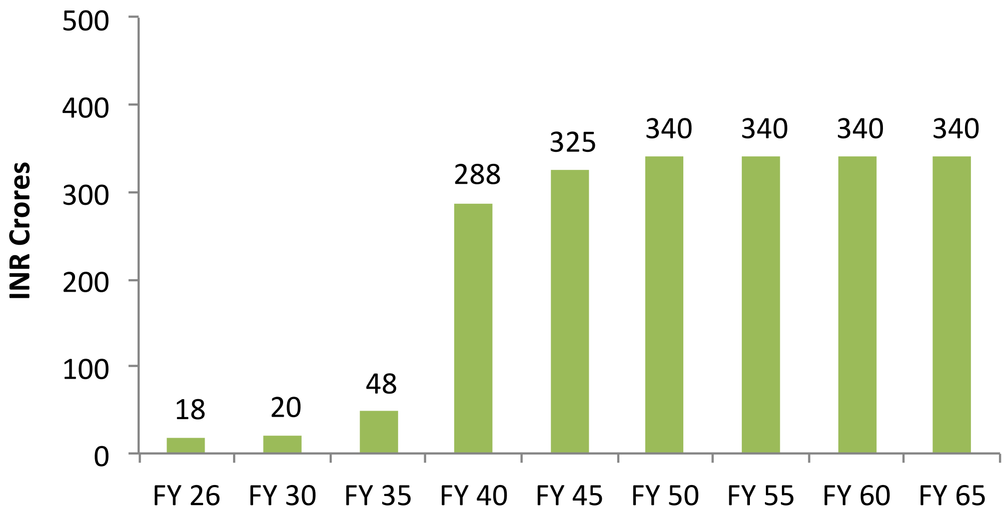


Fig. 11.33 Fuel Saving at Fairway

11.6.10 Cumulative Fairway & Terminals Phase 1 Model

Fuel saving cost in the below graph is based on the projected traffic, which would be handled in Phase 1 Model. It has been considered that traffic beyond FY 47 for each terminal would remain constant. Hence, after FY 47, fuel saving cost would also remain constant.

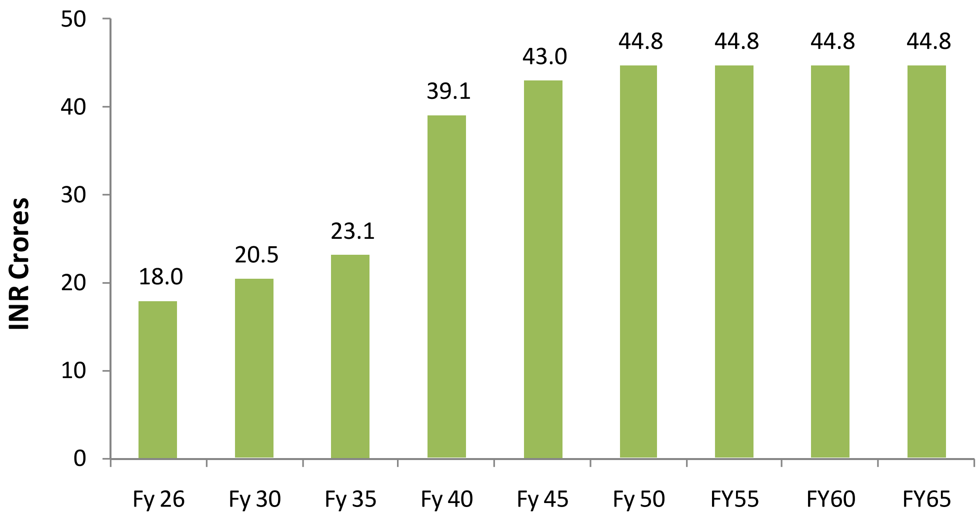


Fig. 11.34 Fuel Saving in Phase 1 Model

11.6.11 Cumulative Fairway & Terminals Phase 2 Model

Fuel saving cost in the below graph is based on the projected traffic, which would be handled at Phase 2 Model.

Fig. 11.35 Fuel Saving in Phase 2 Model

11.6.12 Cumulative Fairway & Terminals Phase 3 Model

The below graph depicts fuel saving cost after Phase 3 Model of Cumulative development becomes operational. For calculating fuel saving cost, it is assumed that 1 Litre of fuel would be used to move 105 Tonne cargo per kilometre (T-Km) by IWT, whereas by railway 85 T-Km could be moved. Roadway is not considered for comparison of fuel consumption because most of the targeted traffic for NW 110 is transported using railway at present. For Calculation, it is considered that fuel price is INR 69.40/ Litre. Fuel saving cost in the below graph is based on the projected traffic, which would be handled at Phase 3 Model.

Fig. 11.36 Fuel Saving in Phase 3 Models

11.7 Carbon credit earned due to savings on fuel consumption in IWT movement

Use of NW 110 would help to reduce social and environmental impacts such as pollution, created by other modes of transportation. The amount of CO_2 emissions, which are particularly relevant for climate change, can be directly derived from the amount of fuel consumption. These emissions result from burning of fuel by trucks, diesel locomotives as well as inland vessels. At present, electricity-powered railway transport causes lower emissions of CO_2 and pollutants. The highest CO_2 emissions are caused by road trucks. IWT is relevant in present scenario when climate and environment protection is a matter of grave concern. IWT causes less CO_2 emissions compared to roadways. A shift in modal split from road to IWT would have a dramatic impact on overall CO_2 emissions.

Increase in fuel cost and road congestion is two major factors that could make IWT route attractive compared to roadway/railways. Low emission of air pollutants compared to roadways is a major strength of inland waterway. Savings on fuel (diesel) consumption have a commensurate savings of CO_2 emission. This CO_2 equivalence savings on fuel consumption when quantified using market instruments is carbon credit earned.

For IWT, the volume of cargo transported as well as the type of engine or propulsion used determines the specific emissions and thus the environmental impacts for a trip. The more cargo is transported by one vessel per trip, higher the environmental benefits due to less carbon emission.

The Shadow carbon pricing is used for calculating reduction in carbon emission in terms of value, as the Shadow price of carbon would impact the economic aspect of the project (NW 110). For calculating carbon emission by using IWT and Railway, following assumptions are considered. Roadway is not considered for comparison of carbon emission because most of the targeted traffic for NW 110 is transported using railway at present. Assumptions for calculation of Carbon emission and saving in fuel price using IWT is presented below.

- ✓ Carbon Emission by Railway- 13.3 gram (g.) CO_2/ Tonne –Km
- ✓ Carbon Emission by IWT - 6 g. CO_2 / Tonne –Km
- ✓ Carbon Shadow price- USD 20 Per Tonne (Exchange Rate - INR 67)

11.7.1 Terminal1

The below graph depicts reduction in carbon emission in terms of value due to less pollution. Measuring the cost of emission is complex. However, the analysis in this section is useful to assess the broad economic effects of emissions using IWT on NW 110.

Reduction in carbon emission in terms of value in the below graph is based on the projected traffic, which would be handled at Terminal 1. It has been considered that traffic beyond FY 47 for each terminal would remain constant. Hence, after FY 47, reduction in carbon emission in terms of value would also remain constant.

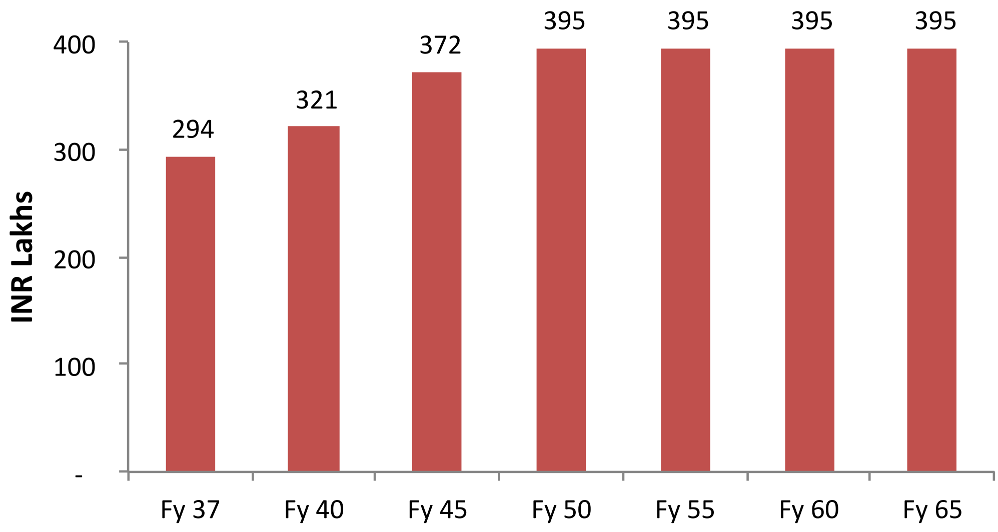


Fig. 11.37 Reduction in Carbon Emission at T1

11.7.2 Terminal 2

The below chart indicates reduction in carbon emission in terms of value due to less pollution. However, the analysis in this section for terminal 2 is required to assess the broad economic effects of emissions using IWT on NW 110. Reduction in carbon emission in terms of value in the below graph is based on the projected traffic, which would be handled at Terminal 2. It has been considered that traffic beyond FY 47 for each terminal would remain constant. Hence, after FY 47, reduction in carbon emission in terms of value would also remain constant.

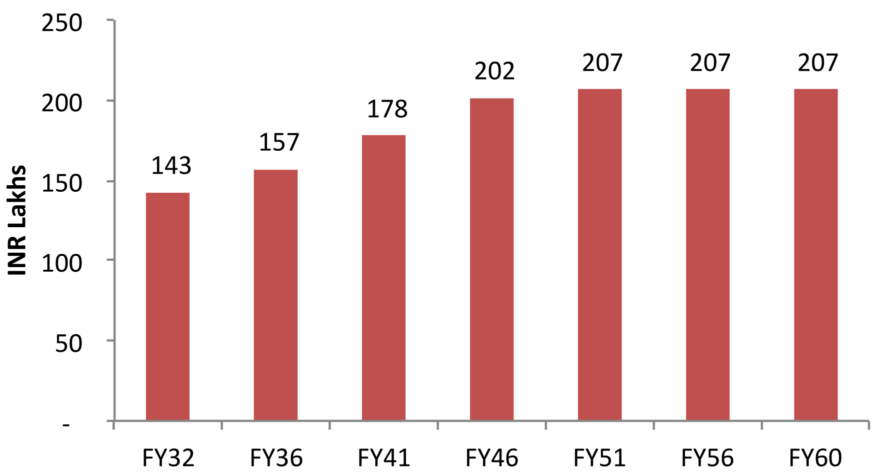


Fig. 11.38 Reduction in Carbon Emission at T2

11.7.3 Terminal 3

Reduction in carbon emission in terms of value in the below graph is based on the projected traffic, which would be handled at Terminal 3. It has been considered that traffic beyond FY 47 for each terminal would remain constant. Hence, after FY 47, reduction in carbon emission in terms of value would also remain constant.

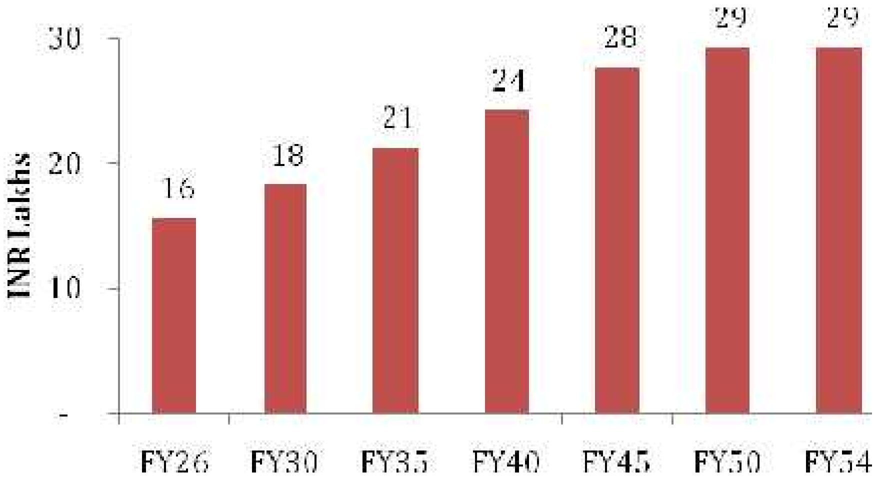


Fig. 11.39 Reduction in Carbon Emission at T3

11.7.4 Terminal 4

Reduction in carbon emission in terms of value in the below graph is based on the projected traffic, which would be handled at Terminal 4.

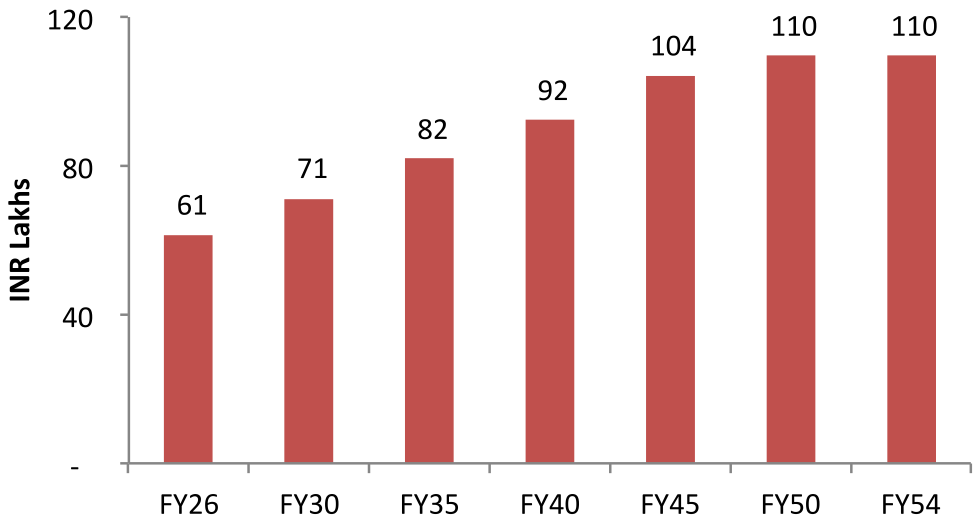


Fig. 11.40 Reduction in Carbon Emission at T4

11.7.5 Terminal 5

Reduction in carbon emission in terms of value in the below graph is based on the projected traffic, which would be handled at Terminal 5.

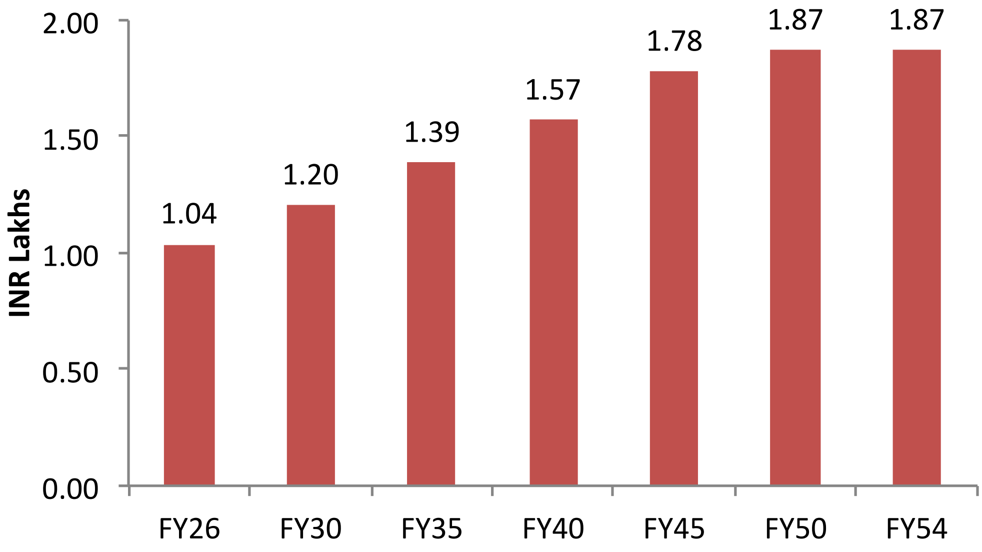


Fig. 11.41 Reduction in Carbon Emission at T5

11.7.6 Terminal 6

Reduction in carbon emission in terms of value in the below graph is based on the projected traffic, which would be handled at Terminal 6.

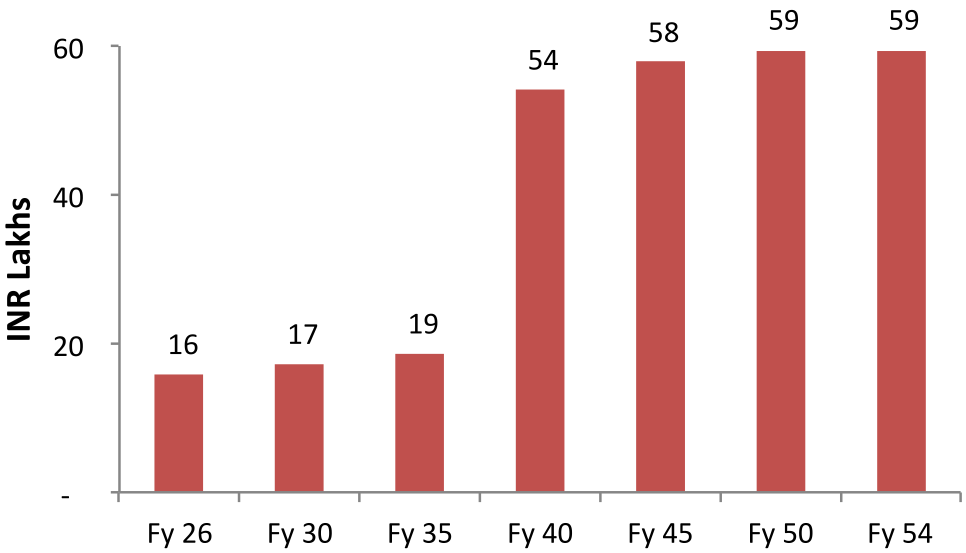


Fig. 11.42 Reduction in Carbon Emission at T6

11.7.7 Terminal 7

Reduction in carbon emission in terms of value in the below graph is based on the projected traffic, which would be handled at Terminal 7.

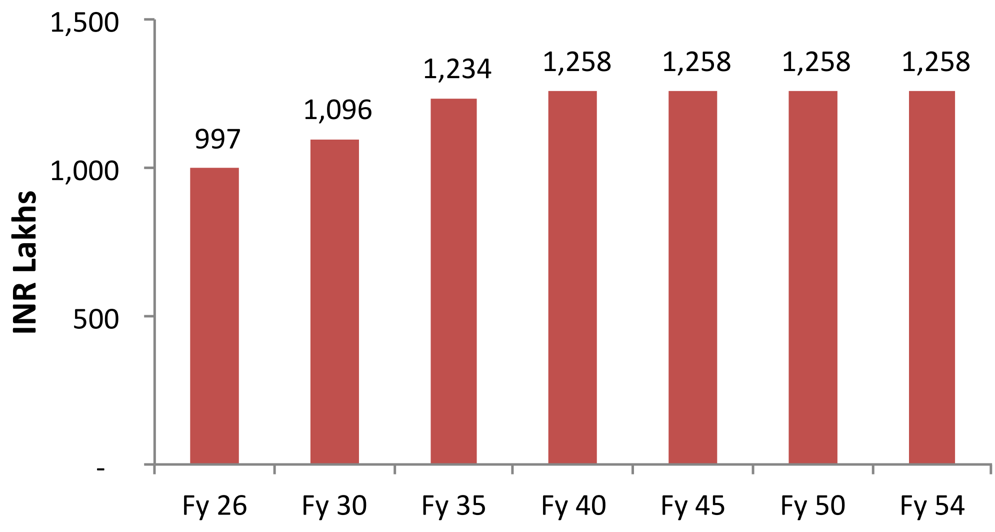


Fig. 11.43 Reduction in Carbon Emission at T7

11.7.8 Terminal 8

Reduction in carbon emission in terms of value in the below graph is based on the projected traffic, which would be handled at Terminal 8.

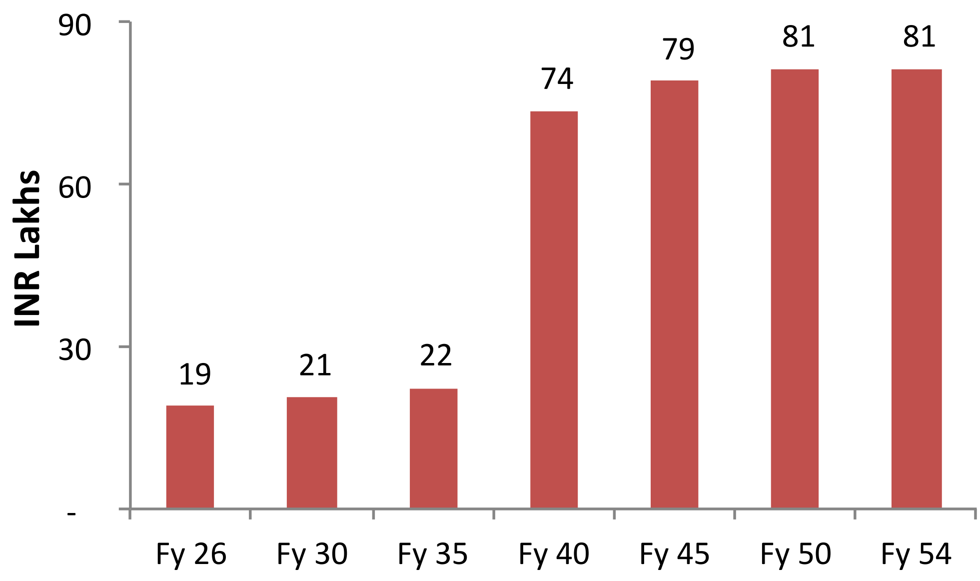


Fig. 11.44 Reduction in Carbon Emission at T8

11.7.9 Fairway

The below graph depicts reduction in carbon emission in terms of value due to less pollution. Measuring the cost of emission is complex. However, the analysis in this section is useful to assess the broad economic effects of emissions using IWT on NW 110. Reduction in carbon emission in terms of value in the below graph is based on the projected traffic, which would be handled by entire fairway. It has been considered that traffic beyond FY 47 would remain constant. Hence, after FY 47, reduction in carbon emission in terms of value would also remain constant.

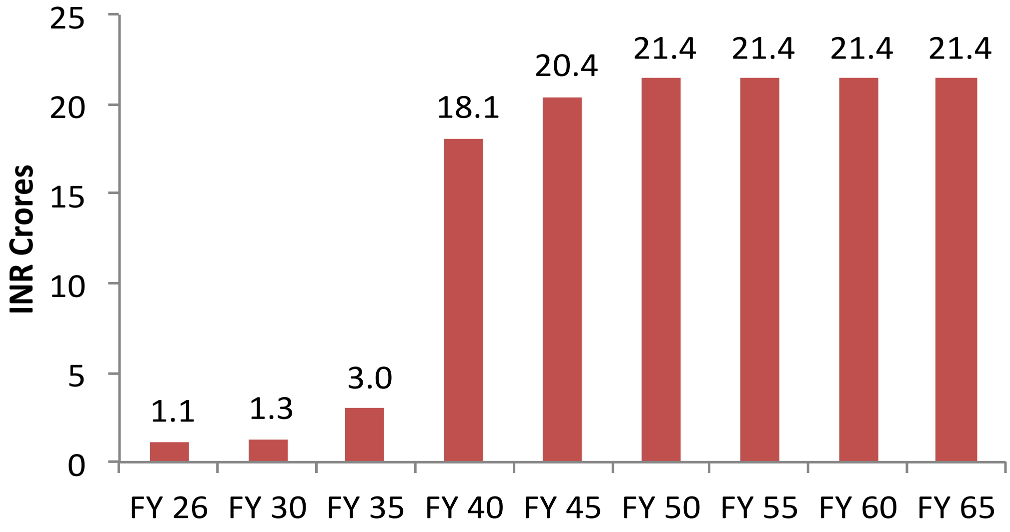


Fig. 11.45 Reduction in Carbon Emission IN Fairway Development

11.7.9.1 Cumulative Fairway & Terminals Phase 1 Model

The below graph depicts reduction in carbon emission in terms of value due to less pollution. Measuring the cost of emission is complex. However, the analysis in this section is useful to assess the broad economic effects of emissions using IWT on NW 110. Reduction in carbon emission in terms of value in the below graph is based on the projected traffic, which would be handled Phase 1 Model. It has been considered that traffic beyond FY 47 would remain constant. Hence, after FY 47, reduction in carbon emission in terms of value would also remain constant.

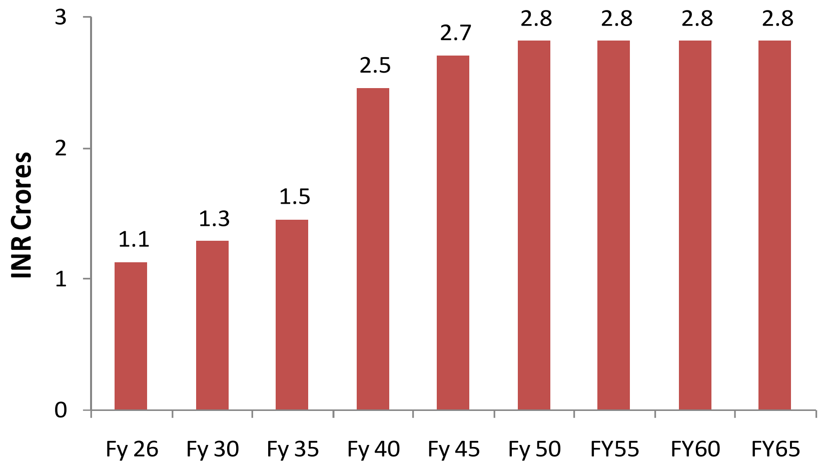


Fig. 11.46 Reduction in Carbon Emission in Phase 1 Model

11.7.9.2 Cumulative Fairway & Terminals Phase 2 Model

The below graph depicts reduction in carbon emission in terms of value due to less pollution. Measuring the cost of emission is complex. However, the analysis in this section is useful to assess the broad economic effects of emissions using IWT on NW 110. Reduction in carbon emission in terms of value in the below graph is based on the projected traffic, which would be handled Phase 2 Model. It has been considered that traffic beyond FY 47 would remain constant. Hence, after FY 47, reduction in carbon emission in terms of value would also remain constant.

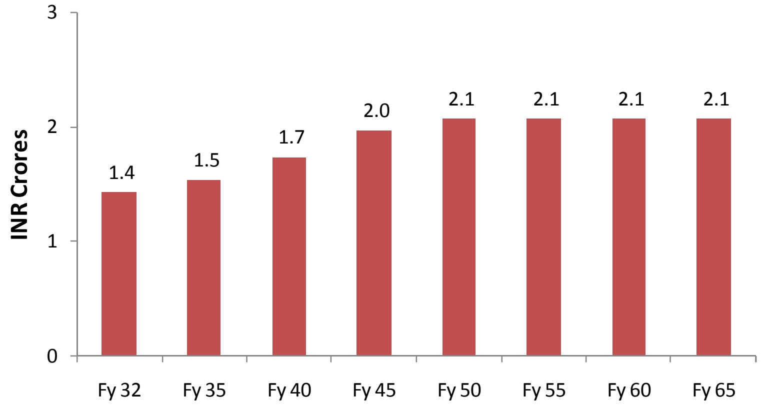


Fig. 11.47 Reduction in Carbon Emission in Phase 2 Model

11.7.9.3 Cumulative Fairway & Terminals Phase 3 Model

The below graph depicts reduction in carbon emission in terms of value due to less pollution. Measuring the cost of emission is complex. Reduction in carbon emission in terms of value in the below graph is based on the projected traffic, which would be handled Phase 3 Model. It has been considered that traffic beyond FY 47 would remain constant. Hence, after FY 47, reduction in carbon emission in terms of value would also remain constant.

Fig. 11.48 Reduction in Carbon Emission in Phase 3 Model

11.8 Other Benefits such as reduction in Accidents, Noise etc.

There are other benefits associated with transportation activities and these benefits have been identified in terms of average external costs due to accidents, noise pollution, infrastructure, wear and tear cost, congestion cost etc. Development of NW 110 would help to reduce external cost of existing transport system. IWT has significant advantages over road in terms of average external cost, which is lower compared to roadway.

Advantage of using IWT is increasing safety of transportation by developing infrastructure as per latest standards, such as proper concrete approach roads to ensure smooth traffic flow. IWT mode has negligible cost associated with accidents, noise pollution and congestion. In case of road, external costs due to accidents, air pollution and congestion are quite significant. This low marginal average external cost of IWT operation is perhaps one of the strongest reason that modal shift to IWT from other modes should take place in the interests of the society. In the Indian context, this statement becomes stronger due to larger number of road accidents.

Freight transport on roads, railways and inland waterways causes noise emissions which affect populations in adjacent areas. The level of emissions varies significantly among trucks, trains and inland vessels. Both roadway and railway cause high noise emissions per unit of freight, whereas IWT causes only lower emissions.

11.9 Reduction of congestion on existing modes

Infrastructure developed on IWT route in river Yamuna would enable to divert road traffic on waterway. Inland waterway transportation reduces road congestion by undertaking load of road transport. Cities like Delhi, Agra, Mathura, Prayagraj, which are densely populated are located on banks of river Yamuna. NW 110 runs through the populated parts of cities, which create possibilities to use waterway for public transport on proposed routes. Proposed passenger ferry would connect these places by IWT. However, to have higher appeal, it is necessary that prices and timetable for users is competitive with existing modes of transportation (road/rail).

In urban areas of Delhi, where water taxi is proposed for daily commute, it might reduce road congestion and could be a preferable option instead of city buses that are unreliable due to improper timetable. This water taxi might play an important role in rush hours. Many a times, water transport is leisure oriented. But in Sweden, there are waterbus services running in Karlstad that provides both leisure and daily commuting services. NW 110 could follow the same model for handling local passengers and tourists at the same time.

11.10 Less Cost of development

The per km. cost of development of IWT is less compared to that of an equivalent length or equivalent traffic capacity of railway or highway. The maintenance cost of a waterway is also less compared to the corresponding costs for rail or road. The time taken to develop waterway routes is also negligible.

11.11 Less land occupancy

For development of railway and roadway, acquisition of land is a major hurdle. This is not the case with waterway. IWT routes are developed along existing rivers, canals and waterways. Unlike road and rail, IWT does not need to get into the complexities and problems of land acquisition. However, land would be required for development of cargo/passenger terminals on waterways. Parcels of land are usually available on the bank of the rivers. Acquisition of these lands would not be as difficult as land acquisition for longer stretch for developing railway track or highway. Huge parcel of barren or agricultural lands are available on the bank of river Yamuna. Some of these lands could be acquired for developing dirty cargo, multi-purpose or passenger terminals for NW 110.

11.12 Property uplift and regeneration

Waterfront development and new services on NW 110 such as water taxi etc. would likely to increase the property rates in nearby areas. It would also increase the appeal thereby attracting large number of residents, businessmen, and tourists in the hinterland.
Waterfront locations have been shown to raise the value of properties located close to them, in the case of residential properties by up to 20% of their value. These effects accrue to the landowners in the first instance and only occur once. However, they can help support the sustainable development of an area by increasing the desirability of a location for new residents and businesses.

Waterways have played a role in regenerating existing urban areas. By providing an attractive environment and an interesting backdrop, waterfronts of NW 110 can attract both residents and visitors.

11.13 Transportation of goods and passengers

Waterway faces tough competition from existing modes of transportation, i.e. roadway and railways. Waterways network is more preferred for transporting bulky, non-perishable goods. There are aspirations to increase the use of waterways as a transport conduit to reduce social and environmental impacts from other forms of transport. Vessels in inland waterway have bigger capacity, which facilitates transportation of more tons per km per unit of fuel than what is possible with other modes. This benefits the environment and makes IWT relatively cost-efficient. One of the main impacts of development of transport infrastructure in inland waterway has been to reduce the costs of long-distance trade. This would further make markets more integrated. One of the supply drivers for using inland waterway (NW 110) for cargo movement is changing freight costs (for example, through use of Class III, IV & VI vessels and trucks), and demand drivers include the growth of the region and variations in regional economic activity. Business efficiency of NW 110 could be increased through time savings and improved reliability for freight and logistics operations.

Inland waterway would play a key role in passenger transportation for tourism and recreational purpose. Demand-based drivers include income, population and population density, and social attitudes and other factors affecting mode choice. The demand for passenger transport using inland waterways arises from the need for journeys to work, education, consumption centres, and social needs. Users want several things from the transport system, placing different weights on their relative importance. The key characteristics, which are valued, are journey time, journey time reliability, cost, network coverage, comfort, safety and security. These factors could be addressed by IWAI while developing NW 110. This would help both intra and inter district movement on NW 110 to attract large number of passengers and tourists.

11.14 Ecosystem Services

Apart from being an environment friendly transportation method, IWT provides a range of ecosystem services, such as flood control and water transport. While these benefits are difficult to cost, they do make a contribution to sustainable economic development. In the case of NW 110, it will help in managing water movements in the defined stretch of river Yamuna throughout the year. Development of waterway on the river would also prevent occurrence of flood during monsoon.

11.15 Conclusion

There exists an urgent need to involve NW 110 development agenda under major Government policies and objectives to increase socio economic benefits offered by NW 110. By doing so, it would attain long-term sustainability and would gain a wider recognition as a waterway dedicated for transport and leisure. Government should promote carbon-sensitive policies to reduce sector emissions, which would encourage industries to opt inland waterways. Apart from being an alternate option of transportation, NW 110 would generate various economic activities such as tourism, boating, water taxi, vessel/boat building& repairs, dredging services, hydrographical survey, safety management etc. Apart from industries, NW 110 would be attractive to both local residents and to visitors/tourists. For both of these groups, planning and investment is required to maximize the level of engagement on river Yamuna.The efficiency of NW 110 could be increased by providing training to local government of districts, located on the bank of Yamuna. This would increase their knowledge of Project Management, IWT development, Terminal operation etc. Economic & social benefits of NW 110 could be further increased by following points

- Providing support and encouragement for IWT development
- Proper integration of public & private sector to create profitable situation for involved parties
- By putting emphasis on urban & rural development
- By promoting waterways
- Supporting & preserving river bank protection & conservation

There exists a need to involve both public and private sector for development and operation of inland waterway on river Yamuna. Involvement of both the sectors would ensure that the waterway is developed with all required facilities& technologies and there would be smooth operation and maintenance of the waterway. Investors could provide services specifically designed to meet some particular needs of industries, like establishing terminal facilities, parking for trucks and trailers, providing warehousing and storage facilities, operating material handling equipment such as cranes & forklifts, loaders etc. There exists huge investment opportunities in IWT system in river Yamuna. Government needs to generate public interest, encouragement and involvement in the prospects and potential inherent in the inland waterways in river Yamuna. Government needs to be determined to provide an investment friendly climate and generate policy and incentives that will encourage new investors and investments in NW 110.

11.15.1 Employment Generation

Table 11.1 Employment Generation for Cumulative Fairway + Terminal (in Numbers)

Employment Generation for Cumulative Fairway + Terminal (in Numbers)									
Years	**Fy 21 - Fy 23**	**Fy 24**	**Fy 25**	**Fy 30**	**Fy 35**	**Fy 36**	**Fy 45**	**Fy 55**	**Fy 65**
Phase 1 Model	5,468	7,172	6,797	1,315	4,007	3,510	2,766	2,878	2,878
Years	**Fy 27- Fy 29**	**Fy 30**	**Fy 31**	**Fy 32**	**Fy 35**	**Fy 36**	**Fy 45**	**Fy 55**	**Fy 65**
Phase 2 Model	4,328	4,667	4,616	1,458	1,810	1,811	2,010	2,114	2,114
Years	**Fy 32 - Fy 34**	**Fy 35**	**Fy 36**	**Fy 40**	**Fy45**	**Fy 50**	**Fy 55**	**Fy 60**	**Fy 65**
Phase 3 Model	6,368	7,794	7,488	14,225	16,123	16,893	16,893	16,893	16,893

Table 11.2 Employment Generation for Fairway (in Numbers)

Employment Generation for Fairway (in Numbers)									
Years	**Fy 21 - Fy 25**	**Fy 27 - Fy 31**	**Fy 32 - Fy 36**	**Fy 40**	**Fy45**	**Fy 50**	**Fy 55**	**Fy 60**	**FY 65**
Fairway	5,468	4,382	6,368	18,512	20,899	21,885	21,885	21,885	21,885

Table 11.3 Employment Generation for each Terminals (in Numbers)

Employment Generation for each Terminals (in Numbers)									
Phase 1									
Years	**Fy 24**	**Fy 25**	**Fy 30**	**Fy 35**	**Fy 36**	**Fy 40**	**Fy45**	**Fy 50**	**Fy 54**
Terminal 3	730	523	187	1,472	1,146	248	284	300	300
Terminal 4	189	160	729	1,088	1,089	943	1,066	1,120	1,120
Terminal 5	294	246	12	254	225	16	18	19	19
Terminal 6	198	169	211	398	470	752	807	831	831
Terminal 8	331	319	211	372	328	752	807	831	831
Phase 2									
Years	**Fy 30**	**Fy 31**	**Fy 35**	**Fy 36**	**Fy 40**	**Fy 45**	**Fy 50**	**Fy 55**	**Fy 60**

Employment Generation for each Terminals (in Numbers)									
Terminal 2	255	314	1,791	1,800	1,774	2,010	2,114	2,114	2,114
Phase 3									
Years	Fy 35	Fy 36	Fy 37	Fy 40	Fy 45	Fy 50	Fy 55	Fy 60	Fy 65
Terminal 1	386	318	3,003	3,281	3,803	4,035	4,035	4,035	4,035
Terminal 7	923	722	10,196	10,944	12,319	12,857	12,857	12,857	12,857

11.15.2 Reduction in Carbon Emission

Table 11.4 Reduction in Carbon Emission – Cumulative Fairway + Terminal (INR Crores)

Reduction in Carbon Emission – Cumulative Fairway + Terminal (INR Crores)									
Years	**Fy 26**	**Fy 30**	**Fy 35**	**Fy 40**	**Fy 45**	**Fy 50**	**Fy 55**	**Fy 60**	**Fy 65**
Phase 1 Model	1.10	1.30	1.50	2.50	2.70	2.80	2.80	2.80	2.80
Years	**Fy 32**	**Fy 35**	**Fy 40**	**Fy 45**	**Fy 50**	**Fy 55**	**Fy 60**	**Fy 61**	**Fy 65**
Phase 2 Model	1.40	1.50	1.70	2.00	2.10	2.10	2.10	2.10	2.10
Years	**Fy 37**	**Fy 40**	**Fy 45**	**Fy 50**	**Fy 55**	**Fy 60**	**Fy 61**	**Fy 62**	**Fy 65**
Phase 3 Model	12.90	13.90	15.80	16.50	16.50	16.50	16.50	16.50	16.50

Table 11.5 Reduction in Carbon Emission –Fairway (INR Crores)

Reduction in Carbon Emission in Fairway (INR Crores)									
Years	**Fy 26**	**Fy 30**	**Fy 35**	**Fy 40**	**Fy 45**	**Fy 50**	**Fy 55**	**Fy 60**	**Fy 65**
Fairway	1.10	1.30	3.00	18.10	20.40	21.40	21.40	21.40	21.40

Table 11.6 Reduction in Carbon Emission at each Terminals (INR Crores)

Reduction in Carbon Emission at each Terminals (INR Crores)							
Phase 1	**Fy 26**	**Fy 30**	**Fy 35**	**Fy 40**	**Fy 45**	**Fy 50**	**Fy 54**
Terminal 3	0.16	0.18	0.21	0.24	0.28	0.29	0.29
Terminal 4	0.61	0.71	0.82	0.92	1.04	1.10	1.10
Terminal 5	0.01	0.01	0.01	0.02	0.02	0.02	0.02
Terminal 6	0.16	0.17	0.19	0.54	0.58	0.59	0.59
Terminal 8	0.19	0.21	0.22	0.74	0.79	0.81	0.81
Phase 2	**Fy 32**	**Fy 35**	**Fy 40**	**Fy 45**	**Fy 50**	**Fy 55**	**Fy 60**
Terminal 2	1.43	1.53	1.72	1.97	2.07	2.07	2.07
Phase 3	**Fy 37**	**Fy 40**	**Fy 45**	**Fy 50**	**Fy 55**	**Fy 60**	**Fy 65**
Terminal 1	2.94	3.21	3.72	3.95	3.95	3.95	3.95
Terminal 7	9.97	10.70	12.05	12.58	12.58	12.58	12.58

11.15.3 Saving on Fuel

Table 11.7 Saving on Fuel – Cumulative Fairway + Terminal (INR Crores)

Saving on Fuel – Cumulative Fairway + Terminal (INR Crores)									
Years	**Fy 26**	**Fy 30**	**Fy 35**	**Fy 40**	**Fy 45**	**Fy 50**	**Fy 55**	**Fy 60**	**Fy 65**
Phase 1 Model	18.00	20.50	23.10	39.10	43.00	44.80	44.80	44.80	44.80
Years	**Fy 32**	**Fy 35**	**Fy 40**	**Fy 45**	**Fy 50**	**Fy 55**	**Fy 60**	**Fy 61**	**Fy 65**
Phase 2 Model	22.70	24.40	27.60	31.30	32.90	32.90	32.90	32.90	32.90
Years	**Fy 37**	**Fy 40**	**Fy 45**	**Fy 50**	**Fy 55**	**Fy 60**	**Fy 61**	**Fy 62**	**Fy 65**
Phase 3 Model	205.30	221.20	250.70	262.70	262.70	262.70	262.70	262.70	262.70

Table 11.8 Saving on Fuel –Fairway (INR Crores)

Saving on Fuel in Fairway (INR Crores)									
Years	Fy 26	Fy 30	Fy 35	Fy 40	Fy 45	Fy 50	Fy 55	Fy 60	Fy 65
Fairway	0.18	0.20	0.48	2.88	3.25	3.40	3.40	3.40	3.40

Table 11.9 Saving on Fuel at each Terminals (INR Crores)

Saving on Fuel at each Terminals (INR Crores)							
Phase 1	**Fy 26**	**Fy 30**	**Fy 35**	**Fy 40**	**Fy 45**	**Fy 50**	**Fy 54**
Terminal 3	2.49	2.91	3.38	3.86	4.42	4.66	4.66
Terminal 4	9.77	11.33	13.01	14.67	16.58	17.42	17.42
Terminal 5	16.50	19.20	22.10	24.90	28.30	29.70	29.70
Terminal 6	2.52	2.54	2.96	8.60	9.19	9.46	9.46
Terminal 8	3.01	3.28	3.57	11.67	12.55	12.93	12.93
Phase 2	**Fy 32**	**Fy 35**	**Fy 40**	**Fy 45**	**Fy 50**	**Fy 55**	**Fy 60**
Terminal 2	22.68	24.40	27.59	31.26	32.88	32.88	32.88
Phase 3	**Fy 37**	**Fy 40**	**Fy 45**	**Fy 50**	**Fy 55**	**Fy 60**	**Fy 65**
Terminal 1	46.69	51.02	59.15	62.75	62.75	62.75	62.75
Terminal 7	158.57	170.21	191.58	199.96	199.96	199.96	199.96

CHAPTER –12

CAPACITY BUILDING AND FINANCING

12.1 General

Capacity Building is the process by which Government assesses and assists in sustainable development and improvement of the performance. Capacity Building involves infrastructure development, operation of infrastructure, sustainability of project, manpower and human resources development, etc. It involves a strategy with a long time vision towards the enhanced production, modernization, and development of human resources leading to betterment of organization or country. IWAI would have to invest in infrastructure creation along with efficiency improvement of the navigation education & training in the field of inland navigation. Capacity building need to target at ensuring safety of vessels and providing safe and secured navigation on waterway. For fulfilling agenda, mandatory infrastructure, equipment and other requirements to be placed at appropriate locations.

12.2 Capacity Building

Inland Waterways Authority of India is the nodal agency to create capacity on all the national waterways in India. There is inconsistent water depth in the river along with seasonality. Adequate water depth along with availability of water round the year is critical to development of River Transportation. The responsibility of capacity building to make transportation on waterways at par with other modes of transportation rests on IWAI. IWAI could discharge this responsibility of capacity addition on its own as well as patterning with various other stakeholders including private party. The capacity creation on River Yamuna would include

- Development and Maintenance of fairway
- Connectivity infrastructure with Hinterland
- Development of terminals
- Other associated infrastructure suitable for cargo handling operations
- Training and deployment of manpower

All the 5 aspects of capacity building have to be addressed by IWAI to facilitate transportation of cargo and passengers on River Yamuna at par with other modes of transportation prevailing in India. River Yamuna (National waterways 110) does not have round the year navigability. Hence, the primary step would require developing a navigable waterway on the river. This would require large scale dredging activity on the river along with recurring maintenance dredging for maintaining required depth of water over a period of time. River Yamuna is perennial by nature. Water transport would require maintaining optimum depth of water along with flow round the year.

12.3 Financing Mechanism

12.3.1 Public Investment

This type of funded projects isbuilt, financed, operated and managed by the government. Private participation could take place from nominal works. Under this method, investment in Infrastructure is undertaken, primarily, to increase public characters in the early stage of the development plan. Through initial capital investment in the public sector, a sense of security prevails and private investments are encouraged.

This method of financing is being discarded globally unless the project is commissioned only for social needs or strategic needs (defense and security). There is a growing inclination, globally, for governments to focus on governance and all the business related or commercial activities should be left to the private sector. With time and globalisation, some of the items of necessity such as development of roads, railways, airports, educations (in some countries), etc have been regarded as a commercial activity. The private sector has been allowed to make investments in development of infrastructure and operation of project. Hence, the use of public progression method of financing has been limited by government depending upon the local laws and economy of country including funds available with government.

12.3.2 Private Investment

The investment from government institutions will be utilized to support the infrastructure industry in distress. A grant or concessional loan will be provided from advanced nations to countries that are still under development. The projects that are usually invested under private initiative are used for small and medium-sized projects, not large infrastructure projects.

12.3.3 Public-Private Partnership

Public Private Partnership model is an actual or notional partnership between government and private developer to develop the project. In this model, private party commits to provide specific service by assuming all financing, technical and operational risk of the project and government provides the right to build on waterway, connecting roads, evacuation, etc. The Public-Private Partnership method is the most advantageous, for the government to supplement its limited financial resources at its disposal with private funds while obtaining strategies of those businesses.

The private developer finds it attractive to fund only projects that are commercially viable on a stand-alone basis (i.e. the project after commissioning should generate enough funds to be sustainable and recover initial investments). The private developer makes initial investments using their own and borrowed funds. The initial investment of the project along with annual operation and maintenance cost is recovered over a period of time from the income generated by project. There could be some income from tourism activity induced by the proposed inland water transportation.

Government intervention is needed for projects that are commercially not viable. However, required in the country due to strategic and social needs of the country. For such projects, government has come up with Viability Gap Funding (VGF) scheme. Under this scheme, government could provide some funds to fill the financial gaps that are rendering project commercially unviable. With government support project becomes commercially viable and attracts investors. Ministry of Finance takes care of this scheme and project mount is provided by annual budget. Usually central government grants maximum 20% of total capital cost and this can be clubbed with additional 20% grant by state government. IWT project would fall in the category where government support is inevitable. This is primarily due to very high project cost.

PPP Funding Mechanism

Different types of funding options that can be exercised for development of NW 110 are presented in the following tables.

Table 12.1 Different types of funding mechanisms

Types	Funding Mechanism Description	IWT Project
Full Government Funding	Government provides whole funding for the project, considering the associated risks in return.	Yes
Government Supported Funding	Private sector provides all debt during construction period, with government taking 70% of debt after construction completion	Yes
	Public sector provides all the debt to the project and then receives credit guarantees from banks that mean the government is repaid in the event of a default.	
Viability Gap Funding (VGF)	Government (Centre & State) invests maximum 40 % of total capital cost in any PPP Project in name of VGF/Subsidies.	Yes
Co-Funding Mechanism	Government provides a proportion (50%) of the total funding requirement as a loan at very low rate of interest.	Yes
Capital Contribution Mechanism	Government provides a capital, either through payment of portion of total capital costs, or by providing an element of the works (enabling works) in order to reduce the funding requirement for the private sector.	No

To facilitate unhindered private investment, IWAI can earmark some incentives, in the form of VGF/Subsidies, and attract more private parties in bid participation. The inland waterways project involves significant investment/operating cost, and such a backing from government could prove critical in presenting the project as a lucrative business opportunity to the private sector. Below Table describes, in brief, different types of PPP models that are taken into consideration for the Development of River Yamuna (NW 110).

Table 12.2 PPP Models description

Types of PPP Models	Description & Role of Private Party in different Model
Design-Build (DB)	Designs and builds to specifications at fixed price
Operation & Maintenance (O & M)	Operates & Maintains publicly-owned asset for a definite period of time. Government retains ownership of assets
Design Build Finance Operate (DBFO)	Private Investor to design, construction, finance, and Operate
Build Own Operate (BOO)	Private player finances, builds, owns and operates infrastructure component Ownership to remain with the private party.
Build Operate Transfer (BOT)	Private responsible for design, build, operate (during the contracted period) and transfer the facility to the public sector.
Build Own Operate Transfer (BOOT)	Private to finance, design, build and operate infrastructure (and charge user fees) for a specific period of time, after which ownership back to the public sector.
Build Operate Lease Transfer (BOLT)	Designs, finances and builds a facility on leased public land. Private party operates for the duration of the lease period and then transfers ownership to government.
Lease Develop Operate (LDO)	Government retains ownership of the newly created infrastructure facility and receives payments in terms of a lease agreement with the private promoter.
Management contract	Private player has the responsibility for investment, operation and maintenance. Private party has authority for daily management decisions under a profit-sharing or fixed-fee arrangement.

Taking into account the project specificities, and the prevailing conditions that govern it, Below Table proposes a shortlist of PPP models that will benefit river Yamuna NW 110 Project.

Table 12.3 Features of different type of PPP Models for NW110

Modes	Ownership	PPP Duration	Capital Investment focus & responsibility	PPP Risks & Compensation Terms	Private Partner Roles	Description
Build Lease Transfer (BLT) or Build-Own-Lease-Transfer (BOLT)	Private (Leased to the Government)	Medium Perpetual	Greenfield, Private	Low-medium, Pre-set lease from the government.	Capex	Building IWT terminal, leasing it to the Govt. and transferring after payback period.
Build-Transfer-Lease (BTL)	Public	Medium	Greenfield, Private	High, Revenue from Users	Capex and Operations	Building IWT Terminal, leasing it to the Govt. and leasing it back.
Design-build-operate (DBO)	Public	Short-medium (3-5 yrs.)	Greenfield, Public	Medium-High, Tariff revenue	Design, construct, manage, maintain	Mainly financing obligation is not retained by the public sector.
Build-operate-transfer (BOT)/ Design-Build-Finance-Operate-Transfer (DBFOT)	Public	Long (20-30 yrs.)	Greenfield, Private	High, Tariff Revenue	Design, finance, construct, manage, maintain	Designing, funding, building, Managing & Maintaining Terminal Facility. NhavaSheva International Container Terminal.
Build-operate-transfer (BOT) Annuity	Public	Long (20-30 yrs)	Greenfield, Private	Low Annuity revenue / unitary charge	Design, finance, construct, manage, maintain	Mainly for socially relevant project like sewage plant.
Build-own-operate-transfer (BOOT) or DBOOT	Private	Long (20-30 yrs)	Greenfield, Private	High, Tariff Revenue	Design, construct, own, manage, maintain, transfer	Most common form of BOOT concession in India. Greenfield minor port concessions in Gujarat are on a BOOT basis.
Build-own-operate (BOO)	Private	Perpetual	Greenfield, Private	High, Tariff Revenue	Design, finance, construct, own, manage, maintain	Under this structure the asset ownership is with the private sector and terminal responsibility is also with the private sector. Not common in India.

Table 12.4 Proposed PPP Models for development of IWT Terminals

Types of PPP Models	Reasons
Design Build Finance Operate Transfer (DBFOT)	Often considered in case of greenfield (new projects) & long duration project. In all five cases, private party along with some government help, in the name of viability gap funding or subsidy, will develop project.
Build Own Operate (BOO)	
Build Operate Transfer (BOT)	
Build Own Operate Transfer (BOOT)	
Management contract	Management Contract, Design Build (DB) and Operation & Maintenance (O & M) are also applicable because government is ready to invest 100 % for the project in respective models. As the project is highly capital intensive, therefore, government is willing to initiate the project.
Design Build (DB)	
Operation & Maintenance (O & M)	

12.4 Modalities for IWAI

Inland Waterways Authority of India as the nodal agency for development of national waterways including River Yamuna (NW-110) would require involvement of multi lateral agencies for successful development of transportation on river Yamuna. These agencies would involve a combination of government and private entities including various departments of state government, local district administration in districts and states where the terminals are proposed. Some of the critical stakeholders for development of River Yamuna (NW-110) would include financial agencies, stakeholders predominantly cargo owners, Indian Railways, national and state highways and several others. The policy development for creation of infrastructure, ensuring it's functional and safety requirement along with regular upgradation would have to be undertaken by IWAI.

It is assumed that the IWAI would like to encourage private participation in the development of Terminals and other associated infrastructure for development of NW-110. IWAI would play a role of facilitator and regulator. IWAI would invite private developers and operators to bid for the project wherever it would be commercially viable. However, IWAI would have to make investments in areas essential for creation of basic infrastructure and facilities or wherever a developer is unlikely to make any investment in the development of infrastructure due to lack of financial returns.

There is no precedence in the international water transport system of developing fairway or navigation of rivers by private investment model. This is primarily developed by the government or authorities mandated by government. Private parties depending upon the commercial attractiveness of the project could develop terminals.

12.5 Fairway Development

Development of fairway for round the year navigability of River Yamuna (National Waterway 110) is the most essential part of water transport development. Fairway constitutes maximum importance for water transportation, among the total stretch of the river. This also requires disproportionately higher share among total investments allocated for development of water transport on a river Yamuna.

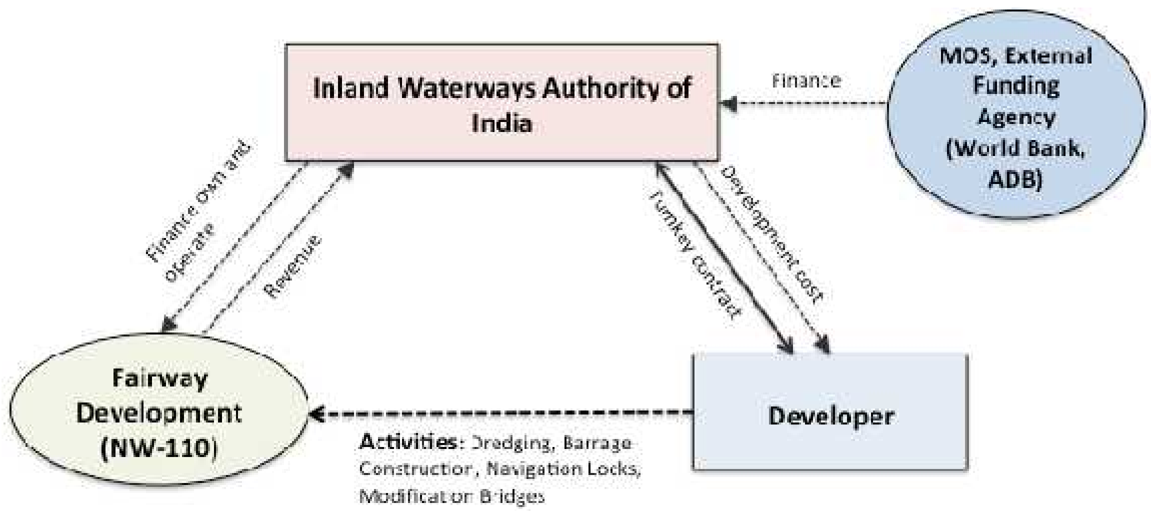


Fig.12.1Modality for Fairway Development

The development of fairway as described in the figure above could be summarized in following pointers

- Private developer Designs and Builds infrastructure on receipt of Government funding and transfer facility to Public body after completion of Construction
- Finance required to design and built Fairway has to be arranged by IWAI
- IWAI could either operate fairway on their own or they could commission a Project Management Unit (PMU) to manage it on their behalf for a fixed cost.

Development of River Yamuna (NW-110) for transportation would require capital dredging, creation of barrages, navigational locks, river navigation system, etc. There would be substantial investment involved in maintaining the navigational depth. Primary maintenance costs associated with the project would include maintenance dredging of river, operational and maintenance of navigational locks, etc.

There has been no precedence of waterway development and fairway development under PPP, Globally. There exists large-scale uncertainty in maintaining desired depth of river due to shift of silt and river water flow. Hence, involvement of private party for investment on development of project against annual revenue share model is becomes impractical. This segment of waterway development has very high risk associated with it. There exist larger areas for developer who is evaluating investments in dredging activity and infrastructure development for maintaining constant depth from the year. The silt below water keeps shifting. Hence, maintenance dredging becomes riskier than capital dredging.

Further above-mentioned reasons, it is unlikely that a private investor would show interest in undertaking fairway development. There have been several litigations affecting project due to dredging activity and its outcome. Some of such projects are listed below

- Dredging in Kochi Harbour affecting Vallarpadam
- Container terminal at Mumbai Port Trust
- Coal transportation upto Farakka in NW-01

Hence, navigation development by Government/Inland Waterways Authority of India would have to be made using Design and Build contract system. Design and Build contract system is the basic contract system in which Government awards the contract to private party for creation of infrastructure. 100% investment under design and build contract is provided by government. The contract hands over infrastructure created under Design and Build contract to the government after completion of his contract. In the present case of River Yamuna (NW-110) development IWAI on behalf of Government would have the sole responsibility of operating and maintaining fairway.

Inland Waterway Authority could monitor and maintain river waterway system on its own. Alternatively, it could appoint a Project Management Unit, which would be working on a fixed fee to monitor and maintain round the year navigability on the waterway system. The professionals working at PMU would be acting on behalf of IWAI for implementation of fairway development project.

12.6 Dirty Cargo Terminals

Dirty cargo terminals are mostly service large Thermal Power plants for their captive use. The Origin and Destination of cargo using Dirty cargo terminals are fixed. The business opportunities for these terminals would run parallel to the prospects of Thermal Power plants needed them to source their raw materials and evaluate by products as discussed in the Traffic Projections section and Terminal Planning section.

Involving thermal power plants or end users develop these terminals along with operation could be rewarding. Independent private operator may not see substantial upside from the project in the absence of new thermal proposed power plants. The existing ones would continue to operate till 2100 at least. The Government of India has targeted to decommission switch to renewal and clean energy sources. Hence, the business prospects for terminal and power plants jointly looks assured till 2100. That provides about 80 years for coal movement opportunity for Cargo Terminals.

12.7 Multipurpose Terminals

There are 3 Multipurpose Terminals proposed on the banks of River Yamuna to handle clean cargo. The clean cargo proposed to be handled at these terminals would include fertiliser, Iron & Steel, Sugar, Containers, etc. This makes operation of Multipurpose Terminal, multi dimensional. The multidimensional approach would require skills for handling varieties of commodities for a wider range of customers. The resource optimisation along with productively handling, storing and evacuating using same infrastructure.

Hence, the ownership, operation and management of Multipurpose Terminal are to be undertaken by independent third party logistics service providers. There would not be a single entity among the cargo owners to have such multidimensional skills to operate them. Hence any large Logistics company or companies with terminal operation experience could be shortlisted for the development and operation of these terminals.

The Multipurpose terminals could be developed using Build, Own, Operate and Transfer (BOOT) model. The time duration for BOOT operator of this project could be 30 years or more. There are several instances of terminal being developed by private entities in India with finances secured from financial institutions and banks. The multipurpose terminals could be developed on similar lines.

Inland Waterways Authority of India could award development of Multi-Purpose Terminals following a competitive bidding route. This could be developed following a principal used for development of terminals and freight villages on River Ganga (National Waterways NW-01). These terminals were found to be commercially viable on a standalone basis. Allowing Third Party Logistics Company or terminal operators develop this terminal following a Public-Private Partnership (PPP) model would help bring best practices in handling, storage, processing and evacuation of clean cargo.

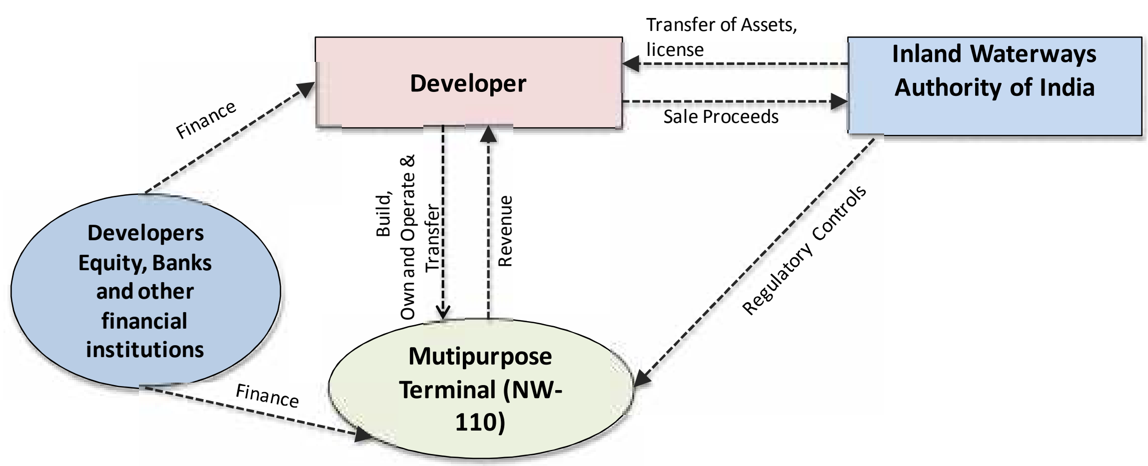
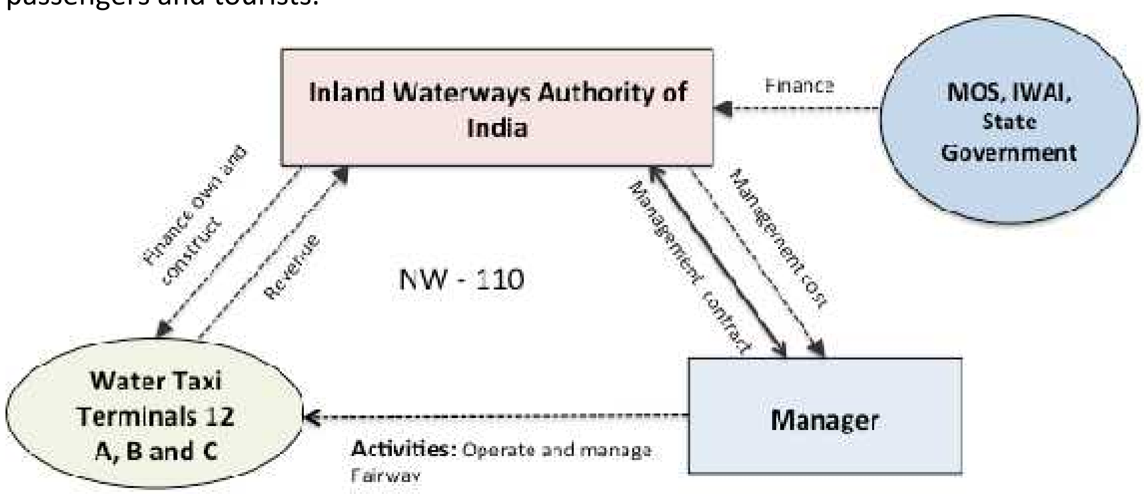


Fig.12.2 BOOT Modality for Multipurpose Terminal Development

12.8 Passenger Terminals – Local

Small-scale terminals developed for passenger transportation locally operates on a very small scale. They require smaller investments for development. The core principle behind development is social benefits rather than profit maximization. Several parallels could be drawn about passenger terminals development by Government authorities such as MMB in Maharashtra, IWAI or local IWT in Assam, Capt of Ports in Goa, Bangladesh, etc. These terminals attract nominal returns to sometimes cover the cost. There are several such terminals in Maharashtra, Goa operating successfully on government support. The development of proposed water taxi project in Delhi would fall in similar categories. The returns from these terminals are nominal and would not attract commercial interests from the developers.

These terminals have nominal passenger traffic. The distance travelled on boats is shorter. Hence, the cost associated with total transportation is nominal. This leads to minuscule revenue prospects for the terminal operator. Internationally, such water projects are clubbed with real estate with development of large scale residential and commercial infrastructure along with marina and water based lifestyle activities. However, the present project is limited to the water transportation activities for passengers and tourists.



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ig.12.3 Management Contract Modality for Passenger Terminals

The operation of terminals associated for water taxi project could be summarized as below

- IWAI hires a Private Operator for management and day-to-day operation of Water Taxi Services in Delhi
- Operator is paid a fixed fee for his services
- IWAI retains the ownership of facility & infrastructure at Water Taxi
- The private operator would have to deploy passenger ferries for local movement ofpassengers. The financials of Terminals developed for water taxi shows poor returns. This is unattractive for private operator to invest
- Operator would maintain the existing infrastructure assets for IWAI

12.9 Passenger Terminals

Passenger Terminals catering to long distance cruises could be developed following O&M (Operational and Management model) with responsibility as described in the flow chart below. Cruise tourism is at the nascent stage in India. Several cruise terminals developed on the coast of India in Major ports are operating far below their optimum utilization. The terminals on the coast could be catering to both domestic as well as overseas cruise passengers. There could be lower enthusiasm among investors and developers invest in build and operate cruise terminals on River Yamuna, considering the nascent stage of tourism and cruising industry. Hence, IWAI could invest in creation of cruise terminals along with related infrastructure. This could be then awarded to 3rd party on operation and management contract.

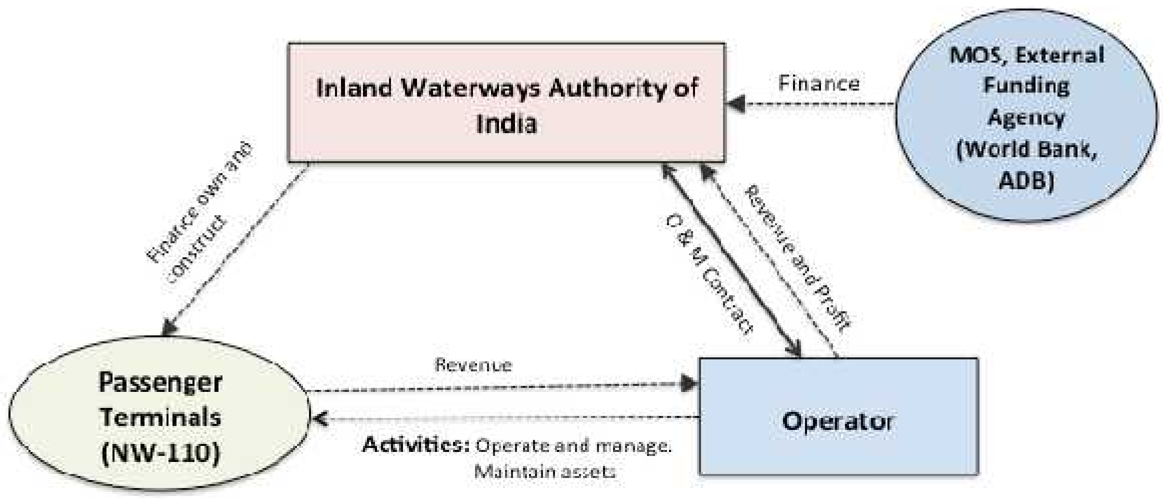

Fig. 12.4 Management Contract Modality for Passenger Terminals

12.10 Institutional Requirement

This organisation is set up for the development & maintenance of waterway for cargo as well as passenger movement. It is an integral part of Government of India, thus implements various regulations & policies. This organization should integrate administrative functions with operation, maintenance, and development function and run this enterprise on sound Business Management Principals. The set up should also have jurisdiction and control over all other Government, Public and Private Vessel Operators on the River Yamuna (NW-110).

Other Government, Public and Private Parties can be allowed to carry on their present business as usual but under the administrative control on IWAI which frames rules and regulations for such operation.The conceptual set up of such organization envisages setting up of Inland Waterway Authority construction and maintenance division for RiverYamunawith its headquarters at Prayagraj.ProposedTerminalsforRiverYamunacan be run under this setup.

The Inland Waterway Authority, GoIwill be responsible for following discipline in River Yamuna (NW-110).

- Developing and maintaining navigable waterway.
- Enforcement of rules and regulations of IWT Act.
- River route survey
- Issue of river notices, river chart and river warnings
- Rescue and salvage operations enroute.
- River training and maintenance work such as bandalling, bottom paneling, dredging, bank protection etc. required to the extent of maintaining navigable waterway.
- Registration of vessels and issue of certificate of survey (compulsory for any craft plying on the river route)
- Issuing certificate of competency to masters, drivers, sarangs and engineers of crafts plying on the route.
- Levy and collection of vessel registration fee, which will be related to capacity of vessels and river, route it travels. (Normally this levy will be linked to river route development and maintenance expenditure).
- Operation and maintenance of terminals run by IWAI and collection of berthing, handling and storage charges.
- Operation and maintenance of various crafts, equipment and other facilities owned by IWAI.
- Maintaining liaison with Inland Waterway Authorities to ensure smooth passage of crafts and loading/unloading of cargo.
- Purchasing new equipment/ floating craft as and when required.
- Planning and developing new terminals in River Yamuna depending on traffic and additions to existing terminals, fleet and other facilities.
- Liaison with various concerned organizations to ensure efficient functioning.
- Business development and expansion of facilities.
- Financial / Administrative/ Technical control of operations with a view to raise efficiency reduce cost and accomplish better handling.

To execute above responsibilities, staff requirement is suggested hereby.The administrative function and jurisdiction of various departments are briefly described below:

Director - The organization setup of Inland Water Transport division of River Yamuna in Uttar Pradesh and Delhi is headed by a Director who will have his headquarter at Prayagraj. He will be overall in charge of all constructions, operation and maintenance work. The specific tasks of some key personnel are detailed below:

- **Repairs& Maintenance Division**
  Assistant Director heads this division. The main function of this division is to maintain the floating crafts owned by IWAI in working order. Minor repairs are

carried out by the Departmental personnel and crafts sent to different repair yards if in need of major repair or overhauling. Adequate stocks of spares are kept in ready stock by timely ordering and procurement of it. The division will arrange fuel and lubricants required for operation. Division will also arrange replacement or additional crafts if required.

- **Waterway Maintenance Division**
  For effective maintenance waterway the river stretchwill be under the joint administrative control of Assistant Director and Senior Hydrographic Surveyor. The major task of this group is to maintain the waterway navigable. The following tasks are entrusted to Deputy Director and Senior Hydrographic Surveyor.

Assistant Director: Assistant Director will be incharge of infrastructure maintenance works, security of waterway&terminals salvage duty.These departments will perform following tasks:

- ✓ Finding and marking best channel for navigation and clearing these channels from any obstructions.
- ✓ Checking on observation of rules and regulations of waterways and bring to book the offenders.
- ✓ Go to rescue of boats in distress.
- ✓ Maintenance of river training work such as bank protective works, bandalling works, bottom paneling works etc. (normally major works are sub-contracted out).
- ✓ Maintenance of minimum depth in the waterway by dredging the shallow patches wherever required.
- ✓ Legal enforcement of rules and regulations by catching offenders and legally prosecuting them.
- ✓ Operation and maintenance of various communication equipment.

Senior hydrographic surveyor: Itwill include checking of the water levels in channels, checking position of marking systems and buoys, collection of morphological data, regular cross-section soundings and bank levels, discharge measurements, etc. This department of IWAI would communicatefollowing information in the form of river notice and over radio contact on daily basis to barge operators.

- ✓ Water level at fixed gauge stations.
- ✓ Available depth (LAD) for particular river section in their command and the location of shallowest place/ stretch.
- ✓ General information on changes in channels and marking system.
- ✓ Execution of river and other similar works. Route mapping shall be carried out on regular basis once in 2-3 weeks and charts issued to barge operators immediately.

Their tasks would include maintaining the river channel marking buoys andbeacons.

- **Terminals**

  Each terminal will be under the control of Terminal Manager.Terminal Manager will be responsible for operation and maintenance of the terminal. Their tasks include:

  ✓ Operations and maintenance of all mechanical handling equipment.
  ✓ Berthing of cargo and passenger crafts.
  ✓ Loading and unloading of cargo crafts.
  ✓ Storage and dispatch of cargo
  ✓ Collection of berthing, handling, &storage charges.
  ✓ Operation and maintenance of all utilities in the terminal area.
  ✓ Terminal security and communication.

Safety and Security

- Vessel operator and wharf/ghat management authorities are main responsible party for vessels' safety. State and district authorities have controls over administrative and socio-economic situation.
- Unqualified crew, exceeding vessels capacity, ageing of vessels, faulty designs and lack of regulatory standards are some of the major factors leading to vessel accidents on IWT route.
- Central Water Commission is the responsible body in providing water level forecast in rivers. Such information would be helpful in smooth and safe operations of vessels and other cargo.
- Nodal officers to be selected for each terminal location and control room need to be developed at terminal for smooth 24/7 operational. Personnel in charge of control room should be knowledgeable enough to inspect round the clock operation of all equipment's.
- Uttar Pradesh IWT transport department needs to support to develop supportive infrastructural facilities such as electricity, Internet connectivity, and digital screen for displaying latest updates etc.
- State IWT officials need to conduct regular inspection of the vessels and ensure all necessaryequipment are available on board.

Wharfs/ Terminals: Local authorities should be in charge of providing adequate facilities at terminals for cargo & passenger embarkment and disembarkment. As per water level in river, appropriate landings need to be provided such as floating platform etc. Terminal should be equipped with guard to stop damage to vessels when berthing.

Fire Safety: Standard fire extinguisher to be established at terminal and to be carried on vessels to prohibit fire accidents on rivers

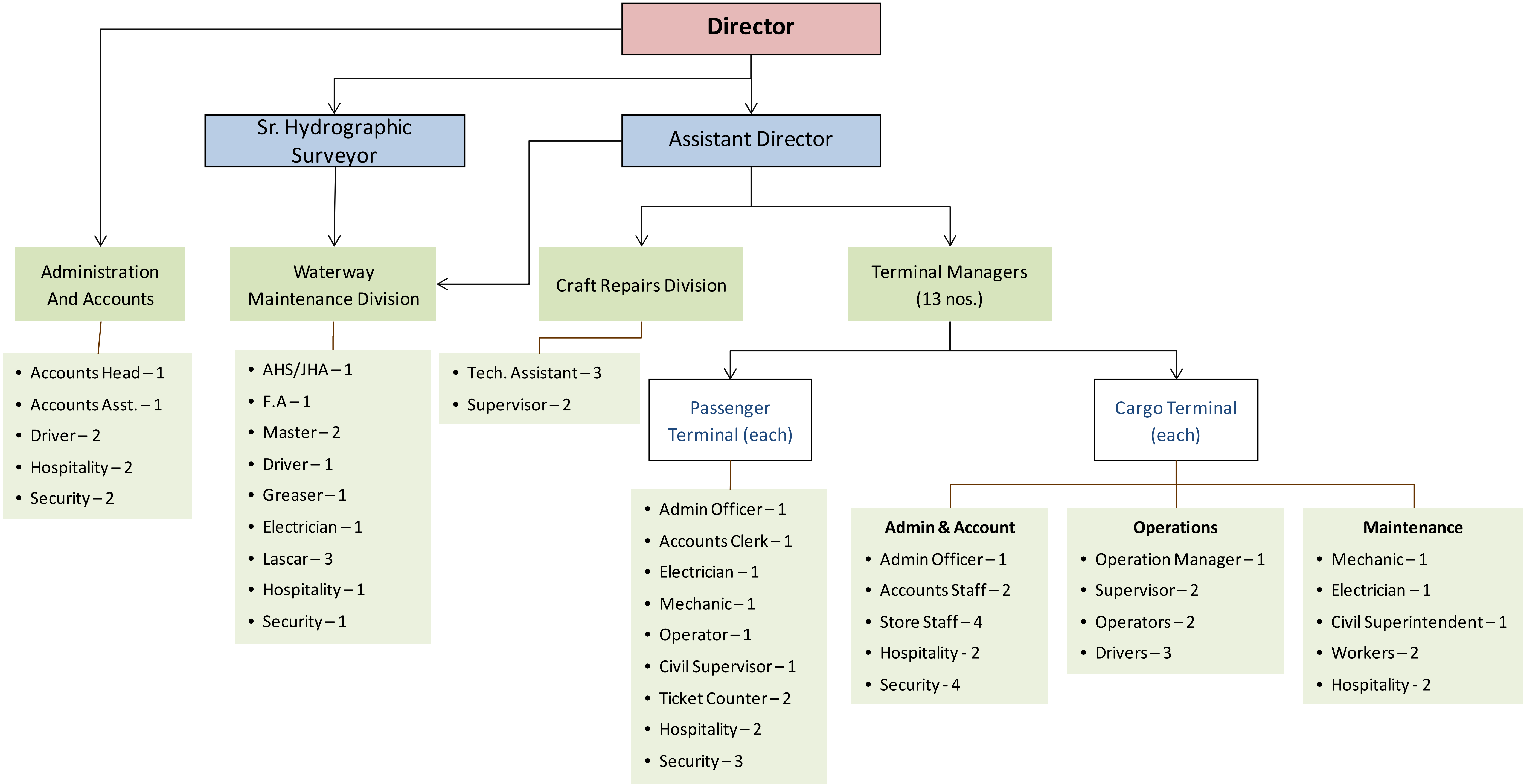

Fig. 12.5Organizational Chart for NW110 Terminal Operation

12.10.1 Man Power Requirement

Man power requirement for operation of waterway in River Yamuna includes for terminaloperations, Navigational lock operation and departmental requirement.Departmental regional office will be set up at Prayagraj. Waterway maintenance division will be setup under the regional office for maintenance of navigable waterway. Every terminal will require institutional setup for proper functioning of terminal operations. Terminal manager will be the head at terminal responsible for overall terminal operations.

Table 12.5 Requirement of Manpower in each Department

Sr. No.	Designation	Manpower Required
1.	Director	1
2.	Asst. Director	1
3.	Senior Hydrographic Surveyor	1
4.	Man Power at Surveyor’s Office	12
5.	Man Power at Director's Office	8
6.	Terminal Manager	14
7.	Man Power at Nine Cargo Terminal office	252
8.	Man Power at Ten Passenger Terminaloffice	100

12.10.2 Training Requirement / Capacity Building

Capacity Building is the process by which the Organization assesses and assists in sustainable development and improvement of the performance. Capacity Building involves more than training. It should be a strategythat involves a long-time vision towards theenhanced production, modernization, and development of human resources leading to overall organizational objectives.In order to improve the efficiency of working personnel at the terminal, education & training would be provided to the respective manpower regarding inland navigation.

12.10.3 Infrastructure

- **Immovable**

  Immovable infrastructure like Administrative building, Security office, Electrical substation, parking area etc. will be required at terminals.

- **Movable**

  Movable cranes, vehicles and survey boats will also be required at terminals.

12.10.4 Cost Implications

Cost implication for establishing institutional requirement will includesalaries of employees deployed at terminals, navigational lock and regional offices. Institutional setup required for operation and maintenance of waterway, locks and terminals. Capacity building through education and trainingto the staff and employees will also have cost implications. Average annual salary of top management is taken as Rs. 18,00,000. Average annual salary of Terminal Managers, Officers and staff are taken as Rs. 9,00,000.

Table 12.6 General Annual Salary for Cargo Terminal Operations

Items	Quantity	Annual Salaries (INR)	
		Rate	Amount
Top Management	17	18,00,000	3,06,00,000
Other Staff	372	9,00,000	33,48,00,000
Misc	Lump sum		50,00,000
		Total	**37,04,00,000**

CHAPTER – 13

PROJECT IMPLEMENTATION SCHEDULE

13.1 General

Project Implementation schedule is an techno-economic process and must be planned judiciously in order to achive over all economy and efficiency. It must be recognised that careful planning, and pre engineering would precede construction of a project, so that, the construction activity proceeds without any hinderance.

13.2 Overview

The overview of the project reveal from the implementation point of view the project could be divided into the following parts:

- **Pre-construction activities**
  - Investigations
  - Model Studies
  - Market Survey
  - Detailed Project Report
  - Detailed Engineering
  - Clearances (including Environmental Clearance)
  - Financial Closure
  - Water supply
  - Power
  - Tender engineering and fixing of EPC Contractor

- **Construction activities**
  - Barrage along with Navigational Lock
  - Regulator along with Navigational Lock
  - Reconstruction of Bridges
  - Demolition of Existing Bridges
  - Dredging
  - Jetty
  - Approach Trestle, if required
  - Buildings
  - Development of storage areas including consolidation, if required
  - Road and rail linkages
  - Internal road/rail
  - Fencing
  - Procurement and installation of treatment plants

- o Procurement and installation of Mechanical and electrical equipment
- o Procurement and installation of Navigational Aids
- o Procurement and installation of River Information Systems

- **Post Construction Activities**

  - o Post Construction Surveys
  - o Preparation of as built drawings
  - o Commissioning of equipments and control systems

- **Ancillary Activities**

  - o Agreement with stakeholders
  - o Recruitment and training of waterway operation manpower
  - o Contracting of O&M Agencies

13.3 Looking at the sub–soil condition from the geotechnical investigations results, piled construction appears to be most appropriate and construction schedule for the jetty has been worked out with piled jetty**.**

13.4 It is presumed that specialised dredging contractors would be deployed for the dredging of the fairway channel. It is assumed that dredged would be dumped the banks of river. Some dredged material will be utilized in reclamation and filling works for guide bunds.

13.5 For working out construction schedule following rates for execution of various items of works has been assumed.

i) Batching plant capacity @ 30 cum/hr
ii) Earth work and stone dumping @ 75 cum/hour
iii) Dredging @ 250 cum/hour
iv) Railway line 50m per day.
v) Road 50m per day.

13.6 Phasing of Project

Phasing of the project has been considered on the basis of navigable depth, traffic potential and economic considerations. The project has been proposed to be developed in following three phases:

Table 13.1 Phasing of Project

Phase	Stretch	Construction period
Phase 1	Prayagraj (Ch. 0.0 Km) to River Chambal Mouth (Ch. 453 Km) and Upstream of Wazirabad Barrage, Delhi (Ch. 1074 Km) up to Jagatpur (Ch. 1081 Km)	Year 2021 to Year 2025
Phase 2	River Chambal Mouth (Ch. 453 Km) to Agra (Ch. 743 Km)	Year 2027 to Year 2031
Phase 3	Agra (Ch. 743 Km) to Okhla Barrage, Delhi to (Ch. 1052 Km)	Year 2032 to Year 2036

Terminals will be developed in three phases as given in table below:

Table 13.2 Phase-wise details of terminals

Terminal No.	Tentative Location	Chainage (km)	Type of Terminal
Phase-1 (2021-2025)			
3	Mahewa Khachhar, Kaushambi	98.0	Dirty Cargo
4	Dilauliya Kachhar, Kalpi	349.2	Dirty Cargo
5	Near Naini Bridge, Prayagraj	3.0	Dirty Cargo
6	Near Jamuna Bridge, Prayagraj	4.2	Multipurpose Cargo
8	Kalpi	349.8	Multipurpose Cargo
12A	Sonia Vihar, Delhi	1077.5	Passenger
12B	Jagatpur, Delhi	1079	Passenger
12C	Tronica City, Delhi	1081	Passenger
13A	Sujawan Ghat, Prayagraj	19.5	Passenger
13B	Saraswati, Prayagraj	3.4	Passenger
13C	Near Boat Club, Prayagraj	4.0	Passenger
13D	Hanuman Ghat, Prayagraj	2.0	Passenger
Phase-2 (2027-2031)			
2	Near Agra	731	Dirty Cargo
10	Near Tajmahal	742.4	Passenger
Phase-3 (2032-2036)			
1	Madanpur Khadar	1047.8	Dirty Cargo
7	Madanpur Khadar	1049	Multipurpose Cargo
9	Madanpur Khadar	1050	Passenger

The implementation schedule of the project is given in **Annexure 13.1**

CHAPTER – 14

PROJECT COSTING

14.1 General and Financial Assumptions

In the present chapter project cost estimates has been done. In order to arrive at capital cost for the proposal it is necessary to ascertain, for budgetary purposes, unit rates of materials used for construction, dredging etc. Accordingly, efforts were made to obtain the above information from the relevant sources.

14.2 Basis of Costing

An estimate of the capital cost of various facilities is made. The cost arrived at are based on the budgetary quotes and the in house data base available with WAPCOS on cost estimates. The rates for various works have been prepared on the basis of current rates for various items of work prevailing in the region.

The items and costs have been arrived at broadly on the following:

- Rates taken from current works of similar nature
- Updated rates of work of similar nature completed in the recent past.
- Consultant's in house data bank of cost estimates and budgetary quotations.

Delhi Schedule of Rate, 2018 has been followed to arrive at the cost of the project.

14.3 Capital Expenditure

The estimate of capital cost is made for the various items of civil, mechanical, electrical and utilities works for the development of terminals in the waterway stretch, phase wise cost estimate is presented in Table 14.1 to Table 14.3

The capital cost worked out is excluding cost of land for construction of terminals, barrages, regulators & navigational locks.

Table 14.1 Capital Cost Estimate – Phase – 1 (2021-2025)

S. No.	Capital Cost	Rs. in Crores
(I)	**Fairway Development Cost**	
	Navigation Locks (4 Nos.)	442.39
	Construction of Barrages (2 Nos.)	996.23
	Construction of Regulator (2 Nos.)	878.18
	Demolition & Reconstruction of bridges (13 Nos.)	1382.87
	Total Fairway Development Cost	**3699.67**
(II)	**Terminal Cost**	
	Cargo Terminals	
T3	*Mahewa Khachhar, Kaushambi*	125.27
T4	*Dilauliya Kachhar, Kanpur Dehat*	131.90
T5	*Near Naini Bridge, Prayagraj*	169.57
T6	*Near Yamuna Bridge, Prayagraj*	132.84
T8	*Daulatpur, Kanpur Dehat*	137.43
	Total	**697.02**
	Passenger Terminals	
T12(a)	*Soniya Vihar, Delhi*	11.50
T12(b)	*Jagatpur, Delhi*	11.50
T12(c)	*Tronica City, Delhi*	11.50
T13(a)	*Sujawan Ghat, Prayagraj*	23.00
T13(b)	*Saraswati Ghat, Prayagraj*	11.50
T13(c)	*Near Boat Club, Prayagraj*	11.50
T13(d)	*Hanuman Ghat, Prayagraj*	11.50
T14	*Ro Ro Terminal*	11.00
	Total	**103.00**
	Approach Rail & Road Connectivity to the Terminals	**476.95**
	Total Terminal Cost including approaches	**1276.97**
(III)	**Navigation & Communication Cost**	
(A)	DGPS	2.00
(B)	VTMS	10.00
(C)	Marine Lantern/Buoys	4.50
(D)	RIS	39.13
	Total Navigation & Communication Cost	**55.63**
(IV)	**Material Handling Equipment**	
	Mechanical & Electrical	220.05
	Total Material Handling Equipment Cost	**220.05**
(V)	**Dredging**	
	Dredging (14.33 Mm^3)	**429.90**
	Total Dredging Cost	**429.90**
(VI)	**Ship Repair and Maintenance Facility**	
	Ship Repair and Maintenance Facility (1 Site)	50.00
	Total Ship Repair and Maintenance Facility	**50.00**
	Total (I) to (VI)	**5732.21**
(VII)	**Physical and price contingencies, interest during construction and other financing costs, pre-construction expenses etc. @ 25%**	1433.05
	Total Capital Cost	**7165.26**

Table 14.2 Capital Cost Estimate – Phase – 2 (2027-2031)

S. No.	Capital Cost	Rs. in Crores
(I)	**Fairway Development Cost**	
	Navigation Locks (9 Nos.)	995.37
	Construction of Barrages (9 Nos.)	2007.29
	Demolition & Reconstruction of bridges (14 Nos.)	692.92
	Total Fairway Development Cost	**3695.58**
(II)	**Terminal Cost**	
	Cargo Terminals	
T2	*Etmadpur, Agra*	86.27
	Total	**86.27**
	Passenger Terminals	
T10	*Near Taj Mahal, Agra*	11.50
	Total	**11.50**
	Approach Rail & Road Connectivity to the Terminals	**57.07**
	Total Terminal Cost including approaches	**154.84**
(III)	**Navigation & Communication Cost**	
(A)	DGPS	1.00
(B)	VTMS	2.00
(C)	Marine Lantern/Buoys	2.90
(D)	RIS	26.08
	Total Navigation & Communication Cost	**31.98**
(IV)	**Material Handling Equipment**	
	Mechanical & Electrical	21.7
	Total Material Handling Equipment Cost	**21.70**
(V)	**Dredging**	
	Dredging **(3.61Mm^3)**	**108.30**
	Total Dredging Cost	**108.30**
(VI)	**Ship Repair and Maintenance Facility**	
	Ship Repair and Maintenance Facility	50.00
	Total Ship Repair and Maintenance Facility	**50.00**
	Total (I) to (VI)	**4062.41**
(VII)	**Physical and price contingencies, interest during construction and other financing costs, pre-construction expenses etc. @ 25%**	1015.60
	Total Capital Cost	**5078.01**

Table 14.3 Capital Cost Estimate – Phase – 3 (2032-2036)

S. No.	Capital Cost	Rs. in Crores
(I)	**Fairway Development Cost**	
	Navigation Locks (10 Nos.)	1105.97
	Construction of Barrages (9 Nos.)	2448.70
	Demolition & Reconstruction of bridges (18 Nos.)	1436.56
	Total Fairway Development Cost	**4991.23**
(II)	**Terminal Cost**	
	Cargo Terminals	
T1	*Raipur Khadar, Delhi*	87.05
T7	*Madanpur Khadar, Delhi*	403.98
	Total	**491.03**
	Passenger Terminals	
T9	*Madanpur Khadar, Delhi*	11.50
T11	*Panigaon Khadar, Mathura*	11.50
	Total	**23.00**
	Approach Rail & Road Connectivity to the Terminals	**46.74**
	Total Terminal Cost including approaches	**560.77**
(III)	**Navigation & Communication Cost**	
(A)	DGPS	2.00
(B)	VTMS	4.00
(C)	Marine Lantern/Buoys	3.00
(D)	RIS	39.13
	Total Navigation & Communication Cost	**48.13**
(IV)	**Material Handling Equipment**	
	Mechanical & Electrical	166.5
	Total Material Handling Equipment Cost	**166.45**
(V)	**Dredging**	
	Dredging (3.09 Mm^3)	92.70
	Total Dredging Cost	**92.70**
(VI)	**Ship Repair and Maintenance Facility**	
	Ship Repair and Maintenance Facility (1 Site)	50.00
	Total Ship Repair and Maintenance Facility	**50.00**
	Total (I) to (VI)	**5909.28**
(VI)	**Physical and price contingencies, interest during construction and other financing costs, pre-construction expenses etc. @ 25%**	1477.32
	Total Capital Cost	**7386.60**

Detailed BOQ for the capital cost estimate is given in Annexure-14.

14.4 Operation and Maintenance Expenditure

The annual operation and maintenance cost on different components of the project will be dependent on a number of variables such as the life of the component, repair and maintenance requirements, wages of crew of consumables, etc. Hence, accurate assessment of cost is not possible. Further even if all the variables are fixed such as the maintenance schedules for each structure and equipment is determined, crew strength is fixed, requirement of consumables quantified, etc., the estimation of O&M costs cannot be precise because of unpredictable breakdowns incurring considerable expenditure on repairs and replacement. The only practicable approach in this scenario is to fix the annual repair expenditure as a percentage of capital cost of project. This percentage is to be fixed on the basis of the past performance of similar structures and equipment functioning in the project or elsewhere under similar marine conditions.

The operation and maintenance cost is calculated based on the following basis:

i. Civil Works : 1% of Capital cost
ii. Dredging : 10% of Capital Dredging Cost
iii. Mechanical and Electrical works : 5% of Capital cost

CHAPTER – 15

ECONOMIC &FINANCIAL ANALYSIS

15.1 Financial Study

River Yamuna has been approached with the scope of handling both types of traffic i.e. Cargo and Passenger for along the river movement. Financial modeling for each terminal on River Yamuna has undertaken in this chapter. It constitutes financial analysis for 9 Cargo terminals i.e. Terminal no. 1 to 8& 14 and 10 Passenger Terminals i.e. Terminal no. 9, 10, 11, 12 (a,b,c) and 13 (a,b,c,d). Market-driven rates, benchmarks, and assumptions have been considered to develop financial models for each terminal.

Development of River Yamuna will be done in 3 Phases. A certain km of stretch will be developed in each Phase. The table below shows the development of terminals in each phase

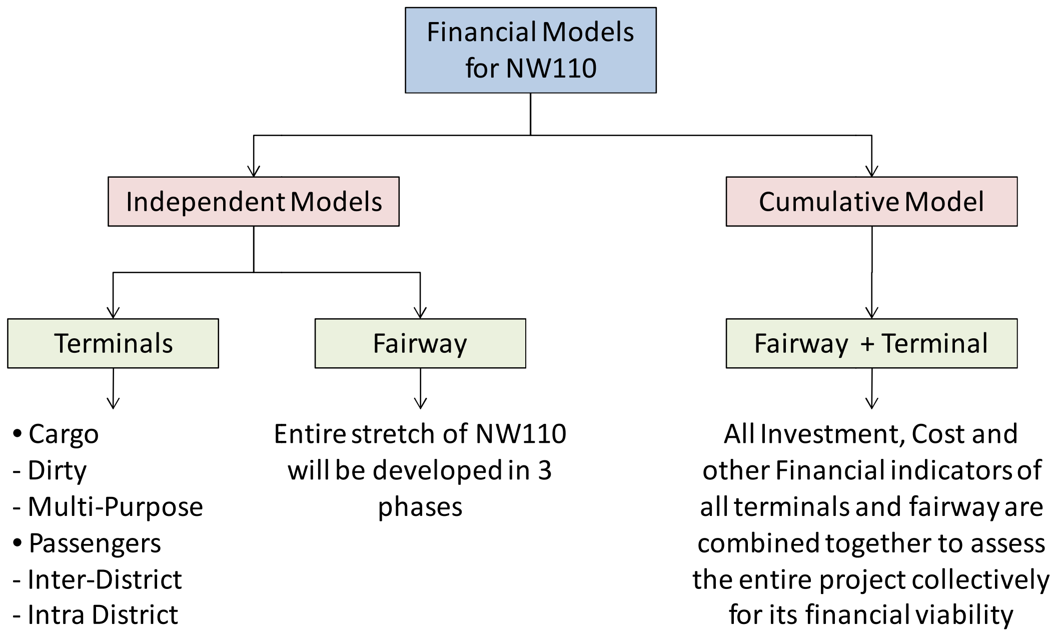

Fig. 15.1Structuring of Financial Model

Table 15.1 Phase wise Fairway Development and TerminalsConstruction in NW110

Development Phases	Duration (Years)	Chainage (km)	Terminals for Development		
			Coal & Fly Ash	Multi-Purpose	Passenger & Tourist
Phase 1	Fy21-Fy25	0 – 453	T3, T4, T5	T6, T8	T12 (a, b, c), T13 (a, b, c, d)
Phase 2	Fy27-Fy31	453 -743	T2	-	T10
Phase 3	Fy32-Fy36	743 –1,051	T1	T7	T9, T11

It has been assumed that the project would be completed in 3 phases. Development of Phase 1 would start on FY 21 and would be completed in FY 25. Phase 1 would commence operation from FY 26. Construction of Phase 2 would start on FY27 till FY 31 and would commence operation from FY 32. Construction of Phase 3 would start on FY 32and would be completed on FY 36. Phase 3 would commence operation from FY37.

15.2 Assumptions for Financial Analysis

General assumptions for financial analysis for terminals and fairways in NW 110 is discussed below

- The Financials of Fairway has been prepared using tariff structure suggested by IWAI in NW-5. The tariff for using fairway would be INR 1/ Tonne-kms. However, very large capital and operational cost for fairway maintenance renders project unviable and non-existent FIRR as well as EIRR. Increasing tariff would make cost of transportation higher on waterway (increasing end to end logistics cost), which would further discourage industries to make a shift to IWT. Therefore, financial analysis for terminals and fairway has been done separately and independent of each other, though both have been derived from the same traffic projections.
- It has been assumed that Government (IWAI) would develop the waterway and Fairway on NW 110. Private party could develop terminals under PPP model. IWAI would also develop other supportive infrastructure, which would be required for efficient operations of the terminals. This would be made with an intention to bring parity between waterway transportation and railway/roadway transportation.
- Shift of cargo transportation and traffic to waterway is paramount for the success of the project. It has been assumed that industries/power plants would shift their existing movement of cargo through roadway/railway to NW 110 as described in Traffic Projections Section. Government (IWAI) would facilitate this by removing infrastructure bottlenecks and logistics hurdle as described in Logistics Cost Analysis Chapter. For Shifting of cargo from existing modes to IWT on NW 110, it is necessary that IWT would be highly subsidized by the Government.
- Industry benchmarks have been considered for validating a few assumptions. The details of the basis of assumptions have been mentioned in the subsequent sections.
- Repair & Maintenance (Mechanical & Civil): 1% of total Civil Infrastructure Cost & 5% of total Mechanical Cost is considered as Repair & Maintenance expenses.

Table 15.2 Assumptions for Civil Repair & Maintenance Cost Terminals

Description	Unit	Item
Civil Repair & Maintenance	Capex Civil	1%
Mechanical Repair & Maintenance	Capex Mechanical	5%

- Insurance (Mechanical & Civil): 1% of total Civil Cost and 2% of total Mechanical is considered as Insurance cost for Cargo Terminals.

Table 15.3 Assumptions for Insurance Cost Terminals

Description	Unit	Item
Insurance Civil	Capex Civil	1%

Insurance Mechanical	Capex Mechanical	2%

- For Tax calculation of terminals and fairways, 30% corporate tax is assumed. It is considered that Terminal Operator would pay IWAI INR 10/Tonne per annum as Royalty and 4% of total Revenue share from Cargo terminals and fairways. 2% of total revenue is considered as Administrative Cost of terminals and fairways. Total Revenue shall be computed on the basis of the maximum Tariffs leviable for and in respect of the Terminal/ Fairway Facilities and Services provided during the relevant period of computation. It is clarified that discounts and deferments, if any offered by the Terminal Operator to the users or amounts if any not collected by the Operator for any reason whatsoever in respect of the Terminal/Fairway Facilities and Services, shall be ignored for the purpose of Total Revenue.

Table 15.4 General Assumptions for Terminals

Description	Unit	Item
Corporate Tax	-	30%
Royalty to IWAI	INR/Tonne	10
Revenue Share	-	4%
Administrative Cost	Revenue	2%
Escalation Rate	This financial is prepared for constant pricing. The escalation rate is null.	

- Power & Water Supply at Dirty Cargo Terminals: For calculation of the cost of power requirement, the rate of commercial power for all dirty cargo terminals are considered as 8.5 INR/kWH and power factor as 0.8. The table also depicts assumed rate of water supply, i.e. INR 0.175 per litre in each Cargo terminal on NW 110 per Delhi Jal Board rates.

Table 15.5 Assumptions for Power & Water Supply Calculation for Cargo Terminals

Particulars	Unit	Rate
Number of Operational	Days	300
Rate of Commercial Power	INR/kWh	8.5
Power Factor for Electricity Supply	-	0.8
Price of Water	INR/Litre	0.175

- Depreciation: The table below depicts assumptions for depreciation calculation for terminals and fairway. Calculation of Depreciation is done for Income Tax Act for computation of taxes.

Table 15.6 Assumptions for Depreciation Calculation for Terminals

Assets	SLM
As per Income Tax Act	
Civil	15%
Mechanical	15%
Utilities	15%
Systems and IT	10%

15.2.1 Phase wise Development of Terminals and Fairway

Assumptions for Financial analysis for phase wise development of terminals and fairways in NW 110 is discussed below

- For Terminal development, it has been assumed that construction and operational period would be in three phases, as mentioned below. 2 years is considered as construction period for Terminals and next 28 years is considered as Operational period in each phase.

Table 15.7 Distribution of Phases in Terminals Development

Phase 1	**FY24 - FY25**	**FY26 - FY54**
	Construction Period	
		Operational Period
Phase 2	**FY30 - FY31**	**FY32 - FY60**
	Construction Period	
		Operational Period
Phase 3	**FY35 - FY36**	**FY37 - FY65**
	Construction Period	
		Operational Period

- For Fairway development, it has been assumed that Fairway construction would be done in three phases, as mentioned below. 4 years has been considered as development period.

Table 15.8 Distribution of Phases in Fairway Development

Phase 1	**Chainage (km)**	**FY21 - FY25**	**FY26 - FY65**
	0 – 453	*Development Period*	
			Operational Period
Phase 2	**Chainage (km)**	**FY27 - FY31**	**FY32 - FY65**
	453 –743	*Development Period*	
			Operational Period
Phase 3	**Chainage (km)**	**FY32 - FY36**	**FY37 - FY65**
	743 –1,051	*Development Period*	
			Operational Period

- As per Government norms, for any PPP or other infrastructure project, minimum period for operation should be 30 years. This period is required to recover capital investment and generate revenue. Financial modeling for Terminals on NW 110 in each phase is done for 30 years from the date of start of phase (including construction period). Traffic projection for each terminal in Traffic Study is done till FY 47; FY 17 has been considered as the base year. However, in Financial Model, project implementation has been proposed to be in phased manner, starting from FY 21. It has been considered that Phase 3 will end at FY 65, as Phase 1 will start from FY 21instead of FY 17, followed by Phase 2, which will start from FY 31and Phase 3, which will start from FY 32.

- As per Traffic projection in Traffic Study, in Phase 2, the construction and operation period would be FY 30- FY 47, i.e. 17 years. Since 17 years is a short period and would not be enough to recover capital investment, no Operator would be interested in a capital intensive infrastructure project for such a short period. Hence, it has been considered that instead of 17 years, operational period would be for 30 years, i.e. FY 22- FY 52 in Phase 1; FY 30- FY 60 in Phase 2 and FY 35- FY 65 in Phase 3. This period of 30 years would be enough to recover capital investment and generate revenue.
- In Traffic Study Report, traffic projections for each terminal is done till FY 47. However, for financial modeling, operation period has been increased till FY 60. It has been assumed that traffic beyond FY 47 would remain constant for next 18 years.
- It has been assumed that industries would shift only a certain % of cargo to IWT from existing road/rail movement, provided IWT is fully developed and deemed to be cost effective/reliable compared to the present mode of transportation, i.e. road/rail. For Shifting of cargo from existing modes to IWT on NW 110, it is necessary that IWT would be highly subsidized by the Government. Basis for a certain % of cargo shift is already discussed in Traffic Study and Logistics Cost Analysis Report.

15.2.2 Development and Maintenance of Waterway

Assumptions for Financial analysis for development and maintenance of waterway in River Yamuna are discussed below.

- It has been assumed that the IWAI would ensure availability of water round the year in the river and maintain uniform water depth for smooth navigation. It has been assumed that IWAI would bear the cost associated with development of navigation on waterway and maintenance of Least Available Depth (LAD) round the year. The cost of developing waterway and maintaining water depth should not be transferred to the Vessel Operator or Cargo Owner. An analysis for shifting this cost was made which led to rise in waterway transportation cost along with negative implications on financials.
- The LAD should be constant for complete stretch of the waterway. If LAD varies after a certain stretch, it would be challenging to use different categories of vessels due to hurdles or intermittent hindrance. Difference of LAD in different stretches of NW 110 would result in multiple handling of cargo and change ofvessels.This would increase the cost of transportation through IWT on NW 110. Considering that transportation cost using IWT is higher than transportation cost using road/rail, Industries would not be willing to use IWT on NW 110. Shifting of cargo to IWT would be impractical for industries and would further threaten the viability of waterway on River Yamuna.
- It has been assumed that due to operational inefficiency and longer distance of travel on NW110 and cost comparison between existing mode (roadway/railway) and IWT, cost of IWT would be higher. For example, distance between Origin point and Destination point is 50% -60% more using IWT than roadway and railway. Considering longer distance using IWT, it is necessary that Government would subsidize the difference in logistics cost and reduce the cost of IWT to

make the project viable. This would have to be done till the time, Multimodal transportation using IWT becomes competitive to Railway and Roadways in its natural course.

- It has been assumed that existing bridges on river Yamuna and Ganga would be modified to facilitate seamless movement of IWT vessels.

15.2.3 Financials for Terminals

- Financial of each Terminal is based on the proposed location for Terminals on NW 110. Factors, which are considered for proposing terminal sites are availability of land parcel, availability of least water depth (LAD), availability of cargo and presence of industries in the vicinity.
- Terminals on NW 110 would be developed according to type of cargo/passenger they would handle, for instance, dirty cargo terminals; clean cargo terminals and passenger terminals would be different in layout and operations. Classification of terminals has been undertaken to accommodate different types of vessels for handling cargo, type of the terminal, its location and proposed infrastructure in and around the terminal.
- Financial model for each terminal is different, based on the type of terminal. Capital investment, tariff structure and operating cost for dirty cargo, multi modal cargo and passenger would be different.
- For viability of terminals and attracting customers, it is necessary to keep the cost of terminals competitive.
- Financial of Terminals is independent of fairway. For financial of Terminals, it has been assumed that fairway is fully developed. It may be viable or heavily subsidized by Government.
- The cost of land acquisition has not been factored in development of Fairway. It has been assumed that the Government would bear the land acquisition cost.

15.2.4 Financials for Fairway

Financial of fairway is independent of Terminal. It has been assumed that fairway is fully developed by the Government (IWAI). It may be viable or heavily subsidized by the Government. It has been assumed that Government would waive off the cost of fairway. No tariff would be charged for using fairway developed by IWAI, so that the total logistics cost of transportation using waterway would not exceed.

15.2.5 Connectivity Development

Assumptions for Financial analysis for development of connectivity around terminals in NW 110 are discussed below.

- It has been assumed that the Government would develop approach roads to make all the terminals accessible. There has to be sufficient liaison between different departments, such as Railways, National Highway Authorities,State Highways etc. to facilitate development around the terminals on NW 110. IWAI will take the responsibility of development with support of the aforementioned departments. Financial implications involved in connectivity development have been considered in financial analysis.

- Cost of local roads has been considered as part of terminal development and corresponding costs have been factored in. Investments for 1st mile or last mile railway connectivity for terminals falling on NW110 have been factored in capital cost of terminals.
- The cost of land acquisition for railway connectivity has to be borne by IWAI and railways. This cost would include land acquisition cost for railways connectivity. A separate study would be required for detailed alignment study and costing for railways connectivity.
- IWAI would facilitate connectivity with road and rail to the terminal. These rail and road link from terminal should be connected to the existing nearest transportation grid. This connectivity development cost has been factored in the Financials.

15.2.6 Vessels

Assumptions for Financial analysis for vessels, which would be used on NW 110 is discussed below.

- The design of vessels and their operational parameters indirectly influence Financial Analysis of terminals and fairway. IWAI's specially designed barges of 1800-2000 DWT have been considered as an attractive proposition during Logistics cost analysis. Same assumptions have been considered for Financial Analysis. It is assumed that the operator/vessel owner would build custom designed IWAI vessels for deployment in NW 110.
- Changing classifications of vessels to generic might increase per ton logistics cost and impact the overall cargo volume calling to terminal. This would reduce revenue prospects of terminals adversely affecting its financials. Using different classification of vessel would change financial analysis, as cost would vary for different categories of vessel. Size of vessels would determine the number of ship calls in the terminals and class of fairway.
- It has been assumed that Vessel owner would bear the cost related to vessels, i.e. acquisition cost, repair & maintenance cost, operational cost etc. IWAI would not bear these vessel costs; hence, these costs are not factored in the financial model of terminals or fairway. The vessel owner would recover cost of service provided on NW110 from cargo owner. The cargo owner could be power plants for coal transportation, industries for raw material and finished product movement or passengers for availing cruise ride etc.

15.3 Financial Analysis for Terminals (Dirty Cargo, Multi-Purpose & Passenger)

The terminals proposed on NW110 are categorized into dirty cargo (Coal & Fly Ash), Multi-Purpose cargo (Clean commodities) and Passengers (Inter and Intra district). 5 terminals are proposed for handling coal & fly ash, 3 terminals for clean cargo i.e. fertilizer, sugar, iron & steel, etc., 5 (T9,T10,T11,T12, T13a,b,c,d) for passengers and 1 for ro-ro. Development of these terminals are divided into 3 phases, as shown in the table below.

Table 15.9 Phase wise development of Terminals on NW110

Development Phases	Coal & Fly Ash	Multi-Purpose	Passenger & Tourist
Phase 1	T3, T4, T5	T6, T8	T12 (a, b, c), T13 (a, b, c, d)
Phase 2	T2	-	T10
Phase 3	T1	T7	T9, T11

15.3.1 Dirty Cargo Terminals

15.3.1.1 Inputs for Financial Analysis of Dirty Cargo Terminals

All the assumptions and inputs used in developing financial analysis of Dirty cargo terminals on River Yamuna are discussed in this section. The financial analysis is done for Dirty cargo terminal operations on NW 110.

- **Tariff Assumptions for Dirty Cargo Terminals**

Tariff assumptions for dirty cargo handling at Terminals 1-5 are based on Industry inputs and current Tariff of IWAI. The below table presents proposed tariff for various facilities for users in dirty cargo terminals. Competitive Tariff is considered for cargo handling at Dirty Cargo Terminals to attract industries for using IWT on river Yamuna.

Vessel berthing cost is charged for the use of a berth. It includes vessels' anchorage and mooring at a berth. Vessel berthing cost is based on the duration of a vessel's stay and length overall (LOA). The below table depicts assumed vessel berthing charge in Dirty Cargo terminals. Vessel berthing charges for Coal and Fly Ash are kept same, i.e. INR 7,000 per Day/Vessel. However, other charges for coal and fly ash vary.

Table 15.10 Vessel Berthing Cost at Dirty Cargo Terminal

Description	Rate	Unit	Reference
Coal	7,000	Per Day/Vessel	Industries Input
Fly Ash	7,000	Per Day/Vessel	Industries Input

Wharfage charge is cost for the movement of cargo through the facility (Terminal) within distribution system. The wharfage dues shall be calculated on the total tonnage of each item of goods. The proposed rates to be paid for the use of wharves, jetties and landing places (hereinafter referred to as Wharfage dues) on goods landed at Dirty cargo Terminals on NW 110 is specified in the below table.

Table 15.11 Wharfage Cost at Dirty Cargo Terminal

Description	Rate	Unit	Reference
Coal	80	Per Tonne	Industries Input
Fly Ash	40	Per Tonne	Industries Input

Stevedoring charge includes Fees for loading and stowing or unloading a vessel. The below table depicts assumed stevedoring charge in Dirty Cargo terminals for coal and fly ash.

Table 15.12 Stevedoring Cost at Dirty Cargo Terminal

Description	Rate	Unit	Reference
Coal	120	Per Tonne	Industries Input
Fly Ash	60	Per Tonne	Industries Input

Storage Tariff is charges towards rent for storage of goods in the stackyards, warehouses and transit sheds in the Terminal. This tariff would be charged for storage of coal and fly ash in the stackyard. This tariff would be charged until the cargo is removed from the storage facility. The below table shows storage charges in Dirty Cargo terminals.

Table 15.13 Storage Cost at Dirty Cargo Terminal

Description	Rate	Unit	Reference
Coal	50	Per Tonne	Industries Input
Fly Ash	20	Per Tonne	Industries Input

Stackyard handling and evacuation tariff is charged for handling Dirty cargo, i.e. coal and fly ash. This charge includes transportation of cargo to the yard, offloading in yard, loading cargo in railway rake for evacuation.

Table 15.14 Stackyard Handling & Evacuation Cost at Dirty Cargo Terminal

Description	Rate	Unit	Reference
Coal	120	Per Tonne	Industries Input
Fly Ash	60	Per Tonne	Industries Input

- **Coal & Fly Ash Handling Cost at Terminals**

The detailed cargo handling cost at Dirty Cargo terminals (1-5) is prescribed in the below table. These bulk handling cost is for various cargo handling activities on the terminals, such as unloading of the cargo from the vessel and transfer of the same up to the point of storage, storage at the stackyard, reclaiming from stackyard and loading onto railway rake, sweeping of cargo on the wharf, dust suppression services and all other miscellaneous services. The handling cost includes handling cost of equipment, like excavator cost, tipper truck cost, water sprinkler cost, labour cost etc. All these costs are assumed based on industry inputs. Bulk handling cost for coal and fly ash is kept same.

Table 15.15 Assumptions for Cargo Handling Cost at Dirty Cargo Terminals for Coal

Description	Unit	Item
Cargo Handling at Jetty	INR/Tonnes	55.0
Storage	INR/Tonnes	30.0
Stackyard Handling	INR/Tonnes	20.0
Evacuation	INR/Tonnes	60.0

Table 15.16 Assumptions for Cargo Handling Cost at Dirty Cargo Terminals for Fly Ash

Description	Unit	Item

Cargo Handling at Jetty	INR/Tonnes	40.0
Storage	INR/Tonnes	20.0
Stackyard Handling	INR/Tonnes	10.0
Evacuation	INR/Tonnes	30.0

- **Salary Calculation for Dirty Cargo Terminals**

The below table depicts proposed salaries for employees in Dirty cargo terminals. As shown in the below table, number of employees would vary in some departments in Phase 1 and Phase 2.

Table 15.17 Assumptions for Manpower at Each Dirty Cargo Terminal

Department	Person	Monthly Salary (INR/Person)	No. of Employees	
			Phase 1	Phase 2
-	Manager	90,000	1	1
Admin & Account	Admin Officer	40,000	1	2
	Account Staff	30,000	2	3
	Store Staff	15,000	4	5
	Hospitality	15,000	2	4
	Security	15,000	4	6
Operation	Ops Manager	50,000	1	2
	Supervisor	50,000	2	3
	Operator	40,000	2	3
	Drivers	20,000	3	3
Maintenance	Mechanic	20,000	1	1
	Electrician	20,000	1	1
	Civil Superintendent	50,000	1	1
	Workers	12,000	2	3
	Hospitality	15,000	2	3

- **Loan Schedule**

The below table depicts assumption for loan schedules for Dirty cargo terminals on NW 110. For Dirty cargo terminals, it is considered that loan tenure would be 20 years. Construction period of 2 years is considered for Dirty cargo terminals. Moratorium Period, i.e. Post Construction Period for Dirty cargo terminals would be 2 years. 11% Rate of interest is considered for Dirty cargo terminals.

Table 15.18 Assumption for Loan Schedule for Dirty Cargo Terminals

Description	Item
Loan Tenure	20 Years
Moratorium Period (Post Construction Period)	2 Years
Construction Period	2 Years
Rate of Interest	11%

15.3.1.2 Terminal 1 –MadanpurKhadar

- **Phasing**

Terminal 1 is proposed to be developed in Phase 3 i.e. from FY35. This is the last phase of fairway development, in this phase the entire stretch of NW110 would become operational i.e. from Prayagraj to Delhi. The construction of infrastructure, equipment handling, connectivity will take 2 years and the terminal will get operational from FY37 for next 30 years.

Table 15.19Development of Terminal 1

Type	Terminal No. (Total Jetties)	Chainage (km)	FY35	FY36	FY37	FY65
Coal	T1 (2 Jetties)	1047.8	Construction - 2 Jetties			
					Operational - 2 Jetties	

- **Traffic**

This terminal is proposed for handling dirty cargo i.e. Coal for nearby TPP i.e. Dadri&Badarpur. Presently these plants are procuring coal from eastern region by rail; certain share of this movement is diverted to IWT using NW1 till Prayagraj and thereafter NW110 till Okhla Barrage. Traffic for Terminal 1 for next 30 years is projected in the table below.

Table 15.20Traffic at Terminal 1 ('000 T)

Cargo	Origin	Destination	Fy35	Fy37	Fy40	Fy45	Fy50	Fy60	Fy65
Coal	Piparwar / Haldia	Dadri	-	2,150	2,349	2,723	2,889	2,889	2,889
	ECL	Badarpur		716	782	907	962	962	962
Total			**-**	**2,866**	**3,131**	**3,630**	**3,851**	**3,851**	**3,851**

- **Capital Cost**

This section represents the total capital expenditure in a phased manner for Terminal 1 proposed at MadanpurKhadar for coal handling in River Yamuna.

Table 15.21 Project Cost for Construction Terminal-1 (INR Lakhs)

Sl. No.	Description	Total Investment	Fy 35	Fy36
A	Terminal	7,800	4,680	3,120
B	Approach Rail / Road	3,240	1,944	1,296
C	Supporting Infrastructure	5,905	3,543	2,362
D	Cargo Handling Equipment	4,102	820	3,281
E	Other Financial Cost	6,071	3,035	3,035
	Total Capex	**27,117**	**14,023**	**13,095**

Construction of this terminal would take 2 years to get completed i.e. in FY35 and FY36. It would start operating from FY37 till FY65. Detailed cost of cargo handling and other supporting infrastructure along with ship repair facility required at terminal is listed in the table below.

Table 15.22Supporting Infrastructure Requirement Cost at Terminals-1 (INR Lakhs)

S.No.	Description	No.	Rate (INR Lakhs)	Cost (INR Lakhs)
1	Parking Area	1.0	15.0	15.0
2	Canteen	1.0	15.0	15.0
3	Admin Building	1.0	40.0	40.0
4	STP	1.0	20.0	20.0
5	Fire Tender	1.0	20.0	20.0
6	Dispensary	1.0	15.0	15.0
7	Electrical Substation	1.0	-	-
8	Fencing and Guard	1.0	40.0	40.0
9	Cold Storage	0.0	300.0	0.0
10	Storage area, Warehouses	45,600 Sq.m	0.162	740.2
11	Ship Repair &Maintenance Facility	1.0	5,000	5,000
	Total			**5,905.2**

- **Project Financing**

Construction Phase 1 & Phase 2 has been assumed to be funded in an Equity-Debt ratio of 35:65. Details of the means of financing for both the phases are shown below.

Table 15.23 Equity-Debt Share Distribution for Terminal 1 (INR Lakhs)

Particulars	%	Investment
Equity	35%	9,491
Debt	65%	17,626

- **Financial Indicators**

This section shows the financial indicator that leads to the generation of FIRR for Terminal – 1. Revenue, Salary, Depreciation, Cash Flow, P&L Statement & Balance Sheet helps on understanding the returns on investment made for this terminal.

Revenue from Terminal 1 proposed on River Yamuna will be generated from core operations that include cargo handling at the jetty, Storage, Stackyard, Evacuation from yard to Rail. The detailed breakup of revenue is shown in the table above.

Table 15.24 Revenue from Terminal-1 (INR Lakhs)

Particulars	FY35	FY37	FY40	FY45	FY50	FY55	FY60	FY65
Vessels Charges	0	112	122	141	150	150	150	150
Wharfage	0	2,292	2,505	2,904	3,081	3,081	3,081	3,081
Stevedoring	0	3,439	3,758	4,356	4,621	4,621	4,621	4,621
Cargo Storage	0	1,433	1,566	1,815	1,926	1,926	1,926	1,926
Stackyard Operation	0	3,439	3,758	4,356	4,621	4,621	4,621	4,621
Total Revenue	**0**	**10,714**	**11,708**	**13,572**	**14,399**	**14,399**	**14,399**	**14,399**

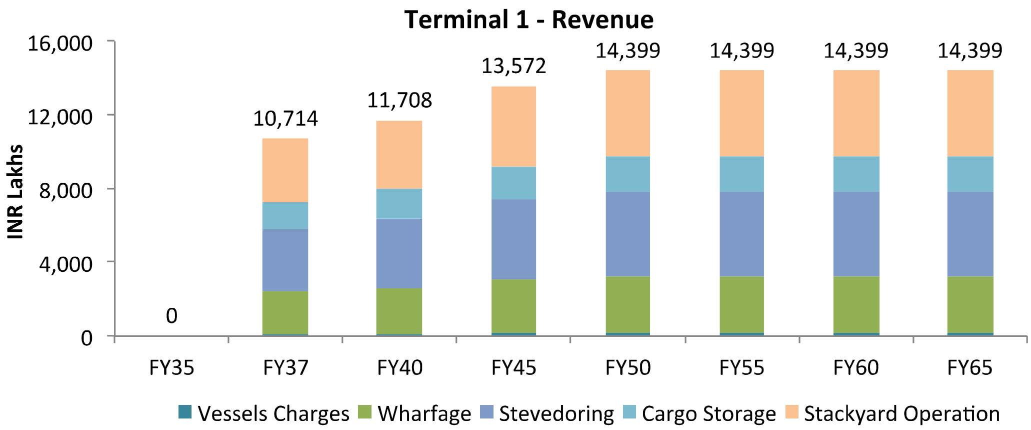

Fig.15.2 Revenue for Terminal 1

The following table indicates the direct operating cost for development of Terminal 1. This direct operating cost include cargo Handling charges, Storage cost, evacuation cost &stackyard handling cost.

Table 15.25 Direct Operating Cost for Terminal 1 (INR Lakhs)

Particulars	FY35	FY37	FY40	FY45	FY50	FY55	FY60	FY65
Cargo Handling at Jetty	0	1,576	1,722	1,996	2,118	2,118	2,118	2,118
Storage Cost	0	860	939	1,089	1,155	1,155	1,155	1,155
Evacuation Cost	0	1,719	1,879	2,178	2,311	2,311	2,311	2,311
Stackyard Handling	0	573	626	726	770	770	770	770
Salary	0	130	130	130	130	130	130	130
Power & Water	0	943	943	943	943	943	943	943
Total	0	5,801	6,240	7,063	7,427	7,427	7,427	7,427

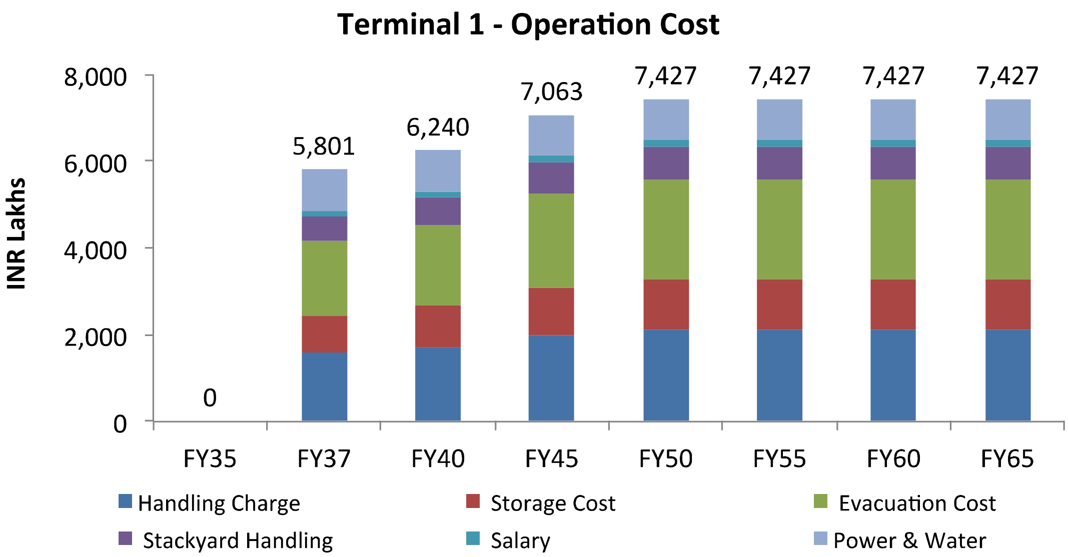

Fig. 15.3Operating Costat Terminal 1

Table 15.26 Maintenance Cost for Terminal 1 (INR Lakhs)

Particulars	FY35	FY37	FY40	FY45	FY50	FY55	FY60	FY65
Civil	102	169	169	169	169	169	169	169
Mechanical	41	205	205	205	205	205	205	205
Insurance Cost	118	207	143	81	48	30	20	14

Administration Cost	0	214	234	271	288	288	288	288
Total	261	796	752	727	711	693	682	676

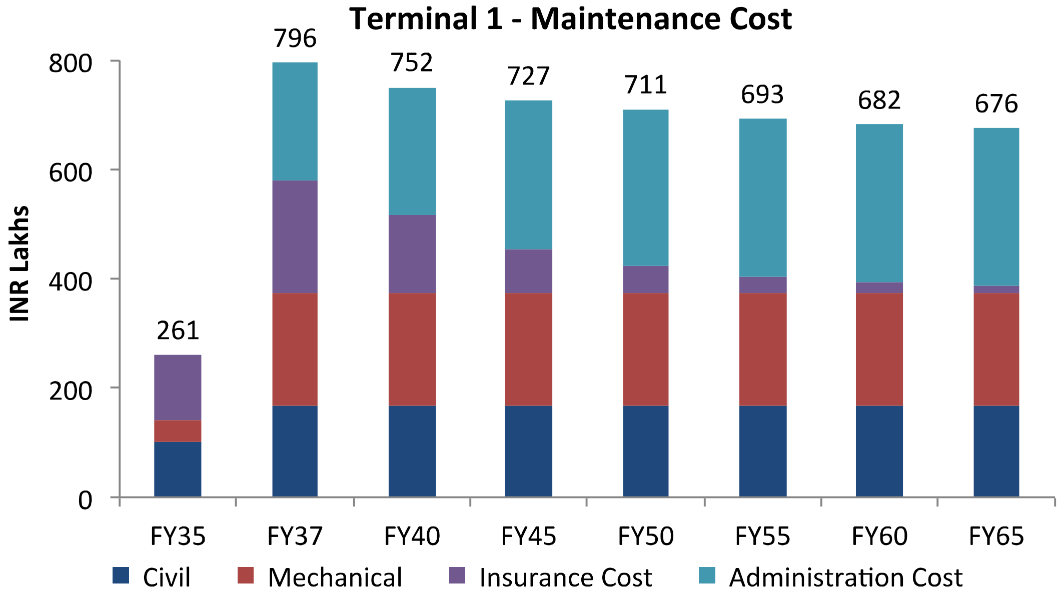

Fig. 15.4 Maintenance Costat Terminal 1

The operator would share 4% of its revenue with IWAI and pay royalty of INR 10 per Tonne. The table below indicates the amount of total outflow to IWAI in case of Terminal 1.

Table 15.27Regulatory Royalty to IWAI for Terminal 1 (INR Lakhs)

Particulars	FY35	FY37	FY40	FY45	FY50	FY55	FY60	FY65
Royalty to IWAI	0	287	313	363	385	385	385	385
Revenue Share	0	429	468	543	576	576	576	576
Total Outflow to IWAI	0	715	781	906	961	961	961	961

The section above summaries the Revenue generated by operation of Terminal 1 and total cost i.e. O&M cost and out-flow to IWAI (Royalty and Revenue Share) from FY35 till FY47. The operator would share 4% of its revenue with IWAI and pay royalty of INR 10 per Tonne.

The following table depicts the P/L statement for development of Terminal 1 on River Yamuna near MadanpurKhadar.

Table 15.28 Profit & Lost Statement for Terminal 1 (INR Lakhs)

Particulars	FY35	FY37	FY40	FY45	FY50	FY55	FY60	FY65
Revenue	-	10,714	11,708	13,572	14,399	14,399	14,399	14,399
O & M Cost	261	5,654	6,048	6,846	7,195	7,177	7,167	7,161
Total Outflow to IWAI	-	715	781	906	961	961	961	961
PBDIT	-261	4,345	4,878	5,820	6,242	6,260	6,271	6,277
Depreciation	-	2,546	2,546	1,332	1,332	-	-	-
Interest	1,003	1,834	1,519	994	469	-	-	-
PBT	- 1,263	-36	812	3,493	4,441	6,260	6,271	6,277
Tax	-	-	244	1,048	1,332	1,878	1,881	1,883
PAT	- 1,263	- 36	569	2,445	3,109	4,382	4,389	4,394

The terminal will start generating profit from 1st year of operation only i.e. Fy-37. This is mainly due to high Revenue& high traffic whereas lower development cost. These are the major factors that heavily impacts commercial prospects of proposed terminal.

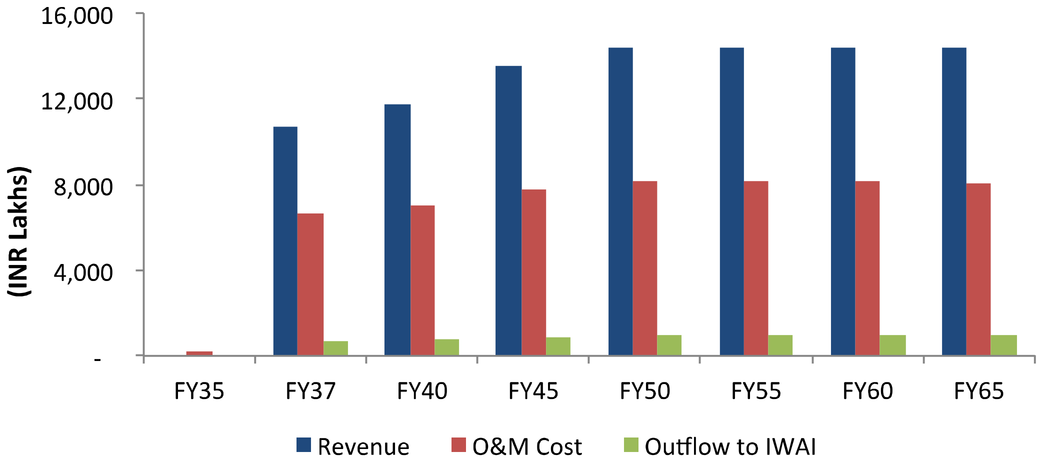

Fig. 15.5 Comparison among Revenue, O&M Cost and Total Outflow to IWAI

Depreciation has been calculated using the Straight Line Method (SLM). Under this method, cost of asset is evenly distributed across its useful life. Straight Line Method (SLM) has been used to calculate depreciation for Terminal 1, under which the cost of tangible and intangible assets are evenly distributed across its life.

Table 15.29 Depreciation for Terminal 1 (INR Lakhs)

Particulars	FY35	FY37	FY40	FY45	FY50	FY55	FY60	FY65
Gross Block	14,023	27,117	27,117	27,117	27,117	27,117	27,117	14,023
Depreciation & Amortization	-	2,546	1,332	1,332	-	-	-	-
Cumulative Depreciation & Amortization	-	12,732	19,393	26,054	27,117	27,117	27,117	-
Net Block	14,023	14,385	7,724	1,063	-	-	-	14,023

The table below depicts the cash inflow & outflow in case of development of Terminal 1.

Table 15.30 Cash Flow for 1 (INR Lakhs)

Particulars	FY35	FY36	FY40	FY45	FY50	FY60	FY65
Cash Inflow							
Equity	4,908	4,583	0	0	0	0	0
Debt	9,115	8,512	0	0	0	0	0
Net Cash from Investment	14,023	13,095	0	0	0	0	0
Operations							
PBDIT	-261	-610	4,878	5,820	6,242	6,271	6,277
(-) Taxes Paid	0	0	244	1,048	1,332	1,881	1,883
Net Cash from Operations	-261	-610	4,634	4,772	4,910	4,389	4,394
Total Cash Inflow	13,762	12,485	4,634	4,772	4,910	4,389	4,394

Particulars	FY35	FY36	FY40	FY45	FY50	FY60	FY65
Cash Outflow							
Capital Investment	14,023	13,095	0	0	0	0	0
Long Term Debt	0	0	954	954	954	0	0
Interest	1,003	1,939	1,519	994	469	0	0
Total Cash Outflow	15,025	15,034	2,473	1,948	1,424	0	0
Net Cash Flow	-1,263	-2,549	2,161	2,823	3,487	4,389	4,394
Opening Balance of Cash	0	-1,263	1,470	12,845	28,702	67,096	89,053
Closing Balance Cash	-1,263	-3,812	3,631	15,669	32,188	71,486	93,447

Table 15.31 Balance Sheet for Terminal 1 (INR Lakhs)

Sources of Funds	**FY35**	**FY36**	**FY40**	**FY45**	**FY50**	**FY60**	**FY65**
Shareholder's funds							
Capital	4,908	9,491	9,491	9,491	9,491	9,491	9,491
Reserves & Surplus	-1,263	-6,358	-5,284	4,865	19,495	61,995	83,956
Borrowings							
Secured Loans	9,115	17,626	13,809	9,037	4,265	0	0
Total Funds	**12,759**	**20,759**	**18,016**	**23,393**	**33,251**	**71,486**	**93,447**
Usages of Fund							
Fixed Assets							
Gross Block	14,023	27,117	27,117	27,117	27,117	27,117	27,117
Less: Depreciation	0	2,546	12,732	19,393	26,054	27,117	27,117
Net Block	14,023	24,571	14,385	7,724	1,063	0	0
Net Current Assets	-1,263	-3,812	3,631	15,669	32,188	71,486	93,447
Total Assets	**12,759**	**20,759**	**18,016**	**23,393**	**33,251**	**71,486**	**93,447**

- **Financial IRR**

  Financial FIRR presented below will help IWAI to measure the financial returns on investment and assist take a firm decision on the implementation of this development. Final viability assessment for developing coal handling terminal on this River Yamuna would be done based on this outcome.

Table 15.32 Financial IRR Calculation for Terminal 1 (INR Lakhs)

Particulars	FY35	FY37	FY40	FY45	FY50	FY60	FY65
PBDIT	-261	4,345	4,878	5,820	6,242	6,271	6,277
Interest	1,003	1,834	1,519	994	469	0	0
Principal repayment	0	954	954	954	954	0	0
Equity	4,908	0	0	0	0	0	0
Debt	9,115	0	0	0	0	0	0
Total Investment	14,023	0	0	0	0	0	0
Tax	0	0	244	1,048	1,332	1,881	1,883
Cash flow to Equity(Pre-tax)	-6,171	1,556	2,404	3,871	4,819	6,271	6,277
Equity IRR(Pre-tax)	**20%**						
Cash flow to Equity(Post-tax)	-6,171	1,556	2,161	2,823	3,487	4,389	4,394
Equity IRR(Post-tax)	**16%**						
Project Cash flow(Pre-tax)	-14,283	4,345	4,878	5,820	6,242	6,271	6,277

Particulars	FY35	FY37	FY40	FY45	FY50	FY60	FY65
Project IRR(Pre-tax)	**17%**						
Project Cash flow(Post-tax)	-14,283	4,345	4,634	4,772	4,910	4,389	4,394
Project IRR(Post-tax)	**15%**						

- **Economic IRR**

Economic IRR (EIRR) comprises all financial and non-financial benefits of the project. Non-Financial benefits include carbon emission, employment generation, reduction in congestion, less vehicle operating cost, saving on fuel, etc. EIRR helps in investment decision from prospects of improving welfare of society. If any project is commercially unviable then its economic viability is considered. This section evaluates the value addition that, this project induces in society and the impact on various social factors. These impacts are transformed into financial gains which can bring the state and central government to fund resources for the implementation. Government undertake the detailed assessment at projects contribution to the betterment of society like employment generation, improvement in connectivity, pollution control, trade improvement, etc.

Assumptions considered for computing EIRR are for Terminal 1 is listed below.

Table 15.33Assumptions for EIRR Calculations

Parameters Adopted	Value	Unit
Economic loss due to Road Accidents	0.03	of GDP
Value of economic loss due to road accidents	3.76	Rs. Lakhs Crores
Safety Index (IWT as base)	5.00	times safer than rail
Accident Loss		
Rail	0.77	Rs Lakhs/KM
IWT	0.15	Rs Lakhs/KM
Fuel Cost		
Rail	85.00	t-km / per liter
IWT	105.00	t-km / per liter
Fuel price	69.40	Rs/Litre
Vehicular operating cost (VOC)		
Rail	1.41	Rs/t-km
IWT	1.04	Rs/t-km
Direct Employment Creation		
Rail	2.00	Per Million t-km
IWT	0.50	Per Million t-km
Employment cost	2.50	Rs Lakhs per Annum
Emission Reduction		
Rail	13.30	g CO2/t-km
IWT	6.00	g CO2/t-km
Shadow factor		
CAPEX/O&M Cost (Convert financial cost to economic cost)	0.85	-

Parameters Adopted	Value	Unit
Carbon Credits factors		
Carbon Shadow price	20.00	$/Tonne
Exchange rate	67.00	Rs/USD

All the essential assumptions with respect to fuel efficiency, direct employment multiplier, reduction in carbon emission, and carbon credit factors have been taken from the common industrial benchmarks.

Estimated impact of each factor at terminal 1 for the period of 30 years is presented in the table below.

Table 15.34 Economic IRR Calculation for Terminal 1 (INR Crore)

Operation years	FY35	FY36	FY37	FY40	FY45	FY50	FY55	FY60	FY65
Accident Loss			6	6	6	6	6	6	6
Saving on fuel			47	48	50	51	59	63	63
Saving on account of VOC			111	114	118	121	141	149	149
Job creation			75	77	80	82	95	101	101
Reduction in Emissions			3	3	3	3	4	4	4
Total Revenue			107	110	114	117	136	144	144
Total Economic Impact	-	-	349	360	370	381	441	467	467
O&M Expenditure	3	6	57	58	59	60	68	72	72
Economic Cash Outflow	- 3	-6	293	302	311	321	372	395	396
Investment	140	131				-		-	
Net Cash Flow to Project	-143	-137	293	302	311	321	372	395	396
Project EIRR	**77.9%**								

15.3.1.3 Terminal 2–SamogarMustkil

- **Phasing**

Terminal 2 is proposed to be developed in Phase 2 i.e. from FY30. This is the second phase of fairway development, in this phase Prayagraj to Agra stretch would be developed. The construction of infrastructure, equipment handling, connectivity will take 2 years and the terminal will get operational from FY32 till FY60.

Table 15.35 Development of Terminal 2

<table>
<tr><th>Total Jetties</th><th>Chainage (km)</th><th>FY30</th><th>FY31</th><th>FY32</th><th>FY35</th><th>FY36</th><th>FY37</th><th>FY60</th></tr>
<tr><td rowspan="4">2</td><td rowspan="4">731</td><td colspan="2">Construction - 1 Jetty</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td colspan="5">Operational - 1 Jetty</td></tr>
<tr><td></td><td></td><td></td><td colspan="2">Construction - +1 Jetties</td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td colspan="2">Operational - +1 Jetties</td></tr>
</table>

- **Traffic**

This terminal is proposed for handling dirty cargo i.e. Coal for nearby TPP i.e. Harduaganj and Jawaharpur. Presently these plants are procuring coal from eastern region by rail, certain share of this movement is diverted to IWT using NW1 till Prayagraj and thereafter NW110. Traffic for Terminal 2 for next 30 years is projected in the table below.

Table 15.36 Traffic at Terminal 2 ('000 T)

Cargo	Origin	Destination	Fy30	Fy35	Fy40	Fy45	Fy50	Fy55	Fy60
Coal	BCCL	Harduaganj, Aligarh	629	743	862	999	1,029	1,029	1,029
	NCL	Jawaharpur	713	842	976	1,132	1,166	1,166	1,166
Fly Ash	Jawaha rpur	Singapore	523	561	589	619	626	626	626
Total			1864	2146	2427	2750	2820	2820	2820

- **Capital Cost**

This section represents the total capital expenditure in a phased manner for Terminal 2 proposed at SamogarMustkil for coal handling in River Yamuna.

Table 15.37 Project Cost for Construction Terminal-2 (INR Lakhs)

Sl. No.	Description	Total Investment	Investment Phase I		Investment Phase II	
			Fy-30	Fy-31	Fy 35	Fy36
A	Terminal	7,800	2,340	1,560	2,340	1,560
B	Approach Rail/Road	5,594	1,678	1,119	1,678	1,119
C	Supporting Infra	5,827	3,496	2,331	-	-
D	Cargo Handling Equipment	2,101	312	1,247	108	434
E	Utilities	-	-	-	-	-
F	IT		-	-	-	-
G	Other Financial Cost	94,042	23,511	23,511	23,511	23,511
I	Consultancy			-		-
	Total Capex	**115,364**	31,337	29,767	27,637	26,623

Construction of this terminal would take 2 years to get completed i.e. in FY30 and FY31. It would start operating from FY32. Detailed cost of cargo handling and other supporting infrastructure required at terminal is listed in the table below.

Table 15.38Infrastructure Requirement Cost at Terminal-2 (INR Lakhs)

S.No.	Description	No.	Rate (INR Lakhs)	Cost (INR Lakhs)
1	Parking Area	1.0	15.0	15.0
2	Canteen	1.0	15.0	15.0
3	Admin Building	1.0	40.0	40.0
4	STP	1.0	20.0	20.0
5	Fire Tender	1.0	20.0	20.0

6	Dispensary	1.0	15.0	15.0
7	Fencing and Guard	1.0	40.0	40.0
8	Cold Storage	0.0	300.0	0.0
9	Storage area, Warehouses	40,800 Sq.m	1,623.1	662.25
	Total			**827.25**

- **Project Financing**

  Construction Phase 1 & Phase 2 has been assumed to be funded in an Equity-Debt ratio of 35:65. Details of the means of financing for both the phases are shown below.

Table 15.39 Equity-Debt Share Distribution for Terminal 2 (INR Lakhs)

Particulars	%	Investment Phase I	Investment Phase II
Equity	35%	21,386	18,991
Debt	65%	39,717	35,269

- **Financial Indicators**

  This section shows the financial indicator that leads to the generation of FIRR for Terminal – 2. Revenue, Salary, Depreciation, Cash Flow, P&L Statement & Balance Sheet helps on understanding the returns on investment made for this terminal.

  Revenue from Terminal 2 proposed on River Yamuna will be generated from core operations that include cargo handling at the jetty, Storage, Stackyard, Evacuation from yard to Rail. The detailed breakup of revenue is shown in the table above.

Table 15.40 Revenue from Terminal-2 (INR Lakhs)

Particulars	FY32	FY35	FY40	FY45	FY50	FY55	FY60
Vessels Charges	78	84	95	107	110	110	110
Wharfage	1,378	1,493	1,706	1,952	2,006	2,006	2,006
Stevedoring	2,068	2,239	2,559	2,928	3,009	3,009	3,009
Cargo Storage	834	905	1,037	1,189	1,222	1,222	1,222
Stackyard Operation	2,068	2,239	2,559	2,928	3,009	3,009	3,009
Total Revenue	6,425	6,959	7,955	9,105	9,356	9,356	9,356

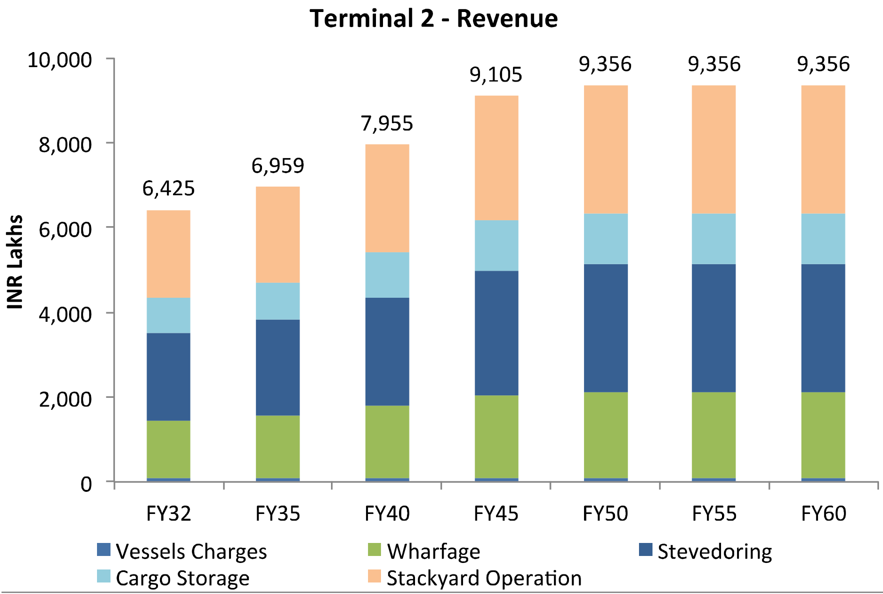

Fig. 15.6 Revenue for Terminal 2

The following table indicates the direct operating cost for development of Terminal 2. This direct operating cost include cargo Handling charges, Storage cost, evacuation cost &stackyard handling cost.

Table 15.41 Direct Operating Cost for Terminal 2 (INR Lakhs)

Particulars	FY32	FY35	FY40	FY45	FY50	FY55	FY60
Cargo Handling at Jetty	1,016	1,096	1,247	1,420	1,457	1,457	1,457
Storage Cost	544	588	669	763	783	783	783
Evacuation Cost	345	373	427	488	501	501	501
Stackyard Handling	1,034	1,119	1,280	1,464	1,504	1,504	1,504
Power & Water	826	841	841	841	841	841	841
Salary	93	93	130	130	130	130	130
Total	**3,857**	**4,111**	**4,593**	**5,106**	**5,218**	**5,218**	**5,218**

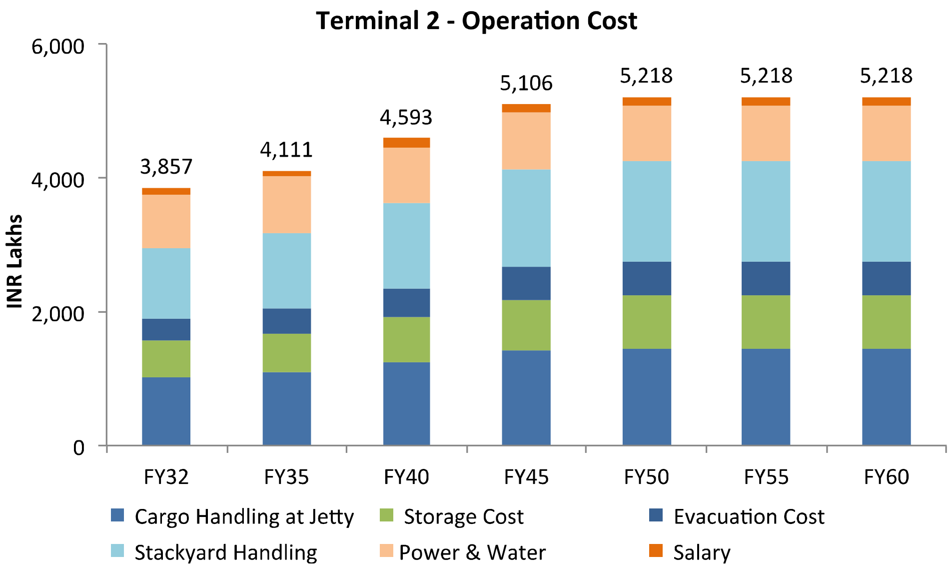

Fig. 15.7 Operating Cost at Terminal 2

Table 15.42 Maintenance Cost for Terminal 2 (INR Lakhs)

Particulars	FY32	FY35	FY40	FY45	FY50	FY55	FY60

Civil	125	165	192	192	192	192	192
Mechanical	78	83	105	105	105	105	105
Insurance Cost	123	118	71	31	14	6	3
Administration Cost	129	139	159	182	187	187	187
Total	454	506	527	511	498	491	487

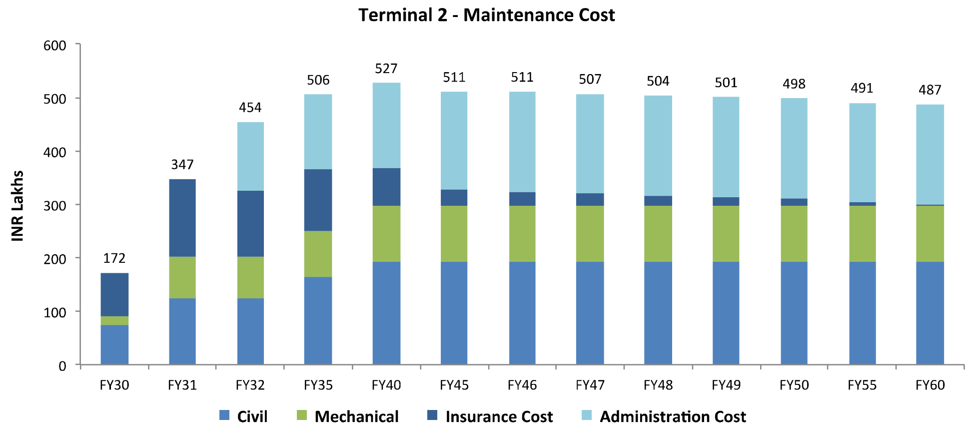

Fig. 15.8 Maintenance Cost at Terminal 2

The operator would share 4% of its revenue with IWAI and pay royalty of INR 10 per Tonne. The table below indicates the amount of total outflow to IWAI in case of Terminal 2.

Table 15.43 Regulatory Royalty to IWAI for Terminal 2 (INR Lakhs)

Particulars	FY32	FY35	FY40	FY45	FY50	FY55	FY60
Royalty to IWAI	200	215	243	275	282	282	282
Revenue Share	257	278	318	364	374	374	374
Total Outflow to IWAI	457	493	561	639	656	656	656

The section above shows the Revenue generated by operation of Terminal 2 and total cost i.e. O&M cost and out-flow to IWAI (Royalty and Revenue Share) from FY32 till FY60. The following table depicts the P/L statement for development of Terminal 2 on River Yamuna near SamogarMustkil.

Table 15.44 Profit& Lost Statement for Terminal 2 (INR Lakhs)

Particulars	FY32	FY35	FY40	FY45	FY50	FY55	FY60
Revenue	6,425	6,959	7,955	9,105	9,356	9,356	9,356
O & M Cost	4,312	4,616	5,120	5,617	5,716	5,708	5,705
Outflow to IWAI	457	493	561	639	656	656	656
PBDIT	1,657	1,850	2,274	2,849	2,983	2,991	2,994
Depreciation	10,296	15,259	1,350	1,350	0	0	0
Interest	4,132	5,399	6,120	4,938	3,880	3,880	3,880
PBT	-12,771	-18,808	-5,195	-3,438	-896	-889	-885
Tax	0	0	0	0	0	0	0
PAT	-12,771	-18,808	-5,195	-3,438	-896	-889	-885

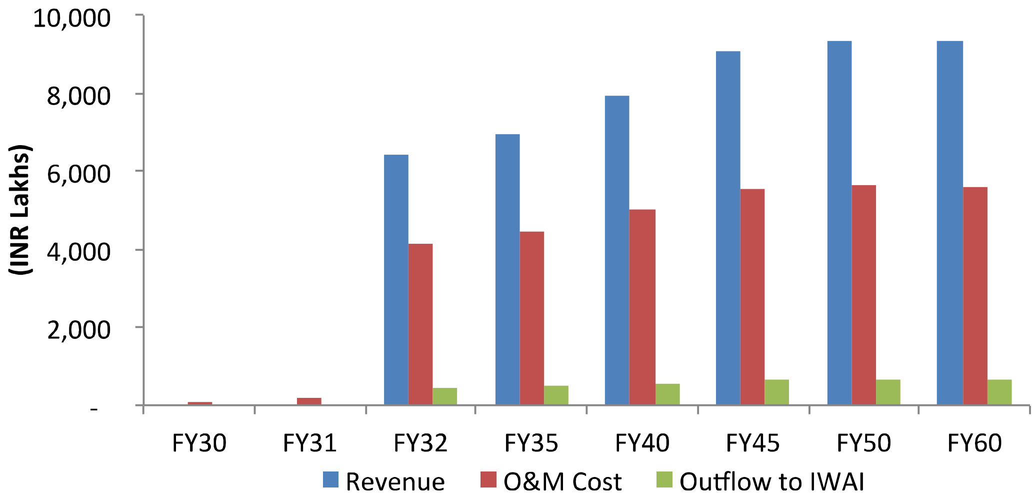

Fig. 15.9 Comparison among Revenue, O&M Cost and Total Outflow to IWAI

The terminal will start generating profit from 1st year of operation only i.e. Fy-32. This is mainly due to high Revenue& high traffic whereas lower development cost. These are the major factors that heavily impacts commercial prospects of proposed terminal.

Depreciation has been calculated using the Straight Line Method (SLM). Under this method, cost of asset is evenly distributed across its useful life. Straight Line Method (SLM) has been used to calculate depreciation for Terminal 2, under which the cost of tangible and intangible assets are evenly distributed across its life.

Table 15.45Depreciation for Terminal 2 (INR Lakhs)

Particulars	FY30	FY35	FY40	FY45	FY50	FY55	FY60
Gross Block	31,337	88,741	115,364	115,364	115,364	115,364	115,364
Depreciation & Amortization	0	15,259	1,350	1,350	0	0	0
Cumulative Depreciation & Amortization	0	56,442	105,509	112,257	115,364	115,364	115,364
Net Block	31,337	32,299	9,855	3,107	0	0	0

The table below depicts the cash inflow & outflow in case of development of Terminal 2.

Table 15.46 Cash Flow for Terminal 2 (INR Lakhs)

Particulars	FY30	FY31	FY35	FY40	FY45	FY50	FY60
Equity	10,968	10,418	9,673	-	-	-	-
Debt	20,369	19,349	17,964	-	-	-	-
Net Cash from Investment	31,337	29,767	27,637	-	-	-	-
Operations							
PBDIT	-172	-347	1,850	2,274	2,849	2,983	2,994
(-) Taxes Paid	-	-	-	-	-	-	-
Net Cash from Operations	- 172	-347	1,850	2,274	2,849	2,983	2,994
Total Cash Inflow	31,165	29,420	29,487	2,274	2,849	2,983	2,994

Particulars	FY30	FY31	FY35	FY40	FY45	FY50	FY60
Cash Outflow							
Capital Investment	31,337	29,767	27,637	0	0	0	0
Long Term Debt	0	0	2,150	2,150	2,150	1,018	0
Interest	2,241	4,369	5,399	6,120	4,938	3,880	3,880
Total Cash Outflow	33,577	34,136	35,186	8,270	7,088	4,898	3,880
Net Cash Flow	-2,413	-4,716	-5,699	-5,996	-4,239	-1,915	-885
Opening Balance of Cash	0	-2,413	-19,999	-53,149	-79,632	-97,952	-107,871
Closing Balance Cash	-2,413	-7,129	-25,699	-59,145	-83,870	-99,867	-108,756

Table 15.47Balance Sheet for Terminal 2 (INR Lakhs)

Fund Sources	FY30	FY31	FY35	FY40	FY45	FY50	FY60
Shareholder's funds							
Capital	10,968	21,386	31,059	40,377	40,377	40,377	40,377
Reserves & Surplus	-2,413	-17,425	- 73,540	-145,304	- 166,028	-175,513	-184,402
Borrowings							
Secured Loans	20,369	39,717	49,082	55,637	44,887	35,269	35,269
Total Funds	**28,924**	**43,679**	**6,601**	**-49,290**	**-80,764**	**-99,867**	**-108,756**
Usages of Fund							
Fixed Assets							
Gross Block	31,337	61,104	88,741	115,364	115,364	115,364	115,364
Less: Depreciation	-	10,296	56,442	105,509	112,257	115,364	115,364
Net Block	31,337	50,808	32,299	9,855	3,107	-	-
Net Current Assets	-2,413	-7,129	-25,699	- 59,145	- 83,870	-99,867	-108,756
Total Assets	**28,924**	**43,679**	**6,601**	**-49,290**	**-80,764**	**-99,867**	**-108,756**

- **Financial IRR**

Financial FIRR presented below will help IWAI to measure the financial returns on investment and assist take a firm decision on the implementation of this development. Final viability assessment for developing coal handling terminal on this River Yamuna would be done based on this outcome.

Table 15.48 Financial IRR Calculation for Terminal 2 (INR Lakhs)

Particulars	FY30	FY35	FY40	FY45	FY50	FY55	FY60
PBDIT	-172	1,850	2,274	2,849	2,983	2,991	2,994
Interest	2,241	5,399	6,120	4,938	3,880	3,880	3,880
Principal repayment	0	2,150	2,150	2,150	1,018	0	0
Equity	10,968	9,673	0	0	0	0	0
Debt	20,369	17,964	0	0	0	0	0
Total Investment	31,337	27,637	0	0	0	0	0
Tax	0	0	0	0	0	0	0
Cash flow to	-13,380	-15,372	-5,996	-4,239	-1,915	-889	-885

Equity(Pre-tax)							
Equity IRR(Pre-tax)	**N.A**						
Cash flow to Equity(Post-tax)	-13,380	-15,372	-5,996	-4,239	-1,915	-889	-885
Equity IRR(Post-tax)	**N.A**						
Project Cash flow(Pre-tax)	-31,509	-25,787	2,274	2,849	2,983	2,991	2,994
Project IRR(Pre-tax)	**N.A**						
Project Cash flow(Post-tax)	-31,509	-25,787	2,274	2,849	2,983	2,991	2,994
Project IRR(Post-tax)	**N.A**						

- **Economic IRR**

Economic IRR (EIRR) comprises all financial and non-financial benefits of the project. Non-Financial benefits include carbon emission, employment generation, reduction in congestion, less vehicle operating cost, saving on fuel, etc. EIRR helps in investment decision from prospects of improving welfare of society. If any project is commercially unviable then its economic viability is considered. This section evaluates the value addition that, this project induces in society and the impact on various social factors. These impacts are transformed into financial gains which can bring the state and central government to fund resources for the implementation. Government undertake the detailed assessment at projects contribution to the betterment of society like employment generation, improvement in connectivity, pollution control, trade improvement, etc. Assumptions considered for computing EIRR are for Terminal 2 is listed below

Table 15.49Assumptions for EIRR Calculations

Parameters Adopted	Value	Unit
Economic loss due to Road Accidents	0.03	of GDP
Value of economic loss due to road accidents	3.76	Rs Lakhs Crores
Safety Index (IWT as base)	5.00	times safer than rail
Accident Loss		
Rail	0.77	Rs Lakhs/KM
IWT	0.15	Rs Lakhs/KM
Fuel Cost		
Rail	85.00	t-km / per liter
IWT	105.00	t-km / per liter
Fuel price	69.40	Rs/Litre
Vehicular operating cost (VOC)		
Rail	1.41	Rs/t-km
IWT	1.10	Rs/t-km
Direct Employment Creation		
Rail	2.00	Per Million t-km
IWT	0.50	Per Million t-km
Employment cost	2.50	Rs Lakhs per Annum
Emission Reduction		

Parameters Adopted	Value	Unit
Rail	13.30	g CO2/t-km
IWT	6.00	g CO2/t-km
Shadow factor		
CAPEX/O&M Cost (Convert financial cost to economic cost)	0.85	-
Carbon Credits factors		
Carbon Shadow price	20.00	$/Tonne
Exchange rate	67.00	Rs/USD

All the essential assumptions with respect to fuel efficiency, direct employment multiplier, reduction in carbon emission, and carbon credit factors have been taken from the common industrial benchmarks. Estimated impact of each factor at terminal 2 for the period of 30 years is presented in the table below.

Table 15.50Economic IRR Calculation for Terminal 2 (INR Crore)

Operation years	FY30	FY31	FY35	FY36	FY40	FY45	FY50	FY55	FY60
Accident Loss			5	5	5	5	5	5	5
Saving on fuel			24	25	28	31	33	33	33
Saving on account of VOC			49	50	55	62	66	66	66
Job creation			39	40	44	50	53	53	53
Reduction in Emissions			2	2	2	2	2	2	2
Total Revenue			70	71	80	91	94	94	94
Total Economic Impact	0	0	188	193	213	241	251	251	251
O&M Expenditure	2	3	46	48	51	56	57	57	57
Economic Cash Outflow	-2	-3	142	145	162	185	194	194	194
Investment	313	298	276	266		0			
Net Cash Flow to Project	-315	-301	-135	-122	162	185	194	194	194
Project EIRR	**15.9%**								

Terminal 3–MahewaKachchar

- **Phasing**

  Terminal 3 is proposed to be developed in Phase 1 i.e. from FY24. This is the first phase of fairway development, in this phase the stretch from Prayagraj to Kanpur would be developed. The construction of infrastructure, equipment handling, and connectivity will take 2 years i.e. FY24 and FY25 and the terminal will get operational from FY26 till FY54.

Table 15.51 Development of Terminal 3

<table>
<tr><th>Total Jetties</th><th>Chainage (km)</th><th>FY24</th><th>FY25</th><th>FY26</th><th>FY35</th><th>FY36</th><th>FY37</th><th>FY54</th></tr>
<tr><td rowspan="4">3</td><td rowspan="4">98</td><td colspan="2">Construction - 1 Jetty</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td colspan="5">Operational - 1 Jetty</td></tr>
<tr><td></td><td></td><td></td><td colspan="2">Construction - +2 Jetties</td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td colspan="2">Operational - +2 Jetties</td></tr>
</table>

- **Traffic**

This terminal is proposed for handling dirty cargo i.e. Coal for nearby TPP i.e. Unchahar and Tanda. Presently these plants are procuring coal from NKCL by rail; certain share of this movement is diverted to IWT using NW1 till Prayagraj and thereafter NW110. Traffic for Terminal 3 for next 30 years is projected in the table below.

Table 15.52 Traffic at Terminal 3 ('000 T)

Cargo	Origin	Destination	Fy24	Fy30	Fy35	Fy40	Fy45	Fy50	Fy54
Coal	NKCL	Tanda	405	527	623	722	837	888	888
	NKCL	Unchahar	811	1,056	1,248	1,447	1,677	1,779	1,779
Fly Ash	Tanda	Singapore	265	325	349	366	385	393	393
	Unchahar		320	393	421	443	465	474	474
Total			1,800	2,301	2,640	2,978	3,364	3,534	3,534

- **Capital Cost**

This section represents the total capital expenditure in a phased manner for Terminal 3 proposed at MahewaKachchar for coal handling in River Yamuna.

Table 15.53 Project Cost for Construction Terminal-3 (INR Lakhs)

Sl. No.	Description	Total Investment	Phase I		Phase II	
			FY24	FY25	FY35	FY36
A	Terminal	11,700	2,340	1,560	4,680	3,120
B	Approach Rail/Road	39,757	7,951	5,301	15,903	10,602
C	Supporting Infrastructure	827	496	331	-	-
D	Cargo Handling Equipment	2,246	346	1,385	103	412
E	Utilities		-	-	-	-
F	IT		-	-	-	-
G	Other Financial Cost	22,723	11,361	11,361	-	-
H	Consultancy			-		-
	Total Capex	77,253	22,495	19,938	20,686	14,134

Construction of this terminal would take 2 years to get completed i.e. in FY24 and FY25. It would start operating from FY26. Detailed cost of cargo handling and other supporting infrastructure required at terminal is listed in the table below.

Table 15.54 Infrastructure Requirement Cost at Terminal-3 (INR Lakhs)

S.No	Description	No.	Rate (INR Lakhs)	Cost (INR Lakhs)

S.No	Description	No.	Rate (INR Lakhs)	Cost (INR Lakhs)
1	Parking Area	1	15	15
2	Canteen	1	15	15
3	Admin Building	1	40	40
4	STP	1	20	20
5	Fire Tender	1	20	20
6	Dispensary	1	15	15
7	Electrical Substation	1		0
8	Fencing and Guard room	1	40	40
9	Cold Storage	0	300	0
10	Storage area, Warehouses	40,800 sqm	662.25	662.25
Total				**827.25**

- **Project Financing**

Construction Phase 1 & Phase 2 has been assumed to be funded in an Equity-Debt ratio of 35:65. Details of the means of financing for both the phases are shown below.

Table 15.55 Equity-Debt Share Distribution for Terminal 3 (INR Lakhs)

Particulars	%	Investment Phase I		Investment Phase II	
		FY24	FY25	FY35	FY36
Equity	35%	7,873	6,978	7,240	4,947
Debt	65%	14,622	12,960	13,446	9,187

- **Financial Indicators**

This section shows the financial indicator that leads to the generation of FIRR for Terminal 3. Revenue, Salary, Depreciation, Cash Flow, P&L Statement & Balance Sheet helps on understanding the returns on investment made for this terminal.

Revenue from Terminal 3 proposed on River Yamuna will be generated from core operations that include cargo handling at the jetty, Storage, Stackyard, Evacuation from yard to Rail. The detailed breakup of revenue is shown in the table above.

Table 15.56 Revenue from Terminal-3 (INR Lakhs)

Particulars	FY24	FY26	FY30	FY35	FY40	FY45	FY50	FY54
Vessels Charges	0	77	90	103	116	131	138	138
Wharfage	0	1,330	1,553	1,804	2,058	2,351	2,481	2,481
Stevedoring	0	1,995	2,330	2,707	3,088	3,527	3,721	3,721
Cargo Storage	0	799	935	1,089	1,246	1,427	1,507	1,507
Stackyard Operation	0	1,995	2,330	2,707	3,088	3,527	3,721	3,721
Total Revenue	0	6,195	7,238	8,410	9,596	10,963	11,567	11,567

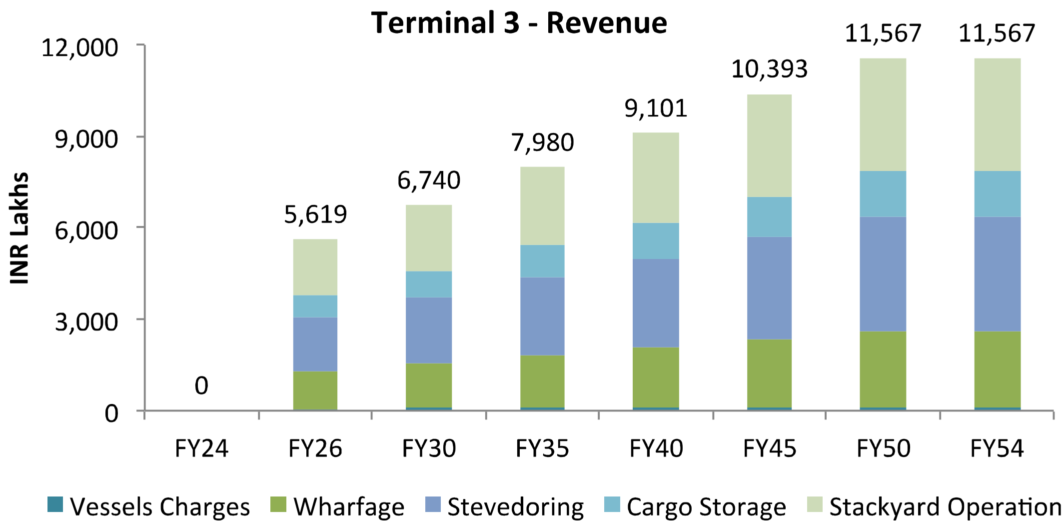

Fig. 15.10 Revenue for Terminal 3

The following table indicates the direct operating cost for development of Terminal 3. This direct operating cost include cargo Handling charges, Storage cost, evacuation cost &stackyard handling cost.

Table 15.57 Direct Operating Cost for Terminal 3 (INR Lakhs)

Particulars	FY24	FY26	FY30	FY35	FY40	FY45	FY50	FY54
Cargo Handling at Jetty	0	995	1,158	1,337	1,516	1,723	1,814	1,814
Storage Cost	0	531	618	715	812	924	974	974
Evacuation Cost	0	332	388	451	515	588	620	620
Stackyard Handling	0	997	1,165	1,353	1,544	1,763	1,860	1,860
Power & Water	0	975	975	975	1,028	1,028	1,028	1,028
Salary	0	93	93	93	130	130	130	130
Total	0	3,924	4,398	4,924	5,546	6,157	6,427	6,427

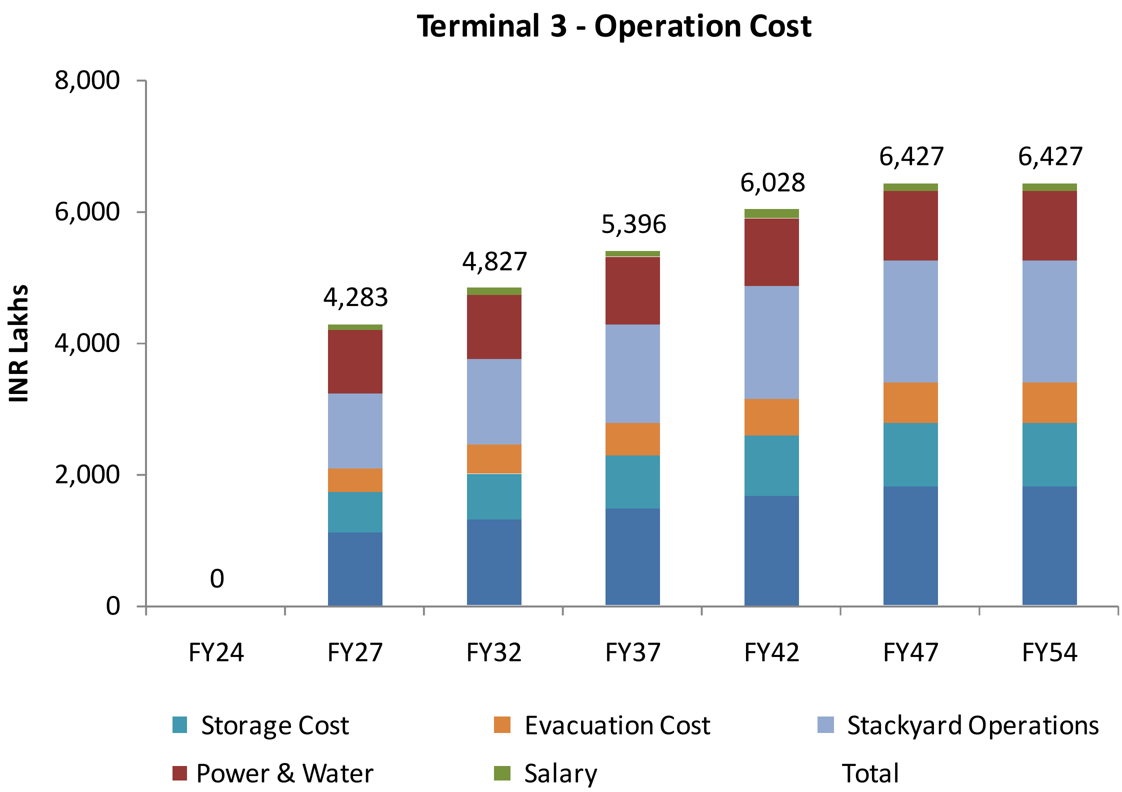

Fig. 15.11 Operating Cost at Terminal 3

Table 15.58 Maintenance Cost for Terminal 3 (INR Lakhs)

Particulars	FY24	FY26	FY30	FY35	FY40	FY45	FY50	FY54
Civil	108	180	180	386	523	523	523	523
Mechanical	17	87	87	92	112	112	112	112
Insurance Cost	115	168	87	247	185	82	37	19
Administration Cost	0	124	145	168	192	219	231	231
Total	240	558	499	892	1,012	937	903	886

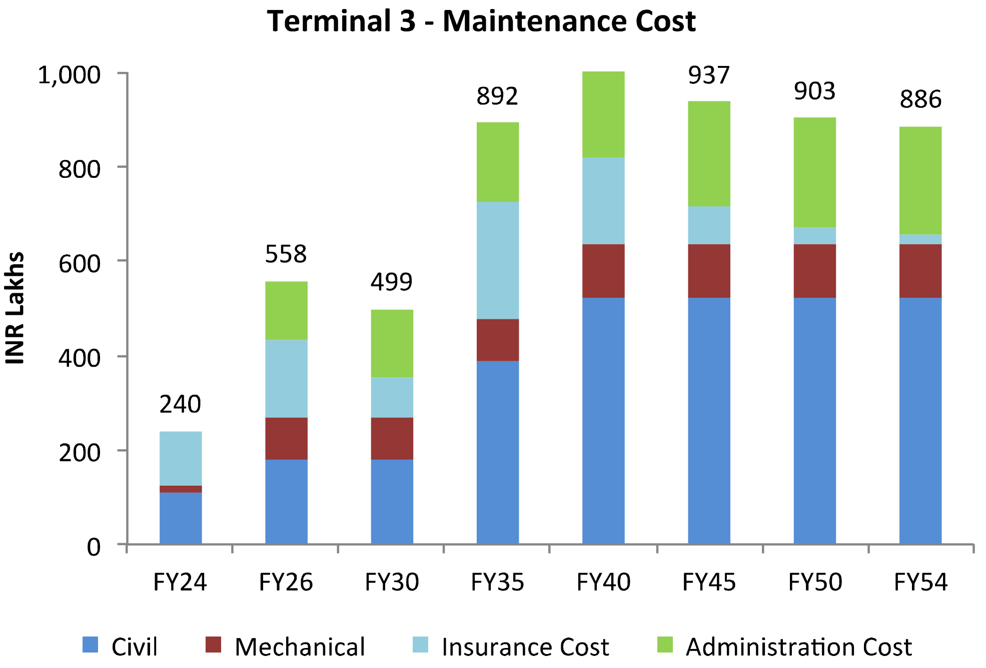

Fig. 15.12 Maintenance Cost at Terminal 3

The operator would share 4% of its revenue with IWAI and pay royalty of INR 10 per Tonne. The table below indicates the amount of total outflow to IWAI in case of Terminal 3.

Table 15.59 Regulatory Royalty to IWAI for Terminal 3 (INR Lakhs)

Particulars	FY24	FY26	FY30	FY35	FY40	FY45	FY50	FY54
Royalty to IWAI	-	198	230	264	298	336	353	353
Revenue Share	-	248	290	336	384	439	463	463
Total Outflow to IWAI	-	446	520	600	682	775	816	816

The section above summaries the Revenue generated by operation of Terminal 3 and total cost i.e. O&M cost and out-flow to IWAI (Royalty and Revenue Share) from FY24 till FY54. The operator would share 4% of its revenue with IWAI and pay royalty of INR 10 per Tonne.

The following table depicts the P/L statement for development of Terminal 3 on River Yamuna.

Table 15.60 Profit& Lost Statement for Terminal 3 (INR Lakhs)

Particulars	FY24	FY26	FY30	FY35	FY40	FY45	FY50	FY54
Revenue	0	6,195	7,238	8,410	9,596	10,963	11,567	11,567
O & M Cost	365	5,544	5,958	6,884	7,699	8,234	8,470	8,453
Total Outflow to IWAI	0	446	520	600	682	775	816	816
PBDIT	-240	1,268	1,822	1,992	2,356	3,094	3,421	3,438
Depreciation	0	5,792	1,248	2,557	3,452	3,310	0	0
Interest	1,608	2,870	2,212	2,869	3,058	2,490	2,490	2,490
PBT	-1,848	-7,394	-1,638	-3,434	-4,154	-2,705	931	949
Tax	0	0	0	0	0	0	279	285
PAT	**-1,848**	**-7,394**	**-1,638**	**-3,434**	**-4,154**	**-2,705**	**652**	**664**

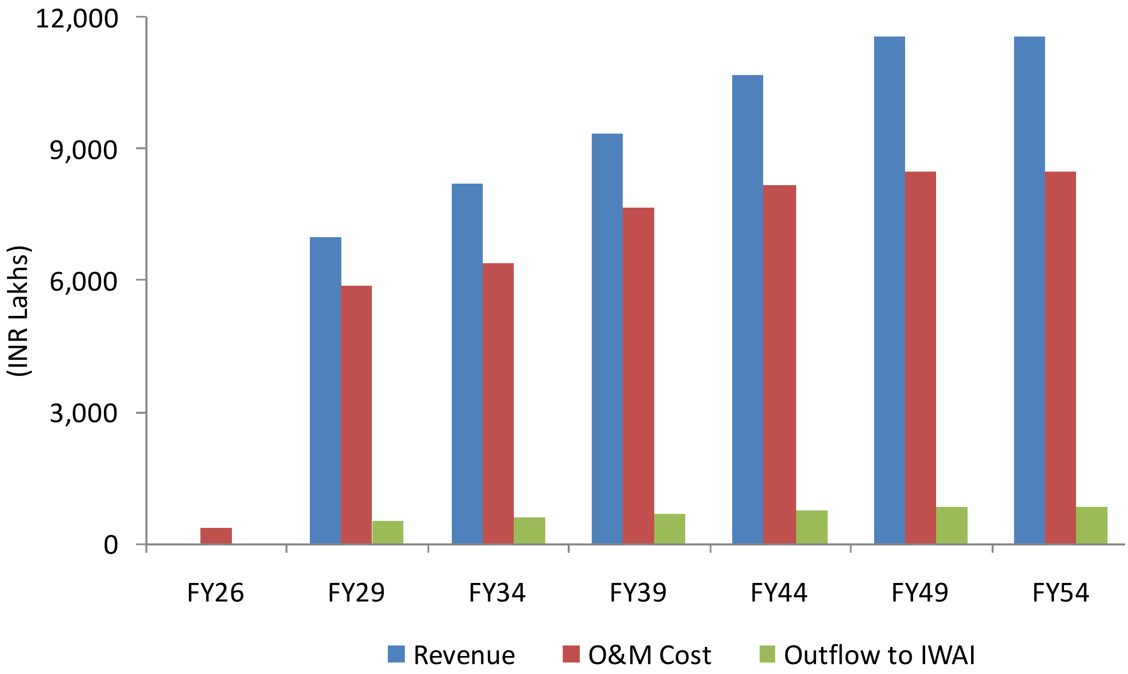

Fig.15.13Comparison among Revenue, O&M Cost and Total Outflow to IWAI

Depreciation has been calculated using the Straight Line Method (SLM). Under this method, cost of asset is evenly distributed across its useful life. Straight Line Method (SLM) has been used to calculate depreciation for Terminal 3, under which the cost of tangible and intangible assets are evenly distributed across its life.

Table 15.61 Depreciation for Terminal 3 (INR Lakhs)

Particulars	FY24	FY30	FY35	FY40	FY45	FY50	FY54
Gross Block	22,495	42,433	63,119	77,253	77,253	77,253	77,253
Depreciation & Amortization	0	1,248	2,557	3,452	3,310	0	0
Cumulative Depreciation & Amortization	0	30,209	37,757	55,015	71,887	77,253	77,253
Net Block	22,495	12,224	25,362	22,238	5,366	0	0

The table below depicts the cash inflow & outflow in case of development of Terminal 3.

Table 15.62 Cash Flow for Terminal 3 (INR Lakhs)

Particulars	FY24	FY25	FY35	FY36	FY45	FY50	FY54
Cash Inflow							
Equity	7,873	6,978	7,240	4,947	0	0	0
Debt	14,622	12,960	13,446	9,187	0	0	0
Net Cash from Investment	22,495	19,938	20,686	14,134	0	0	0
Operations							
PBDIT	-240	-464	1,992	1,830	3,094	3,421	3,438
(-) Taxes Paid	0	0	0	0	0	279	285
Net Cash from Operations	-240	-464	1,992	1,830	3,094	3,142	3,154

Particulars	FY24	FY25	FY35	FY36	FY45	FY50	FY54
Total Cash Inflow	22,255	19,474	22,678	15,964	3,094	3,142	3,154
Cash Outflow							
Capital Investment	22,495	19,938	20,686	14,134	0	0	0
Long Term Debt	0	0	1,494	1,494	0	0	0
Interest	1,608	3,034	2,869	3,715	2,490	2,490	2,490
Total Cash Outflow	24,104	22,972	25,049	19,344	2,490	2,490	2,490
Net Cash Flow	-1,848	-3,498	-2,371	-3,380	605	652	664
Opening Balance of Cash	0	-1,848	-22,383	-24,754	-43,644	-40,086	-37,457
Closing Balance Cash	-1,848	-5,346	-24,754	-28,134	-43,040	-39,434	-36,793

Table 15.63 Balance Sheet for Terminal 3 (INR Lakhs)

Sources of Funds	FY24	FY30	FY35	FY40	FY45	FY50	FY54
Shareholder's funds							
Capital	7,873	14,852	22,092	27,038	27,038	27,038	27,038
Reserves & Surplus	-1,848	-40,487	-47,566	-71,298	-87,345	-89,105	-86,464
Borrowings							
Secured Loans	14,622	20,109	26,083	27,798	22,633	22,633	22,633
Total Funds	20,647	-5,526	608	-16,462	-37,673	-39,434	-36,793
Usages of Fund							
Fixed Assets							
Gross Block	22,495	42,433	63,119	77,253	77,253	77,253	77,253
Less: Depreciation	0	30,209	37,757	55,015	71,887	77,253	77,253
Net Block	22,495	12,224	25,362	22,238	5,366	0	0
Net Current Assets	-1,848	-17,750	-24,754	-38,699	-43,040	-39,434	-36,793
Total Assets	20,647	-5,526	608	-16,462	-37,673	-39,434	-36,793

- **Financial IRR**

Financial FIRR presented below will help IWAI to measure the financial returns on investment and assist take a firm decision on the implementation of this development. Final viability assessment for developing coal handling terminal on this River Yamuna would be done based on this outcome.

Table 15.64 Financial IRR Calculation for Terminal 3 (INR Lakhs)

Particulars	FY24	FY25	FY35	FY36	FY45	FY50	FY54
PBDIT	-240	-464	1,992	1,830	3,094	3,421	3,438
Interest	1,608	3,034	2,869	3,715	2,490	2,490	2,490
Principal repayment	0	0	1,494	1,494	0	0	0
Equity	7,873	6,978	7,240	4,947	0	0	0
Debt	14,622	12,960	13,446	9,187	0	0	0
Total Investment	22,495	19,938	20,686	14,134	0	0	0
Tax	0	0	0	0	0	279	285
Cash flow to	-9,722	-10,476	-9,611	-8,327	605	931	949

Particulars	FY24	FY25	FY35	FY36	FY45	FY50	FY54
Equity(Pre-tax)							
Equity IRR(Pre-tax)	NA						
Cash flow to Equity(Post-tax)	-9,722	-10,476	-9,611	-8,327	605	652	664
Equity IRR(Post-tax)	NA						
Project Cash flow(Pre-tax)	NA	-20,401	-18,693	-12,304	3,094	3,421	3,438
Project IRR(Pre-tax)	NA						
Project Cash flow(Post-tax)	-22,735	-20,401	-18,693	-12,304	3,094	3,142	3,154
Project IRR(Post-tax)	NA						

- **Economic IRR**

EIRR helps in investment decision from prospects of improving welfare of society. If any project is commercially unviable then its economic viability is considered. This section evaluates the value addition that, this project induces in society and the impact on various social factors. Economic IRR (EIRR) comprises all financial and non-financial benefits of the project. Non-Financial benefits include carbon emission, employment generation, reduction in congestion, less vehicle operating cost, saving on fuel, etc. These impacts are transformed into financial gains which can bring the state and central government to fund resources for the implementation. Government undertake the detailed assessment at projects contribution to the betterment of society like employment generation, improvement in connectivity, pollution control, trade improvement, etc.

Assumptions considered for computing EIRR are for Terminal 3 is listed below.

Table 15.65 Assumptions for EIRR Calculations

Parameters Adopted	Value	Unit
Economic loss due to Road Accidents	0.03	of GDP
Value of economic loss due to road accidents	3.76	Rs Lakhs Crores
Safety Index (IWT as base)	5.00	times safer than rail
Accident Loss		
Rail	0.77	Rs Lakhs/KM
IWT	0.15	Rs Lakhs/KM
Fuel Cost		
Rail	85.00	t-km / per liter
IWT	105.00	t-km / per liter
Fuel price	69.40	Rs/Litre
Vehicular operating cost (VOC)		
Rail	1.41	Rs/t-km
IWT	1.10	Rs/t-km
Direct Employment Creation		
Rail	2.00	Per Million t-km
IWT	0.50	Per Million t-km

Parameters Adopted	Value	Unit
Employment cost	2.50	Rs Lakhs per Annum
Emission Reduction		
Rail	13.30	g CO2/t-km
IWT	6.00	g CO2/t-km
Shadow factor		
CAPEX/O&M Cost (Convert financial cost to economic cost)	0.85	-
Carbon Credits factors		
Carbon Shadow price	20.00	$/Tonne
Exchange rate	67.00	Rs/USD

All the essential assumptions with respect to fuel efficiency, direct employment multiplier, reduction in carbon emission, and carbon credit factors have been taken from the common industrial benchmarks.

Estimated impact of each factor at terminal 3 for the period of 30 years is presented in the table below.

Table 15.66Economic IRR Calculation for Terminal (INR Crore)

Operation years	FY24	FY25	FY35	FY36	FY40	FY45	FY50	FY54
Accident Loss			0.6	0.6	0.6	0.6	0.6	0.6
Saving on fuel			3.4	3.5	3.9	4.4	4.7	4.7
Saving on account of VOC			27.6	28.4	31.6	36.1	38.1	38.1
Job creation			5.4	5.6	6.2	7.1	7.5	7.5
Reduction in Emissions			0.2	0.2	0.2	0.3	0.3	0.3
Total Revenue	0.0	0.0	84.1	86.3	96.0	109.6	115.7	115.7
Total Economic Impact	0.0	0.0	121.4	124.6	138.4	158.1	166.8	166.8
O&M Expenditure	2.4	2.4	58.2	61.9	65.6	70.9	73.3	73.1
Economic Cash Outflow	-2.4	-2.4	63.2	62.7	72.8	87.2	93.5	93.7
Investment	225.0	199.4	206.9	141.3				
Net Cash Flow to Project	-227.3	-201.8	-143.7	-78.6	72.8	87.2	93.5	93.7
Project EIRR	**10.1%**							

15.3.1.4 Terminal 4–DilauliyaKachhar

- **Phasing**
  Terminal 4 is proposed to be developed in Phase 1 i.e. from FY24. This is the first phase of fairway development, in this phase the stretch from Prayagraj to Kanpur would be developed. The construction of infrastructure, equipment handling, and connectivitywill take 2 years i.e. FY24 and FY25 and the terminal will get operational from FY26 till FY54.

Table 15.67Development of Terminal 4

Total	Chainage	FY24	FY25	FY26	FY35	FY36	FY37	FY54

<table>
<tr><th>Jetties</th><th>(km)</th><th></th><th></th><th></th><th></th><th></th><th></th><th></th></tr>
<tr><td rowspan="4">3</td><td rowspan="4">349.2</td><td colspan="2">Construction - 1 Jetty</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td colspan="5">Operational - 1 Jetty</td></tr>
<tr><td></td><td></td><td></td><td colspan="2">Construction - +2 Jetties</td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td colspan="2">Operational - +2 Jetties</td></tr>
</table>

- **Traffic**

  This terminal is proposed for handling dirty cargo i.e. Coal for nearby TPP Paricha, Panki and Rosa. Presently these plants are procuring coal from eastern region by rail; certain share of this movement is diverted to IWT using NW1 till Prayagraj and thereafter NW110 till Okhla Barrage. Traffic for Terminal 4till FY54 is projected in the table below.

Table 15.68Traffic at Terminal 4 ('000 T)

Cargo	Origin	Destination	FY24	FY27	FY32	FY37	FY42	FY47	FY54
Coal	ECL	Parichha	787	1,025	1,211	1,404	1,628	1,727	1,727
	ECL	Panki	149	193	229	265	307	326	326
	Haldia	Rosa	169	220	260	301	349	370	370
Fly Ash	Parichha	Singapore	528	648	695	731	768	783	783
	Rosa		421	518	555	583	613	625	625
Total			2,054	2,604	2,950	3,284	3,665	3,832	3,832

- **Capital Cost**

  This section represents the total capital expenditure in a phased manner for Terminal 4 proposed at DilauliyaKachchar for coal handling in River Yamuna.

Table 15.69 Project Cost for Construction Terminal-4 (INR Lakhs)

Sl. No.	Description	Total Investment	Phase I		Phase II	
			FY24	FY25	FY35	FY36
A	Terminal	11,700	2,340	1,560	4,680	3,120
B	Approach Rail/Road	1,729	346	231	692	461
C	Stackyard	1,490	894	596	-	-
D	Cargo Handling Equipment	2,335	361	1,444	106	424
E	Utilities	-	-	-	-	-
F	IT	-	-	-	-	-
G	Other Financial Cost	24,924	5,981	5,981	5,981	5,981
H	Consultancy	-	-	-	-	-
	Total Capex	42,177	9,921	9,811	11,458	9,986

Construction of this terminal would take 2 years to get completed i.e. in FY24 and FY25. It would start operating from FY26. Detailed cost of cargo handling and other supporting infrastructure required at terminal is listed in the table below.

Table 15.70 Infrastructure Requirement Cost at Terminal-4 (INR Lakhs)

S.No	Description	No.	Rate (INR Lakhs)	Cost (INR Lakhs)
1	Parking Area	1	15	15
2	Canteen	1	15	15
3	Admin Building	1	40	40
4	STP	1	20	20
5	Fire Tender	1	20	20
6	Dispensary	1	15	15
7	Electrical Substation			0
8	Fencing and Guard room	1	40	40
9	Cold Storage	0	300	0
10	Storage area, Warehouses	81,600	0.016232	1324.51
Total				1489.51

- **Project Financing**

Construction Phase 1 & Phase 2 has been assumed to be funded in an Equity-Debt ratio of 35:65. Details of the means of financing for both the phases are shown below.

Table 15.71 Equity-Debt Share Distribution for Terminal 4 (INR Lakhs)

Particulars	%	Investment Phase I	Investment Phase II
Equity	35%	6,906	7,506
Debt	65%	12,826	13,939

- **Financial Indicators**

This section shows the financial indicator that leads to the generation of FIRR for Terminal – 4. Revenue, Salary, Depreciation, Cash Flow, P&L Statement & Balance Sheet helps on understanding the returns on investment made for this terminal.Revenue from Terminal 4 proposed on River Yamuna will be generated from core operations that include cargo handling at the jetty, Storage, Stackyard, Evacuation from yard to Rail. The detailed breakup of revenue is shown in the table above.

Table 15.72 Revenue from Terminal-4 (INR Lakhs)

Particulars	FY24	FY30	FY35	FY40	FY45	FY50	FY54
Vessels Charges	-	1,109	1,312	1,519	1,760	1,868	1,868
Wharfage	-	243	287	333	385	409	409
Stevedoring	-	364	430	499	578	613	613
Cargo Storage	-	141	166	193	223	237	237
Stackyard Operation	-	364	430	499	578	613	613
Total Revenue	-	2,220	2,625	3,042	3,525	3,740	3,740

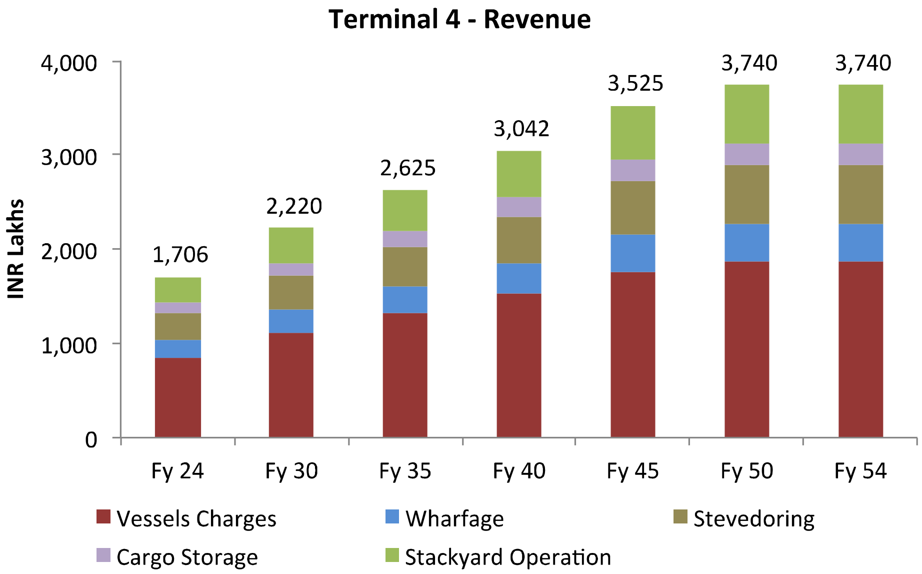

Fig. 15.14 Revenue for Terminal 4

The following table indicates the direct operating cost for development of Terminal 4. This direct operating cost include cargo Handling charges, Storage cost, evacuation cost &stackyard handling cost.

Table 15.73 Direct Operating Cost for Terminal 4 (INR Lakhs)

Particulars	FY24	FY30	FY35	FY40	FY45	FY50	FY54
Cargo Handling at Jetty	0	194	230	266	309	327	327
Storage Cost	0	102	121	140	162	172	172
Evacuation Cost	0	61	72	83	96	102	102
Stackyard Handling	0	182	215	249	289	307	307
Power & Water	0	800	800	943	943	943	943
Salary	0	93	93	130	130	130	130
Total	0	1,432	1,530	1,812	1,929	1,981	1,981

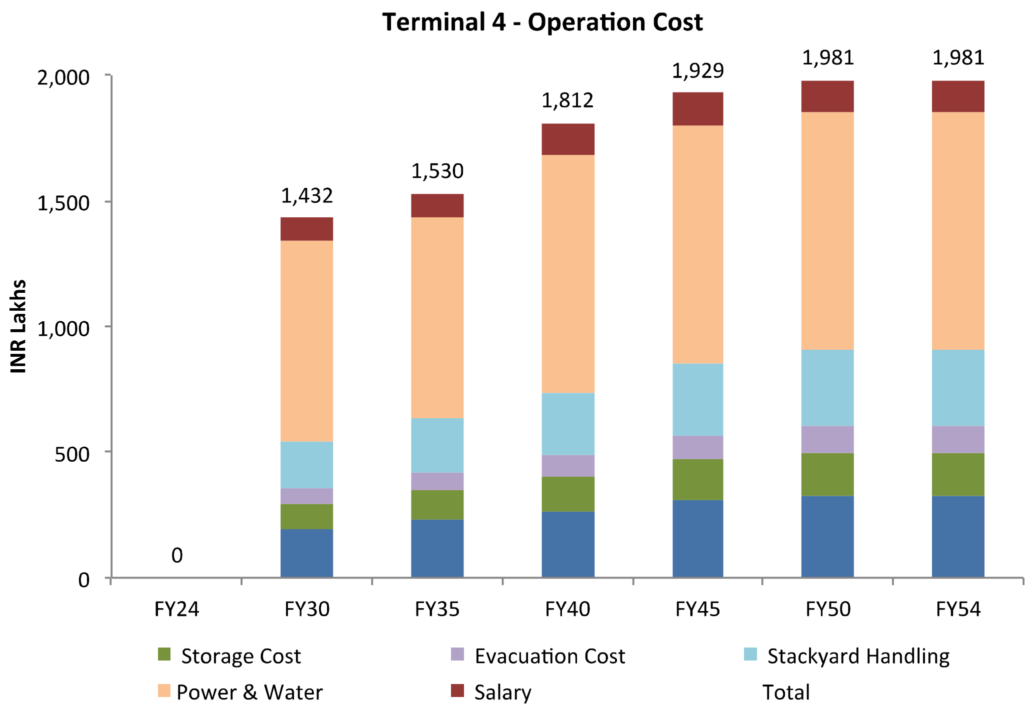

Fig. 15.15 Operating Cost at Terminal 4

Table 15.74 Maintenance Cost for Terminal 4 (INR Lakhs)

Particulars	FY24	FY30	FY35	FY40	FY45	FY50	FY54
Civil	36	60	113	149	149	149	149
Mechanical	18	90	96	117	117	117	117
Insurance Cost	43	40	73	56	25	11	6
Administration Cost	0	44	53	61	71	75	75
Total	97	234	335	382	361	352	346

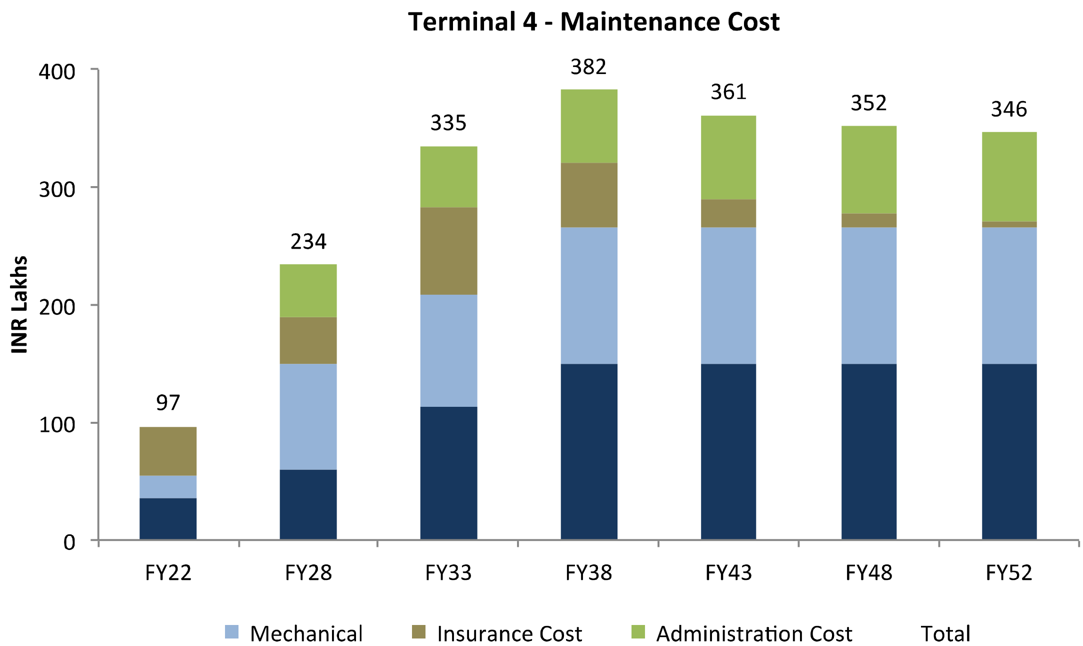

Fig. 15.16 Maintenance Cost at Terminal 4

The operator would share 4% of its revenue with IWAI and pay royalty of INR 10 per Tonne. The table below indicates the amount of total outflow to IWAI in case of Terminal 4.

Table 15.75 Regulatory Royalty to IWAI for Terminal 4 (INR Lakhs)

Particulars	FY24	FY30	FY35	FY40	FY45	FY50	FY54
Royalty to IWAI	-	41	49	57	66	70	70
Revenue Share	-	89	105	122	141	150	150
Total Outflow to IWAI	**-**	**130**	**154**	**178**	**207**	**219**	**219**

The section above summaries the Revenue generated by operation of Terminal 4 and total cost i.e. O&M cost and out-flow to IWAI (Royalty and Revenue Share) from FY26 till FY54. The operator would share 4% of its revenue with IWAI and pay royalty of INR 10 per Tonne. The following table depicts the P/L statement for development of Terminal 4 on River Yamuna.

Table 15.76 Profit& Lost Statement for Terminal 4 (INR Lakhs)

Particulars	FY24	FY30	FY35	FY40	FY45	FY50	FY54
Revenue	0	2,220	2,625	3,042	3,525	3,740	3,740
O & M Cost	151	2,556	2,760	3,253	3,350	3,392	3,387
Total Outflow to IWAI	0	130	154	178	207	219	219
PBDIT	-97	424	607	670	1,028	1,188	1,193
Depreciation	0	492	4,427	1,092	944	0	0
Interest	709	1,029	1,467	1,799	1,533	1,533	1,533
PBT	-806	-1,097	-5,288	-2,222	-1,449	-345	-340
Tax	0	0	0	0	0	0	0
PAT	**-806**	**-1,097**	**-5,288**	**-2,222**	**-1,449**	**-345**	**-340**

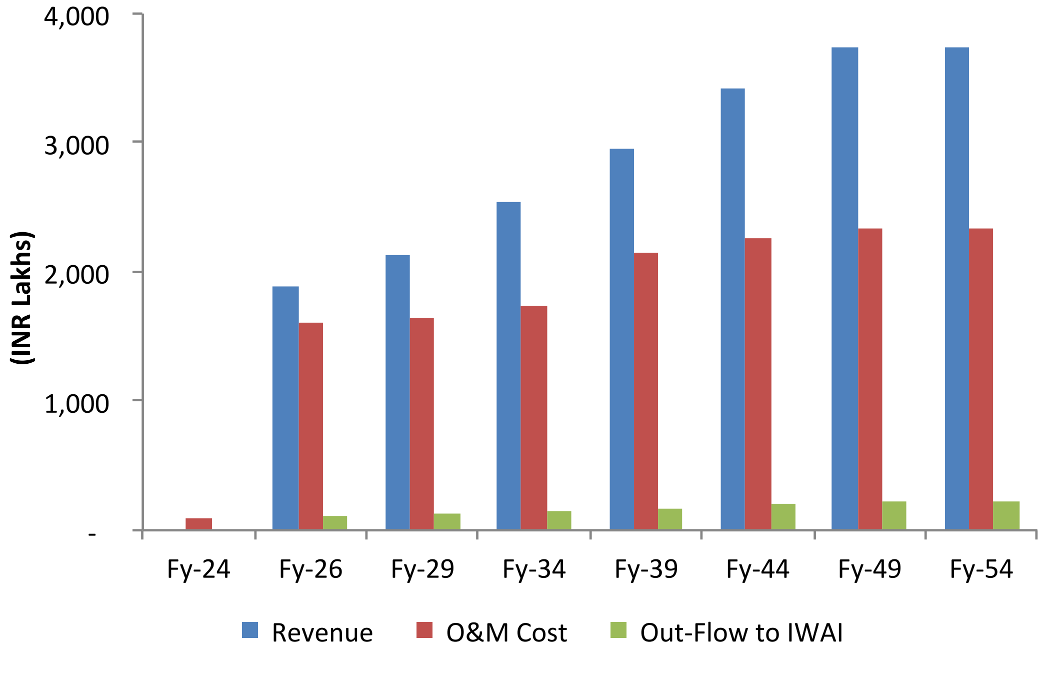

Fig. 15.17 Comparison among Revenue, O&M Cost and Total Outflow to IWAI

Depreciation has been calculated using the Straight Line Method (SLM). Under this method, cost of asset is evenly distributed across its useful life. Straight Line Method (SLM) has been used to calculate depreciation for Terminal 4, under which the cost of tangible and intangible assets are evenly distributed across its life.

Table 15.77 Depreciation for Terminal 4 (INR Lakhs)

Particulars	FY24	FY30	FY35	FY40	FY45	FY50	FY54
Gross Block	9,921	19,733	31,191	41,177	41,177	41,177	41,177
Depreciation & Amortization	0	492	4,427	1,092	944	0	0
Cumulative Depreciation &Amortization	0	14,913	21,308	35,142	40,196	41,177	41,177
Net Block	9,921	4,819	9,883	6,035	981	0	0

The table below depicts the cash inflow & outflow in case of development of Terminal 4.

Table 15.78 Cash Flow for Terminal 4 (INR Lakhs)

Particulars	Fy-24	Fy-30	Fy-35	Fy-40	Fy-45	Fy-50	Fy-54
Cash Inflow							
Equity	3,473	0	4,010	0	0	0	0
Debt	6,449	0	7,448	0	0	0	0
Net Cash from Investment	9,921	0	11,458	0	0	0	0
PBDIT							
(-) Taxes Paid	-97	424	607	670	1,028	1,188	1,193
Net Cash from Operations	0	0	0	0	0	0	0
Total Cash Inflow	-97	424	607	670	1,028	1,188	1,193
Cash Outflow							
Capital Investment	9,921	0	11,458	0	0	0	0
Long Term Debt	0	694	694	694	0	0	0
Interest	709	1,029	1,467	1,799	1,533	1,533	1,533
Total Cash Outflow	10,631	1,723	13,619	2,493	1,533	1,533	1,533
Net Cash Flow	-806	-1,299	-1,554	-1,823	-505	-345	-340
Opening Balance of Cash	0	-9,068	-14,171	-24,195	-31,524	-33,508	-34,879
Closing Balance Cash	-806	-10,366	-15,725	-26,019	-32,029	-33,853	-35,219

Table 15.79 Balance Sheet for Terminal 4 (INR Lakhs)

Sources of Funds	Fy-24	Fy-30	Fy-35	Fy-40	Fy-45	Fy-50	Fy-54
Shareholder's funds							
Capital	3,473	6,906	10,917	14,412	14,412	14,412	14,412
Reserves & Surplus	-806	-21,810	-30,094	-50,752	-59,399	-62,204	-63,570
Borrowings							
Secured Loans	6,449	9,357	13,335	16,356	13,939	13,939	13,939

Sources of Funds	Fy-24	Fy-30	Fy-35	Fy-40	Fy-45	Fy-50	Fy-54
Total Funds	**9,115**	**-5,547**	**-5,842**	**-19,983**	**-31,048**	**-33,853**	**-35,219**
Usages of Fund							
Fixed Assets							
Gross Block	9,921	19,733	31,191	41,177	41,177	41,177	41,177
Less: Depreciation	0	14,913	21,308	35,142	40,196	41,177	41,177
Net Block	9,921	4,819	9,883	6,035	981	0	0
Net Current Assets	-806	-10,366	-15,725	-26,019	-32,029	-33,853	-35,219
Total Assets	**9,115**	**-5,547**	**-5,842**	**-19,983**	**-31,048**	**-33,853**	**-35,219**

- **Financial IRR**

Financial FIRR presented below will help IWAI to measure the financial returns on investment and assist take a firm decision on the implementation of this development. Final viability assessment for developing coal handling terminal on this River Yamuna would be done based on this outcome.

Table 15.80 Financial IRR Calculation for Terminal 4 (INR Lakhs)

Particulars	Fy-24	Fy-30	Fy-35	Fy-40	Fy-45	Fy-50	Fy-54
PBDIT	-97	-239	607	568	670	1,028	1,188
Interest	709	1,411	1,467	2,105	1,799	1,533	1,533
Principal repayment	0	0	694	694	694	0	0
Equity	3,473	3,434	4,010	3,495	0	0	0
Debt	6,449	6,377	7,448	6,491	0	0	0
Total Investment	9,921	9,811	11,458	9,986	0	0	0
Tax	0	0	0	0	0	0	0
Cash flow to Equity(Pre-tax)	-4,279	-5,084	-5,565	-5,725	-1,823	-505	-345
Equity IRR(Pre-tax)	**NA**						
Cash flow to Equity(Post-tax)	-4,279	-5,084	-5,565	-5,725	-1,823	-505	-345
Equity IRR(Post-tax)	**NA**						
Project Cash flow(Pre-tax)	- 10,018	- 10,050	-10,852	-9,418	670	1,028	1,188
Project IRR(Pre-tax)	**NA**						
Project Cash flow(Post-tax)	- 10,018	- 10,050	-10,852	-9,418	670	1,028	1,188
Project IRR(Post-tax)	**NA**						

- **Economic IRR**

EIRR section evaluates the value addition that, this project induces in society and the impact on various social factors. Economic IRR (EIRR) comprises all financial and non-financial benefits of the project. It helps in investment decision from prospects of improving welfare of society. If any project is commercially unviable then its economic viability is considered. These impacts are transformed into financial gains which can bring the state and central government to fund resources for the implementation. Government undertake the detailed assessment at projects contribution to the betterment of society like employment generation, improvement in connectivity, pollution control, trade improvement, carbon emission, employment generation, reduction in congestion, less vehicle operating cost, saving on fuel, etc.

Assumptions considered for computing EIRR are for Terminal 4 is listed below.

Table 15.81Assumptions for EIRR Calculations

Parameters Adopted	Value	Unit
Economic loss due to Road Accidents	0.03	of GDP
Value of economic loss due to road accidents	3.76	Rs Lakhs Crores
Safety Index (IWT as base)	5.00	times safer than rail
Accident Loss		
Rail	0.77	Rs Lakhs/KM
IWT	0.15	Rs Lakhs/KM
Fuel Cost		
Rail	85.00	t-km / per liter
IWT	105.00	t-km / per liter
Fuel price	69.40	Rs/Litre
Vehicular operating cost (VOC)		
Rail	1.41	Rs/t-km
IWT	1.02	Rs/t-km
Direct Employment Creation		
Rail	2.00	Per Million t-km
IWT	0.50	Per Million t-km
Employment cost	2.50	Rs Lakhs per Annum
Emission Reduction		
Rail	13.30	g CO2/t-km
IWT	6.00	g CO2/t-km
Shadow factor		
CAPEX/O&M Cost (Convert financial cost to economic cost)	0.85	-
Carbon Credits factors		
Carbon Shadow price	20.00	$/Tonne
Exchange rate	67.00	Rs/USD

All the essential assumptions with respect to fuel efficiency, direct employment multiplier, reduction in carbon emission, and carbon credit factors have been taken from the common industrial benchmarks.

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Estimated impact of each factor at terminal 4 for the period of 30 years is presented in the table below.

Table 15.82Economic IRR Calculation for Terminal 4 (INR Crore)

Particulars	2024	2025	2035	2036	2040	2045	2050	2054
Accident Loss			2.2	2.2	2.2	2.2	2.2	2.2

Saving on fuel			13.0	13.3	14.7	16.6	17.4	17.4
Saving on account of VOC			32.6	33.4	36.8	41.6	43.7	43.7
Job creation			20.9	21.4	23.6	26.6	28.0	28.0
Reduction in Emissions			0.8	0.8	0.9	1.0	1.1	1.1
Total Revenue			26.3	27.0	30.4	35.3	37.4	37.4
Total Economic Impact	0.0	0.0	95.8	98.2	108.5	123.2	129.7	129.7
O&M Expenditure	1.0	2.4	18.6	19.8	21.9	22.9	23.3	23.3
Economic Cash Outflow	-1.0	-2.4	77.1	78.4	86.6	100.3	106.4	106.5
Investment	99.2	98.1	114.6	99.9				
Net Cash Flow to Project	-100.2	-100.5	-37.5	-21.5	86.6	100.3	106.4	106.5
Project EIRR	26.5%							

15.3.1.5 Terminal 5–Near Naini Bridge

- **Phasing**

Terminal 5 is proposed to be developed in Phase 1 i.e. from FY24. This is the first phase of fairway development, in this phase the stretch from Prayagraj to Kanpur would be developed. The construction of infrastructure, equipment handling, and connectivity will take 2 years i.e. FY24 and FY25 and the terminal will get operational from FY26 till FY54.

Table 15.83 Development of Terminal 5

<table>
<tr><th>Total Jetties</th><th>Chainage (km)</th><th>FY24</th><th>FY25</th><th>FY26</th><th>FY35</th><th>FY36</th><th>FY37</th><th>FY54</th></tr>
<tr><td rowspan="4">4</td><td rowspan="4">3</td><td colspan="2">Construction - 2 Jetties</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td colspan="5">Operational - 2 Jetties</td></tr>
<tr><td></td><td></td><td></td><td colspan="2">Construction - +2 Jetties</td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td colspan="2">Operational - +2 Jetties</td></tr>
</table>

- **Traffic**

This terminal is proposed for handling dirty cargo i.e. Coal for nearby TPP i.e. Meja and Bara. Presently these plants are procuring coal from NCL by rail; certain share of this movement is diverted to IWT using NW1 till Prayagraj. Traffic for Terminal 5 for next 30 years is projected in the table below.

Table 15.84 Traffic at Terminal 5 ('000 T)

Cargo	Origin	Destination	Fy24	Fy29	Fy34	Fy39	Fy44	Fy49	Fy54
Coal	NCL	Prayagraj	912	1,142	1,363	1,580	1,831	2,001	2,001

	NCL	Prayagraj	1,368	1,713	2,044	2,370	2,747	3,002	3,002
Fly Ash	Prayagraj	Singapore	435	524	568	597	627	646	646
	Prayagraj		489	589	638	670	705	726	726
Total			3,205	3,968	4,612	5,217	5,910	6,375	6,375

- **Capital Cost**

This section represents the total capital expenditure in a phased manner for Terminal 5 proposed at Prayagraj for coal handling in River Yamuna.

Table 15.85 Project Cost for Construction Terminal-5 (INR Lakhs)

Sl. No.	Description	Total Investment	Phase I		Phase II	
			FY24	FY23	FY35	FY36
A	Terminal	15,600	4,680	3,120	4,680	3,120
B	Approach Rail/Road	2,076	623	415	623	415
C	Stackyard	1,357	814	543	-	-
D	Cargo Handling Equipment	4,846	716	2,864	253	1,013
E	Utilities	-	-	-	-	-
F	IT	-	-	-	-	-
G	Other Financial Cost	41,010	10,253	10,253	10,253	10,253
H	Consultancy	-	-	-	-	-
	Total Capex	**64,890**	**17,086**	**17,194**	**15,809**	**14,801**

Construction of this terminal would take 2 years to get completed i.e. in FY24 and FY25. It would start operating from FY26. Detailed cost of cargo handling and other supporting infrastructure required at terminal is listed in the table below.

Table 15.86 Infrastructure Requirement Cost at Terminal-5 (INR Lakhs)

S.No	Description	No.	Rate (INR Lakhs)	Cost (INR Lakhs)
1	Parking Area	1	15	15
2	Canteen	1	15	15
3	Admin Building	1	40	40
4	STP	1	20	20
5	Fire Tender	1	20	20
6	Dispensary	1	15	15
7	Electrical Substation			0
8	Fencing and Guard room	1	40	40
9	Cold Storage	0	300	0
10	Storage area, Warehouses	73,440 sqm	1192.06	1192.06
Total				1357.06

- **Project Financing**

  Construction Phase 1 & Phase 2 has been assumed to be funded in an Equity-Debt ratio of 35:65. Details of the means of financing for both the phases are shown below.

Table 15.87 Equity-Debt Share Distribution for Terminal 5 (INR Lakhs)

Particulars	%	Investment Phase I	Investment Phase II
Equity	35%	11,998	10,714
Debt	65%	22,282	19,897

- **Financial Indicators**

  This section shows the financial indicator that leads to the generation of FIRR for Terminal 5. Revenue, Salary, Depreciation, Cash Flow, P&L Statement & Balance Sheet helps on understanding the returns on investment made for this terminal.

  Revenue from Terminal 5 proposed on River Yamuna will be generated from core operations that include cargo handling at the jetty, Storage, Stackyard, Evacuation from yard to Rail. The detailed breakup of revenue is shown in the table above.

Table 15.88 Revenue from Terminal-5 (INR Lakhs)

Particulars	FY24	FY30	FY35	FY40	FY45	FY50	FY54
Vessels Charges	-	160	184	208	236	248	248
Wharfage	-	3,149	3,662	4,182	4,782	5,047	5,047
Stevedoring	-	4,244	4,941	5,649	6,466	6,827	6,827
Cargo Storage	-	1,712	1,998	2,290	2,627	2,776	2,776
Stackyard Operation	-	4,244	4,941	5,649	6,466	6,827	6,827
Total Revenue	**-**	**13,509**	**15,727**	**17,979**	**20,577**	**21,725**	**21,725**

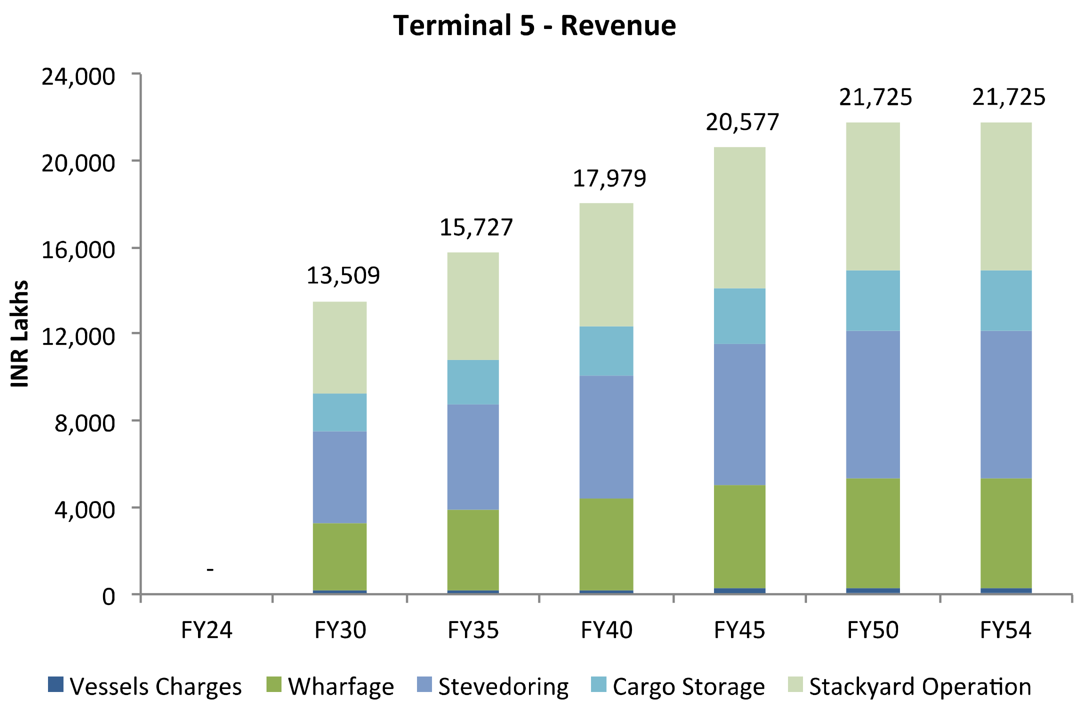

Fig. 15.18 Revenue for Terminal 5

The following table indicates the direct operating cost for development of Terminal 5. This direct operating cost include cargo Handling charges, Storage cost, evacuation cost &stackyard handling cost.

Table 15.89 Direct Operating Cost for Terminal 5 (INR Lakhs)

Particulars	FY24	FY30	FY35	FY40	FY45	FY50	FY54
Cargo Handling at Jetty	0	1,946	2,297	2,611	2,972	3,300	3,300
Storage Cost	0	1,042	1,231	1,401	1,597	1,775	1,775
Evacuation Cost	0	658	781	892	1,021	1,138	1,138
Stackyard Handling	0	1,975	2,343	2,677	3,063	3,413	3,413
Power & Water	0	708	708	725	725	725	725
Salary	0	93	93	130	130	130	130
Total	**0**	**6,422**	**7,452**	**8,436**	**9,508**	**10,482**	**10,482**

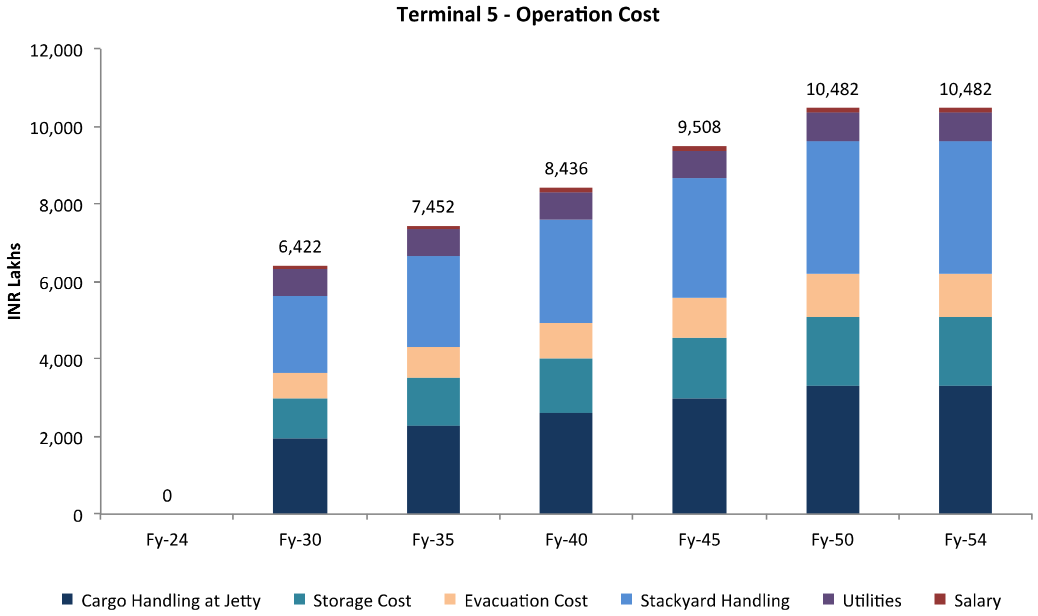

Fig.15.19 Operating Cost at Terminal 5

Table 15.90 Maintenance Cost for Terminal 5 (INR Lakhs)

Particulars	FY24	FY30	FY35	FY40	FY45	FY50	FY54
Civil	61	102	155	190	190	190	190
Mechanical	36	179	192	242	242	242	242
Insurance Cost	75	72	90	69	31	14	7
Administration Cost	-	251	298	341	390	434	434
Total	172	604	735	842	853	881	874

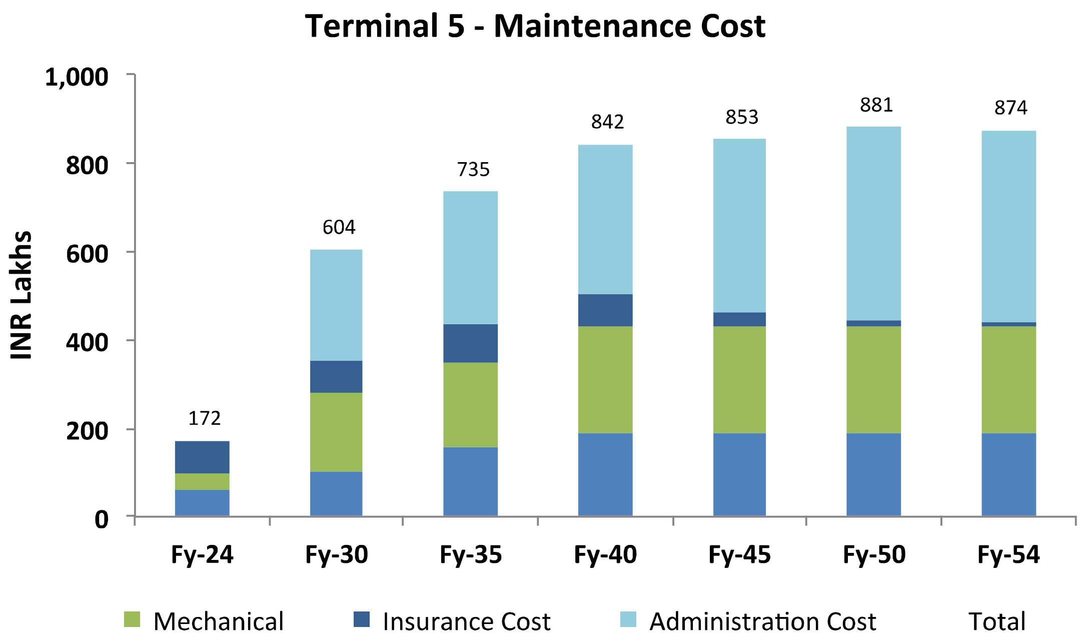

Fig. 15.20Maintenance Cost at Terminal 5

The operator would share 4% of its revenue with IWAI and pay royalty of INR 10 per Tonne. The table below indicates the amount of total outflow to IWAI in case of Terminal 5.

Table 15.91 Regulatory Royalty to IWAI for Terminal 5 (INR Lakhs)

Particulars	FY24	FY30	FY35	FY40	FY45	FY50	FY54
Royalty to IWAI	0	384	450	509	576	638	638
Revenue Share	0	503	596	682	780	869	869
Total Outflow to IWAI	0	886	1,047	1,190	1,356	1,507	1,507

The section above summaries the Revenue generated by operation of Terminal 5 and total cost i.e. O&M cost and out-flow to IWAI (Royalty and Revenue Share) from FY26 till FY54. The operator would share 4% of its revenue with IWAI and pay royalty of INR 10 per Tonne. The following table depicts the P/L statement for development of Terminal 5on River Yamuna.

Table 15.92 Profit& Lost Statement for Terminal 5 (INR Lakhs)

Particulars	FY24	FY30	FY35	FY40	FY45	FY50	FY54
Revenue	0	12,570	14,912	17,040	19,493	21,725	21,725
O & M Cost	172	7,026	8,187	9,279	10,361	11,363	11,356
Total Outflow to IWAI	0	886	1,047	1,190	1,356	1,507	1,507
PBDIT	-172	4,657	5,679	6,571	7,776	8,856	8,862
Depreciation	0	872	7,375	1,512	755	0	0
Interest	1,222	1,788	2,256	2,485	1,476	928	491
PBT	-1,394	1,997	-3,952	2,574	5,545	7,927	8,372
Tax	0	599	0	772	1,663	2,378	2,511
PAT	-1,394	1,398	-3,952	1,802	3,881	5,549	5,860

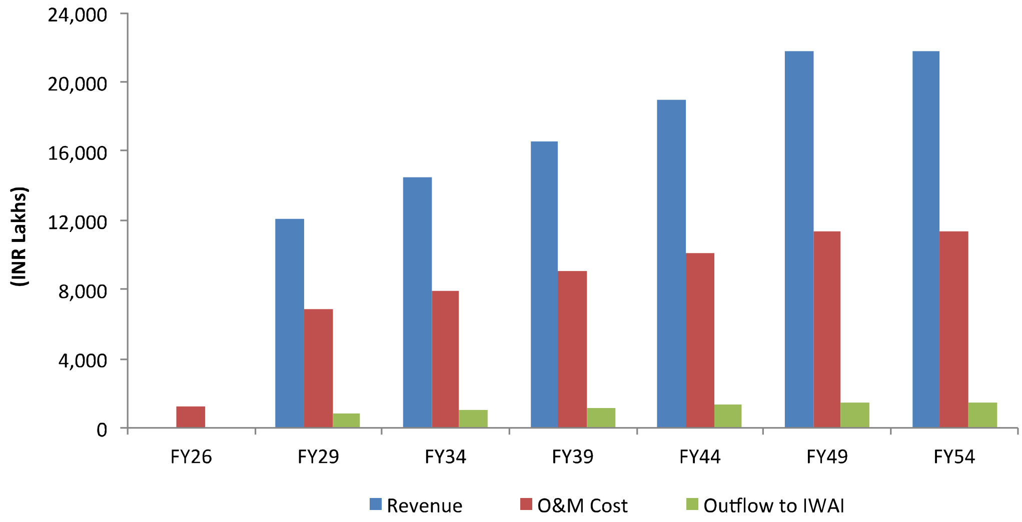

Fig. 15.21Comparison among Revenue, O&M Cost and Total Outflow to IWAI

The terminal will start generating profit from 1st year of operation only i.e. Fy-24. This is mainly due to high Revenue& high traffic whereas lower development cost. These are the major factors that heavily impacts commercial prospects of proposed terminal.

Depreciation has been calculated using the Straight Line Method (SLM). Under this method, cost of asset is evenly distributed across its useful life. Straight Line Method (SLM) has been used to calculate depreciation for Terminal 5, under which the cost of tangible and intangible assets are evenly distributed across its life.

Table 15.93 Depreciation for Terminal 5 (INR Lakhs)

Particulars	FY24	FY30	FY35	FY40	FY45	FY50	FY54
Gross Block	17,086	34,280	64,890	64,890	64,890	64,890	17,086
Depreciation & Amortization	0	872	1,512	755	0	0	0
Cumulative Depreciation & Amortization	0	25,737	58,511	64,890	64,890	64,890	0
Net Block	17,086	8,543	6,379	0	0	0	17,086

The table below depicts the cash inflow & outflow in case of development of Terminal 5.

Table 15.94 Cash Flow for Terminal 5 (INR Lakhs)

Particulars	FY24	FY25	FY35	FY36	FY45	FY50	FY54
Cash Inflow							
Equity	5,980	6,018	5,533	5,180	0	0	0
Debt	11,106	11,176	10,276	9,621	0	0	0
Net Cash from Investment	17,086	17,194	15,809	14,801	0	0	0
Operations							
PBDIT	-172	-443	5,679	5,741	6,571	7,776	8,856
(-) Taxes Paid	0	0	0	0	772	1,663	2,378
Net Cash from	-172	-443	5,679	5,741	5,798	6,112	6,478

Particulars	FY24	FY25	FY35	FY36	FY45	FY50	FY54
Operations							
Total Cash Inflow	16,913	16,751	21,488	20,543	5,798	6,112	6,478
Cash Outflow							
Capital Investment	17,086	17,194	15,809	14,801	0	0	0
Long Term Debt	0	0	1,205	1,205	995	995	995
Interest	1,222	2,451	2,256	3,181	1,476	928	491
Total Cash Outflow	18,307	19,645	19,270	19,188	2,470	1,923	1,485
Net Cash Flow	-1,394	-2,894	2,218	1,355	3,642	4,554	4,865
Opening Balance of Cash	0	-1,394	-3,520	-1,302	13,902	33,833	52,518
Closing Balance Cash	**-1,394**	**-4,288**	**-1,302**	**53**	**17,545**	**38,387**	**57,383**

Table 15.95 Balance Sheet for Terminal 5 (INR Lakhs)

Sources of Funds	Fy-22	Fy-27	Fy-32	Fy-37	Fy-42	Fy-47	Fy-52
Shareholder's funds							
Capital	5,980	11,998	17,531	22,711	22,711	22,711	22,711
Reserves &Surplus	- 1,394	- 30,062	- 25,850	- 33,261	- 18,581	7,236	30,211
Borrowings							
Secured Loans	11,106	16,256	20,506	22,592	13,414	8,440	4,460
Total Funds	15,691	- 1,809	12,187	12,043	17,545	38,387	57,383
Usages of Fund							
Fixed Assets							
Gross Block	17,086	34,280	50,089	64,890	64,890	64,890	64,890
Less: Depreciation	-	25,737	36,600	58,511	64,890	64,890	64,890
Net Block	17,086	8,543	13,489	6,379	-	-	-
Net Current Assets	- 1,394	- 10,352	- 1,302	5,664	17,545	38,387	57,383
Total Assets	**15,691**	**- 1,809**	**12,187**	**12,043**	**17,545**	**38,387**	**57,383**

- **Financial IRR**

Financial FIRR presented below will help IWAI to measure the financial returns on investment and assist take a firm decision on the implementation of this development. Final viability assessment for developing coal handling terminal on this River Yamuna would be done based on this outcome.

Table 15.96 Financial IRR Calculation for Terminal 5 (INR Lakhs)

Particulars	FY24	FY25	FY35	FY36	FY45	FY50	FY54
PBDIT	-172	-443	5,679	5,741	7,776	8,856	8,862
Interest	1,222	2,451	2,256	3,181	1,476	928	491
Principal repayment	0	0	1,205	1,205	995	995	995
Equity	5,980	6,018	5,533	5,180	0	0	0
Debt	11,106	11,176	10,276	9,621	0	0	0
Total Investment	17,086	17,194	15,809	14,801	0	0	0

Particulars	FY24	FY25	FY35	FY36	FY45	FY50	FY54
Tax	0	0	0	0	1,663	2,378	2,511
Cash flow to Equity(Pre-tax)	-7,374	-8,912	-3,315	-3,826	5,305	6,933	7,377
Equity IRR(Pre-tax)	7.0%						
Cash flow to Equity(Post-tax)	-7,374	-8,912	-3,315	-3,826	3,642	4,554	4,865
Equity IRR(Post-tax)	4.4%						
Project Cash flow(Pre-tax)	-17,258	-17,637	-10,130	-9,060	7,776	8,856	8,862
Project IRR(Pre-tax)	8.8%						
Project Cash flow(Post-tax)	-17,258	-17,637	-10,130	-9,060	6,112	6,478	6,351
Project IRR(Post-tax)	7.3%						

- **Economic IRR**

EIRR section evaluates the value addition that, this project induces in society and the impact on various social factors. Economic IRR (EIRR) comprises all financial and non-financial benefits of the project. It helps in investment decision from prospects of improving welfare of society. If any project is commercially unviable then its economic viability is considered. These impacts are transformed into financial gains which can bring the state and central government to fund resources for the implementation. Government undertake the detailed assessment at projects contribution to the betterment of society like employment generation, improvement in connectivity, pollution control, trade improvement, carbon emission, employment generation, reduction in congestion, less vehicle operating cost, saving on fuel, etc.

Assumptions considered for computing EIRR are for Terminal 5 is listed below.

Table 15.97Assumptions for EIRR Calculations

Parameters Adopted	Value	Unit
Economic loss due to Road Accidents	0.03	of GDP
Value of economic loss due to road accidents	3.76	Rs Lakhs Crores
Safety Index (IWT as base)	5.00	times safer than rail
Accident Loss		
Rail	0.77	Rs Lakhs/KM
IWT	0.15	Rs Lakhs/KM
Fuel Cost		
Rail	85.00	t-km / per liter
IWT	105.00	t-km / per liter
Fuel price	69.40	Rs/Litre
Vehicular operating cost (VOC)		
Rail	1.41	Rs/t-km
IWT	1.27	Rs/t-km
Direct Employment Creation		

Parameters Adopted	Value	Unit
Rail	2.00	Per Million t-km
IWT	0.50	Per Million t-km
Employment cost	2.50	Rs Lakhs per Annum
Emission Reduction		
Rail	13.30	g CO2/t-km
IWT	6.00	g CO2/t-km
Shadow factor		
CAPEX/O&M Cost (Convert financial cost to economic cost)	0.85	-
Carbon Credits factors		
Carbon Shadow price	20.00	$/Tonne
Exchange rate	67.00	Rs/USD

All the essential assumptions with respect to fuel efficiency, direct employment multiplier, reduction in carbon emission, and carbon credit factors have been taken from the common industrial benchmarks.

Estimated impact of each factor at terminal 5 for the period of 30 years is presented in the table below.

Table 15.98 Economic IRR Calculation for Terminal 5 (INR Crore)

Operation years	FY24	FY25	FY35	FY36	FY40	FY45	FY50	FY55
Accident Loss			0.02	0.02	0.02	0.02	0.02	0.02
Saving on fuel			0.22	0.23	0.25	0.28	0.30	0.30
Saving on account of VOC			0.20	0.20	0.22	0.25	0.27	0.27
Job creation			0.35	0.36	0.40	0.45	0.48	0.48
Reduction in Emissions			0.01	0.01	0.02	0.02	0.02	0.02
Total Revenue	0.0	0.0	157.3	161.5	179.8	205.8	217.2	217.2
Total Economic Impact	0.0	0.0	158.1	162.3	180.7	206.8	218.3	218.3
O&M Expenditure	1.7	4.4	81.9	85.0	92.8	103.6	113.6	113.6
Economic Cash Outflow	-1.7	-4.4	76.2	77.4	87.9	103.2	104.7	104.8
Investment	170.9	171.9	158.1	148.0				
Net Cash Flow to Project	-172.6	-176.4	-81.9	-70.7	87.9	103.2	104.7	104.8
Project EIRR	**19.0%**							

15.3.2 Multi-Purpose Cargo Terminals

15.3.2.1 Inputs for Financial Analysis of Multi-Purpose Cargo Terminals

All the assumptions and inputs used in developing financial analysis of Multi-Purpose cargo terminals on River Yamuna are discussed in this section. The financial analysis is done for Multi-Purpose terminal operations on NW 110.

- **Tariff Assumptions for Multi-Purpose Cargo Terminals**
  Tariff assumptions for Multi- purpose Terminals are based on Rate Schedule of GMB and MMB Ports and current Tariff of IWAI. The below table presents proposed tariff for various facilities for users in Multi- purpose cargo terminals. Competitive Tariff is considered for multipurpose cargo handling at these Terminals to attract industries

for using IWT on river Yamuna. Vessel berthing cost is charged for the use of a berth. It includes vessels' anchorage and mooring at a berth. Vessel berthing cost is based on the duration of a vessel's stay and length overall (LOA). The below table depicts assumed vessel berthing charge in Multi- purpose Cargo terminals. Vessel berthing charges for commodities, like Fertilizer, Automobile, Food grain, Sugar, Iron & Steel are kept same, i.e. GRT2.35 Per Day. However, other charges for these commodities vary.

Table 15.99 Vessel Berthing Charges at Multi-Purpose Cargo Terminals

Commodities	Rate	Unit	Reference
Fertilizer	2.35	GRT/Day	As per GMB
Automobile	2.35	GRT/Day	
Food Grain	2.35	GRT/Day	
Sugar	2.35	GRT/Day	
Iron & Steel	2.35	GRT/Day	

Wharfage charge is cost for the movement of cargo through the facility (Terminal) within distribution system. The wharfage dues shall be calculated on the total tonnage of each item of goods. The proposed rates to be paid for the use of wharves, jetties and landing places (hereinafter referred to as Wharfage dues) on goods landed at Multi- purpose cargo Terminals on NW 110 is specified in the below table.

Table 15.100Wharfage Charges at Multi-Purpose Cargo Terminals

Commodities	Rate	Unit	Reference
Fertilizer	26	Per Tonne	As per Cochin Port
Automobile	2,160.00	Per PCU	As per MMB
Food Grain	22	Per Tonne	As per Cochin Port
Sugar	10	Per Tonne	As per Cochin Port
Iron & Steel	72	Per Tonne	As per Cochin Port
Container	706	Per Container	As per Cochin Port, 20ft, 40ft-1058

Stevedoring charge includes Fees for loading and stowing or unloading a vessel. The below table depicts assumed stevedoring charge in Multi- purpose Cargo terminals.

Table 15.101 Stevedoring Charges at Multi-Purpose Cargo Terminals

Commodities	Rate	Unit	Reference
Fertilizer	70	Per Tonne	As per MMB, Coastal
Automobile	30	Per PCU	
Food Grain	68	Per Tonne	
Sugar	70	Per Tonne	
Iron & Steel	42	Per Tonne	
Container	252	Per TEU	As per MMB, brought by barges, per box

Storage Tariff is charges towards rent for storage of goods in the stackyards, warehouses and transit sheds in the Terminal. This tariff is charged for storage of multi- purpose cargo (goods) on which payment of duties is deferred until the cargo is removed from the storage facility. The below table shows storage charges in Multi-purpose Cargo terminals.

Table 15.102 Storage Charges at Multi-Purpose Cargo Terminals

Commodities	Rate	Unit	Reference
Fertilizer	60	Per Tonne	As per MMB approx.
Automobile	640	Per PCU	As per MMB approx.
Food Grain	60	Per Tonne	As per MMB approx.
Sugar	60	Per Tonne	As per MMB approx.
Iron & Steel	60	Per Tonne	As per MMB approx.
Container	138	Per TEU	Cochin Port, 20ft, 40ft-276

Stackyard handling and evacuation tariff is charged for handling multi- purpose commodities, like fertilizer, food grain, sugar, iron & steel etc. This charge includes transportation of cargo to the yard, offloading in yard, loading cargo in railway rake for evacuation.

Table 15.103 Stackyard Handling & Evacuation Charges at Multi-Purpose Terminals

Commodities	Rate	Unit	Reference
Fertilizer	284	Per Tonne	Ennore Port
Automobile	500	*Per PCU*	
Food Grain	290	Per Tonne	
Sugar	300	Per Tonne	
Iron & Steel	266	Per Tonne	
Container (from Container yard to Rail/Truck)	844	Per TEU	JNPT Tariff

- **Handling Cost at Terminals**

The cargo handling cost at Multi- purpose Cargo terminals is prescribed in the below tables for different commodities. These handling costs are for various clean cargo handling activities on the terminals, such as unloading of the cargo from the vessel and transfer of the same up to the point of storage, storage at the stackyard (warehouse, silo etc.), reclaiming from stackyard and loading onto railway rake and all other miscellaneous services. The handling cost includes cost of cargo handling equipment in the terminals, like crane cost, fork lift cost, labour cost etc. All these costs are assumed based on industry inputs. The tables below depict handling cost for handling fertilizer, automobile, food grain, sugar, iron & steel and containers in Multi- purpose terminals.

Handling of Fertiliser& sugar would include unloading at jetty, after unloading, carrying cargo by forklift trucks (or other equipment) to the warehouse in the terminal premise for storage and further evacuation of cargo from the stackyard (warehouse). For railway evacuation, bagged fertiliser and sugar would be loaded in rakes in the railways yard inside the terminal.

Table 15.104 Cargo Handling Cost at Multi-Purpose Terminals for Fertilizer

Commodities	Rate	Unit	Reference

Commodities	Rate	Unit	Reference
Stevedoring	25	INR/Tonnes	As per Industries inputs
Storage	21	INR/Tonnes	
Wharfage	10	INR/Tonnes	
Stackyard Handling & Evacuation	100	INR/Tonnes	

Table 15.105 Cargo Handling Cost at Multi-Purpose Terminals for Automobile

Commodities	Rate	Unit	Reference
Stevedoring	11	Per PCU	As per Industries inputs
Storage	224	Per PCU	
Wharfage	756	Per PCU	
Stackyard Handling & Evacuation	175	Per PCU	

Table 15.106 Cargo Handling Cost at Multi-Purpose Terminals for Food Grain

Commodities	Rate	Unit	Reference
Stevedoring	24	INR/Tonnes	As per Industries inputs
Storage	21	INR/Tonnes	
Evacuation	8	INR/Tonnes	
Stackyard Handling & Evacuation	102	INR/Tonnes	

Table 15.107 Cargo Handling Cost at Multi-Purpose Cargo Terminals for Sugar

Commodities	Rate	Unit	Reference
Stevedoring	25	INR/Tonnes	As per Industries inputs
Storage	21	INR/Tonnes	
Wharfage	4	INR/Tonnes	
Stackyard Handling & Evacuation	105	INR/Tonnes	

Table 15.108 Cargo Handling Cost at Multi-Purpose Cargo Terminals for Iron & Steel

Commodities	Rate	Unit	Reference
Stevedoring	15	INR/Tonnes	As per Industries inputs
Storage	21	INR/Tonnes	
Wharfage	26	INR/Tonnes	
Stackyard Handling & Evacuation	94	INR/Tonnes	

As shown in the below table, Handling cost of containers would be same irrespective of the contents of the containers.

Table 15.109 Cargo Handling Cost at Multi-Purpose Cargo Terminals for Containers

Commodities	Rate	Unit	Reference
Stevedoring	89	Per TEU	As per Industries inputs
Storage	49	Per TEU	
Wharfage	248	Per TEU	
Stackyard Handling & Evacuation	296	Per TEU	

- **Salary Calculation for Multi- Purpose Cargo Terminals**

The below table depicts proposed salaries for employees in each multi-purpose cargo terminal. As shown in the table, number of employees would vary in some departments in Phase 1 and Phase 2.

Table 15.110 Assumptions for Manpower at Each Terminal

Department	Person	Monthly Salary (INR/Person)	No. of Employees	
			Phase 1	Phase 2
-	Manager	90,000	1	1
Admin & Account	Admin Officer	40,000	1	2
	Account Staff	30,000	2	3
	Store Staff	15,000	4	5
	Hospitality	15,000	2	4
	Security	15,000	4	6
Operation	Ops Manager	50,000	1	2
	Supervisor	50,000	2	3
	Operator	40,000	2	3
	Drivers	20,000	3	3
Maintenance	Mechanic	20,000	1	1
	Electrician	20,000	1	1
	Civil Superintendent	50,000	1	1
	Workers	12,000	2	3
	Hospitality	15,000	2	3

- **Loan Schedule**

The below table depicts assumption for loan schedules for Multi- purpose cargo terminals. For Multi- purpose cargo terminals, it is considered that loan tenure would be 20 years. Construction period of 2 years is considered for these cargo terminals. Moratorium Period, i.e. Post Construction Period for Multi- purpose cargo terminals would be 2 years. 11% Rate of interest is considered for Multi-purpose cargo terminals on NW 110.

Table 15.111 Assumption for Loan Schedule for Multi-Purpose Cargo Terminals

Description	Item
Loan Tenure	20 Years
Moratorium Period (Post Construction Period)	2 Years
Construction Period	2 Years
Rate of Interest	11%

15.3.2.2 Terminal 6

- **Phasing**

Terminal 6 is proposed to be developed in Phase 1 i.e. from FY24. This is the first phase of fairway development, in this phase the stretch from Prayagraj to Kanpur would be developed. The construction of infrastructure, equipment handling, and connectivity will take 2 years i.e. FY24 and FY25 and the terminal will get operational from FY26 till FY54.

Table 15.112 Development of Terminal 6

Total Jetties	Chainage (km)	FY24	FY25	FY26	FY35	FY36	FY37	FY54
3	4.2	Construction - 2 Jetties						
				Operational - 2 Jetties				
					Construction - +1 Jetty			
							Operational - +1 Jetty	

- **Traffic**

This terminal is proposed as multi-purpose cargo terminal to handle Automobile, Fertilizer, Food Grain and Sugar. Initially terminal would only be used for handling fertilizer and after the development further stretch in next 2 phases, terminal would start handling other commodities as well. 30 years traffic projects for terminal 6 are shown in the table below.

Table 15.113 Traffic at Terminal 6 ('000 T)

Cargo	Origin	Destination	Fy24	Fy30	FY35	FY40	FY45	FY50	FY54
Fertilizer	Phulpur	Kanpur	-	510	551	568	568	568	568
Automobile	NCR Cluster	Prayagraj	-	-	-	76	88	94	94
Food Grains	Punjab, Haryana	Prayagraj	-	-	-	381	421	438	438
Sugar	Shamli, Muzaffarnagar	Prayagraj	-	-	-	113	118	121	121
Total			**-**	**510**	**551**	**1,138**	**1,196**	**1,221**	**1,221**

- **Capital Cost**

This section represents the total capital expenditure in a phased manner for Terminal 6 proposed at River Yamuna.

Table 15.114 Project Cost for Construction Terminals-6 (INR Lakhs)

Description	Total Investment	Investment Phase 1		Investment Phase 2	
		FY24	FY23	Fy 35	Fy36
Terminal	11,600	2,320.0	1,546.7	4,640.0	3,093.3
Approach Rail/Road	1,337	267.4	178.3	534.8	356.5
Infrastructure	6,584	3,950.5	2,633.7	-	-
Cargo Handling Equipment	2,490	265.1	1,060.4	232.9	931.5
Utilities		-	-	-	-
IT		-	-	-	-
Other Financial Cost	23,914	11,957.2	11,957.2	-	-
Consultancy			-		-

TOTAL CAPEX	45,925	18,760.2	17,376.2	5,407.6	4,381.3

Construction of this terminal would take 2 years to get completed i.e. in FY24 and FY25. It would start operating from FY26 till FY54. Detailed cost of cargo handling and other supporting infrastructure required at terminal is listed in the table below.

Table 15.115 Infrastructure Requirement Cost at Terminals-6 (INR Lakhs)

S.No	Description	No.	Rate (INR Lakhs)	Cost (INR Lakhs)
1	Parking Area	1.0	20.0	20.0
2	Canteen	1.0	20.0	20.0
3	Admin Building	1.0	40.0	40.0
4	STP	1.0	20.0	20.0
5	Fire Tender	1.0	20.0	20.0
6	Dispensary	1.0	15.0	15.0
7	Electrical Substation	1.0		-
8	Fencing and Guard	1.0	40.0	40.0
9	Cold Storage	0.0	300.0	300.0
10	Storage area, Warehouses	52,936 Sq.m	859.2	859.2
11	Silo	5.0	50.0	250.0
	Total			**1,584.2**

- **Project Financing**

Investment Phase 1 & Phase 2 has been assumed to be funded in an Equity-Debt ratio of 35:65. Details of the means of financing for both the phases are shown below.

Table 15.116 Equity-Debt Share Distribution for Terminal 6 (INR Lakhs)

Particulars	%	Investment Phase 1	Investment Phase 2
Equity	35%	12,648	3,426
Debt	65%	23,489	6,363

- **Financial Indicators**

This section shows the financial indicator that leads to the generation of FIRR for Terminal – 6. Revenue, Salary, Depreciation, Cash Flow, P&L Statement & Balance Sheet helps on understanding the returns on investment made for this terminal.

Revenue from Terminal 6 proposed on River Yamuna will be generated from core operations that include cargo handling at the jetty, Storage, Stackyard, Evacuation from yard to Rail. The detailed breakup of revenue is shown in the table above.

Table 15.117 Revenue from Terminals-6 (INR Lakhs)

Particulars	FY24	FY26	FY30	FY35	FY40	FY45	FY50	FY54
Vessels Charges	-	9	9	10	36	40	41	41
Wharfage	-	122	133	143	1,885	2,153	2,287	2,287
Stevedoring	-	329	357	386	759	793	808	808
Cargo Storage	-	282	306	331	1,124	1,228	1,278	1,278

Stackyard Operation	-	1,334	1,449	1,565	3,438	3,630	3,717	3,717
Total Revenue	**-**	**2,076**	**2,254**	**2,435**	**7,241**	**7,844**	**8,131**	**8,131**

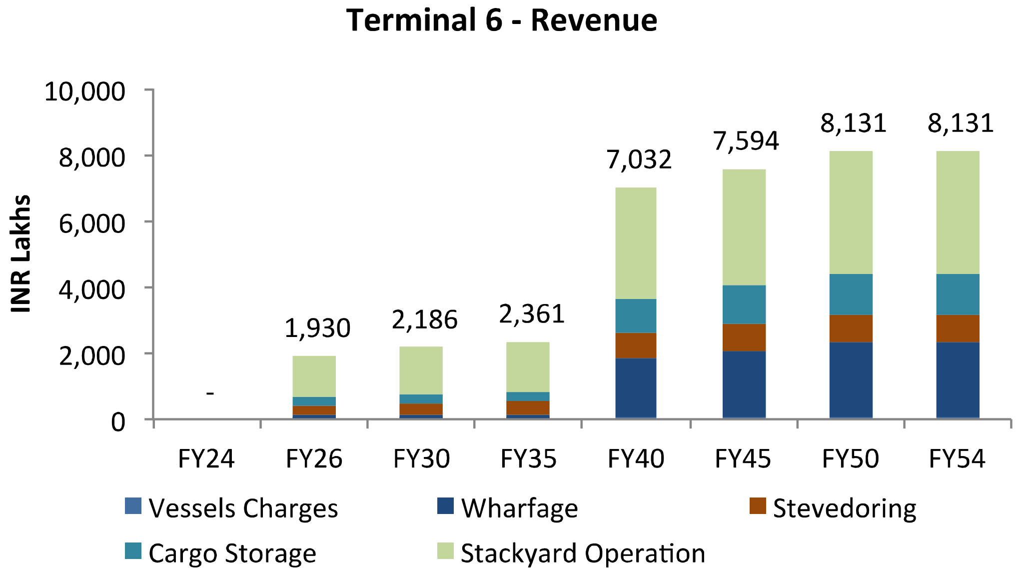

Fig. 15.22 Revenue for Terminal 6

The following table indicates the direct operating cost for development of Terminal 6. This direct operating cost include cargo Handling charges, Storage cost, evacuation cost &stackyard handling cost.

Table 15.118 Direct Operating Cost for Terminal 6 (INR Lakhs)

Particulars	FY24	FY26	FY30	FY35	FY40	FY45	FY50	FY54
Fertilizer	0	733	796	860	887	887	887	887
Automobile	0	822	893	965	1748	1867	1926	1926
Food Grain	0	479	520	562	782	803	812	812
Sugar	0	493	536	579	653	656	657	657
Iron & Steel	0	442	480	518	534	534	534	534
Power & Water	0	434	434	434	449	449	449	449
Salary	0	93	93	93	130	130	130	130
Total	0	3496	3752	4010	5183	5326	5396	5396

Table 15.119Maintenance Cost for Terminal 6 (INR Lakhs)

Particulars	FY24	FY26	FY30	FY35	FY40	FY45	FY50	FY54
Civil	65	109	109	161	195	195	195	195
Mechanical	13	66	66	78	124	124	124	124
Insurance Cost	71	106	55	81	64	28	13	7
Administration Cost	0	42	45	49	145	157	163	163
Total	149	323	276	368	528	505	495	489

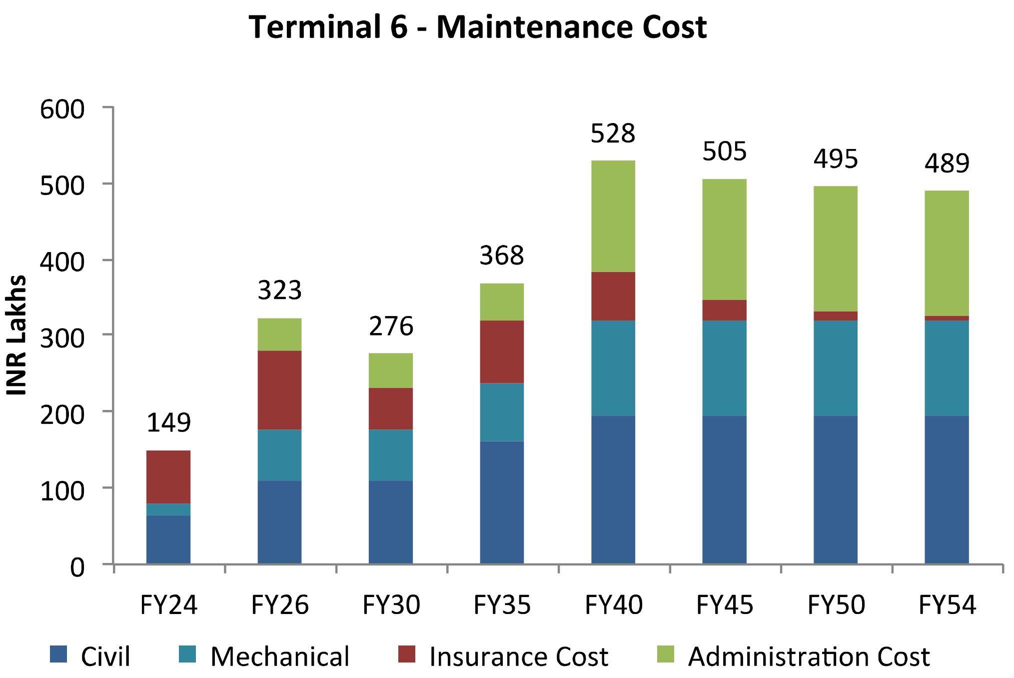

Fig. 15.23 Maintenance Cost at Terminal 6

The operator would share 4% of its revenue with IWAI and pay royalty of INR 10 per Tonne. The table below indicates the amount of total outflow to IWAI in case of Terminal 6.

Table 15.120 Regulatory Royalty to IWAI for Terminal 6 (INR Lakhs)

Particulars	FY24	FY26	FY30	FY35	FY40	FY45	FY50	FY54
Royalty to IWAI	0	47	51	55	106	111	113	113
Revenue Share	0	83	90	97	290	314	325	325
Total Outflow to IWAI	0	130	141	153	396	425	438	438

The section above summaries the Revenue generated by operation of Terminal 6 and total cost i.e. O&M cost and out-flow to IWAI (Royalty and Revenue Share) from FY35 till FY54. The operator would share 4% of its revenue with IWAI and pay royalty of INR 10 per Tonne.The following table depicts the P/L statement for development of Terminal 6 on River Yamuna.

Table 15.121Profit & Lost Statement for Terminal 6 (INR Lakhs)

Particulars	FY24	FY26	FY30	FY35	FY40	FY45	FY50	FY54
Revenue	0	2,076	2,254	2,435	7,241	7,844	8,131	8,131
O & M Cost	149	3,949	4,169	4,531	6,107	6,255	6,328	6,322
Total Outflow to IWAI	0	130	141	153	396	425	438	438
PBDIT	-149	-1,873	-1,914	-2,096	1,134	1,589	1,803	1,809
Depreciation	0	5,557	774	1,116	1,393	619	0	0
Interest	1,341	2,444	1,884	1,571	1,185	700	700	700
PBT	-1,491	-9,874	-4,572	-4,783	-1,444	271	1,103	1,109
Tax	0	0	0	0	0	81	331	333
PAT	-1,491	-9,874	-4,572	-4,783	-1,444	189	772	776

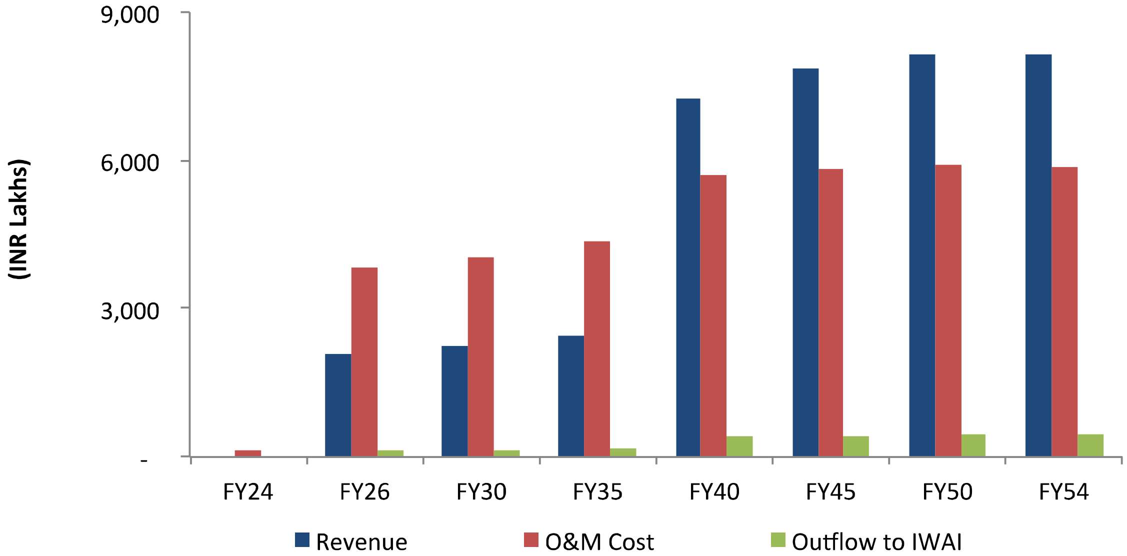

Fig.15.24 Comparison among Revenue, O&M Cost and Total Outflow to IWAI

The terminal will start generating profit from FY43. Revenue and development cost are the major factors that heavily impacts commercial prospects of proposed terminal.

Depreciation has been calculated using the Straight Line Method (SLM). Under this method, cost of asset is evenly distributed across its useful life. Straight Line Method (SLM) has been used to calculate depreciation for Terminal 6, under which the cost of tangible and intangible assets are evenly distributed across its life.

Table 15.122Depreciation for Terminal 6 (INR Lakhs)

Particulars	FY24	FY26	FY30	FY35	FY40	FY45	FY50	FY54
Gross Block	18,760	36,136	36,136	41,544	45,925	45,925	45,925	45,925
Depreciation & Amortization	0	5,557	774	1,116	1,393	619	0	0
Cumulative Depreciation & Amortization	0	11,113	28,556	32,767	39,733	45,925	45,925	45,925
Net Block	18,760	25,023	7,580	8,777	6,192	0	0	0

The table below depicts the cash inflow & outflow in case of development of Terminal 6.

Table 15.123 Cash Flow for Terminal 6 (INR Lakhs)

Particulars	FY24	FY25	Fy35	FY36	FY40	FY45	FY50	FY54
Cash Inflow								
Equity	6,566	6,082	1,893	1,533	0	0	0	0
Debt	12,194	11,295	3,515	2,848	0	0	0	0
Net Cash from Investment	18,760	17,376	5,408	4,381	0	0	0	0
PBDIT	-149	-300	-2,096	-2,237	1,134	1,589	1,803	1,809
(-) Taxes Paid	0	0	0	0	0	81	331	333
Net Cash from Operations	-149	-300	-2,096	-2,237	1,134	1,508	1,472	1,476

Particulars	FY24	FY25	Fy35	FY36	FY40	FY45	FY50	FY54
Total Cash Inflow	18,611	17,076	3,312	2,144	1,134	1,508	1,472	1,476
Cash Outflow								
Capital Investment	18,760	17,376	5,408	4,381	0	0	0	0
Long Term Debt	0	0	1,272	1,272	1,272	0	0	0
Interest	1,341	2,584	1,571	1,745	1,185	700	700	700
Total Cash Outflow	20,102	19,960	8,251	7,398	2,457	700	700	700
Net Cash Flow	-1,491	-2,884	-4,939	-5,254	-1,323	808	772	776
Opening Balance of Cash	0	-1,491	-50,039	-54,978	-65,449	-69,123	-65,314	-62,219
Closing Balance Cash	-1,491	-4,375	-54,978	-60,232	-66,772	-68,315	-64,542	-61,442

Table 15.124 Balance Sheet for Terminal 6 (INR Lakhs)

Particulars	FY24	FY26	FY30	FY35	FY40	FY45	FY50	FY54
Shareholder's funds								
Capital	6,566	12,648	12,648	14,540	16,074	16,074	16,074	16,074
Reserves & Surplus	-1,491	-19,805	-53,242	-75,026	-87,427	-90,752	-86,979	-83,879
Borrowings								
Secured Loans	12,194	22,217	17,129	14,285	10,773	6,363	6,363	6,363
Total Funds	17,270	15,060	-23,465	-46,201	-60,580	-68,315	-64,542	-61,442
Usages of Fund								
Fixed Assets								
Gross Block	18,760	36,136	36,136	41,544	45,925	45,925	45,925	45,925
Less: Depreciation	0	11,113	28,556	32,767	39,733	45,925	45,925	45,925
Net Block	18,760	25,023	7,580	8,777	6,192	0	0	0
Net Current Assets	-1,491	-9,964	-31,045	-54,978	-66,772	-68,315	-64,542	-61,442
Total Assets	17,270	15,060	-23,465	-46,201	-60,580	-68,315	-64,542	-61,442

- **Financial IRR**

Financial FIRR presented below will help IWAI to measure the financial returns on investment and assist take a firm decision on the implementation of this development. Final viability assessment for developing coal handling terminal on this River Yamuna would be done based on this outcome.

Table 15.125 Financial IRR Calculation for Terminal 6 (INR Lakhs)

Particulars	FY24	FY25	Fy35	FY36	FY40	FY45	FY50	FY54
PBDIT	-149	-300	-2,096	-2,237	1,134	1,589	1,803	1,809
Interest	1,341	2,584	1,571	1,745	1,185	700	700	700
Principal repayment	0	0	1,272	1,272	1,272	0	0	0
Equity	6,566	6,082	1,893	1,533	0	0	0	0
Debt	12,194	11,295	3,515	2,848	0	0	0	0
Total Investment	18,760	17,376	5,408	4,381	0	0	0	0
Tax	0	0	0	0	0	81	331	333
Cash flow to Equity	-8,057	-8,966	-6,832	-6,787	-1,323	889	1,103	1,109

Particulars	FY24	FY25	Fy35	FY36	FY40	FY45	FY50	FY54
(Pre-tax)								
Equity IRR(Pre-tax)	NA							
Cash flow to Equity(Post-tax)	-8,057	-8,966	-6,832	-6,787	-1,323	808	772	776
Equity IRR(Post-tax)	NA							
Project Cash flow(Pre-tax)	-18,910	-17,676	-7,504	-6,619	1,134	1,589	1,803	1,809
Project IRR(Pre-tax)	NA							
Project Cash flow(Post-tax)	-18,910	-17,676	-7,504	-6,619	1,134	1,508	1,472	1,476
Project IRR(Post-tax)	NA							

- **Economic IRR**

EIRR section evaluates the value addition that, this project induces in society and the impact on various social factors. Economic IRR (EIRR) comprises all financial and non-financial benefits of the project. It helps in investment decision from prospects of improving welfare of society. If any project is commercially unviable then its economic viability is considered. These impacts are transformed into financial gains which can bring the state and central government to fund resources for the implementation. Government undertake the detailed assessment at projects contribution to the betterment of society like employment generation, improvement in connectivity, pollution control, trade improvement, carbon emission, employment generation, reduction in congestion, less vehicle operating cost, saving on fuel, etc.

Assumptions considered for computing EIRR are for Terminal 6 is listed below.

Table 15.126Assumptions for EIRR Calculations

Parameters Adopted	Value	Unit
Economic loss due to Road Accidents	0.03	of GDP
Value of economic loss due to road accidents	3.76	Rs Lakhs Crores
Safety Index (IWT as base)	5.00	times safer than rail
Accident Loss		
Rail	0.77	Rs Lakhs/KM
IWT	0.15	Rs Lakhs/KM
Fuel Cost		
Rail	85.00	t-km / per liter
IWT	105.00	t-km / per liter
Fuel price	69.40	Rs/Litre
Vehicular operating cost (VOC)		
Rail	1.41	Rs/t-km
IWT	1.15	Rs/t-km
Direct Employment Creation		
Rail	2.00	Per Million t-km

Parameters Adopted	Value	Unit
IWT	0.50	Per Million t-km
Employment cost	2.50	Rs Lakhs per Annum
Emission Reduction		
Rail	13.30	g CO2/t-km
IWT	6.00	g CO2/t-km
Shadow factor		
CAPEX/O&M Cost (Convert financial cost to economic cost)	0.85	-
Carbon Credits factors		
Carbon Shadow price	20.00	$/Tonne
Exchange rate	67.00	Rs/USD

All the essential assumptions with respect to fuel efficiency, direct employment multiplier, reduction in carbon emission, and carbon credit factors have been taken from the common industrial benchmarks.

Estimated impact of each factor at terminal 6 for the period of 30 years is presented in the table below.

Table 15.127Economic IRR Calculation for Terminal 6 (INR Crore)

Operation years	FY24	FY25	FY35	FY36	FY40	FY45	FY50	FY55
Accident Loss			0	0	0	0	0	0
Saving on fuel			2.96	3.01	8.60	9.19	9	9
Saving on account of VOC			4.95	5.03	14.38	15.37	16	16
Job creation			4.76	4.84	13.83	14.78	15	15
Reduction in Emissions			0.19	0.19	0.54	0.58	1	1
Total Revenue			24	25	72	78	81	81
Total Economic Impact	-	-	37	38	110	118	122	122
O&M Expenditure	1	3	45	47	61	63	63	63
Economic Cash Outflow	-1	-3	- 8	-9	49	56	59	59
Investment	188	174	54	44				
Net Cash Flow to Project	-189	-177	-62	-53	49	56	59	59
Project EIRR	**3.2%**							

15.3.2.3 Terminal 7

- **Phasing**

Terminal 7 is proposed to be developed in Phase 3 i.e. from FY35. This is the last phase of fairway development, in this phase the entire stretch of NW110 would become operational i.e. from Prayagraj to Delhi. The construction of infrastructure, equipment handling, connectivity will take 2 years and the terminal will get operational from FY37 till FY65.

Table 15.128 Development of Terminal 7

Total Jetties	Chainage (km)	FY35	FY36	FY37	FY65
10	1049	Construction - 10 Jetties			

				Operational - 10 Jetties	

- **Traffic**

This terminal is proposed as multi-purpose cargo terminal to handle Automobile, Iron & Steel, Food Grain, Container and Sugar. Initially terminal would only be used for handling fertilizer and after the development further stretch in next 2 phases, terminal would start handling other commodities as well. 30 years traffic projects for terminal 6 are shown in the table below.

Table 15.129 Traffic at Terminal 7 ('000 T)

Cargo	Origin	Destination	Fy35	Fy40	Fy45	Fy50	Fy55	Fy60	Fy65
Automobile ('000 Nos.)	NCR Automobile Cluster	Prayagraj& Kanpur	0	139	152	176	186	186	186
Food Grains	Punjab, Haryana	Prayagraj& Kanpur	0	900	955	1054	1097	1097	1097
Sugar	Shamli, Muzaffar nagar	Prayagraj, Kanpur & Patna	0	546	563	592	604	604	604
Iron & Steel	Haldia& Kolkata	Delhi	0	257	280	323	285	285	285
Containers ('000TEU)	Container	Delhi & UP	625	657	707	800	840	840	840

- **Capital Cost**

This section represents the total capital expenditure in a phased manner for Terminal 7 proposed at MadanpurKhadar in River Yamuna.

Table 15.130 Project Cost for Construction Terminals 7 (INR Lakhs)

Sl. No.	Description	Total Investment	Fy 35	Fy36
A	Terminal	39,100	23,460	15,640
B	Approach Rail / Road	3,204	1,922	1,281
C	Infrastructure	1,298	779	519
D	Cargo Handling Equipment	7,267	1,453	5,814
E	Utilities		-	-
F	IT	-	-	-
G	Other Financial Cost	140,859	70,430	70,430
	Total Capex	191,728	98,044	93,684

Construction of this terminal would take 2 years to get completed i.e. in FY35 and FY36. It would start operating from FY37 till FY65. Detailed cost of cargo handling and other supporting infrastructure required at terminal is listed in the table below.

Table 15.131 Infrastructure Requirement Cost at Terminals 7 (INR Lakhs)

S.No	Description	No.	Rate (INR Lakhs)	Cost (INR Lakhs)
1	Parking Area	1.0	20.0	20.0
2	Canteen	1.0	20.0	20.0

3	Admin Building	1.0	40.0	40.0
4	STP	1.0	20.0	20.0
5	Fire Tender	1.0	20.0	20.0
6	Dispensary	1.0	15.0	15.0
7	Electrical Substation	1.0	-	-
8	Fencing and Guard	1.0	40.0	40.0
9	Cold Storage	0.0	300.0	300.0
10	Storage area, Warehouses	41,472 Sq.m	1,623.2	673.2
11	Silo	3.0	50.0	150.0
	Total			**1,298.2**

- **Project Financing**

Construction Phase 1 & Phase 2 has been assumed to be funded in an Equity-Debt ratio of 35:65. Details of the means of financing for both the phases are shown below.

Table 15.132 Equity-Debt Share Distribution for Terminal 7 (INR Lakhs)

Particulars	%	Investment Phase 3
Equity	35%	67,105
Debt	65%	124,623

- **Financial Indicators**

This section shows the financial indicator that leads to the generation of FIRR for Terminal 7. Revenue, Salary, Depreciation, Cash Flow, P&L Statement & Balance Sheet helps on understanding the returns on investment made for this terminal.

Revenue from Terminal 7 proposed on River Yamuna will be generated from core operations that include cargo handling at the jetty, Storage, Stackyard, Evacuation from yard to Rail. The detailed breakup of revenue is shown in the table above.

Table 15.133Revenue from Terminals-7 (INR Lakhs)

Particulars	FY35	FY37	FY40	FY45	FY50	FY55	FY60	FY65
Vessels Charges	-	62	66	75	77	77	77	77
Wharfage	-	8,068	8,733	9,966	10,467	10,467	10,467	10,467
Stevedoring	-	2,798	2,988	3,335	3,462	3,462	3,462	3,462
Cargo Storage	-	2,815	3,024	3,410	3,544	3,544	3,544	3,544
Stackyard Operation	-	11,165	11,927	13,321	13,775	13,775	13,775	13,775
Total Revenue	-	24,909	26,738	30,106	31,324	31,324	31,324	31,324

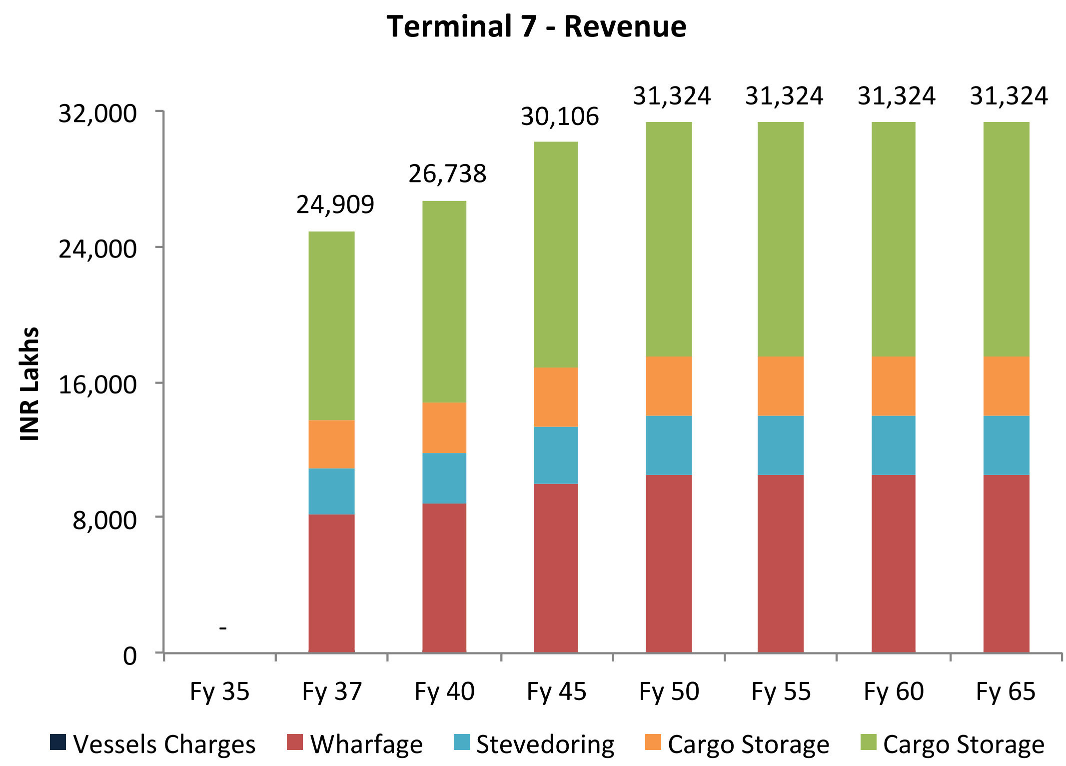

Fig.15.25 Revenue for Terminal 7

The following table indicates the direct operating cost for development of Terminal 7. This direct operating cost include cargo Handling charges, Storage cost, evacuation cost &stackyard handling cost.

Table 15.134 Direct Operating Cost for Terminal 7 (INR Lakhs)

Particulars	FY35	FY37	FY40	FY45	FY50	FY55	FY60	FY65
Container	-	1,617	1,767	2,049	2,173	2,173	2,173	2,173
Automobile	-	1,395	1,480	1,634	1,700	1,700	1,700	1,700
Food Grain	-	847	873	917	936	936	936	936
Sugar	-	400	436	504	445	445	445	445
Iron & Steel	-	9,583	10,225	11,406	11,832	11,832	11,832	11,832
Salary	-	130	130	130	130	130	130	130
Power &Water	-	847	847	847	847	847	847	847
Total	-	14,819	15,758	17,486	18,063	18,063	18,063	18,063

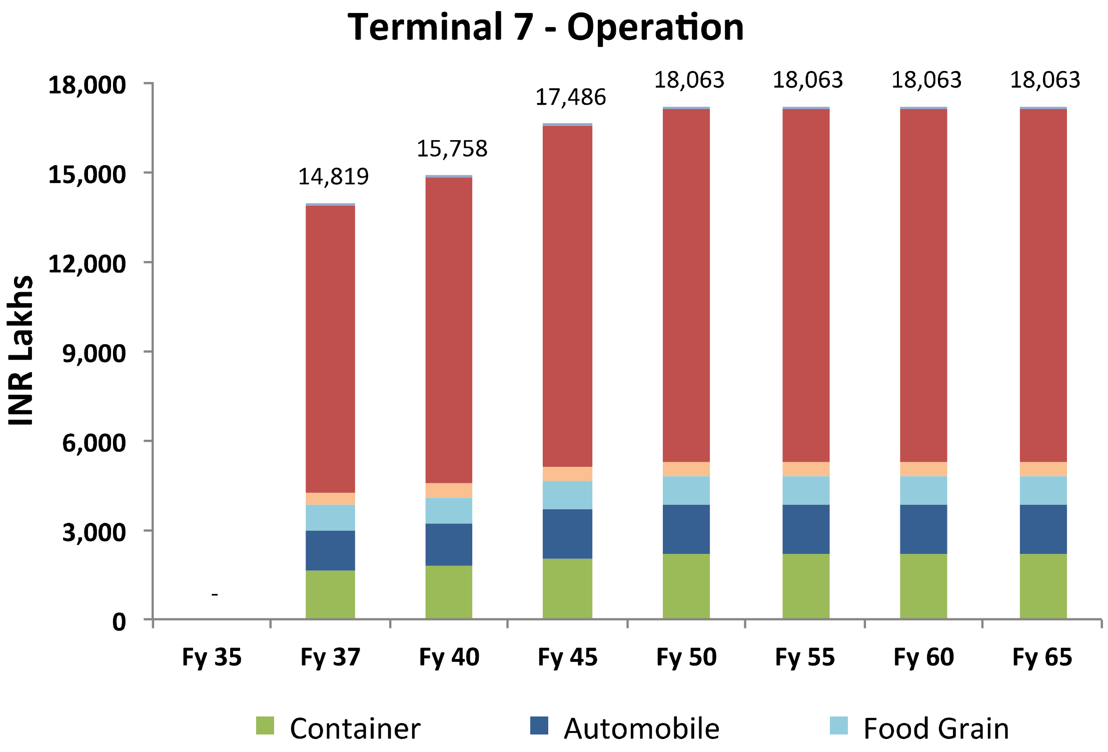

Fig. 15.26 Operational Cost at Terminal 7

Table 15.135 Maintenance Cost for Terminal 7 (INR Lakhs)

Particulars	FY35	FY37	FY40	FY45	FY50	FY55	FY60	FY65
Civil	128	105	105	105	-	-	-	-
Mechanical	21	847	847	847	847	847	847	847
Insurance Cost	136	10,100	10,665	11,778	11,832	11,832	11,832	11,832
Administration Cost	-	498	535	602	626	626	626	626
Total	285	11,550	12,151	13,331	13,305	13,305	13,305	13,305

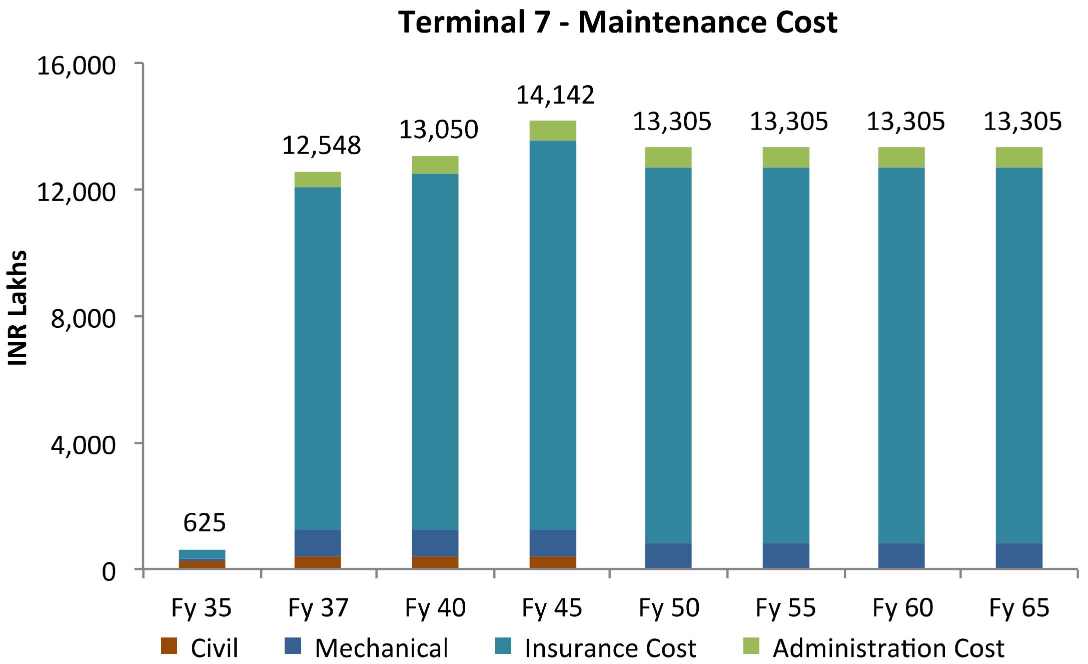

Fig.15.27 Maintenance Cost at Terminal 7

The operator would share 4% of its revenue with IWAI and pay royalty of INR 10 per Tonne. The table below indicates the amount of total outflow to IWAI in case of Terminal 7.

Table 15.136 Regulatory Royalty to IWAI for Terminal 7 (INR Lakhs)

Particulars	FY35	FY37	FY40	FY45	FY50	FY55	FY60	FY65
Royalty to IWAI	-	170	180	197	199	199	199	199
Revenue Share	-	996	1,070	1,204	1,253	1,253	1,253	1,253
Total Outflow to IWAI	-	1,167	1,249	1,401	1,451	1,451	1,451	1,451

The section above summaries the Revenue generated by operation of Terminal 7 and total cost i.e. O&M cost and out-flow to IWAI (Royalty and Revenue Share) from FY35 till FY65. The operator would share 4% of its revenue with IWAI and pay royalty of INR 10 per Tonne.

The following table depicts the P/L statement for development of Terminal 7 on River Yamuna.

Table 15.137 Profit & Lost Statement for Terminal 7 (INR Lakhs)

Particulars	FY35	FY37	FY40	FY45	FY50	FY55	FY60	FY65
Revenue	0	24,909	26,738	30,106	31,324	31,324	31,324	31,324
O & M Cost	285	26,369	27,908	30,818	31,368	31,368	31,368	31,368
Total Outflow to IWAI	0	1,167	1,249	1,401	1,451	1,451	1,451	1,451
PBDIT	-285	13,013	14,159	16,195	17,284	17,284	17,284	17,284
Depreciation	0	1,736	1,736	1,482	1,482	0	0	0
Interest	990	1,669	1,382	903	424	0	0	0
PBT	-1,275	9,608	11,041	13,810	15,378	17,284	17,284	17,284
Tax	0	2,882	3,312	4,143	4,613	5,185	5,185	5,185
PAT	-1,275	6,726	7,729	9,667	10,764	12,099	12,099	12,099

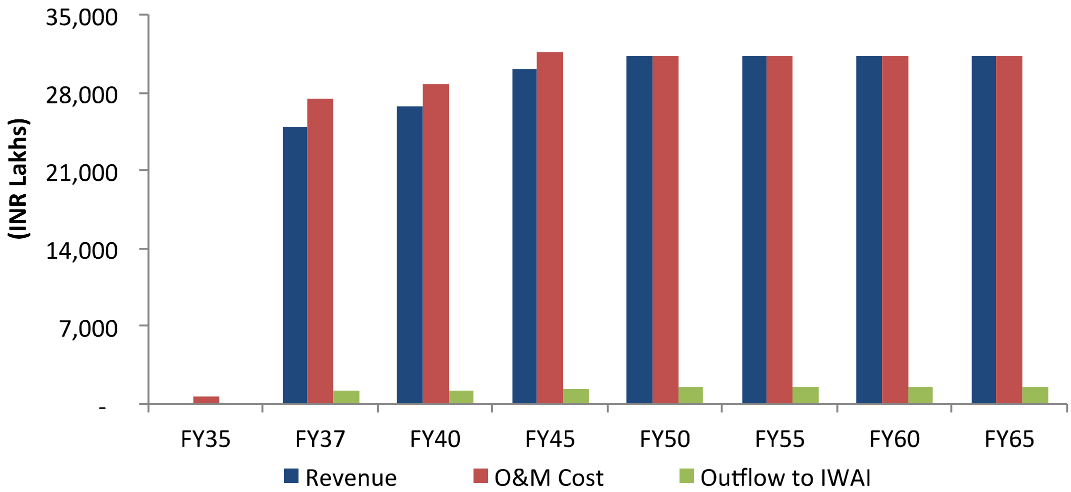

Fig. 15.28Comparison among Revenue, O&M Cost and Total Outflow to IWAI

The terminal will start generating profit from 1st year of operation only i.e. Fy-35. This is mainly due to high Revenue& high traffic whereas lower development cost. These are the major factors that heavily impacts commercial prospects of proposed terminal.

Depreciation has been calculated using the Straight Line Method (SLM). Under this method, cost of asset is evenly distributed across its useful life. Straight Line Method (SLM) has been used to calculate depreciation for Terminal 7, under which the cost of tangible and intangible assets are evenly distributed across its life.

Table 15.138 Depreciation for Terminal 7 (INR Lakhs)

Depreciation & Amortization - SLM	**Fy 35**	**Fy 36**	**Fy 40**	**Fy 45**	**Fy 50**	**Fy 55**	**Fy 60**	**Fy 65**
Gross Block	98,044	191,728	191,728	191,728	191,728	191,728	191,728	191,728
Depreciation & Amortization	-	31,392	31,392	3,220	3,220	-	-	-
Cumulative Depreciation & Amortization	-	31,392	156,959	173,059	189,159	191,728	191,728	191,728
Net Block	**98,044**	**160,336**	**34,769**	**18,669**	**2,569**	**-**	**-**	**-**

The table below depicts the cash inflow & outflow in case of development of Terminal 7.

Table 15.139 Cash Flow for Terminal 7 (INR Lakhs)

Particulars	**Fy 35**	**Fy 36**	**Fy 40**	**Fy 50**	**Fy 60**	**Fy 65**
Cash Inflow						
Equity	34,315	32,789	-	-	-	-
Debt	63,729	60,895	-	-	-	-
Net Cash from Investment	98,044	93,684	-	-	-	-
Operations						
PBDIT	- 625	- 2,169	13,519	17,284	17,284	17,284
(-) Taxes Paid	-	-	-	3,223	5,185	5,185
Net Cash from Operations	- 625	-2,169	13,519	14,061	12,099	12,099

Particulars	Fy 35	Fy 36	Fy 40	Fy 50	Fy 60	Fy 65
Total Cash Inflow	97,419	91,515	13,519	14,061	12,099	12,099
Cash Outflow						
Capital Investment	98,044	93,684	-	-	-	-
Long Term Debt	-	-	6,745	6,745	-	-
Interest	7,010	13,709	10,741	3,321	-	-
Total Cash Outflow	105,054	107,393	17,486	10,066	-	-
Net Cash Flow	-7,635	-15,878	- 3,967	3,995	12,099	12,099
Opening Balance of Cash	-	-7,635	-42,355	- 43,953	35,410	95,903
Closing Balance Cash	-7,635	-23,513	-46,323	- 39,959	47,508	108,001

Table 15.140 Balance Sheet for Terminal 7 (INR Lakhs)

Sources of Funds	Fy 35	Fy 36	Fy 40	Fy 50	Fy 60	Fy 65
Shareholder's funds						
Capital	34,315	67,105	67,105	67,105	67,105	67,105
Reserves & Surplus	-7,635	-54,905	-176,300	-134,681	-19,597	40,897
Borrowings						
Secured Loans	63,729	124,623	97,642	30,187	0	0
Total Funds	**90,409**	**136,823**	**-11,554**	**-37,390**	**47,508**	**108,001**
Usages of Fund						
Fixed Assets						
Gross Block	98,044	191,728	191,728	191,728	191,728	191,728
Less: Depreciation	0	31,392	156,959	189,159	191,728	191,728
Net Block	98,044	160,336	34,769	2,569	0	0
Net Current Assets	-7,635	-23,513	-46,323	-39,959	47,508	108,001
Total Assets	**90,409**	**136,823**	**-11,554**	**-37,390**	**47,508**	**108,001**

- **Financial IRR**

Financial FIRR presented below will help IWAI to measure the financial returns on investment and assist take a firm decision on the implementation of this development. Final viability assessment for developing multipurpose cargo handling terminal on this River Yamuna would be done based on this outcome.

Table 15.141Financial IRR Calculation for Terminal 7 (INR Lakhs)

Particulars	Fy 35	Fy 36	Fy 37	Fy 40	Fy 50	Fy 60	Fy 65
PBDIT	- 625	-2,169	12,274	13,519	17,284	17,284	17,284
Interest	7,010	13,709	12,967	10,741	3,321	-	-
Principal repayment	-	-	6,745	6,745	6,745	-	-
Equity	34,315	32,789	-	-	-	-	-
Debt	63,729	60,895	-	-	-	-	-
Total Investment	98,044	93,684	-	-	-	-	-
Tax	-	-	-	-	3,223	5,185	5,185
Cash flow to Equity(Pre-tax)	-41,951	-48,667	-7,438	-3,967	7,218	17,284	17,284
Equity IRR(Pre-tax)	**3.7%**						
Cash flow to	-41,951	-48,667	-7,438	-3,967	3,995	12,099	12,099

Particulars	Fy 35	Fy 36	Fy 37	Fy 40	Fy 50	Fy 60	Fy 65
Equity(Post-tax)							
Equity IRR(Post-tax)	**1.4%**						
Project Cash flow(Pre-tax)	-98,669	-95,853	12,274	13,519	17,284	17,284	17,284
Project IRR(Pre-tax)	**6.4%**						
Project Cash flow(Post-tax)	-98,669	-95,853	12,274	13,519	14,061	12,099	12,099
Project IRR(Post-tax)	**5.0%**						

- **Economic IRR**

EIRR section evaluates the value addition that, this project induces in society and the impact on various social factors. Economic IRR (EIRR) comprises all financial and non-financial benefits of the project. It helps in investment decision from prospects of improving welfare of society. If any project is commercially unviable then its economic viability is considered. These impacts are transformed into financial gains which can bring the state and central government to fund resources for the implementation. Government undertake the detailed assessment at projects contribution to the betterment of society like employment generation, improvement in connectivity, pollution control, trade improvement, carbon emission, employment generation, reduction in congestion, less vehicle operating cost, saving on fuel, etc.

Assumptions considered for computing EIRR are for Terminal 7 is listed below.

Table 15.142Assumptions for EIRR Calculations

Parameters Adopted	Value	Unit
Economic loss due to Road Accidents	0.03	of GDP
Value of economic loss due to road accidents	3.76	Rs Lakhs Crores
Safety Index (IWT as base)	5.00	times safer than rail
Accident Loss		
Rail	0.77	Rs Lakhs/KM
IWT	0.15	Rs Lakhs/KM
Fuel Cost		
Rail	85.00	t-km / per liter
IWT	105.00	t-km / per liter
Fuel price	69.40	Rs/Litre
Vehicular operating cost (VOC)		
Rail	1.41	Rs/t-km
IWT	1.15	Rs/t-km
Direct Employment Creation		
Rail	2.00	Per Million t-km
IWT	0.50	Per Million t-km
Employment cost	2.50	Rs Lakhs per Annum
Emission Reduction		

Parameters Adopted	Value	Unit
Rail	13.30	g CO2/t-km
IWT	6.00	g CO2/t-km
Shadow factor		
CAPEX/O&M Cost (Convert financial cost to economic cost)	0.85	-
Carbon Credits factors		
Carbon Shadow price	20.00	$/Tonne
Exchange rate	67.00	Rs/USD

All the essential assumptions with respect to fuel efficiency, direct employment multiplier, reduction in carbon emission, and carbon credit factors have been taken from the common industrial benchmarks.

Estimated impact of each factor at terminal 7 for the period of 30 years is presented in the table below.

Table 15.143Economic IRR Calculation for Terminal 7 (INR Crore)

Operation years	Fy 35	Fy 36	Fy 40	Fy 50	Fy 60	Fy 65
Accident Loss			6	6	6	6
Saving on fuel			170	200	200	200
Saving on account of VOC			285	334	334	334
Job creation			274	321	321	321
Reduction in Emissions			11	13	13	13
Total Revenue			267	313	99	99
Total Economic Impact	0	0	1,013	1,188	974	974
O&M Expenditure	6	50	288	314	47	47
Economic Cash Outflow	-6	-50	725	874	927	927
Investment	980	937	0	0		
Net Cash Flow to Project	-987	-987	725	874	927	927
Project EIRR	**31.7%**					

15.3.2.2 Terminal 8

- **Phasing**

Terminal 8 is proposed to be developed in Phase 1 i.e. from FY24. This is the first phase of fairway development, in this phase the stretch from Prayagraj to Kanpur would be developed. The construction of infrastructure, equipment handling, and connectivity will take 2 years i.e. FY24 and FY25 and the terminal will get operational from FY26 till FY54.

Table 15.144 Development of Terminal 8

Total Jetties	Chainage (km)	FY24	FY25	FY26	FY35	FY36	FY37	FY54
3	349.8	Construction - 2 Jetties						
				Operational - 2 Jetties				

					Construction - +1 Jetty			
							Operational - +1 Jetty	

- **Traffic**

This terminal is proposed as multi-purpose cargo terminal to handle Automobile, Fertilizer, Food Grain and Sugar. Initially terminal would only be used for handling fertilizer and after the development of further stretch in next 2 phases; terminal would start handling other commodities as well. 30 years traffic projections for terminal 8 are shown in the table below.

Table 15.145 Traffic at Terminal 8 ('000 T)

Cargo	Origin	Destination	FY24	FY30	FY35	FY40	FY45	FY50	FY54
Fertilizer	Phulpur	Kanpur	-	495	534	568	568	568	568
Automobile ('000 Nos.)	NCR Automobile Cluster	Kanpur, Agra, Etawah, etc.	-	-	-	72	83	94	94
Food Grains	Punjab, Haryana	Kanpur, Agra, Etawah, etc.	-	-	-	551	608	659	659
Sugar	Shamli, Muzaffarnagar	Kanpur, Agra, Etawah, etc.	-	-	-	166	174	181	181
Iron & Steel	Khurda Road	Kanpur & Agra	-	88	99	111	117	122	122
Total			-	582	634	1,468	1,551	1,624	1,624

- **Capital Cost**

This section represents the total capital expenditure in a phased manner for Terminal 8 proposed at Daulatpur, Kanpur Dehat for multipurpose Cargo in River Yamuna.

Table 15.146Project Cost for Construction Terminals 8 (INR Lakhs)

Description	Total Investment	Construction Phase 1		Construction Phase 2	
		FY24	FY23	Fy 35	Fy36
Terminal	7,415	2,966	1,977	1,483	989
Approach Rail/Road	1,348	539	360	270	180
Infrastructure	1,943	777	518	389	259
Cargo Handling Equipment	2,090	418	1,672	-	-
Utilities		-	-	-	-
IT		-	-	-	-
Other Financial Cost	525	263	263	-	-
Consultancy			-		-
Total CAPEX	**13,322**	**4,963**	**4,790**	**2,141**	**1,428**

Construction of this terminal would take 2 years to get completed i.e. in FY24 and FY25. It would start operating from FY26 till FY54. Detailed cost of cargo handling and other supporting infrastructure required at terminal is listed in the table below.

Table 15.147 Infrastructure Requirement Cost at Terminals 8 (INR Lakhs)

S.No	Description	No.	Rate (INR Lakhs)	Cost (INR Lakhs)
1	Parking Area	1.0	20.0	20.0
2	Canteen	1.0	20.0	20.0
3	Admin Building	1.0	40.0	40.0
4	STP	1.0	20.0	20.0
5	Fire Tender	1.0	20.0	20.0
6	Dispensary	1.0	15.0	15.0
7	Electrical Substation	1.0		-
8	Fencing and Guard	1.0	40.0	40.0
9	Cold Storage	0.0	300.0	300.0
10	Storage area, Warehouses	81,225 Sq.m	1,623.2	1,318.4
11	Silo	5.0	50.0	150.0
	Total			**1,943.4**

- **Project Financing**

Construction Phase 1 & Phase 2 has been assumed to be funded in an Equity-Debt ratio of 35:65. Details of the means of financing for both the phases are shown below.

Table 15.148Equity-Debt Share Distribution for Terminal 8 (INR Lakhs)

Particulars	%	Investment Phase 1	Investment Phase 2
Equity	35%	3,414	1,249
Debt	65%	6,339	2,320

- **Financial Indicators**

This section shows the financial indicator that leads to the generation of FIRR for Terminal 8. Revenue, Salary, Depreciation, Cash Flow, P&L Statement & Balance Sheet helps on understanding the returns on investment made for this terminal. Revenue from Terminal 8 proposed on River Yamuna will be generated from core operations that include cargo handling at the jetty, Storage, Stackyard, Evacuation from yard to Rail. The detailed breakup of revenue is shown in the table above.

Table 15.149Revenue from Terminals 8 (INR Lakhs)

Particulars	FY24	FY26	FY30	FY35	FY40	FY45	FY50	FY54
Vessels Charges	-	12	13	16	33	36	39	40
Wharfage	-	260	298	332	1,921	2,176	2,429	2,429
Stevedoring	-	666	764	853	957	1,008	1,052	1,052
Cargo Storage	-	596	683	763	1,298	1,412	1,520	1,520
Stackyard Operation	-	2,847	3,266	3,647	4,365	4,627	4,862	4,862
Total Revenue	-	4,380	5,025	5,610	8,574	9,259	9,902	9,903

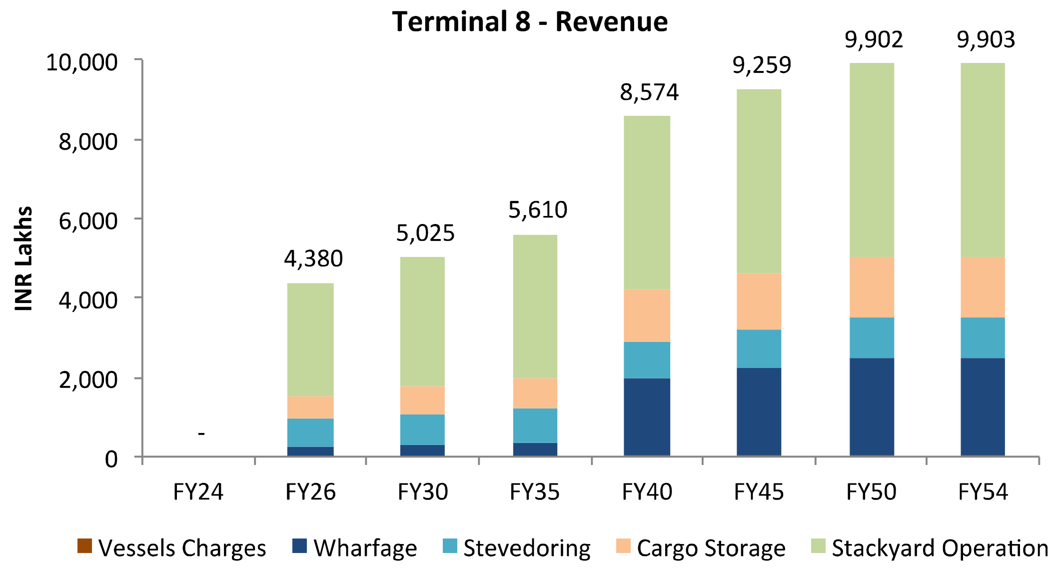

Fig.15.29 Revenue for Terminal 8

The following table indicates the direct operating cost for development of Terminal 8. This direct operating cost include cargo Handling charges, Storage cost, evacuation cost &stackyard handling cost.

Table 15.150 Direct Operating Cost for Terminal 8 (INR Lakhs)

Particulars	FY24	FY26	FY30	FY35	FY40	FY45	FY50	FY54
Fertilizer	-	681	772	834	887	887	887	887
Automobile	-	-	-	-	840	968	1,096	1,096
Food Grain	-	554	648	751	854	943	1,021	1,021
Sugar	-	187	215	237	257	270	281	281
Iron & Steel	-	122	137	155	173	183	190	190
Power & Water	-	686	686	686	701	701	701	701
Salary	-	93	93	93	130	130	130	130
Total	**-**	2,323	2,551	2,756	3,842	4,081	4,306	4,306

Table 15.151 Maintenance Cost for Terminal 8 (INR Lakhs)

Particulars	FY24	FY26	FY30	FY35	FY40	FY45	FY50	FY54
Civil	43	71	71	71	107	107	107	107
Mechanical	21	105	105	105	105	105	105	105
Insurance Cost	51	90	47	21	33	15	6	0
Administration Cost	0	88	101	112	171	185	198	198
Total	115	353	323	309	416	411	416	410

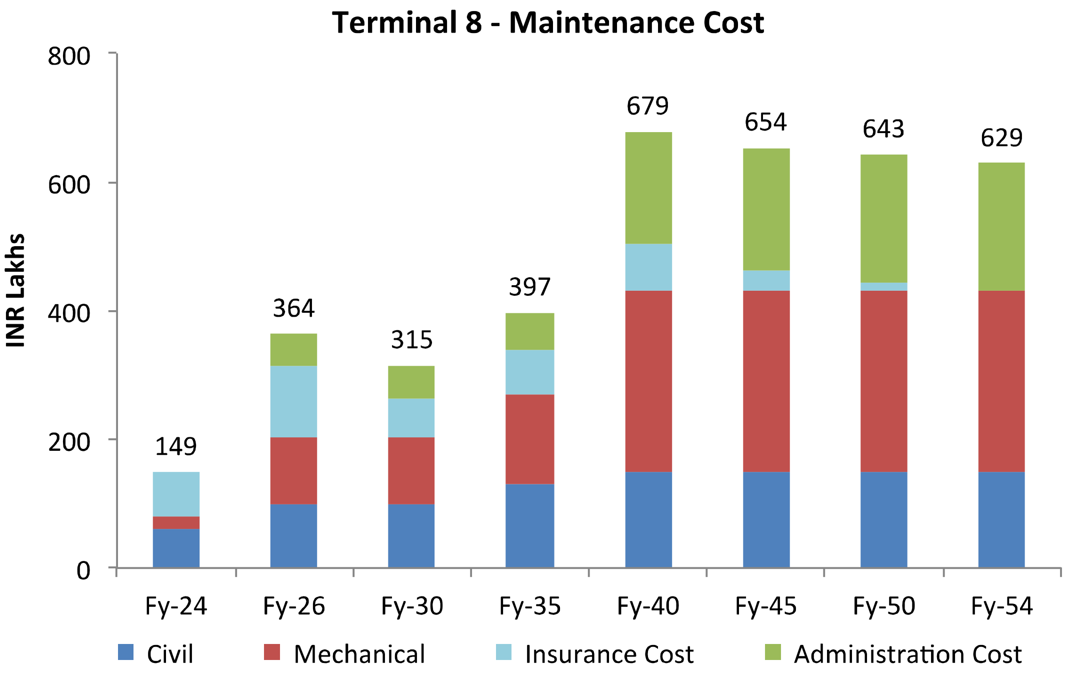

Fig. 15.30 Maintenance Cost at Terminal 8

The operator would share 4% of its revenue with IWAI and pay royalty of INR 10 per Tonne. The table below indicates the amount of total outflow to IWAI in case of Terminal 8.

Table 15.152 Regulatory Royalty to IWAI for Terminal 8 (INR Lakhs)

Particulars	FY24	FY26	FY30	FY35	FY40	FY45	FY50	FY54
Royalty to IWAI	0	44	49	53	105	109	113	113
Revenue Share	0	77	87	94	281	304	325	325
Total Outflow to IWAI	**0**	**121**	**137**	**148**	**386**	**413**	**438**	**438**

The section above summaries the Revenue generated by operation of Terminal 8 and total cost i.e. O&M cost and out-flow to IWAI (Royalty and Revenue Share) from FY24 till FY54. The operator would share 4% of its revenue with IWAI and pay royalty of INR 10 per Tonne.

The following table depicts the P/L statement for development of Terminal 8 on River Yamuna.

Table 15.153 Profit & Lost Statement for Terminal 8 (INR Lakhs)

Particulars	FY24	FY26	FY30	FY35	FY40	FY45	FY50	FY54
Revenue	0	4,380	5,025	5,610	8,574	9,259	9,902	9,903
O & M Cost	115	2,951	3,189	3,417	4,747	5,018	5,281	5,274
Total Outflow to IWAI	-115	1,429	1,837	2,194	3,827	4,241	4,622	4,628
PBDIT	0	689	584	584	783	0	0	0
Depreciation	355	660	509	320	386	255	255	255
Interest	-470	81	744	1,290	2,657	3,986	4,367	4,373
PBT	0	24	223	387	797	1,196	1,310	1,312
Tax	-470	57	521	903	1,860	2,790	3,057	3,061
PAT	0	4,380	5,025	5,610	8,574	9,259	9,902	9,903

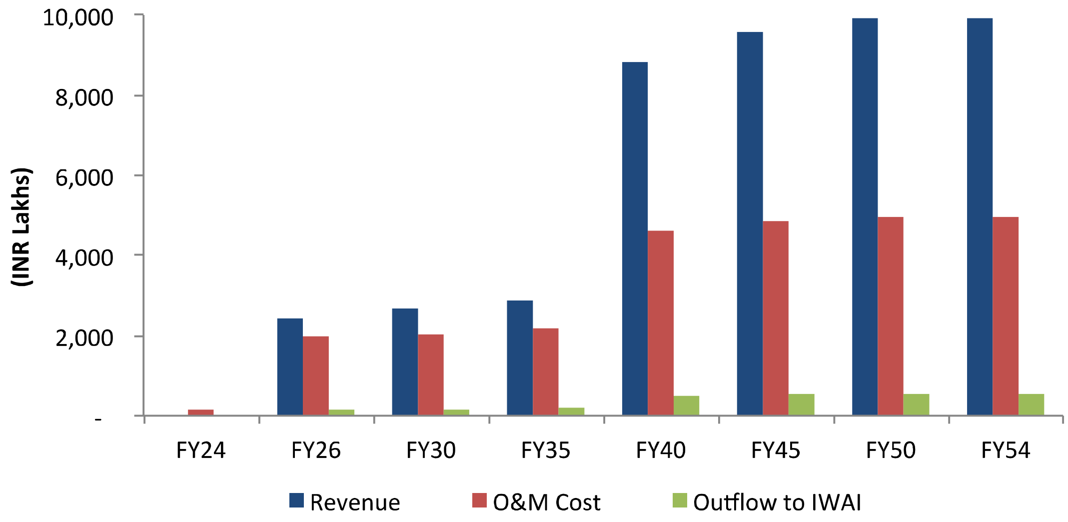

Fig. 15.31Comparison among Revenue, O&M Cost and Total Outflow to IWAI

The terminal will start generating profit from FY26. Revenue and development cost are the major factors that heavily impacts commercial prospects of proposed terminal.

Depreciation has been calculated using the Straight Line Method (SLM). Under this method, cost of asset is evenly distributed across its useful life. Straight Line Method (SLM) has been used to calculate depreciation for Terminal 6, under which the cost of tangible and intangible assets are evenly distributed across its life.

Table 15.154Depreciation for Terminal 8 (INR Lakhs)

Particulars	FY24	FY26	FY30	FY35	FY40	FY45	FY50	FY54
Gross Block	4,963	9,753	9,753	9,753	13,322	13,322	13,322	13,322
Depreciation &Amortization	-	689	584	584	783	-	-	-
Cumulative Depreciation & Amortization	-	1,378	4,030	6,951	10,658	13,322	13,322	13,322
Net Block	4,963	8,375	5,723	2,803	2,664	-	-	-

The table below depicts the cash inflow & outflow in case of development of Terminal 8.

Table 15.155 Cash Flow for Terminal 8 (INR Lakhs)

Particulars	FY24	FY26	FY37	FY38	FY40	FY45	FY50	FY54
Cash Inflow								
Equity	1,737	1,676	749	500	-	-	-	-
Debt	3,226	3,113	1,392	928	-	-	-	-
Net Cash from Investment	4,963	4,790	2,141	1,428	-	-	-	-
PBDIT								
(-) Taxes Paid	-115	-281	2,300	2,351	3,827	4,241	4,622	4,625
Net Cash from Operations	-	-	355	324	797	1,196	1,310	1,311
Total Cash Inflow	**-115**	**-281**	**1,945**	**2,028**	**3,030**	**3,045**	**3,312**	**3,314**

Particulars	FY24	FY26	FY37	FY38	FY40	FY45	FY50	FY54
Cash Outflow								
Capital Investment	4,963	4,790	2,141	1,428	-	-	-	-
Long Term Debt	-	-	343	343	343	-	-	-
Interest	355	697	398	462	386	255	255	255
Total Cash Outflow	5,318	5,487	2,882	2,233	730	255	255	255
Net Cash Flow	-470	-979	1,205	1,223	2,300	2,790	3,057	3,059
Opening Balance of Cash	-	-470	7,742	8,947	12,396	24,765	39,371	51,602
Closing Balance Cash	**-470**	**-1,449**	**8,947**	**10,169**	**14,696**	**27,555**	**42,428**	**54,661**

Table 15.156Balance Sheet for Terminal 8 (INR Lakhs)

Particulars	FY24	FY26	FY30	FY35	FY40	FY45	FY50	FY54
Shareholder's funds								
Capital	1,737	3,414	3,414	3,414	4,663	4,663	4,663	4,663
Reserves & Surplus	-470	-2,081	-743	3,001	9,184	20,572	35,445	47,678
Borrowings								
Secured Loans	3,226	5,996	4,624	2,909	3,513	2,320	2,320	2,320
Total Funds	4,494	7,329	7,294	9,323	17,360	27,555	42,428	54,661
Usages of Fund								
Fixed Assets								
Gross Block	4,963	9,753	9,753	9,753	13,322	13,322	13,322	13,322
Less: Depreciation	-	1,378	4,030	6,951	10,658	13,322	13,322	13,322
Net Block	4,963	8,375	5,723	2,803	2,664	-	-	-
Net Current Assets	-470	-1,046	1,571	6,520	14,696	27,555	42,428	54,661
Total Assets	**4,494**	**7,329**	**7,294**	**9,323**	**17,360**	**27,555**	**42,428**	**54,661**

- **Financial IRR**

Financial FIRR presented below will help IWAI to measure the financial returns on investment and assist take a firm decision on the implementation of this development. Final viability assessment for developing coal handling terminal on this River Yamuna would be done based on this outcome.

Table 15.157 Financial IRR Calculation for Terminal 8 (INR Lakhs)

Particulars	FY24	FY26	FY30	FY35	FY40	FY45	FY50	FY54
PBDIT	-115	1,429	1,837	2,194	3,827	4,241	4,622	4,625
Interest	355	660	509	320	386	255	255	255
Principal repayment	-	343	343	343	343	-	-	-
Equity	1,737	-	-	-	-	-	-	-
Debt	3,226	-	-	-	-	-	-	-
Total Investment	4,963	-	-	-	-	-	-	-
Tax	-	24	223	387	797	1,196	1,310	1,311

Particulars	FY24	FY26	FY30	FY35	FY40	FY45	FY50	FY54
Cash flow to Equity(Pre-tax)	-2,207	427	985	1,531	3,097	3,986	4,367	4,370
Equity IRR(Pre-tax)	20.3%							
Cash flow to Equity(Post-tax)	-2,207	403	762	1,144	2,300	2,790	3,057	3,059
Equity IRR(Post-tax)	17.2%							
Project Cash flow(Pre-tax)	-5,078	1,429	1,837	2,194	3,827	4,241	4,622	4,625
Project IRR(Pre-tax)	17.5%							
Project Cash flow(Post-tax)	-5,078	1,405	1,613	1,807	3,030	3,045	3,312	3,314
Project IRR(Post-tax)	15.4%							

- **Economic IRR**

EIRR section evaluates the value addition that, this project induces in society and the impact on various social factors. Economic IRR (EIRR) comprises all financial and non-financial benefits of the project. It helps in investment decision from prospects of improving welfare of society. If any project is commercially unviable then its economic viability is considered. These impacts are transformed into financial gains which can bring the state and central government to fund resources for the implementation. Government undertake the detailed assessment at projects contribution to the betterment of society like employment generation, improvement in connectivity, pollution control, trade improvement, carbon emission, employment generation, reduction in congestion, less vehicle operating cost, saving on fuel, etc.

Assumptions considered for computing EIRR are for Terminal 8 is listed below.

Table 15.158Assumptions for EIRR Calculations

Parameters Adopted	Value	Unit
Economic loss due to Road Accidents	0.03	of GDP
Value of economic loss due to road accidents	3.76	Rs Lakhs Crores
Safety Index (IWT as base)	5.00	times safer than rail
Accident Loss		
Rail	0.77	Rs Lakhs/KM
IWT	0.15	Rs Lakhs/KM
Fuel Cost		
Rail	85.00	t-km / per liter
IWT	105.00	t-km / per liter
Fuel price	69.40	Rs/Litre
Vehicular operating cost (VOC)		
Rail	1.41	Rs/t-km
IWT	1.15	Rs/t-km
Direct Employment Creation		
Rail	2.00	Per Million t-km
IWT	0.50	Per Million t-km
Employment cost	2.50	Rs Lakhs per

Parameters Adopted	Value	Unit
		Annum
Emission Reduction		
Rail	13.30	g CO2/t-km
IWT	6.00	g CO2/t-km
Shadow factor		
CAPEX/O&M Cost (Convert financial cost to economic cost)	0.85	-
Carbon Credits factors		
Carbon Shadow price	20.00	$/Tonne
Exchange rate	67.00	Rs/USD

All the essential assumptions with respect to fuel efficiency, direct employment multiplier, reduction in carbon emission, and carbon credit factors have been taken from the common industrial benchmarks.

Estimated impact of each factor at terminal 8 for the period of 30 years is presented in the table below.

Table 15.159Economic IRR Calculation for Terminal 8 (INR Crore)

Operation years	FY24	FY25	FY35	FY36	FY40	FY45	FY50	FY55
Accident Loss			4.3	4.3	4.3	4.3	4.3	4.3
Saving on fuel			3.6	3.6	11.7	12.5	12.9	12.9
Saving on account of VOC			6.0	6.1	19.5	21.0	21.6	21.6
Job creation			5.7	5.8	18.8	20.2	20.8	20.8
Reduction in Emissions			0.2	0.2	0.7	0.8	0.8	0.8
Total Revenue			56.1	57.4	85.7	92.6	99.0	99.0
Total Economic Impact	0.0	0.0	75.9	77.4	140.8	151.4	159.5	159.5
O&M Expenditure	1.1	2.8	30.7	31.1	42.6	44.9	47.2	47.2
Economic Cash Outflow	-1.1	-2.8	45.3	46.3	98.2	106.5	112.3	112.3
Investment	49.6	47.9	21.4	14.3				
Net Cash Flow to Project	-50.8	-50.7	23.9	32.1	98.2	106.5	112.3	112.3
Project EIRR	**33.4%**							

15.3.3 Passenger Terminals

15.3.3.1 Inputs for Financial Analysis of Passenger Terminals

All the assumptions and inputs used in Financial Analysis of Passenger terminals on River Yamuna are discussed in this section. The Financial Analysis is done for Passenger terminal development and operations on NW 110.

- **Tariff Assumptions for Passenger Terminals**
  The below table depicts assumptions for tariff at Passenger Terminals. There would be separate charges for passengers to use viewing deck and terminals. Competitive Tariff is considered for Passenger Terminals to attract passengers for using IWT on river Yamuna.

Tariff for terminals is prescribed in the below table. This tariff would be chargedtopassengersforembarkment and disembarkment from vessels (cruise). Tariff for viewing deck is used for using viewing deck in the Reception/lounge area of the terminal. This deck would provide passengers a scenic view of the riverfront and surrounding area. Passenger Tariff mentioned below are assumed based on industry inputs. It has been assumed that IWAI will get 10 % of passenger fee for Terminals as IWAI Royalty fee.

Table 15.160Assumptions for Tariff at Passenger Terminals

Various Revenue Sources	Rate (INR)	Unit
Passenger Fee for Terminals	200.00	Per Pax
Passenger Fee for Viewing Deck	80.00	Per Pax

- **Loan Schedule**

The below table depicts assumption for loan schedules for passenger terminals. For passenger terminals, it is considered that loan tenure would be 15 years. Construction period of 1 year is considered for passenger terminals. Moratorium Period, i.e. Post Construction Period would also be 1 year. 11% Rate of interest is considered for each passenger terminal on NW 110.

Table 15.161 Assumption for Loan Schedule for PassengerTerminals

Description	Item
Loan Tenure	15 Years
Moratorium Period (Post Construction Period)	1 Years
Construction Period	1 Years
Rate of Interest	11%

15.3.3.2 Terminal 9–Inter District Passenger Terminal

- **Salary Calculation for Passenger Terminals**

The below table depicts proposed salaries for employees in passenger terminals. As shown in the below table, number of employees would vary in every department.

Table 15.162Assumptions for Manpower Salary at Terminal 9

Manpower	No.	Annual
Direct Payroll		
Manager	1	10,80,000
Admin Officer	2	12,00,000
Firefighting	2	9,60,000
Electrician	3	12,60,000
Mechanic	3	14,40,000
Operator	2	14,40,000
Civil Supervisor	3	21,60,000
Ticket Counter	4	14,40,000
Hospitality	5	18,00,000
Security	5	12,00,000
Total (Direct Payroll)	30	1,39,80,000
Subcontractor		

Manpower	No.	Annual
Accident Management Team		
Team Leader	1	7,20,000
Other Members	15	63,00,000
Additional Firefighting Team	10	42,00,000
Health Care & Medical Facility		
Doctor (Male & Female)	4	48,00,000
Medical Staff	15	72,00,000
Disaster Management Cell	8	48,00,000
Total (Subcontractor)	45	2,80,20,000
Overall Expenditure on Salary		**4,20,00,000**

- **Phasing**

  Terminal 9 is proposed to be developed in Phase 3, i.e. from FY35. This is the last phase of fairway development, in this phase the entire stretch of NW110 would become operational i.e. from Prayagraj to Delhi. The construction of infrastructure, connectivity will take 1 year and the terminal will get operational from FY37 for next 30 years.

Table 15.163 Development of Terminal 9

Total Jetties	Chainage (km)	FY36	FY37	FY65
1	1051.7	Construction - 1 Jetty		
			Operational - 1 Jetty	

- **Traffic**

  This terminal is proposed for handling tourist and passengers. Presently these tourists are using Yamuna expressway or NH 2, a certain share of this movement is diverted to IWT using NW110 from Okhla Barrage to Agra. Traffic for Terminal 9 for next 30 years is projected in the table below.

Table 15.164Traffic at Terminal 9 ('000)

Passenger	Fy 36	Fy 37	Fy 40	Fy 45	Fy 50	Fy 55	Fy 60	Fy 65
Total	287	290	299	314	324	329	334	339

- **Capital Cost**

  This section represents the total capital expenditure in a phased manner for Terminal 9proposed at MadanpurKhadar for handling passenger in River Yamuna.

Table 15.165 Project Cost for Construction Terminal 9(INR Lakhs)

S. No.	Description	Total Cost (INR Lakhs)
A	Terminal	980.0
B	Approach Road	298.2
C	Building & Other Civil Infrastructure	170.0
D	Utilities	-
E	Other Charges	401.0

	Total Capex	1,849.2

Detailed cost of passengermovement and other supporting infrastructure required at terminal is listed in the table below.

Table 15.166Infrastructure Requirement Cost at Terminals-9 (INR Lakhs)

S.No	Description	No.	Rate in lakhs	Amount(lakhs)
1	Parking Area	1	15	15
2	Cafe	1	20	20
3	Restroom	1	25	25
5	Waiting Hall	1	20	20
6	Ticket Counter	1	10	10
7	Admin Building	1	30	30
8	Toilet	1	10	10
9	Book Shop	1	15	15
10	Interpretation Centre	1	40	40
11	Fencing and Guard room	1	40	40
	Total			**225**

- **Project Financing**

Construction Phase 1 has been assumed to be funded in an Equity-Debt ratio of 35:65. Details of the means of financing for both the phases are shown below.

Table 15.167 Equity-Debt Share Distribution for Terminal 9(INR Lakhs)

Particulars	%	Construction Phase 1
Equity	35%	647.2
Debt	65%	1,202.0

Source: By Analysis

- **Financial Indicators**

This section shows the financial indicator that leads to the generation of FIRR for Terminal 9. Revenue, Salary, Depreciation, Cash Flow, P&L Statement & Balance Sheet helps on understanding the returns on investment made for this terminal.

Revenue from Terminal 9 proposed on River Yamuna will be generated from passenger and viewing deck charges. The detailed breakup of revenue is shown in the table above.

Table 15.168 Revenue from Terminals-9 (INR Lakhs)

Particulars	FY36	FY37	FY42	FY47	FY50	FY55	FY60	FY65
Passenger Charges	-	581	610	642	642	642	642	642
Viewing Deck	-	232	244	257	257	257	257	257
Total Revenue	-	813	855	898	898	898	898	898

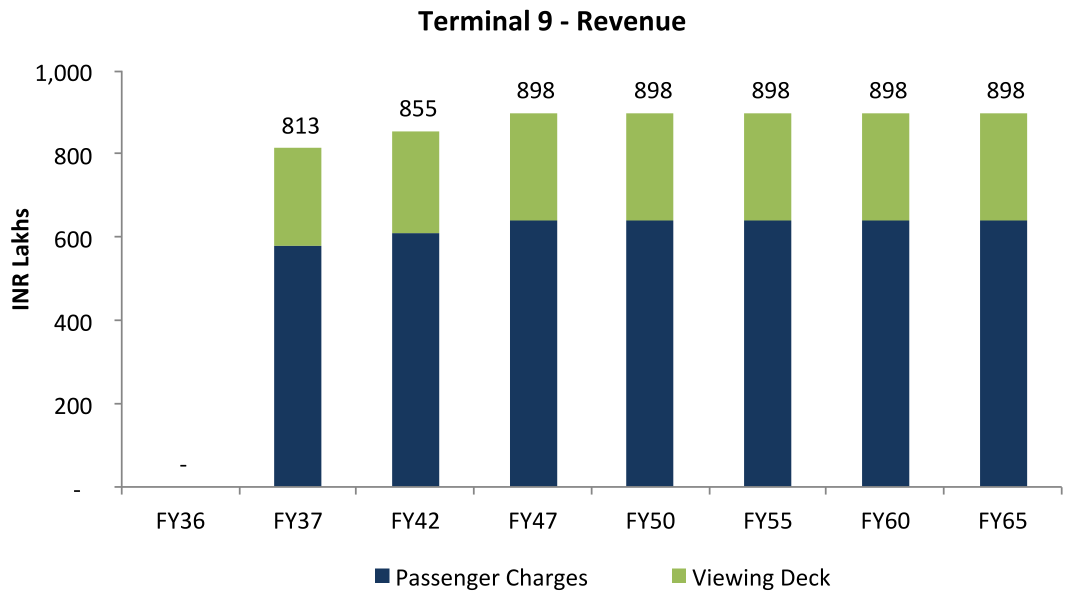

Fig. 15.32 Revenue for Terminal 9

The below table indicates maintenance & insurance cost in detail. Utilities cost include cost of water & power.

Table 15.169Direct Operating & Maintenance Cost for Terminal 9 (INR Lakhs)

	FY36	FY37	FY42	FY47	FY50	FY55	FY60	FY65
Direct Operating Costs								
Maintenance Cost								
Civil	14	14	14	14	14	14	14	14
Mechanical	0	0	0	0	0	0	0	0
Utilities	0	291	291	291	291	291	291	291
Maintenance Cost	**14**	**305**	**305**	**305**	**305**	**305**	**305**	**305**
Insurance Cost								
Civil Insurance	14	12	5	2	1	1	0	0
Mechanical Insurance	0	0	0	0	0	0	0	0
Insurance Cost	14	12	5	2	1	1	0	0
Total Cost	**29**	**318**	**311**	**308**	**307**	**306**	**306**	**305**

The operator would share 4% of its revenue with IWAI and pay royalty of 10% of Passenger fee for terminals. The table below indicates the amount of total outflow to IWAI in case of Terminal 9.

Table 15.170Regulatory Royalty to IWAI for Terminal 9 (INR Lakhs)

Particulars	FY36	FY37	FY42	FY47	FY50	FY55	FY60	FY65
Royalty to IWAI	-	58	61	64	64	64	64	64
Revenue Share	-	33	34	36	36	36	36	36
Total Outflow to IWAI	-	91	95	100	100	100	100	100

The following table depicts the P/L statement for development of Terminal 9 on River Yamuna near MadanpurKhadar.

Table 15.171 Profit & Lost Statement for Terminal 9 (INR Lakhs)

Particulars	FY36	FY37	FY42	FY47	FY50	FY55	FY60	FY65
Revenue	-	813	855	898	898	898	898	898
Cost	29	1,122	1,121	1,124	425	424	424	423

Total Outflow to IWAI	0	91	95	100	100	100	100	100
PBDIT	-29	-309	-266	-225	473	474	475	475
Depreciation	-	172	92	92	92	-	-	-
Interest	132	123	76	28	-	-	-	-
PBT	-161	-604	-434	-345	382	474	475	475
Tax	-	-	-	-	114	142	142	142
PAT	**-161**	**-604**	**-434**	**-345**	**267**	**332**	**332**	**332**

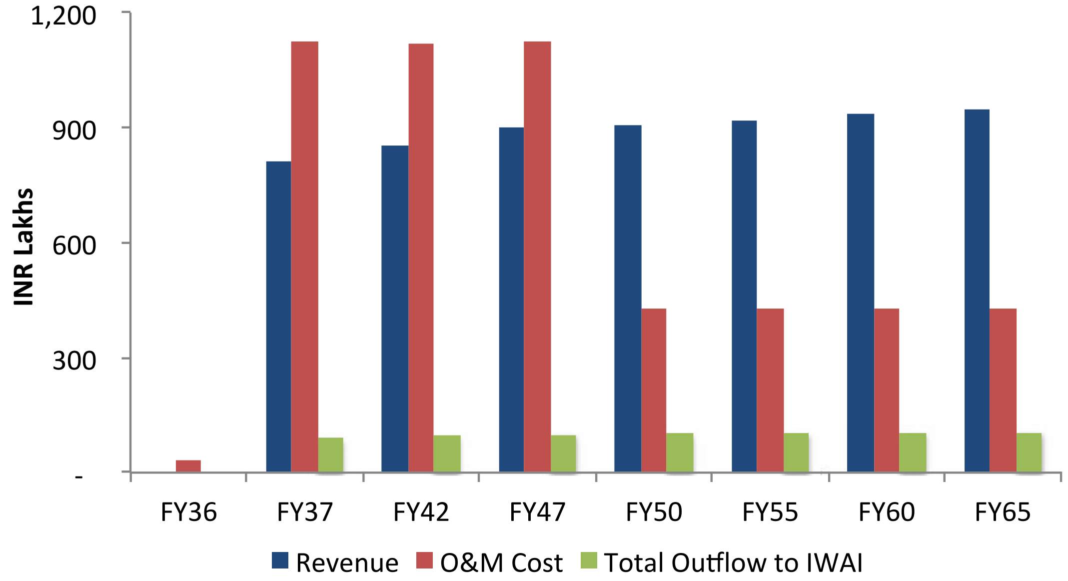

Fig. 15.33Comparison among Revenue, O&M Cost and Total Outflow to IWAI

Depreciation has been calculated using the Straight Line Method (SLM). Under this method, cost of asset is evenly distributed across its useful life. Straight Line Method (SLM) has been used to calculate depreciation for Terminal 9, under which the cost of tangible and intangible assets are evenly distributed across its life.

Table 15.172 Depreciation for Terminal 9 (INR Lakhs)

Depreciation & Amortization - SLM	FY36	FY37	FY42	FY47	FY50	FY55	FY60	FY65
Gross Block	1,849	1,849	1,849	1,849	1,849	1,849	1,849	1,849
Depreciation & Amortization	-	172	92	92	92	-	-	-
Cumulative Depreciation & Amortization	-	172	951	1,409	1,684	1,849	1,849	1,849
Net Block	1,849	1,677	898	440	165	-	-	-

The table below depicts the cash inflow & outflow in case of development of Terminal 9.

Table 15.173 Cash Flow for Terminal 9(INR Lakhs)

	FY36	FY37	FY42	FY47	FY50	FY55	FY60	FY65
Cash Inflow								
Equity	647	0	0	0	0	0	0	0
Debt	1,202	0	0	0	0	0	0	0

	FY36	FY37	FY42	FY47	FY50	FY55	FY60	FY65
Net Cash from Investment	1,849	0	0	0	0	0	0	0
Operations								
PBDIT	-29	-309	-266	-225	473	474	475	475
(-) Taxes Paid	0	0	0	0	114	142	142	142
Net Cash from Operations	-29	-309	-266	-225	359	332	332	332
Total Cash Inflow	1,820	-309	-266	-225	359	332	332	332
Cash Outflow								
Capital Investment	1,849	0	0	0	0	0	0	0
Long Term Debt	0	86	86	86	86	0	0	0
Interest	132	123	76	28	0	0	0	0
Total Cash Outflow	1,981	209	161	114	86	0	0	0
Net Cash Flow	-161	-518	-428	-340	273	332	332	332
Opening Balance of Cash	0	-161	-2,569	-4,531	-5,520	-3,871	-2,211	-550
Closing Balance Cash	-161	-679	-2,996	-4,870	-5,247	-3,539	-1,879	-217

Table 15.174 Balance Sheet for Terminal 9 (INR Lakhs)

Sources of Funds	FY36	FY37	FY42	FY47	FY50	FY55	FY60	FY65
Shareholder's funds								
Capital	647	647	647	647	647	647	647	647
Reserves & Surplus	-161	-765	-3,432	-5,335	-5,729	-4,186	-2,526	-865
Borrowings								
Secured Loans	1,202	1,116	687	258	0	0	0	0
Total Funds	**1,688**	**998**	**-2,098**	**-4,430**	**-5,082**	**-3,539**	**-1,879**	**-217**
Usages of Fund								
Gross Block	1,849	1,849	1,849	1,849	1,849	1,849	1,849	1,849
Less: Depreciation	0	172	951	1,409	1,684	1,849	1,849	1,849
Net Block	1,849	1,677	898	440	165	0	0	0
Net Current Assets	-161	-679	-2,996	-4,870	-5,247	-3,539	-1,879	-217
Total Assets	1,688	998	-2,098	-4,430	-5,082	-3,539	-1,879	-217

- **Financial IRR**

Financial FIRR presented below will help IWAI to measure the financial returns on investment and assist take a firm decision on the implementation of this development. Final viability assessment for developing passenger handling terminal on this River Yamuna would be done based on this outcome.

Table 15.175 Financial IRR Calculation for Terminal 9 (INR Lakhs)

	FY36	FY37	FY42	FY47	FY50	FY55	FY60	FY65
PBDIT	-29	-309	-266	-225	473	474	475	475
Interest	132	123	76	28	0	0	0	0
Principal repayment	0	86	86	86	86	0	0	0
Equity	647	0	0	0	0	0	0	0

	FY36	FY37	FY42	FY47	FY50	FY55	FY60	FY65
Debt	1,202	0	0	0	0	0	0	0
Total Investment	1,849	0	0	0	0	0	0	0
Tax	0	0	0	0	114	142	142	142
Cash flow to Equity(Pre-tax)	-808	-518	-428	-340	387	474	475	475
Equity IRR(Pre-tax)	**N.A**							
Cash flow to Equity(Post-tax)	-808	-518	-428	-340	273	332	332	332
Equity IRR(Post-tax)	**N.A**							
Project Cash flow(Pre-tax)	-1,878	-309	-266	-225	473	474	475	475
Project IRR(Pre-tax)	**2%**							
Project Cash flow(Post-tax)	-1,878	-309	-266	-225	359	332	332	332
Project IRR(Post-tax)	**N.A**							

15.3.3.3 Terminal 10–Inter District Passenger Terminal

- **Salary Calculation for Passenger Terminals**

  The below table depicts proposed salaries for employees in each passenger terminal.

Table 15.176Assumptions for Manpower Salary at Terminal 10

Manpower	No.	Annual Salary(Rs.)
Manager	1	11
Admin Officer	2	12
Firefighting	2	10
Electrician	3	13
Mechanic	3	14
Operator	2	14
Civil Supervisor	3	22
Ticket Counter	4	14
Hospitality	5	18
Security	5	12
Accident Management Team		
Team Leader	1	7
Other Members	19	80
Additional Firefighting Team	25	105
Health Care & Medical Facility		
Doctor (Male & Female)	8	96
Medical Staff	40	192
Disaster Management Cell	20	120
Total	**153**	**740**

- **Phasing**

  Terminal 10 is proposed to be developed in Phase 2 i.e. from FY30. This is the second phase of development, in this phase would become operational i.e. from Prayagraj to Agra. The construction of infrastructure, connectivity will take 1 year and the terminal will get operational from FY37 for next 30 years.

Table 15.177 Development of Terminal 10

Total Jetties	Chainage (km)	FY31	FY32	FY60

1	742	Construction - 1 Jetty		
			Operational - 1 Jetty	

- **Traffic**

This terminal is proposed for handling tourist and passengers. Presently these tourists are using Yamuna expressway or NH 2, a certain share of this movement is diverted to IWT using NW110 from Prayagraj to Agra or MadanpurKhadar to Agra. Traffic for Terminal 10 for next 30 years is projected in the table below.

Table 15.178Traffic at Terminal 10 ('000)

Passenger	Fy 32	Fy 34	Fy35	Fy40	Fy45	Fy 50	Fy 55	Fy 60
Total	66	67	68	71	75	77	77	77

- **Capital Cost**

This section represents the total capital expenditure in a phased manner for Terminal 10 proposed near TajMahal for long distance tourism purpose.

Table 15.179 Project Cost for Construction Terminals-10(INR Lakhs)

S. No.	Description	Total Cost (INR Lakhs)
A	Terminal	1,000
B	Approach Road	161
C	Building & Other Civil Infrastructure	150
D	Other Charges	6,268
	Total Capex	7,579

Detailed cost of passenger movement and other supporting infrastructure required at terminal is listed in the table below.

Table 15.180Infrastructure Requirement Cost at Terminals-10 (INR Lakhs)

S.No	Description	No.	Rate in lakhs	Amount(lakhs)
1	Parking Area	1	15	15
2	Cafe	1	20	20
3	Restroom	1	25	25
5	Waiting Hall	1	20	20
6	Ticket Counter	1	10	10
7	Admin Building	1	10	10
8	Toilet	1	20	20
9	Book Shop	1	30	30
10	Interpretation Centre	1	15	15
11	Fencing and Guard room	1	20	20
	Total			**150**

- **Project Financing**

Construction Phase 1 has been assumed to be funded in an Equity-Debt ratio of 35:65. Details of the means of financing for both the phases are shown below.

Table 15.181 Equity-Debt Share Distribution for Terminal 10 (INR Lakhs)

Particulars	%	Phase 1

Equity	35%	2,653
Debt	65%	4,926

- **Financial Indicators**

This section shows the financial indicator that leads to the generation of FIRR for Terminal – 10. Revenue, Salary, Depreciation, Cash Flow, P&L Statement & Balance Sheet helps on understanding the returns on investment made for this terminal.

Revenue from Terminal 10 proposed on River Yamuna will be generated from passenger and viewing deck charges. The detailed breakup of revenue is shown in the table above.

Table 15.182 Revenue from Terminals-10 (INR Lakhs)

Particulars	FY31	FY32	FY35	FY40	FY45	FY50	FY55	FY60
Passenger Revenue								
Passenger Charges	-	132	136	143	150	153	153	153
Viewing Deck	-	53	54	57	60	61	61	61
Total Revenue	-	185	191	200	211	215	215	215

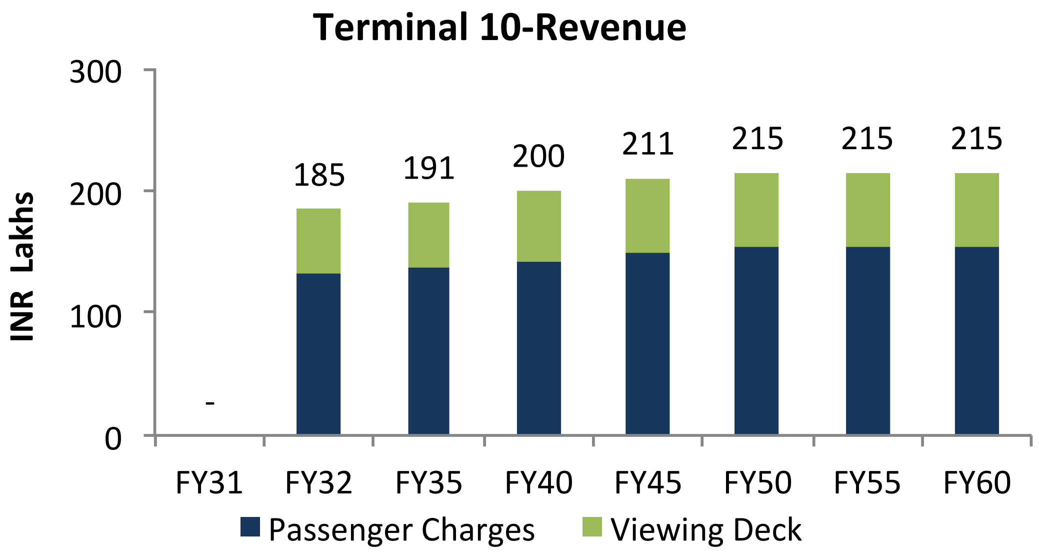

Fig. 15.34 Revenue for Terminal 10

The following table indicates the direct operating cost for development of Terminal 10.

Table 15.183 Direct Operating & Maintenance Cost for Terminal 10 (INR Lakhs)

	FY31	FY35	FY40	FY45	FY50	FY55	FY60
Maintenance Cost							
Civil	13.1	13.1	13.1	13.1	13.1	13.1	13.1
Mechanical	313.4	313.4	313.4	313.4	313.4	313.4	313.4
Utilities	-	290.8	290.8	290.8	290.8	290.8	290.8
Maintenance Cost	**326.5**	**617.3**	**617.3**	**617.3**	**617.3**	**617.3**	**617.3**
Insurance Cost							
Civil Insurance	13.1	6.8	3.0	1.3	0.6	0.3	0.1
Mechanical Insurance	125.4	65.4	29.0	12.9	5.7	2.5	1.1
Insurance Cost	138.5	72.3	32.1	14.2	6.3	2.8	1.2

Total Cost	**465.0**	**689.6**	**649.4**	**631.5**	**623.6**	**620.1**	**618.5**

Table 15.184 Regulatory Royalty to IWAI for Terminal 10 (INR Lakhs)

Particular	FY31	FY32	FY35	FY40	FY45	FY50	FY55	FY60
Royalty to IWAI	-	13	14	14	15	15	15	15
Revenue Share	-	7	8	8	8	9	9	9
Total Outflow	**-**	**20**	**22**	**22**	**23**	**24**	**24**	**24**

The section above summaries the Revenue generated by operation of Terminal 10 and total cost i.e. O&M cost and out-flow to IWAI (Royalty and Revenue Share) from FY35 till FY60. The operator would share 4% of its revenue with IWAI and pay royalty of 10% of Passenger fee for terminal.

The following table depicts the P/L statement for development of Terminal 10on River Yamuna near TajMahal, Agra.

Table 15.185Profit & Lost Statement for Terminal 10 (INR Lakhs)

Particulars	FY31	FY32	FY35	FY40	FY45	FY50	FY55	FY60
Revenue	0	185	191	200	211	215	215	215
Cost	465	735	690	649	632	291	291	291
PBDIT	-465	-595	-545	-498	-472	-128	-128	-128
Depreciation	0	480	480	480	480	-	-	-
Interest	542	503	387	194	0	-	-	-
PBT	-1,007	-1,578	-1,412	-1,171	-952	-128	-128	-128
Tax	0	0	0	0	0	-	-	-
PAT	**-1,007**	**-1,578**	**-1,412**	**-1,171**	**-952**	**-128**	**-128**	**-128**

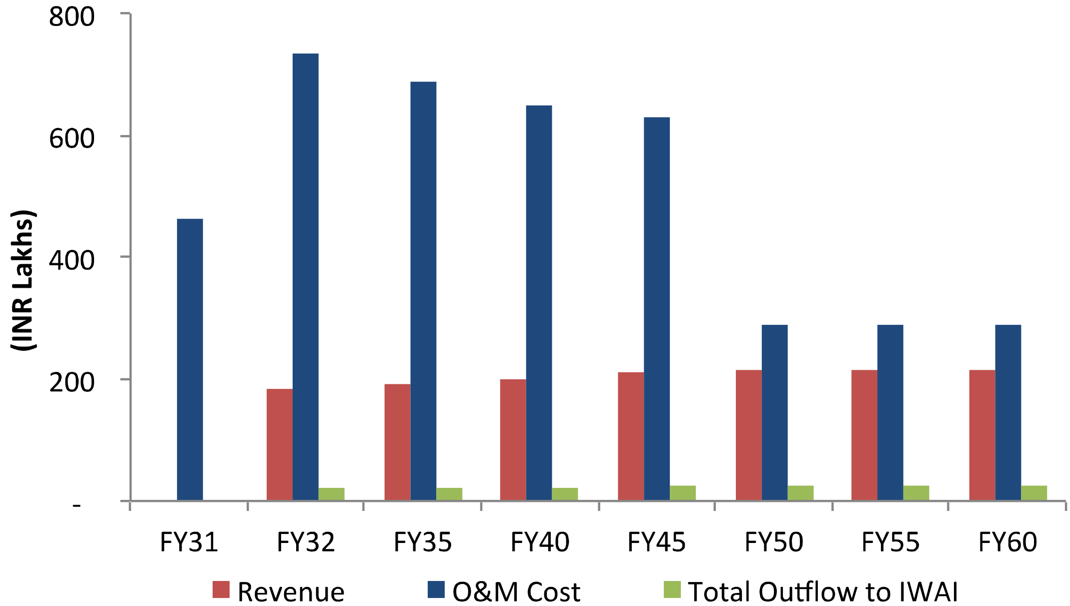

Fig. 15.35Comparison among Revenue, O&M Cost and Total Outflow to IWAI

Depreciation has been calculated using the Straight Line Method (SLM). Under this method, cost of asset is evenly distributed across its useful life. Straight Line Method (SLM) has been used to calculate depreciation for Terminal 10, under which the cost of tangible and intangible assets are evenly distributed across its life.

Table 15.186 Depreciation for Terminal 10(INR Lakhs)

Depreciation &Amortization - SLM	FY31	FY32	FY35	FY40	FY45	FY50	FY55	FY60
Gross Block	7,579	7,579	7,579	7,579	7,579	7,579	7,579	7,579
Depreciation & Amortization	-	480	480	480	383	-	-	-
Cumulative Depreciation & Amortization	-	480	2,879	5,277	7,579	7,579	7,579	7,579
Net Block	7,579	7,099	4,701	2,302	-	-	-	-

The table below depicts the cash inflow & outflow in case of development of Terminal 10.

Table 15.187 Cash Flow for Terminal 10 (INR Lakhs)

	FY31	FY35	FY40	FY45	FY50	FY60
Cash Inflow						
Equity	2,653	0	0	0	0	0
Debt	4,926	0	0	0	0	0
Net Cash from Investment	7,579	0	0	0	0	0
Operations						
PBDIT	-465	-545	-498	-472	-128	-128
(-) Taxes Paid	0	0	0	0	0	0
Net Cash from Operations	-465	-545	-498	-472	-128	-128
Total Cash Inflow	**7,114**	**-545**	**-498**	**-472**	**-128**	**-128**
Cash Outflow						
Capital Investment	7,579	0	0	0	0	0
Long Term Debt	0	352	352	352	0	0
Interest	542	387	194	0	0	0
Total Cash Outflow	8,121	739	545	352	0	0
Net Cash Flow	**-1,007**	**-1,284**	**-1,043**	**-824**	**-128**	**-128**
Opening Balance of Cash	0	-5,186	-11,112	-15,883	-17,897	-19,177
Closing Balance Cash	**-1,007**	**-6,470**	**-12,155**	**-16,707**	**-18,025**	**-19,305**

Table 15.188 Balance Sheet for Terminal 10 (INR Lakhs)

Sources of Funds	FY31	FY35	FY40	FY45	FY50	FY60
Shareholder's funds						
Capital	2,653	2,653	2,653	2,653	2,653	2,653
Reserves & Surplus	-1,007	- 6,982	- 13,306	- 18,497	- 20,677	- 21,958
Borrowings						
Secured Loans	4,926	3,519	1,759	-	-	-
Total Funds	**6,572**	**- 810**	**-8,894**	**-15,845**	**-18,025**	**-19,305**
Usages of Fund						
Fixed Assets						
Gross Block	7,579	7,579	7,579	7,579	7,579	7,579

Less: Depreciation	-	1,919	4,318	6,717	7,579	7,579
Net Block	7,579	5,660	3,261	863	-	-
Net Current Assets	-1,007	-6,470	-12,155	-16,707	-18,025	-19,305
Total Assets	**6,572**	**-810**	**-8,894**	**-15,845**	**-18,025**	**-19,305**

- **Financial IRR**

Financial FIRR presented below will help IWAI to measure the financial returns on investment and assist take a firm decision on the implementation of this development. Final viability assessment for developing passenger handling terminal on this River Yamuna would be done based on this outcome.

Table 15.189 Financial IRR Calculation for Terminal 10 (INR Lakhs)

Particulars	FY31	FY32	FY37	FY42	FY47	FY50	FY55	FY60
PBDIT	-465	-595	-522	-486	-465	-128	-128	-128
Interest	542	503	310	116	0	0	0	0
Principal repayment	0	352	352	352	0	0	0	0
Equity	2,653	0	0	0	0	0	0	0
Debt	4,926	0	0	0	0	0	0	0
Total Investment	7,579	0	0	0	0	0	0	0
Tax	0	0	0	0	0	0	0	0
Cash flow to Equity(Pre-tax)	-3,660	-1,450	-1,184	-954	-465	-128	-128	-128
Equity IRR(Pre-tax)	N.A							
Cash flow to Equity(Post-tax)	-3,660	-1,450	-1,184	-954	-465	-128	-128	-128
Equity IRR(Post-tax)	N.A							
Project Cash flow(Pre-tax)	-8,044	-595	-522	-486	-465	-128	-128	-128
Project IRR(Pre-tax)	N.A							
Project Cash flow(Post-tax)	-8,044	-595	-522	-486	-465	-128	-128	-128
Project IRR(Post-tax)	N.A							

15.3.3.4 Terminal 11 – Inter District Passenger Terminal

- **Salary Calculation for Passenger Terminals**

The below table depicts proposed salaries for employees in each passenger terminal.

Table 15.190Assumptions for Manpower Salary at Terminal 11

Manpower	No.	Annual Salary
Manager	1	1,080,000
Admin Officer	2	1,200,000
Firefighting	2	960,000
Electrician	3	1,260,000
Mechanic	3	1,440,000
Operator	2	1,440,000

Civil Supervisor	3	2,160,000
Ticket Counter	4	1,440,000
Hospitality	5	1,800,000
Security	5	1,200,000
Subcontractor		
Accident Management Team		
Team Leader	1	1,200,000
Other Members	19	12,540,000
Additional Firefighting Team	5	5,100,000
Health Care & Medical Facility		0
Doctor (Male & Female)	5	10,500,000
Medical Staff	17	16,320,000
Disaster Management Cell	5	6,000,000
Total		**65,640,000**

- **Phasing**

Terminal 11 is proposed to be developed in Phase 3 i.e. in FY36. This is the second phase of development, in this phase would become operational i.e. from Prayagraj to Vrindavan, Mathura. The construction of infrastructure, connectivity will take 1 year and the terminal will get operational from FY37.

Table 15.191 Development of Terminal 11

Total Jetties	Chainage (km)	FY36	FY 37 to FY65
1	858.5	Construction -1 Jetties	
			Operational -1 Jetties

- **Traffic**

This terminal is proposed for handling tourist and passengers. Presently these tourists are using Yamuna Expressway or NH 2, a certain share of this movement is diverted to IWT using NW 110 from Mathura to MadanpurKhadar. Traffic for Terminal 11 for next 30 years is projected in the table below.

Table 15.192 Traffic at Terminal 11 ('000)

Passenger	Fy 36	Fy 40	Fy 45	Fy 50	Fy 55	Fy 60	Fy 65
Total	443	461	484	494	494	494	494

- **Capital Cost**

This section represents the total capital expenditure in a phased manner for Terminal 11 proposed at PanigaonKhader, Mathura River Yamuna.

Table 15.193 Project Cost for Construction Terminals-11(INR Lakhs)

S. No.	Description	Total Cost (INR Lakhs)
A	Terminal	925

B	Approach Road	94
C	Building & Other Civil Infrastructure	225
D	Other Charges	401
	Total Capex	**1,645**

Detailed cost of passenger movement and other supporting infrastructure required at terminal is listed in the table below.

Table 15.194Infrastructure Requirement Cost at Terminals-11 (INR Lakhs)

S.No	Description	No.	Rate in lakhs	Amount(lakhs)
1	Parking Area	1	15	15
2	Cafe	1	20	20
3	Restroom	1	25	25
4	Waiting Hall	1	20	20
5	Ticket Counter	1	10	10
6	Admin Building	1	30	30
7	Toilet	1	10	10
8	Book Shop	1	15	15
9	Interpretation Centre	1	40	40
10	Fencing and Guard room	1	40	40
	Total			**225**

- **Project Financing**

Construction Phase 1 has been assumed to be funded in an Equity-Debt ratio of 35:65. Details of the means of financing for both the phases are shown below.

Table 15.195 Equity-Debt Share Distribution for Terminal 11(INR Lakhs)

Particulars	%	Phase 1
Equity	35%	575.8
Debt	65%	1,069.4

- **Financial Indicators**

This section shows the financial indicator that leads to the generation of FIRR for Terminal 11. Revenue, Salary, Depreciation, Cash Flow, P&L Statement & Balance Sheet helps on understanding the returns on investment made for this terminal.

Revenue from Terminal 11 proposed on River Yamuna will be generated from passenger & viewing deck charges. The detailed breakup of revenue is shown in the table above.

Table 15.196 Revenue from Terminals-11 (INR Lakhs)

Particulars	FY36	FY37	FY42	FY47	FY50	FY55	FY60	FY65
Passenger Charges	-	895	940	988	988	988	988	988
Viewing Deck	-	358	376	395	395	395	395	395
Total Revenue	-	1,253	1,316	1,384	1,384	1,384	1,384	1,384

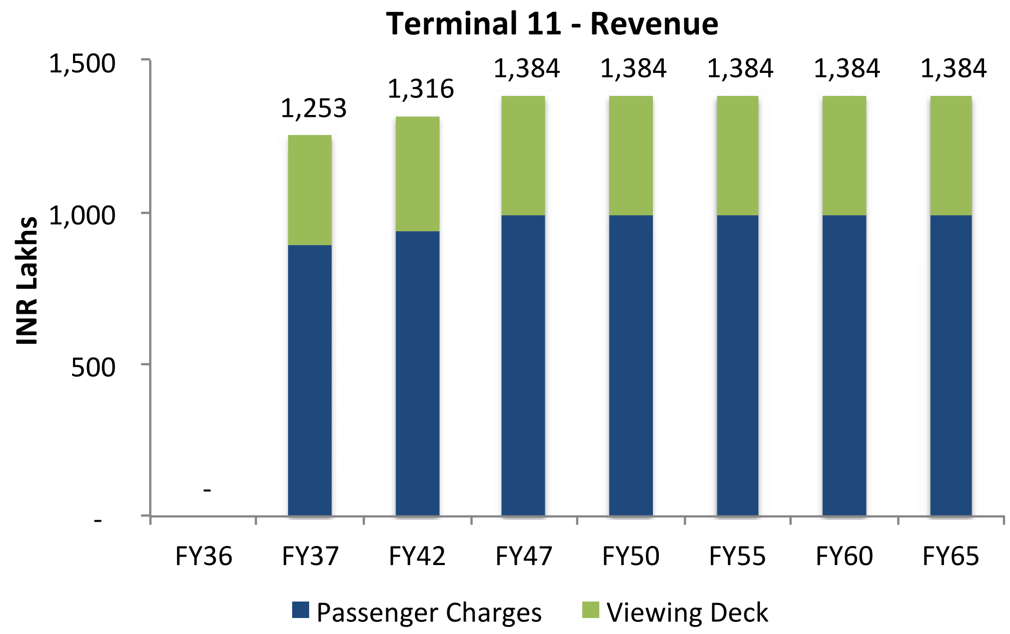

Fig. 15.36 Revenue for Terminal 11

The following table indicates maintenance & insurance cost at Terminal 11.

Table 15.197 Direct Operating & Maintenance Cost for Terminal 11 (INR Lakhs)

Particulars	FY36	FY37	FY42	FY47	FY50	FY55	FY60	FY65
Maintenance Cost								
Civil	12.4	12.4	12.4	12.4	12.4	12.4	12.4	12.4
Mechanical	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Utilities	0.0	189.1	189.1	189.1	189.1	189.1	189.1	189.1
Maintenance Cost	12.4	201.6	201.6	201.6	201.6	201.6	201.6	201.6
Insurance Cost								
Civil Insurance	12.4	10.6	4.7	2.1	1.3	0.6	0.3	0.1
Mechanical Insurance	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Insurance Cost	12.4	10.6	4.7	2.1	1.3	0.6	0.3	0.1
Total Cost	24.9	212.2	206.3	203.7	202.9	202.2	201.8	201.7

The operator would share 4% of its revenue with IWAI and pay royalty of 10% of Passenger fee for terminal. The table below indicates the amount of total outflow to IWAI in case of Terminal 11.

Table 15.198 Regulatory Royalty to IWAI for Terminal 11 (INR Lakhs)

	FY36	FY37	FY42	FY47	FY50	FY55	FY60	FY65
Royalty to IWAI	-	89	94	99	99	99	99	99
Revenue Share	-	50	53	55	55	55	55	55
Total Outflow to IWAI	-	140	147	154	154	154	154	154

The following table depicts the P/L statement for development of Terminal 11on River Yamuna near PanigaonKhader, Mathura.

Table 15.199 Profit & Lost Statement for Terminal 11 (INR Lakhs)

Particulars	FY36	FY37	FY42	FY47	FY50	FY55	FY60	FY65
Revenue	-	1,253	1,316	1,384	1,384	1,384	1,384	1,384
O & M Cost	26	1,072	1,076	1,084	1,083	1,082	1,082	1,081
PBDIT	-26	180	240	299	301	302	302	302
Depreciation	-	86	84	84	79	-	-	-
Interest	95	89	54	20	-	-	-	-
PBT	-122	5	102	195	222	302	302	302
Tax	-	2	31	59	67	90	91	91
PAT	**-122**	**4**	**72**	**137**	**156**	211	211	211

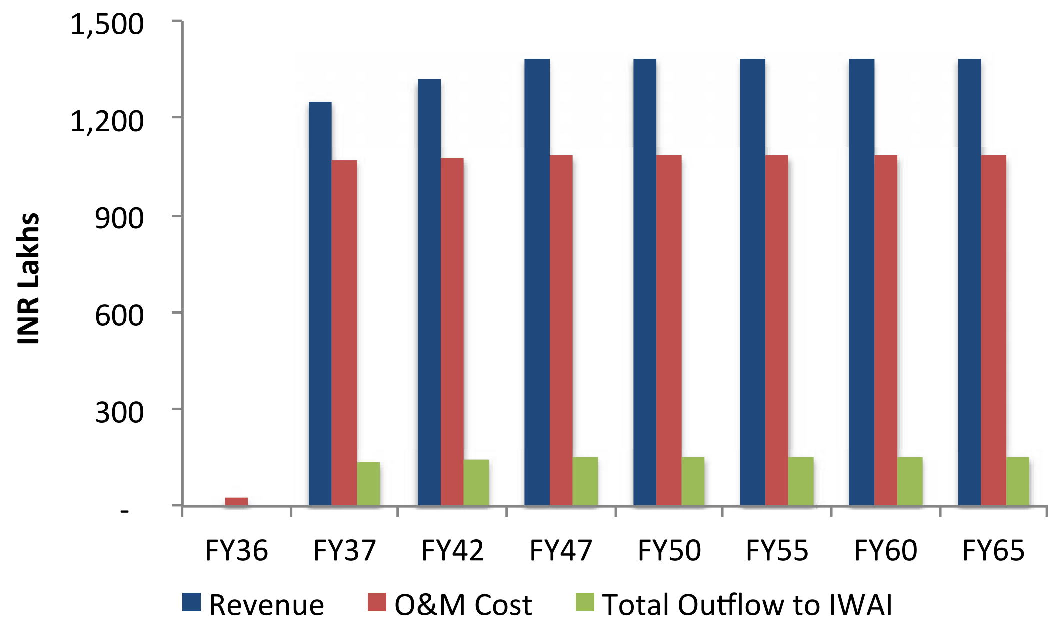

Fig. 15.37Comparison among Revenue, O&M Cost and Total Outflow to IWAI

The terminal will start generating profit from 1st year of operation only i.e. Fy-37. This is mainly due to high Revenue& high traffic whereas lower development cost. These are the major factors that heavily impacts commercial prospects of proposed terminal. Depreciation has been calculated using the Straight Line Method (SLM). Under this method, cost of asset is evenly distributed across its useful life. Straight Line Method (SLM) has been used to calculate depreciation for Terminal 11, under which the cost of tangible and intangible assets are evenly distributed across its life.

Table 15.200 Depreciation for Terminal 11(INR Lakhs)

Depreciation & Amortization - SLM	FY36	FY37	FY42	FY47	FY50	FY55	FY60	FY65
Gross Block	1,645	1,645	1,645	1,645	1,645	1,645	1,645	1,645
Depreciation & Amortization	0	159	79	79	79	0	0	0
Cumulative Depreciation & Amortization	0	159	874	1,267	1,504	1,645	1,645	1,645
Net Block	1,645	1,486	772	378	142	0	0	0

The table below depicts the cash inflow & outflow in case of development of Terminal 11.

Table 15.201Cash Flow for Terminal 11(INR Lakhs)

Particulars	FY36	FY37	FY42	FY47	FY50	FY55	FY60	FY65
Cash Inflow								
Investment								
Equity	576	0	0	0	0	0	0	0
Debt	1,069	0	0	0	0	0	0	0
Net Cash from Investment	1,645	0	0	0	0	0	0	0
Operations								
PBDIT	-25	182	241	300	301	302	302	302
(-) Taxes Paid	0	0	29	59	67	90	91	91
Net Cash from Operations	-25	182	213	241	234	211	211	211
Total Cash Inflow	1,620	182	213	241	234	211	211	211
Cash Outflow								
Capital Investment	1,645	0	0	0	0	0	0	0
Long Term Debt	0	76	76	76	76	0	0	0
Interest	118	109	67	25	0	0	0	0
Total Cash Outflow	1,763	186	144	102	76	0	0	0
Net Cash Flow	-143	-4	69	140	158	211	211	211
Opening Balance of Cash	0	-143	42	528	966	2,010	3,066	4,123
Closing Balance Cash	-143	-146	111	668	1,123	2,221	3,277	4,335

Table 15.202 Balance Sheet for Terminal 11 (INR Lakhs)

Sources of Funds	FY36	FY37	FY42	FY47	FY50	FY55	FY60	FY65
Shareholder's funds								
Capital	576	576	576	576	576	576	576	576
Reserves & Surplus	-143	-229	-304	241	689	1,645	2,702	3,759
Borrowings								
Secured Loans	1,069	993	611	229	-	-	-	-
Total Funds	1,503	1,340	883	1,046	1,265	2,221	3,277	4,335
Fixed Assets								
Gross Block								
Less: Depreciation	1,645	1,645	1,645	1,645	1,645	1,645	1,645	1,645
Net Block	-	159	874	1,267	1,504	1,645	1,645	1,645
Net Current Assets	1,645	1,486	772	378	142	-	-	-
Total Assets	-143	-146	111	668	1,123	2,221	3,277	4,335

- **Financial IRR**

Financial FIRR presented below will help IWAI to measure the financial returns on investment and assist take a firm decision on the implementation of this development. Final viability assessment for developing passenger handling terminal on this River Yamuna would be done based on this outcome.

Table 15.203 Financial IRR Calculation for Terminal 11 (INR Lakhs)

	FY36	FY37	FY42	FY47	FY50	FY55	FY60	FY65
PBDIT	-25	182	241	300	301	302	302	302
Interest	118	109	67	25	0	0	0	0
Principal repayment	0	76	76	76	76	0	0	0
Equity	576	0	0	0	0	0	0	0
Debt	1,069	0	0	0	0	0	0	0
Total Investment	1,645	0	0	0	0	0	0	0
Tax	0	0	29	59	67	90	91	91
Cash flow to Equity (Pre-tax)	-718	-4	98	199	225	302	302	302
Equity IRR(Pre-tax)	5%							
Cash flow to Equity(Post-tax)	-718	-4	69	140	158	211	211	211
Equity IRR(Post-tax)	2%							
Project Cash flow (Pre-tax)	-1,670	182	241	300	301	302	302	302
Project IRR(Pre-tax)	8%							
Project Cash flow(Post-tax)	-1,670	182	213	241	234	211	211	211
Project IRR(Post-tax)	6%							

15.3.3.5 Terminal 12 – Intra District Passenger Terminal

- **Salary Calculation for Passenger Terminals**

The below table depicts proposed salaries for employees in each passenger terminal.

Table 15.204Assumptions for Manpower Salary at Terminal 12

Person	No.	Annual Salary (INR)
Manager	1	1,080,000
Admin Officer	2	1,200,000
Firefighting	2	960,000
Electrician	3	1,260,000
Mechanic	3	1,440,000
Operator	2	1,440,000
Civil Supervisor	3	2,160,000
Ticket Counter	4	1,440,000
Hospitality	5	1,800,000
Security	5	1,200,000
Total	30	13,980,000

- **Phasing**

Terminal 12 is proposed to be developed in Phase 1 i.e. in Fy 25. This is the first phase of development, in this phase would become operational within Delhi. The construction of infrastructure, connectivity will take 1 year and the terminal will get operational from FY26 for next 30 years.

Table 15.205 Development of Terminal 12

No. of Jetties	FY25	FY26 to FY54
3 (1 at each terminal)	Construction -3Jetties	
		Operational -3 Jetties

- **Traffic**

This terminal is proposed for handling tourist and passengers. Presently these tourists are using WazirabadBridge or Signature Bridge to cross Yamuna River, a certain share of this movement is diverted to IWT using NW110. Traffic for Terminal 12 for next 30 years is projected in the table below.

Table 15.206 Traffic at Terminal 12 ('000)

Passenger	FY26	FY27	FY32	FY37	FY42	FY47	FY54
Total	145	149	157	165	173	182	182

- **Capital Cost**

This section represents the total capital expenditure in a phased manner for Terminal 12 proposed at three locations (Jagatpur, SoniyaVihar&Tronica City) for passenger handling in River Yamuna.

Table 15.207 Project Cost for Construction Terminals-12 (INR Lakhs)

S. No.	Description	Total Cost (INR Lakhs)
A	Terminal	2,970
B	Approach Road	50
C	Building	470
E	Other Charges	2,086
	Total Capex	5,576

Detailed cost of cargo handling and other supporting infrastructure required at terminal is listed in the table below.

Table 15.208Infrastructure Requirement Cost at Terminals-12 (INR Lakhs)

S.No	Description	No.	Amount in lakhs
1	Parking Area	1	15
2	Cafe	1	20
3	Restroom	1	25
5	Waiting Hall	1	20
6	Ticket Counter	1	10
7	Admin Building	1	20
8	Toilet	1	10
9	Fencing and Guard room	1	30
10	Changing room	1	10

- **Project Financing**

Construction Phase 1 has been assumed to be funded in an Equity-Debt ratio of 35:65. Details of the means of financing for both the phases are shown below.

Table 15.209 Equity-Debt Share Distribution for Terminal 12 (INR Lakhs)

Particulars	%	Phase 1
Equity	35%	1,951.7
Debt	65%	3,624.6

- **Financial Indicators**

This section shows the financial indicator that leads to the generation of FIRR for Terminal 12. Revenue, Salary, Depreciation, Cash Flow, P&L Statement & Balance Sheet helps on understanding the returns on investment made for this terminal.

Revenue from Terminal 12 proposed on River Yamuna will be generated from passenger and viewing deck charges. The detailed breakup of revenue is shown in the table above.

Table 15.210Revenue from Terminals-12 (INR Lakhs)

Container Traffic	FY25	FY26	FY30	FY35	FY40	FY45	FY50	FY54
Passenger Charges	-	147	153	161	170	178	182	182
Viewing Deck	-	74	77	81	85	89	91	91
Total Revenue	-	221	230	242	254	267	273	273

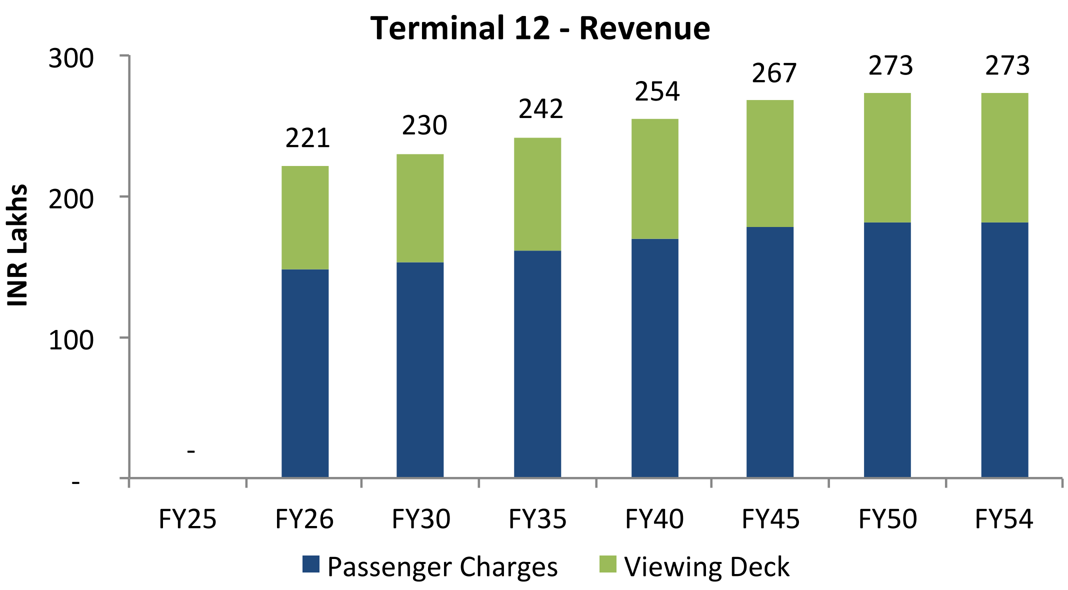

Fig.15.38 Revenue for Terminal 12

The following table indicates the direct operating cost for development of Terminal 12.

Table 15.211 Direct Operating & Maintenance Cost for Terminal 12 (INR Lakhs)

Particulars	FY25	FY26	FY27	FY32	FY37	FY42	FY47	FY54
Direct Operating Costs								
Civil	35	35	35	35	35	35	35	35
Mechanical	0	0	0	0	0	0	0	0
Utilities	0	239	239	239	239	239	239	239
Maintenance Cost	35	274	274	274	274	274	274	274
Insurance Cost								
Civil Insurance	35	30	15	7	3	1	1	0
Mechanical Insurance	0	0	0	0	0	0	0	0
Insurance Cost	35	30	15	7	3	1	1	0
Total Cost	70	303	289	281	277	275	274	274

The operator would share 4% of its revenue with IWAI and pay royalty of 10% of passenger fee for terminal. The table below indicates the amount of total outflow to IWAI in case of Terminal 12.

Table 15.212 Regulatory Royalty to IWAI for Terminal 12 (INR Lakhs)

Particulars	FY25	FY27	FY32	FY37	FY42	FY47	FY54
Royalty to IWAI	0	15	16	16	17	18	19
Revenue Share	0	9	9	10	10	11	11
Total Outflow to IWAI	0	24	25	26	28	29	30

The following table depicts the P/L statement for development of Terminal 12on River Yamuna.

Table 15.213 Profit & Lost Statement for Terminal 12 (INR Lakhs)

Particulars	FY25	FY27	FY32	FY37	FY42	FY47	FY54
Revenue	0	223	235	247	259	273	273
Cost	70	467	455	450	449	449	309
PBDIT	-70	-244	-220	-203	-189	-176	-36
Depreciation	0	638	221	221	0	0	0
Interest	399	342	199	57	0	0	0
PBT	-469	-1,224	-640	-481	-189	-176	-36
Tax	0	0	0	0	0	0	0
PAT	**-469**	**-1,224**	**-640**	**-481**	**-189**	**-176**	**-36**

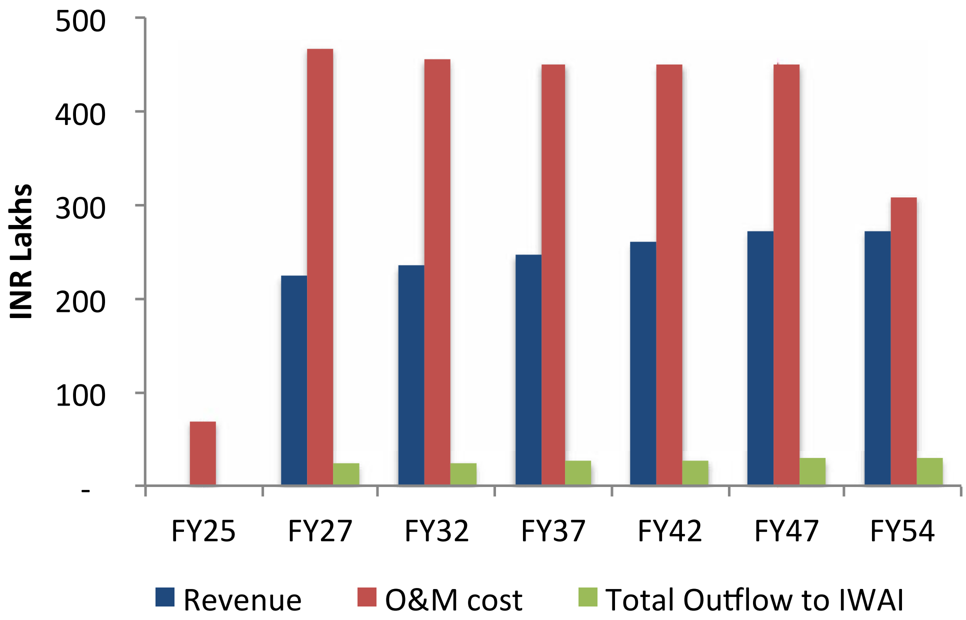

Fig.15.39Comparison among Revenue, O&M Cost and Total Outflow to IWAI

The terminal won't be generating any profit till Fy 54. This is mainly due to very less traffic for the waterway. This is one of the major factors that heavily impacts commercial prospects of proposed terminal.

Depreciation has been calculated using the Straight Line Method (SLM). Under this method, cost of asset is evenly distributed across its useful life. Straight Line Method (SLM) has been used to calculate depreciation for Terminal 12, under which the cost of tangible and intangible assets are evenly distributed across its life.

Table 15.214 Depreciation for Terminal 12(INR Lakhs)

Depreciation & Amortization - SLM	FY25	FY27	FY32	FY37	FY42	FY47	FY54
Gross Block	5,576	5,576	5,576	5,576	5,576	5,576	5,576
Depreciation & Amortization	-	638	221	221	-	-	-
Cumulative Depreciation & Amortization	-	1,276	3,633	4,737	5,576	5,576	5,576
Net Block	5,576	4,300	1,944	839	-	-	-

The table below depicts the cash inflow & outflow in case of development of Terminal 12.

Table 15.215Cash Flow for Terminal 12(INR Lakhs)

Particulars	FY25	FY27	FY32	FY37	FY47	FY54
Cash Inflow						
Investment						
Equity	1,952	0	0	0	0	0
Debt	3,625	0	0	0	0	0
Net Cash from Investment	5,576	0	0	0	0	0

Particulars	FY25	FY27	FY32	FY37	FY47	FY54
Operations						
PBDIT	-70	-244	-220	-203	-176	-36
(-) Taxes Paid	0	0	0	0	0	0
Net Cash from Operations	-70	-244	-220	-203	-176	-36
Total Cash Inflow	**5,507**	**-244**	**-220**	**-203**	**-176**	**-36**
Cash Outflow						
Capital Investment	5,576	0	0	0	0	0
Long Term Debt	0	259	259	259	0	0
Interest	399	342	199	57	0	0
Total Cash Outflow	5,975	601	458	316	0	0
Net Cash Flow	**-469**	**-844**	**-678**	**-519**	**-176**	**-36**
Opening Balance of Cash	0	-1,348	-5,232	-8,302	-11,071	-11,745
Closing Balance Cash	**-469**	**-2,192**	**-5,910**	**-8,821**	**-11,248**	**-11,781**

Table 15.216 Balance Sheet for Terminal 12 (INR Lakhs)

Sources of Funds	FY25	FY27	FY32	FY37	FY47	FY54
Shareholder's funds						
Capital	1,952	1,952	1,952	1,952	1,952	1,952
Reserves & Surplus	-469	-2,950	-7,730	-10,451	-13,199	-13,732
Borrowings						
Secured Loans	3,625	3,107	1,812	518	0	0
Total Funds	**5,108**	**2,108**	**-3,966**	**-7,982**	**-11,248**	**-11,781**
Usages of Fund						
Fixed Assets						
Gross Block	5,576	5,576	5,576	5,576	5,576	5,576
Less: Depreciation	0	1,276	3,633	4,737	5,576	5,576
Net Block	5,576	4,300	1,944	839	0	0
Net Current Assets	-469	-2,192	-5,910	-8,821	-11,248	-11,781
Total Assets	**5,108**	**2,108**	**-3,966**	**-7,982**	**-11,248**	**-11,781**

- **Financial IRR**

Financial FIRR presented below will help IWAI to measure the financial returns on investment and assist take a firm decision on the implementation of this development. Final viability assessment for developing passenger handling terminal on this River Yamuna would be done based on this outcome.

Table 15.217 Financial IRR Calculation for Terminal 12 (INR Lakhs)

Particulars	FY25	FY27	FY32	FY37	FY47	FY54
PBDIT	-70	-244	-220	-203	-176	-36
Interest	399	342	199	57	0	0
Principal repayment	0	259	259	259	0	0
Equity	1,952	0	0	0	0	0
Debt	3,625	0	0	0	0	0
Total Investment	5,576	0	0	0	0	0

Particulars	FY25	FY27	FY32	FY37	FY47	FY54
Tax	0	0	0	0	0	0
Cash flow to Equity(Pre-tax)	-2,420	-844	-678	-519	-176	-36
Equity IRR(Pre-tax)	N.A					
Cash flow to Equity(Post-tax)	-2,420	-844	-678	-519	-176	-36
Equity IRR(Post-tax)	N.A					
Project Cash flow(Pre-tax)	-5,646	-244	-220	-203	-176	-36
Project IRR(Pre-tax)	N.A					
Project Cash flow(Post-tax)	-5,646	-244	-220	-203	-176	-36
Project IRR(Post-tax)	N.A					

15.3.3.6 Terminal 13A – Inter & Intra District Passenger Terminal

- **Salary Calculation for Passenger Terminals**

The below table depicts proposed salaries for employees in each passenger terminal.

Table 15.218Assumptions for Manpower Salary at Terminal 13A

S.No	Description	No.	Amount in lakhs
1	Parking Area	1	15
2	Cafe	1	20
3	Restroom	1	25
5	Waiting Hall	1	20
6	Ticket Counter	1	10
7	Admin Building	1	20
8	Toilet	1	10
9	Fencing and Guard room	1	30
10	Changing room	1	10

- **Phasing**

Terminal 13A is proposed to be developed in Phase 1 i.e. from FY24. This is the first phase of development in this phase, would become operational within Prayagraj. The construction of infrastructure, connectivity will take 1 year and the terminal will get operational from FY26 to FY 54.

Table 15.219 Development of Terminal 13A

No. of Jetties	Chainage (km)	FY25	FY26to FY54
2	19.5	Construction -2 Jetties	
			Operational -2 Jetties

- **Traffic**

This terminal is proposed for handling tourist and passengers. Terminal 13A is inter district as well as intra district passenger terminal for waterway movement.

Table 15.220 Traffic at Terminal 13A ('000)

Passenger	FY24	FY27	FY32	FY37	FY42	FY47	FY54
Total	832	857	901	947	995	1,046	1,046

- **Capital Cost**

This section represents the total capital expenditure in a phased manner for Terminal 13A proposed at SujawanGhat for passenger movement in River Yamuna.

Table 15.221 Project Cost for Construction Terminals-13A(INR Lakhs)

S. No.	Description	Total Cost (INR Lakhs)
A	Terminal	4,280
B	Approach Road	322
C	Building	160
D	Other Charges	2,781
	Total Capex	7,544

Detailed cost of passenger handling &other supporting infrastructure required at terminal is listed in the table below.

Table 15.222Infrastructure Requirement Cost at Terminals-13A (INR Lakhs)

S.No	Description	No.	Amount in lakhs
1	Parking Area	1	15
2	Cafe	1	20
3	Restroom	1	25
5	Waiting Hall	1	20
6	Ticket Counter	1	10
7	Admin Building	1	20
8	Toilet	1	10
9	Fencing and Guard room	1	30
10	Changing room	1	10
	Total		**160**

- **Project Financing**

Construction Phase 1 has been assumed to be funded in an Equity-Debt ratio of 35:65. Details of the means of financing for the phases are shown below.

Table 15.223 Equity-Debt Share Distribution for Terminal 13A(INR Lakhs)

Particulars	%	Phase 1
Equity	35%	2,640
Debt	65%	4,903

- **Financial Indicators**

This section shows the financial indicator that leads to the generation of FIRR for Terminal – 13A. Revenue, Salary, Depreciation, Cash Flow, P&L Statement & Balance Sheet helps on understanding the returns on investment made for this terminal.

Revenue from Terminal 13A proposed on River Yamuna will be generated from passenger and viewing deck charges. The detailed breakup of revenue is shown in the table above.

Table 15.224 Revenue from Terminals-13A (INR Lakhs)

Particulars	FY25	FY27	FY32	FY37	FY42	FY47	FY54
Intra							
Passenger Charges	-	79	83	88	92	97	97
Viewing Deck	-	318	334	351	369	388	388
Inter							
Passenger Charges	-	142	149	156	164	173	173
Viewing Deck	-	0	0	0	0	0	0
Total Revenue	-	539	566	595	625	657	657

The following table indicates the direct operating cost for development of Terminal 13a.

Table 15.225 Direct Operating & Maintenance Cost for Terminal 13A (INR Lakhs)

Particulars	FY25	FY27	FY32	FY37	FY42	FY47	FY54
Direct Operating Costs							
Maintenance Cost							
Civil	47.6	47.6	47.6	47.6	47.6	47.6	47.6
Mechanical	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Utilities		280.7	280.7	280.7	280.7	280.7	280.7
Systems and IT	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Maintenance Cost	47.6	328.3	328.3	328.3	328.3	328.3	328.3
Insurance Cost							
Civil Insurance	47.6	34.4	15.3	6.8	3.0	1.3	0.4
Mechanical Insurance	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Insurance Cost	47.6	34.4	15.3	6.8	3.0	1.3	0.4
Total Cost	95.2	362.7	343.6	335.1	331.3	329.6	328.7

The operator would share 4% of its revenue with IWAI and pay royalty of 10% of Passenger fee for terminal. The table below indicates the amount of total outflow to IWAI in case of Terminal 13A.

Table 15.226 Regulatory Royalty to IWAI for Terminal 13A (INR Lakhs)

Particulars	FY23	FY27	FY32	FY37	FY42	FY47	FY54
Royalty to IWAI	-	17	18	19	20	21	21
Revenue Share	-	22	23	24	25	26	27
Total Outflow to IWAI	-	39	41	43	45	47	48

The following table depicts the P/L statement for development of Terminal 13Aon River Yamuna near SujawanGhat.

Table 15.227 Profit & Lost Statement for Terminal 13A (INR Lakhs)

Particulars	FY23	FY27	FY32	FY37	FY42	FY47	FY54
Revenue	0	539	566	595	625	657	657
Cost	95	762	745	739	739	740	739
PBDIT	-95	-223	-179	-145	-113	-83	-82
Depreciation	0	858	301	301	0	0	0
Interest	539	462	270	77	0	0	0
PBT	-635	-1,543	-750	-523	-113	-83	-82
Tax	0	0	0	0	0	0	0
PAT	-635	-1,543	-750	-523	-113	-83	-82

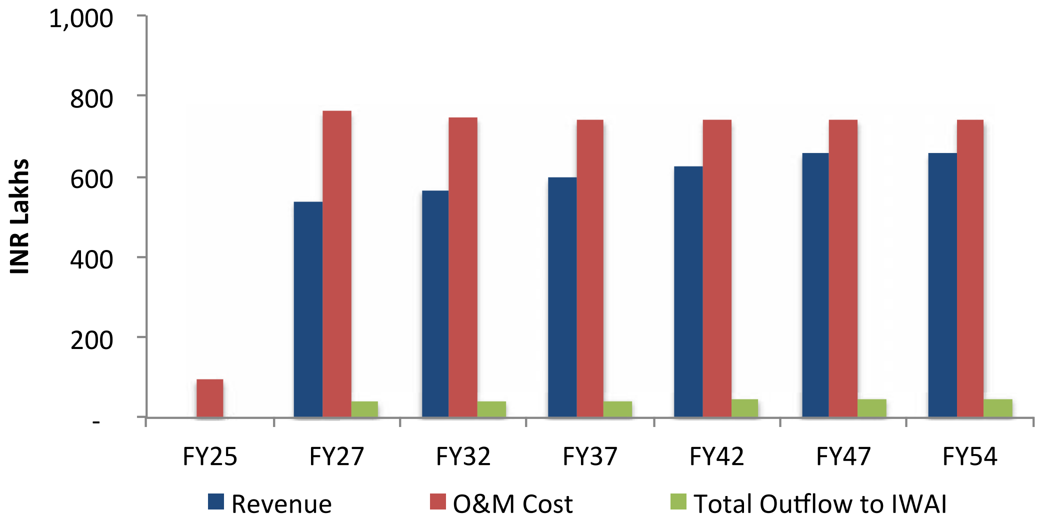

Fig.15.40Comparison among Revenue, O&M Cost and Total Outflow to IWAI

Depreciation has been calculated using the Straight Line Method (SLM). Under this method, cost of asset is evenly distributed across its useful life. Straight Line Method (SLM) has been used to calculate depreciation for Terminal 13a, under which the cost of tangible and intangible assets are evenly distributed across its life.

Table 15.228 Depreciation for Terminal 13A(INR Lakhs)

Depreciation & Amortization - SLM	FY25	FY27	FY32	FY37	FY42	FY47	FY52	FY54
Gross Block	7,544	7,544	7,544	7,544	7,544	7,544	7,544	7,544
Depreciation & Amortization	-	858	301	301	-	-	-	-
Cumulative Depreciation & Amortization	-	1,715	4,891	6,399	7,544	7,544	7,544	-
Net Block	7,544	5,828	2,652	1,145	-	-	-	7,544

The table below depicts the cash inflow & outflow in case of development of Terminal 13A.

Table 15.229 Cash Flow for Terminal 13A(INR Lakhs)

	FY23	FY27	FY32	FY37	FY42	FY47	FY54
Cash Inflow							
Investment							
Equity	2,640	-	-	-	-	-	-
Debt	4,903	-	-	-	-	-	-
Net Cash from Investment	7,544	-	-	-	-	-	-
Operations							
PBDIT	-95	-223	-179	-145	-113	- 83	- 82
(-) Taxes Paid	-	-	-	-	-	-	-
Net Cash from Operations	-95	-223	-179	-145	-113	- 83	- 82
Total Cash Inflow	7,448	-223	-179	-145	-113	- 83	- 82
Cash Outflow							
Capital Investment	7,544	-	-	-	-	-	-
Long Term Debt	-	350	350	350	-	-	-
Interest	539	462	270	77	-	-	-
Total Cash Outflow	8,083	813	620	427	-	-	-
Net Cash Flow	-635	- 1,036	-799	-572	-113	-83	-82
Opening Balance of Cash	-	-1,720	-6,421	-9,960	-11,786	-12,291	-12,866
Closing Balance Cash	- 635	- 2,756	-7,220	-10,532	-11,899	-12,373	-12,947

Table 15.230 Balance Sheet for Terminal 13A (INR Lakhs)

Sources of Funds	FY23	FY27	FY32	FY37	FY42	FY47	FY54
Shareholder's funds							
Capital	2,640	2,640	2,640	2,640	2,640	2,640	2,640
Reserves & Surplus	-635	- 3,771	- 9,660	-12,728	-14,539	-15,014	-15,588
Borrowings							
Secured Loans	4,903	4,203	2,452	700	-	-	-
Total Funds	**6,909**	**3,072**	**- 4,568**	**-9,387**	**-11,899**	**-12,373**	**-12,947**
Usages of Fund							
Fixed Assets							
Gross Block	7,544	7,544	7,544	7,544	7,544	7,544	7,544
Less: Depreciation	-	1,715	4,891	6,399	7,544	7,544	7,544
Net Block	7,544	5,828	2,652	1,145	-	-	-
Net Current Assets	-635	- 2,756	- 7,220	-10,532	-11,899	-12,373	-12,947
Total Assets	**6,909**	**3,072**	**- 4,568**	**-9,387**	**-11,899**	**-12,373**	**-12,947**

- **Financial IRR**

  Financial FIRR presented below will help IWAI to measure the financial returns on investment and assist take a firm decision on the implementation of this development. Final viability assessment for developing passenger handling terminal on this River Yamuna would be done based on this outcome.

Table 15.231 Financial IRR Calculation for Terminal 13A (INR Lakhs)

Particulars	FY23	FY27	FY32	FY37	FY42	FY47	FY54
PBDIT	-95	-223	-179	-145	-113	-83	-82
Interest	539	462	270	77	0	0	0
Principal repayment	0	350	350	350	0	0	0
Equity	2,640	0	0	0	0	0	0
Debt	4,903	0	0	0	0	0	0
Total Investment	7,544	0	0	0	0	0	0
Tax	0	0	0	0	0	0	0
Cash flow to Equity(Pre-tax)	-3,275	-1,036	-799	-572	-113	-83	-82
Equity IRR(Pre-tax)	N.A						
Cash flow to Equity(Post-tax)	-3,275	-1,036	-799	-572	-113	-83	-82
Equity IRR(Post-tax)	N.A						
Project Cash flow(Pre-tax)	-7,639	-223	-179	-145	-113	-83	-82
Project IRR(Pre-tax)	N.A						
Project Cash flow(Post-tax)	-7,639	-223	-179	-145	-113	-83	-82
Project IRR(Post-tax)	N.A						

15.3.3.7 Terminal 13B – Intra District Passenger Terminal

- **Salary Calculation for Passenger Terminals**

The below table depicts proposed salaries for employees in passenger terminal.

Table 15.232Assumptions for Manpower Salary at Terminal 13B

Manpower	No.	Annual
Manager	1	1,080,000
Admin Officer	1	480,000
		-
Electrician	1	240,000
Mechanic	1	240,000
Operator	1	720,000
Civil Supervisor	1	600,000
Ticket Counter	2	480,000
Hospitality	1	180,000
Security	3	540,000
Total		**4,560,000**

- **Phasing**

Terminal 13B is proposed to be developed in Phase 1 i.e. from FY24. This is the first phase of development, in this phase would become operational within the region of Prayagraj. The construction of infrastructure, connectivity will take 1 year and the terminal will get operational from FY26 for next 30 years.

Table 15.233 Development of Terminal 13B

No. of Jetties	Chainage (km)	FY24–FY25	FY26to FY54
1	3.4	Construction -1 Jetties	
			Operational -1Jetties

- **Traffic**

This terminal is proposed for handling inter-district tourist and passengers movement.

Table 15.234 Traffic at Terminal 13B ('000)

Passenger	FY25	FY30	FY35	FY40	FY45	FY50	FY54
Total	445	468	491	516	543	554	554

- **Capital Cost**

This section represents the total capital expenditure in a phased manner for Terminal 13B proposed at SaraswatiGhat, Prayagraj for passenger handling in River Yamuna.

Table 15.235 Project Cost for Construction Terminals-13B(INR Lakhs)

S. No.	Description	Total Cost (INR Lakhs)
A	Terminal	990
B	Approach Road	0
C	Building	160
D	Other Charges	2,781
	Total Capex	3,931

Detailed cost of passenger handling & other supporting infrastructure required at terminal is listed in the table below.

Table 15.236Infrastructure Requirement Cost at Terminals-13B (INR Lakhs)

S.No	Description	No.	Rate in lakhs	Amount in lakhs
1	Parking Area	1	15	15
2	Cafe	1	20	20
3	Restroom	1	25	25
5	Waiting Hall	1	20	20
6	Ticket Counter	1	10	10
7	Admin Building	1	20	20
8	Toilet	1	10	10
9	Fencing and Guard room	1	30	30
10	Changing room	1	10	10
	Total			**160**

- **Project Financing**

Construction Phase 1 has been assumed to be funded in an Equity-Debt ratio of 35:65. Details of the means of financing for both the phases are shown below.

Table 15.237 Equity-Debt Share Distribution for Terminal 13B(INR Lakhs)

Particulars	%	Phase 1
Equity	35%	1,376
Debt	65%	2,555

- **Financial Indicators**

This section shows the financial indicator that leads to the generation of FIRR for Terminal – 13B. Revenue, Salary, Depreciation, Cash Flow, P&L Statement & Balance Sheet helps on understanding the returns on investment made for this terminal.

Revenue from Terminal 13B proposed on River Yamuna will be generated from passenger and viewing deck charges.

Table 15.238 Revenue from Terminals-13B (INR Lakhs)

Particulars	FY25	FY27	FY32	FY37	FY42	FY47	FY54
Vessels Charges	0	2	2	2	2	2	2
Passenger Charges		45	48	50	53	55	55
Viewing Deck		182	191	200	211	221	221
Total Revenue	**0**	**229**	**241**	**253**	**266**	**279**	**279**

The following table indicates the direct operating cost for development of Terminal 13B. The below table indicates maintenance & insurance cost in detail.

Table 15.239 Maintenance & Insurance Cost for Terminal 13B(INR Lakhs)

Particulars	FY25	FY27	FY32	FY37	FY42	FY47	FY54
Maintenance Cost							
Civil	11.5	11.5	11.5	11.5	11.5	11.5	11.5
Mechanical	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Utilities		82.5	82.5	82.5	82.5	82.5	82.5
Systems and IT	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Maintenance Cost	11.5	94.0	94.0	94.0	94.0	94.0	94.0
Insurance Cost							
Civil Insurance	11.5	8.3	3.7	1.6	0.7	0.3	0.1
Mechanical Insurance	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Insurance Cost	11.5	8.3	3.7	1.6	0.7	0.3	0.1
Total Cost	23.0	102.3	97.7	95.6	94.7	94.3	94.1

The operator would share 4% of its revenue with IWAI and pay royalty of 10% of passenger fee for terminal. The table below indicates the amount of total outflow to IWAI in case of Terminal 13B.

Table 15.240 RegulatoryRoyalty to IWAI for Terminal 13B (INR Lakhs)

Particulars	FY23	FY27	FY32	FY37	FY42	FY47	FY54
Royalty to IWAI	-	9	9	10	10	11	11

Revenue Share	-	9	10	10	11	11	11
Total Outflow to IWAI	-	18	19	20	21	22	22

The following table depicts the P/L statement for development of Terminal 13Bon River Yamuna near SaraswatiGhat.The terminal will start generating profit after Fy-37.

Table 15.241 Profit & Lost Statement for Terminal 13B (INR Lakhs)

Particulars	**FY25**	**FY27**	**FY32**	**FY37**	**FY42**	**FY47**	**FY54**
Revenue	-	231	243	255	268	282	282
O & M Cost	23	171	167	167	167	168	168
PBDIT	-23	60	75	88	101	114	114
Depreciation	-	629	73	73	-	-	-
Interest	281	241	141	40	-	-	-
PBT	-304	-810	-138	-24	101	114	114
Tax	-	-	-	-	30	34	34
PAT	**-304**	**-810**	**-138**	**-24**	**71**	**80**	**80**

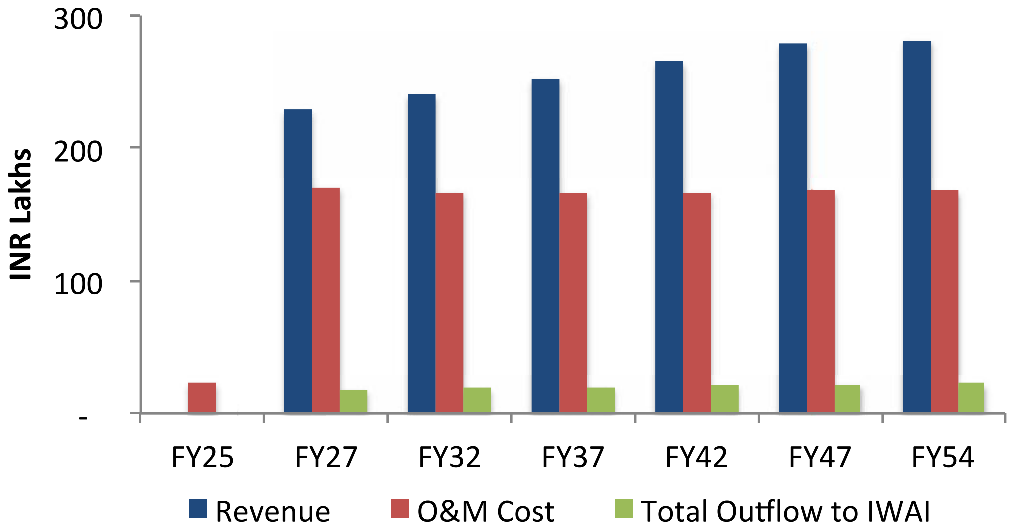

Fig. 15.41Comparison among Revenue, O&M Cost and Total Outflow to IWAI

Depreciation has been calculated using the Straight Line Method (SLM). Under this method, cost of asset is evenly distributed across its useful life. Straight Line Method (SLM) has been used to calculate depreciation for Terminal 13B, under which the cost of tangible and intangible assets are evenly distributed across its life.

Table 15.242 Depreciation for Terminal 13B(INR Lakhs)

Depreciation & Amortization - SLM	**FY25**	**FY27**	**FY32**	**FY37**	**FY42**	**FY47**	**FY54**
Gross Block	3,931	3,931	3,931	3,931	3,931	3,931	3,931
Depreciation & Amortization	-	629	73	73	-	-	-
Cumulative Depreciation &Amortization	-	1,258	3,291	3,655	3,931	3,931	3,931

Depreciation & Amortization - SLM	FY25	FY27	FY32	FY37	FY42	FY47	FY54
Net Block	**3,931**	**2,673**	**640**	**276**	**-**	**-**	**-**

The table below depicts the cash inflow & outflow in case of development of Terminal 13b.

Table 15.243 Cash Flow for Terminal 13B(INR Lakhs)

	FY25	FY27	FY32	FY37	FY42	FY47	FY54
Cash Inflow							
Investment							
Equity	1,376	-	-	-	-	-	-
Debt	2,555	-	-	-	-	-	-
Net Cash from Investment	3,931	-	-	-	-	-	-
Operations							
PBDIT	-23	60	75	88	101	114	114
(-) Taxes Paid	-	-	-	-	30	34	34
Net Cash from Operations	-23	60	75	88	71	80	80
Total Cash Inflow	3,908	60	75	88	71	80	80
Cash Outflow							
Capital Investment	3,931	-	-	-	-	-	-
Long Term Debt	-	183	183	183	-	-	-
Interest	281	241	141	40	-	-	-
Total Cash Outflow	4,212	423	323	223	-	-	-
Net Cash Flow	-304	-363	- 248	- 134	71	80	80
Opening Balance of Cash	-	-682	- 2,267	- 3,278	- 3,443	- 3,072	- 2,513
Closing Balance Cash	-304	-1,045	- 2,514	- 3,412	- 3,373	- 2,992	- 2,434

Table 15.244 Balance Sheet for Terminal 13B (INR Lakhs)

Sources of Funds	FY25	FY27	FY32	FY37	FY42	FY47	FY54
Shareholder's funds							
Capital	1,376	1,376	1,376	1,376	1,376	1,376	1,376
Reserves & Surplus	-304	-1,939	-4,528	-4,877	-4,748	-4,368	-3,809
Borrowings							
Secured Loans	2,555	2,190	1,278	365	-	-	-
Total Funds	**3,627**	**1,628**	**- 1,874**	**- 3,136**	**- 3,373**	**- 2,992**	**- 2,434**
Usages of Fund							
Fixed Assets	3,627	1,628	- 1,874	- 3,136	- 3,373	- 2,992	- 2,434
Gross Block	3,931	3,931	3,931	3,931	3,931	3,931	3,931
Less: Depreciation	-	1,258	3,291	3,655	3,931	3,931	3,931

Sources of Funds	FY25	FY27	FY32	FY37	FY42	FY47	FY54
Net Block	3,931	2,673	640	276	-	-	-
Net Current Assets	-304	- 1,045	- 2,514	- 3,412	- 3,373	- 2,992	- 2,434
Total Assets	**3,627**	**1,628**	**- 1,874**	**- 3,136**	**- 3,373**	**- 2,992**	**- 2,434**

- **Financial IRR**

Financial FIRR presented below will help IWAI to measure the financial returns on investment and assist take a firm decision on the implementation of this development. Final viability assessment for developing passenger handling terminal on this River Yamuna would be done based on this outcome.

Table 15.245 Financial IRR Calculation for Terminal 13B (INR Lakhs)

Particulars	FY25	FY27	FY32	FY37	FY42	FY47	FY54
PBDIT	-23	60	75	88	101	114	114
Interest	281	241	141	40	0	0	0
Principal repayment	0	183	183	183	0	0	0
Equity	1,376	0	0	0	0	0	0
Debt	2,555	0	0	0	0	0	0
Total Investment	3,931	0	0	0	0	0	0
Tax	0	0	0	0	30	34	34
Cash flow to Equity(Pre-tax)	-1,680	-363	-248	-134	101	114	114
Equity IRR(Pre-tax)	N.A						
Cash flow to Equity(Post-tax)	-1,680	-363	-248	-134	71	80	80
Equity IRR(Post-tax)	N.A						
Project Cash flow(Pre-tax)	-3,954	60	75	88	101	114	114
Project IRR(Pre-tax)	N.A						
Project Cash flow(Post-tax)	-3,954	60	75	88	71	80	80
Project IRR(Post-tax)	N.A						

15.3.3.7 Terminal 13C – Intra District Passenger Terminal

- **Salary Calculation for Passenger Terminals**

The below table depicts proposed salaries for employees in each passenger terminal.

Table 15.246Assumptions for Manpower Salary at Terminal 13C

Manpower	No.	Salary	Annual Salary (INR)
Manager	1	90,000	10,80,000
Admin Officer	1	40,000	4,80,000
Electrician	1	20,000	2,40,000
Mechanic	1	20,000	2,40,000
Operator	1	60,000	7,20,000

Manpower	No.	Salary	Annual Salary (INR)
Civil Supervisor	1	50,000	6,00,000
Ticket Counter	2	20,000	4,80,000
Hospitality	1	15,000	1,80,000
Security	3	15,000	5,40,000
Total			**45,60,000**

- **Phasing**

Terminal 13c is proposed to be developed in Phase 1 i.e. from FY24. This is the first phase of development, in this phase would become operational i.e. within Prayagraj. The construction of infrastructure, connectivity will take 1 year and the terminal will get operational from FY26 for next 30 years.

Table 15.247 Development of Terminal 13C

No. of Jetties	Chainage (km)	FY24–FY25	FY26to FY54
1	4	Construction -1 Jetties	
			Operational -1 Jetties

- **Traffic**

This terminal is proposed for handling tourist and passengers. Traffic for Terminal 13C for next 30 years is projected in the table below.

Table 15.248 Traffic at Terminal 13C ('000)

Passenger	FY25	FY30	FY35	FY40	FY45	FY50	FY54
Total	556	584	614	646	678	692	692

- **Capital Cost**

This section represents the total capital expenditure in a phased manner for Terminal 13c proposed near Boat Club in River Yamuna.

Table 15.249 Project Cost for Construction Terminals-13C(INR Lakhs)

S. No.	Description	Total Cost (INR Lakhs)
A	Terminal	990
B	Approach Road	0
C	Building	160
D	Other Charges	2,781
	Total Capex	3,931

Detailed cost of passenger movement and other supporting infrastructure required at terminal is listed in the table below.

Table 15.250 Infrastructure Requirement Cost at Terminals-13C (INR Lakhs)

S.No	Description	No.	Amount in lakhs
1	Parking Area	1	15
2	Cafe	1	20
3	Restroom	1	25
4	Waiting Hall	1	20
5	Ticket Counter	1	10
6	Admin Building	1	20
7	Toilet	1	10
8	Fencing and Guard room	1	30
9	Changing room	1	10
	Total		**160**

- **Project Financing**

Construction Phase 1 has been assumed to be funded in an Equity-Debt ratio of 35:65. Details of the means of financing for both the phases are shown below.

Table 15.251 Equity-Debt Share Distribution for Terminal 13C(INR Lakhs)

Particulars	%	Phase 1
Equity	35%	1,376
Debt	65%	2,555

- **Financial Indicators**

This section shows the financial indicator that leads to the generation of FIRR for Terminal – 13c. Revenue, Salary, Depreciation, Cash Flow, P&L Statement & Balance Sheet helps on understanding the returns on investment made for this terminal.

Revenue from Terminal 13c proposed on River Yamuna will be generated from passenger & viewing deck charges. The detailed breakup of revenue is shown in the table below.

Table 15.252 Revenue from Terminals-13C (INR Lakhs)

Particulars	FY25	FY27	FY32	FY37	FY42	FY47	FY50	FY54
Vessels Charges	**-**	**2**	**3**	**3**	**3**	**3**	**3**	**2**
Intra								
Passenger Charges		57	60	63	66	69	69	57
Viewing Deck		227	238	251	263	277	277	227
Total Revenue from Passenger	**-**	**286**	**301**	**316**	**332**	**349**	**349**	**286**

The following table indicates the direct operating cost for development of Terminal 13 c.

Table 15.253 Direct Operating & Maintenance Cost for Terminal 13C(INR Lakhs)

Particulars	FY25	FY27	FY32	FY37	FY42	FY47	FY54
Direct Operating Costs							
Maintenance Cost							
Civil	11.5	11.5	11.5	11.5	11.5	11.5	11.5
Mechanical	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Utilities		81.6	81.6	81.6	81.6	81.6	81.6
Systems and IT	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Maintenance Cost	11.5	93.1	93.1	93.1	93.1	93.1	93.1
Insurance Cost							
Civil Insurance	11.5	8.3	3.7	1.6	0.7	0.3	0.1
Mechanical Insurance	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Insurance Cost	11.5	8.3	3.7	1.6	0.7	0.3	0.1
Total Cost	23.0	101.4	96.7	94.7	93.8	93.4	93.2

The operator would share 4% of its revenue with IWAI and pay royalty fee of 10% of passenger fee for terminal. The table below indicates the amount of total outflow to IWAI in case of Terminal 13c.

Table 15.254 RegulatoryRoyalty to IWAI for Terminal 13C (INR Lakhs)

Particulars	FY23	FY27	FY32	FY37	FY42	FY47	FY54
Royalty to IWAI	-	12	12	13	13	14	14
Revenue Share	-	12	12	13	14	14	14
Total Outflow to IWAI	-	23	25	26	27	28	28

The Table above summaries the Revenue generated by operation of Terminal 13C and total cost i.e. O&M cost and out-flow to IWAI (Royalty and Revenue Share) from FY26 till FY54.

The following table depicts the P/L statement for development of Terminal 13con River Yamuna near Boat club.

Table 15.255 Profit & Lost Statement for Terminal 13C (INR Lakhs)

Particular	FY25	FY27	FY32	FY37	FY42	FY47	FY54
Revenue	0	289	303	319	335	352	352
O & M Cost	23	176	172	172	173	174	128
PBDIT	-23	113	131	147	162	178	224
Depreciation	0	629	73	73	0	0	0
Interest	281	241	141	40	0	0	0
PBT	-304	-757	-83	34	162	178	224
Tax	0	0	0	10	49	53	67
PAT	**-304**	**-757**	**-83**	**24**	**114**	**125**	**157**

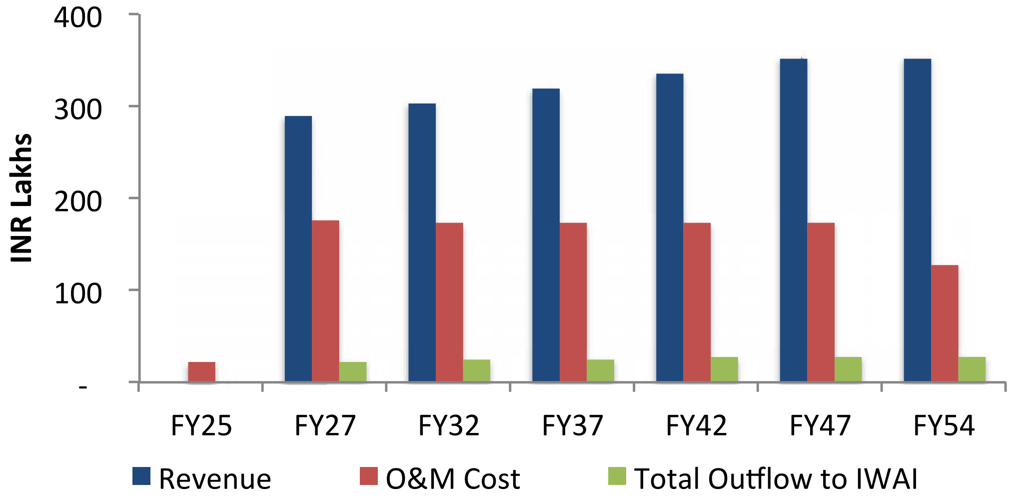

Fig. 15.42Comparison among Revenue, O&M Cost and Total Outflow to IWAI

Depreciation has been calculated using the Straight Line Method (SLM). Under this method, cost of asset is evenly distributed across its useful life. Straight Line Method (SLM) has been used to calculate depreciation for Terminal 13c, under which the cost of tangible and intangible assets are evenly distributed across its life.

Table 15.256 Depreciation for Terminal 13C(INR Lakhs)

Depreciation & Amortization - SLM	FY25	FY27	FY32	FY37	FY42	FY47	FY54
Gross Block	3,931	3,931	3,931	3,931	3,931	3,931	3,931
Depreciation & Amortization	-	629	73	73	-	-	-
Cumulative Depreciation & Amortization	-	1,258	3,291	3,655	3,931	3,931	3,931
Net Block	3,931	2,673	640	276	-	-	-

The table below depicts the cash inflow & outflow in case of development of Terminal 13c.

Table 15.257 Cash Flow for Terminal 13C(INR Lakhs)

Particulars	FY25	FY27	FY32	FY37	FY42	FY47	FY54
Cash Inflow							
Equity	1,376	-	-	-	-	-	-
Debt	2,555	-	-	-	-	-	-
Net Cash from Investment	3,931	-	-	-	-	-	-
PBDIT	-23	113	131	147	162	178	224
(-) Taxes Paid	-	-	-	10	49	53	67
Net Cash from Operations	-23	113	131	137	114	125	157
Total Cash Inflow	3,908	113	131	137	114	125	157
Cash Outflow							
Capital Investment	3,931	-	-	-	-	-	-
Long Term Debt	-	183	183	183	-	-	-

Particulars	FY25	FY27	FY32	FY37	FY42	FY47	FY54
Interest	281	241	141	40	-	-	-
Total Cash Outflow	4,212	423	323	223	-	-	-
Net Cash Flow	-304	-310	- 192	-86	114	125	157
Opening Balance of Cash	-	- 639	-1,953	-2,685	-2,634	-2,044	-1,042
Closing Balance Cash	-304	-949	-2,146	-2,771	-2,520	-1,919	-886

Table 15.258 Balance Sheet for Terminal 13C (INR Lakhs)

Sources of Funds	FY25	FY27	FY32	FY37	FY42	FY47	FY54
Shareholder's funds							
Capital	1,376	1,376	1,376	1,376	1,376	1,376	1,376
Reserves & Surplus	- 304	- 1,842	- 4,159	- 4,235	- 3,896	- 3,295	- 2,262
Borrowings							
Secured Loans	2,555	2,190	1,278	365	-	-	-
Total Funds	3,627	1,724	- 1,505	- 2,494	- 2,520	- 1,919	- 886
Usages of Fund							
Fixed Assets							
Gross Block	3,931	3,931	3,931	3,931	3,931	3,931	3,931
Less: Depreciation	-	1,258	3,291	3,655	3,931	3,931	3,931
Net Block	3,931	2,673	640	276	-	-	-
Net Current Assets	-304	-949	- 2,146	- 2,771	- 2,520	- 1,919	-886
Total Assets	3,627	1,724	- 1,505	- 2,494	- 2,520	- 1,919	-886

- **Financial IRR**

Financial FIRR presented below will help IWAI to measure the financial returns on investment and assist take a firm decision on the implementation of this development. Final viability assessment for developing passenger handling terminal on this River Yamuna would be done based on this outcome.

Table 15.259 Financial IRR Calculation for Terminal 13C (INR Lakhs)

Particulars	FY25	FY27	FY32	FY37	FY42	FY47	FY54
PBDIT	-23	113	131	147	162	178	224
Interest	281	241	141	40	0	0	0
Principal repayment	0	183	183	183	0	0	0
Equity	1,376	0	0	0	0	0	0
Debt	2,555	0	0	0	0	0	0
Total Investment	3,931	0	0	0	0	0	0
Tax	0	0	0	10	49	53	67
Cash flow to Equity(Pre-tax)	-1,680	-310	-192	-76	162	178	224
Equity IRR(Pre-tax)	N.A						
Cash flow to Equity(Post-tax)	-1,680	-310	-192	-86	114	125	157
Equity IRR(Post-tax)	N.A						
Project Cash flow(Pre-tax)	-3,954	113	131	147	162	178	224
Project IRR(Pre-tax)	1%						
Project Cash flow(Post-tax)	-3,954	113	131	137	114	125	157
Project IRR(Post-tax)	**N.A**						

15.3.3.8 Terminal 13D – Intra District Passenger Terminal

- **Salary Calculation for Passenger Terminals**

The below table depicts proposed salaries for employees in the passenger terminal.

Table 15.260 Assumptions for Manpower Salary at Terminal 13D

Manpower	No.	Salary	Annual
Manager	1	90,000	10,80,000
Admin Officer	1	40,000	4,80,000
Electrician	1	20,000	2,40,000
Mechanic	1	20,000	2,40,000
Operator	1	60,000	7,20,000
Civil Supervisor	1	50,000	6,00,000
Ticket Counter	2	20,000	4,80,000
Hospitality	1	15,000	1,80,000
Security	3	15,000	5,40,000
Total			**45,60,000**

- **Phasing**

Terminal 13D is proposed to be developed in Phase 1 i.e. from FY24. This is the first phase of development, in this phase would become operational i.e. within Prayagraj. The construction of infrastructure, connectivity will take 1 years and the terminal will get operational from FY26 for next 30 years.

Table 15.261 Development of Terminal 13D

No. of Jetties	Chainage (km)	FY24–FY25	FY26to FY54
1	2	Construction -1 Jetties	
			Operational -1 Jetties

- **Traffic**

Traffic for Terminal 13Dfor next 30 years is projected in the table below.

Table 15.262 Traffic at Terminal 13D ('000)

Passenger	FY24	FY25	FY30	FY35	FY40	FY45	FY50	FY54
Total	440	445	468	491	516	543	554	554

- **Capital Cost**

This section represents the total capital expenditure in a phased manner for Terminal 13D proposed at Hanuman Ghat for passenger handling in River Yamuna.

Table 15.263 Project Cost for Construction Terminals-13D (INR Lakhs)

S. No.	Description	Total Cost (INR Lakhs)
A	Terminal	990
B	Approach Road	56
C	Building	150
D	Other Charges	2,781
	Total Capex	3,978

Detailed cost of passenger movement and other supporting infrastructure required at terminal is listed in the table below.

Table 15.264Infrastructure Requirement Cost at Terminals-13D (INR Lakhs)

S.No	Description	No.	Amount in lakhs
1	Parking Area	1	15
2	Cafe	1	20
3	Restroom	1	25
4	Waiting Hall	1	20
5	Ticket Counter	1	10
6	Admin Building	1	20
7	Toilet	1	10
8	Fencing and Guard room	1	30
9	Changing room	1	10
Total			**160**

- **Project Financing**

Construction Phase 1 has been assumed to be funded in an Equity-Debt ratio of 35:65. Details of the means of financing for both the phases are shown below.

Table 15.265 Equity-Debt Share Distribution for Terminal 13D (INR Lakhs)

Particulars	%	Phase 1
Equity	35%	1,392
Debt	65%	2,585

- **Financial Indicators**

This section shows the financial indicator that leads to the generation of FIRR for Terminal – 13D. Revenue, Salary, Depreciation, Cash Flow, P&L Statement & Balance Sheet helps on understanding the returns on investment made for this terminal.

Revenue from Terminal 13D proposed on River Yamuna will be generated from passenger & viewing deck charges. The detailed breakup of revenue is shown in the table below.

Table 15.266 Revenue from Terminal-13D (INR Lakhs)

Particulars	FY25	FY27	FY32	FY37	FY42	FY47	FY54
Vessels Charges	-	**2**	**2**	**2**	**2**	**2**	**2**
Intra							
Passenger Charges	-	44	47	49	52	54	55
Viewing Deck	-	178	187	197	207	217	221
Total Revenue from Passenger	**-**	**224**	**236**	**248**	**260**	**274**	**279**

The following table indicates the direct operating cost for development of Terminal 13 D.

Table 15.267 Direct Operating & Maintenance Cost for Terminal 13D(INR Lakhs)

Particulars	FY25	FY27	FY32	FY37	FY42	FY47	FY54
Direct Operating Costs							
Maintenance Cost							
Civil	12.0	12.0	12.0	12.0	12.0	12.0	12.0
Mechanical	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Utilities		81.7	81.7	81.7	81.7	81.7	81.7
Systems and IT	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Maintenance Cost	12.0	93.6	93.6	93.6	93.6	93.6	93.6
Insurance Cost							
Civil Insurance	12.0	8.6	3.8	1.7	0.8	0.3	0.1
Mechanical Insurance	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Insurance Cost	12.0	8.6	3.8	1.7	0.8	0.3	0.1
Total Cost	23.9	102.3	97.5	95.3	94.4	94.0	93.7

The operator would share 4% of its revenue with IWAI and pay royalty fee of 10% of passenger fee for terminal. The table below indicates the amount of total outflow to IWAI in case of Terminal 13D.

Table 15.268 RegulatoryRoyalty to IWAI for Terminal 13D (INR Lakhs)

Particulars	FY25	FY27	FY32	FY37	FY42	FY47	FY54
Royalty to IWAI	-	9	9	10	10	11	11
Revenue Share	-	9	10	10	11	11	11
Total Outflow to IWAI	-	18	19	20	21	22	22

The Table above summaries the Revenue generated by operation of Terminal 13D and total cost i.e. O&M cost and out-flow to IWAI (Royalty and Revenue Share) from FY26 till FY54.

The following table depicts the P/L statement for development of Terminal 13Don River Yamuna near Hanuman Ghat.

Table 15.269 Profit & Lost Statement for Terminal 13D (INR Lakhs)

Particulars	FY25	FY27	FY32	FY37	FY42	FY47	FY54
Revenue	0	226	238	250	263	276	282
O & M Cost	24	170	167	166	166	167	167
PBDIT	-24	56	71	84	97	109	114
Depreciation	0	632	76	76	0	0	0
Interest	284	244	142	41	0	0	0
PBT	-308	-820	-147	-32	97	109	114
Tax	0	0	0	0	29	33	34

Particulars	FY25	FY27	FY32	FY37	FY42	FY47	FY54
PAT	-308	-820	-147	-32	68	76	80

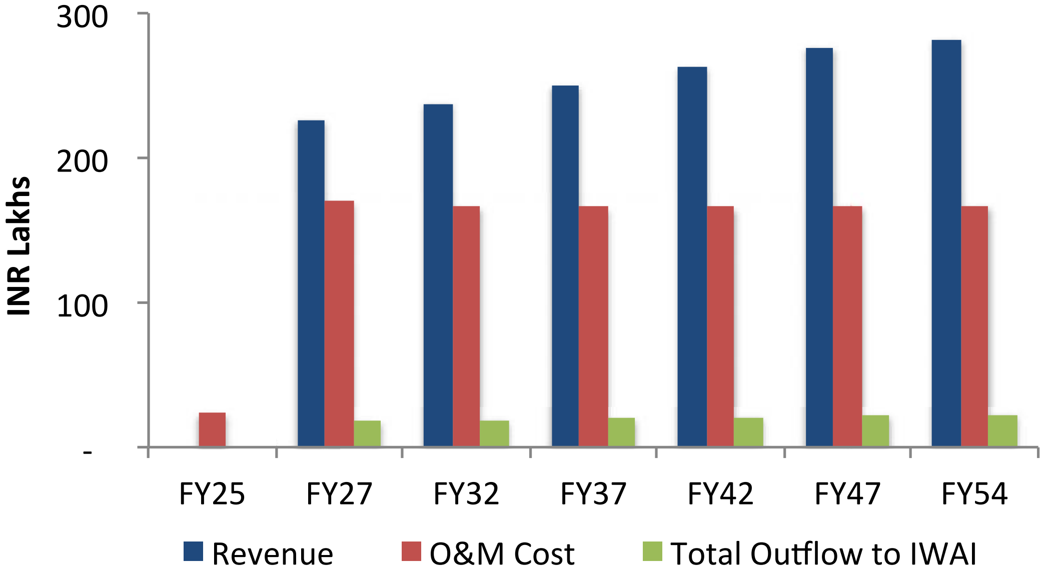

Fig. 15.43Comparison among Revenue, O&M Cost and Total Outflow to IWAI

Depreciation has been calculated using the Straight Line Method (SLM). Under this method, cost of asset is evenly distributed across its useful life. Straight Line Method (SLM) has been used to calculate depreciation for Terminal 13D, under which the cost of tangible and intangible assets are evenly distributed across its life.

Table 15.270 Depreciation for Terminal 13D(INR Lakhs)

Depreciation & Amortization - SLM	FY25	FY27	FY32	FY37	FY42	FY47	FY54
Gross Block	3,978	3,978	3,978	3,978	3,978	3,978	3,978
Depreciation & Amortization	-	632	76	76	-	-	-
Cumulative Depreciation & Amortization	-	1,264	3,311	3,690	3,978	3,978	3,978
Net Block	3,978	2,714	666	288	-	-	-

The table below depicts the cash inflow & outflow in case of development of Terminal 13D.

Table 15.271 Cash Flow for Terminal 13D(INR Lakhs)

Particulars	FY25	FY27	FY32	FY37	FY42	FY47	FY54
Cash Inflow							
Investment							
Equity	1,392	-	-	-	-	-	-
Debt	2,585	-	-	-	-	-	-
Net Cash from Investment	3,978	-	-	-	-	-	-
Operations							
PBDIT	-24	56	71	84	97	109	114
(-) Taxes Paid	-	-	-	-	29	33	34

Particulars	FY25	FY27	FY32	FY37	FY42	FY47	FY54
Net Cash from Operations	-24	56	71	84	68	76	80
Total Cash Inflow	3,954	56	71	84	68	76	80
Cash Outflow							
Capital Investment	3,978	-	-	-	-	-	-
Long Term Debt	-	185	185	185	-	-	-
Interest	284	244	142	41	-	-	-
Total Cash Outflow	4,262	428	327	225	-	-	-
Net Cash Flow	-308	-373	-256	-141	68	76	80
Opening Balance of Cash	-	-705	- 2,332	- 3,381	- 3,569	- 3,213	- 2,659
Closing Balance Cash	-308	- 1,077	- 2,588	- 3,522	- 3,501	- 3,137	- 2,579

Table 15.272 Balance Sheet for Terminal 13D (INR Lakhs)

Sources of Funds	FY25	FY27	FY32	FY37	FY42	FY47	FY54
Shareholder's funds							
Capital	1,392	1,392	1,392	1,392	1,392	1,392	1,392
Reserves & Surplus	-308	-1,972	-4,607	-4,996	-4,894	-4,529	-3,971
Borrowings							
Secured Loans	2,585	2,216	1,293	369	0	0	0
Total Funds	3,669	1,637	-1,922	-3,235	-3,501	-3,137	-2,579
Usages of Fund							
Fixed Assets							
Gross Block	3,978	3,978	3,978	3,978	3,978	3,978	3,978
Less: Depreciation	0	1,264	3,311	3,690	3,978	3,978	3,978
Net Block	3,978	2,714	666	288	0	0	0
Net Current Assets	-308	-1,077	-2,588	-3,522	-3,501	-3,137	-2,579
Total Assets	3,669	1,637	-1,922	-3,235	-3,501	-3,137	-2,579

- **Financial IRR**

Financial FIRR presented below will help IWAI to measure the financial returns on investment and assist take a firm decision on the implementation of this development. Final viability assessment for developing passenger handling terminal on this River Yamuna would be done based on this outcome.

Table 15.273 Financial IRR Calculation for Terminal 13D (INR Lakhs)

Particulars	FY25	FY27	FY32	FY37	FY42	FY47	FY54
PBDIT	-24	56	71	84	97	109	114
Interest	284	244	142	41	0	0	0
Principal repayment	0	185	185	185	0	0	0
Equity	1,392	0	0	0	0	0	0
Debt	2,585	0	0	0	0	0	0
Total Investment	3,978	0	0	0	0	0	0
Tax	0	0	0	0	29	33	34
Cash flow to Equity(Pre-tax)	-1,701	-373	-256	-141	97	109	114
Equity IRR(Pre-tax)	N.A						
Cash flow to Equity(Post-tax)	-1,701	-373	-256	-141	68	76	80
Equity IRR(Post-tax)	N.A						

Particulars	FY25	FY27	FY32	FY37	FY42	FY47	FY54
Project Cash flow(Pre-tax)	-4,002	56	71	84	97	109	114
Project IRR(Pre-tax)	N.A						
Project Cash flow(Post-tax)	-4,002	56	71	84	68	76	80
Project IRR(Post-tax)	N.A						

15.4 Financial Analysis for Fairway

This section would discuss in detail assumptions for Financial Analysis for Fairway development on NW 110. Fairway development on NW 110 would be done in three phases, as depicted in the below table. In Phase 1, i.e. from FY 21 to FY 25, fairway would be developed in the stretch of 0-453 kms in NW 110. In Phase 2, i.e. FY 27- FY 31, fairway would be developed in the stretch of 453-743 kms in NW 110. In Phase 3, i.e. FY 32- FY 36, fairway would be developed in the stretch of 743-1,051 kms in NW 110.In the last two years of each phase, i.e. FY 24 & FY 25 in Phase 1, FY 30 & FY 31 in Phase 2 and FY 35 & FY 36 in Phase 3, terminals would also be developed along with fairway.

Table 15.274 Phase wise development of Fairway on NW110

Phases	Chainage (Km)	Duration
Phase 1	0 – 453	FY 21- FY 25
Phase 2	453 –743	FY 27 - FY 31
Phase 3	743 –1,051	FY 32 - FY 36

15.4.1.1 Inputs for Financial Analysis of development of Fairway

All the assumptions and inputs used in developing Financial Analysis for River Yamuna are listed down in below table. The Financial Analysis is done for Fairway development and operations on NW 110.

- **Assumptions for O&M Cost**

Assumptions for calculating Operation and Maintenance (O&M) Cost of Fairway on NW 110 is depicted in the below table. Operation & maintenance activities would include civil infrastructure, dredging of the identified stretch of River Yamuna, Mechanical activities, Utilities, System & IT and Insurance. It is assumed that Cost of Civil Infrastructure would be 1% of total Capital Cost (INR 12,434 Crores). 5% of total Capital Cost is considered as Mechanical Cost. Cost of Utilities is also considered 5% of total Capital Cost. It is assumed that 10% of total Capital Cost would be required for Systems & IT. Insurance cost would be 1% of Capital Investment in Civil development and 1% of Mechanical development.

Table 15.275 Assumption for Calculation of O& M Cost

Description	Item	Unit
Civil Infrastructure	1%	Total Capital Cost
Dredging	10%	Total Capital Cost
Mechanical	5%	Total Capital Cost

Description	Item	Unit
Utilities	5%	Total Capital Cost
Systems and IT	10%	Total Capital Cost
Insurance Cost	1%	Capex Civil
Insurance Cost	2%	Capex Mechanical

- **Tariff Assumptions for Fairway**

Tariff assumptions for Fairway are based on current Tariff of IWAI. The below table presents proposed tariff for using Fairway on NW 110 for handling cargo and passenger. Competitive Tariff is considered forFairwayuseon NW 110 to attract industries and passengers for using IWT on river Yamuna. As shown in the table, tariff would be charged for per km fairway. Passenger tariff for Fairway usage for Intra and Inter district movement would be different. Tariff for Inter district movement would be higher than Intra district movement, as Inter district movement would be long distance movement on NW 110. It is assumed that Passenger tariff for Intra movement would be INR 1 per person per km, whereas Passenger tariff for Inter district movement would be INR 5 per person per km.

Table 15.276 Cargo Handling Tariff for Fairway Development

Tariff	INR	Unit
Fairway - Coal	1	Per Tonne-Km
Fairway - Fly Ash	1	Per Tonne-Km
Fairway - Fertilizer	1	Per Tonne-Km
Fairway - Automobile	1	Per Tonne-Km
Fairway - Food Grains	1	Per Tonne-Km
Fairway - Sugar	1	Per Tonne-Km
Fairway - Iron & Steel	1.00	Per Tonne-Km
Fairway - Containers	1.00	Per Tonne-Km
Fairway - Intra Passengers	1.00	Per Pax-kms
Fairway - Inter district Passengers	5.00	Per Pax-kms

- **Salary Calculation for Development of Fairway**

The below table depicts proposed salaries for employees for Fairway operation on NW 110. As shown in the table, number of employees would increase in some departments in FY 36, for instance, number of employees in Hospitality in FY 21 would be 2, but in FY 36, there would be 4 numbers of employees. With increased number of employees in FY 36, cost on salary would also increase. Following below table indicates salary for manpower at Fairway Development.

Table 15.277Assumptions for Manpower at Fairway Development

Manpower	FY21	FY32	FY37	FY21	FY32	FY37
Commercial Manager	1	1	1	2,160,000	2,160,000	2,160,000
Chief Hydrographer	1	1	1	2,160,000	2,160,000	2,160,000
Admin Officer	1	2	2	480,000	960,000	960,000
Account Staff	2	3	3	720,000	1,080,000	1,080,000

Manpower	FY21	FY32	FY37	FY21	FY32	FY37
Hospitality	2	4	4	360,000	720,000	720,000
Security	4	6	15	720,000	1,080,000	2,700,000
Ops Manager	1	2	12	600,000	1,200,000	7,200,000
Supervisor	2	9	18	1,200,000	5,400,000	10,800,000
Operator	2	9	18	960,000	4,320,000	8,640,000
Drivers	3	3	3	720,000	720,000	720,000
Hydrographer	1	1	1	240,000	240,000	240,000
Surveyor	1	1	1	240,000	240,000	240,000
Dredging Supervisor	1	4	10	600,000	2,400,000	6,000,000
Workers	2	12	18	288,000	1,728,000	2,592,000
Hospitality	2	12	18	360,000	2,160,000	3,240,000

Table 15.278 Project Cost for Fairway Development (INR Crores)

Sl. No.	Description	Total Investment	Phase - I	Phase - II	Phase - III
A	Fairway	9,911	2,961	2,956	3,993
B	Navigation & Communication Cost	136	56	32	48
C	Dredging	630	429	108	93
D	Mechanical	2,478	740	739	998
	Total Capex	**13,154**	**4,186**	**3,836**	**5,132**

- **Project Financing**

Construction Phase 1, Phase 2 & Phase 3 has been assumed to be funded in an Equity-Debt ratio of 35:65. Details of the means of financing for both the phases are shown below.

Table 15.279 Equity-Debt Share Distribution for Development of Fairway (INR Crores)

Particulars	%	Phase 1	Phase 2	Phase 3
Equity	35%	1,465	1,343	1,796
Dept.	65%	2,721	2,493	3,336

- **Financial Indicators**

This section shows the financial indicator that leads to the generation of FIRR for development of Fairway. Revenue, Salary, Depreciation, Cash Flow, P&L Statement & Balance Sheet helps on understanding the returns on investment made for entire stretch.
Revenue from proposed Fairway on River Yamuna will be generated from different terminals. The detailed breakup of revenue is shown in the table above.

Table 15.280 Revenue from Fairway (INR Crores)

Terminals	Fy-25	Fy-26	Fy-32	Fy-37	Fy-45	Fy-55	Fy-65

T1	-	-	-	90.1	114.1	121.1	121.1
T2	-	-	43.8	49.4	60.3	63.4	63.4
T3	-	4.8	6.0	6.9	8.5	9.0	9.0
T4	-	18.9	23.4	26.3	32.0	33.6	33.6
T5	-	0.3	0.4	0.4	0.5	0.6	0.6
T6	-	0.1	0.1	0.1	0.2	0.2	0.2
T7	-	-	-	78.6	92.7	94.8	94.8
T8	-	5.8	6.5	15.2	16.6	17.0	17.0
T9	-	-	-	91.6	99.2	101.2	101.2
T10	-	-	14.7	15.5	16.7	17.1	17.1
T11	-	-	-	115.2	124.8	127.3	127.3
T12	-	47.8	50.8	53.4	57.8	58.9	58.9
T13	-	14.6	15.5	16.3	17.7	18.0	18.0
Total	**-**	**92.3**	**161.2**	**559.1**	**641.1**	**662.2**	**662.2**

Table 15.281 Direct Operating Cost for development of Fairway (INR Crores)

Particulars	Fy-21	Fy-26	Fy-32	Fy-37	Fy-45	Fy-55	Fy-65
Dredging	0.0	64.4	80.6	94.5	94.5	94.5	94.5
RIS Stations	5.9	5.9	9.8	15.7	15.7	15.7	15.7
Survey & Supervision	15.0	15.0	20.0	30.0	30.0	30.0	30.0
Salary	0.0	1.0	1.0	2.4	4.7	4.7	4.7
Total	**20.9**	**86.2**	**111.3**	**142.6**	**144.9**	**144.9**	**144.9**

Table 15.282 Maintenance Cost for development of Fairway (INR Crores)

Particulars	Fy-21	Fy-26	Fy-32	Fy-37	Fy-45	Fy-55	Fy-65
Civil	8.3	41.3	88.4	128.1	128.1	128.1	128.1
Mechanical	14.8	74.0	167.9	247.8	247.8	247.8	247.8
Utilities	-	-	-	-	-	-	-
Insurance Cost	9.9	31.1	52.8	56.6	15.4	3.0	0.6
Administration Cost	-	3.7	6.4	22.4	25.6	26.5	26.5
Total	**32.9**	**150.1**	**315.6**	**454.9**	**417.0**	**405.4**	**403.0**

The following table depicts the P/L statement for development of Fairway on River Yamuna.

Table 15.283 Profit & Lost Statement for Fairway (INR Crores))

Particulars	Fy-21	Fy-27	Fy-32	Fy-37	Fy-45	Fy-55	Fy-65
O&M Cost	54	281	458	704	684	676	674
PBDIT	-54	-187	-296	-145	-43	-14	-11
Total Outflow to IWAI	0	4	6	22	26	26	26
Depreciation	0	314	573	833	12	0	0
Interest	60	278	422	489	156	0	0
PBT	-114	-778	-1,291	-1,466	-211	-14	-11
Tax	0	0	0	0	0	0	0
PAT	**-114**	**-778**	**-1,291**	**-1,466**	**-211**	**-14**	**-11**

Depreciation has been calculated using the Straight Line Method (SLM). Under this method, cost of asset is evenly distributed across its useful life. Straight Line Method (SLM) has been used to calculate depreciation for Fairway Development, under which the cost of tangible and intangible assets are evenly distributed across its life.

Table 15.284 Depreciation for Fairway (INR Crores)

Depreciation & Amortization - SLM	Fy-21	Fy-27	Fy-32	Fy-37	Fy-45	Fy-55	Fy-65
Gross Block	837	4,953	9,048	13,154	13,154	13,154	13,154
Depreciation & Amortization	-	314	573	833	12	-	-
Cumulative Depreciation & Amortization	-	1,320	3,633	7,406	13,154	13,154	13,154
Net Block	837	3,633	5,415	5,748	-	-	-

The table below depicts the cash inflow & outflow in case of development of Fairway.

Table 15.285 Cash Flow for Development of Fairway (INR Crores)

Particulars	Fy-21	Fy-27	Fy-37	Fy-45	Fy-55	Fy-65
Equity	293	269	0	0	0	0
Debt	544	499	0	0	0	0
Net Cash from Investment	837	767	0	0	0	0
PBDIT	-54	-187	-145	-43	-14	-11
(-) Taxes Paid	0	0	0	0	0	0
Net Cash from Operations	-54	-187	-145	-43	-14	-11
Total Cash Inflow	783	580	-145	-43	-14	-11
Capital Investment	837	767	0	0	0	0
Long Term Debt	0	190	432	291	0	0
Interest	60	278	489	156	0	0
Total Cash Outflow	897	1,235	921	447	0	0
Net Cash Flow	-114	-655	-1,065	-490	-14	-11
Opening Balance of Cash	0	-2,507	-12,734	-19,326	-21,837	-21,962
Closing Balance Cash	**-114**	**-3,162**	**-13,800**	**-19,816**	**-21,851**	**-21,973**

Table 15.286 Balance Sheet for Development of Fairway (INR Crore)

Sources of Funds	**Fy-21**	**Fy-27**	**Fy-37**	**Fy-45**	**Fy-55**	**Fy-65**
Shareholder's funds						
Capital	293	1,734	4,604	4,604	4,604	4,604
Reserves & Surplus	-114	-3,786	-17,099	-25,837	-26,454	-26,577
Borrowings						
Secured Loans	544	2,524	4,444	1,417	-	-
Total Funds	**724**	**471**	**-8,052**	**-19,816**	**-21,851**	**-21,973**
Usages of Fund						
Fixed Assets						
Gross Block	837	4,953	13,154	13,154	13,154	13,154
Less: Depreciation	-	1,320	7,406	13,154	13,154	13,154
Net Block	837	3,633	5,748	-	-	-
Net Current Assets	-114	-3,162	-13,800	-19,816	-21,851	-21,973

Sources of Funds	Fy-21	Fy-27	Fy-37	Fy-45	Fy-55	Fy-65
Total Assets	724	471	-8,052	-19,816	-21,851	-21,973

- **Financial IRR**

Financial FIRR presented below will help IWAI to measure the financial returns on investment and assist take a firm decision on the implementation of this development. Final viability assessment for developing passenger handling terminal on this River Yamuna would be done based on this outcome.

Table 15.287 Financial IRR Calculation for For Development of Fairway (INR Crores)

Particulars	Fy-21	Fy-27	Fy-37	Fy-45	Fy-55	Fy-65
PBDIT	-54	-187	-145	-43	-14	-11
Interest	60	278	489	156	0	0
Principal repayment	0	190	432	291	0	0
Equity	293	269	0	0	0	0
Debt	544	499	0	0	0	0
Total Investment	837	767	0	0	0	0
Tax	0	0	0	0	0	0
Cashflow to Equity(Pre-tax)	-407	-923	-1,065	-490	-14	-11
Equity IRR(Pre-tax)	**N.A**					
Cashflow to Equity(Post-tax)	-407	-923	-1,065	-490	-14	-11
Equity IRR(Post-tax)	**N.A**					
Project Cashflow(Pre-tax)	-891	-954	-145	-43	-14	-11
Project IRR(Pre-tax)	**N.A**					
Project Cashflow(Post-tax)	-891	-954	-145	-43	-14	-11
Project IRR(Post-tax)	**N.A**					

- **Economic IRR**

EIRR section evaluates the value addition that, this fairway development induces in society and the impact on various social factors. Economic IRR (EIRR) comprises all financial and non-financial benefits of the project. It helps in investment decision from prospects of improving welfare of society. If any project is commercially unviable then its economic viability is considered. These impacts are transformed into financial gains which can bring the state and central government to fund resources for the implementation. Government undertake the detailed assessment at projects contribution to the betterment of society like employment generation, improvement in connectivity, pollution control, trade improvement, carbon emission, employment generation, reduction in congestion, less vehicle operating cost, saving on fuel, etc.

Assumptions considered for computing EIRR are fairway development is listed below.

Table 15.288Assumptions for EIRR Calculations

Parameters Adopted	Value	Unit
Economic loss due to Road Accidents	0.03	of GDP

Parameters Adopted	Value	Unit
Value of economic loss due to road accidents	3.76	Rs Lakhs Crores
Safety Index (IWT as base)	5.00	times safer than rail
Accident Loss		
Rail	0.77	Rs Lakhs/KM
IWT	0.15	Rs Lakhs/KM
Fuel Cost		
Rail	85.00	t-km / per litre
IWT	105.00	t-km / per liter
Fuel price	69.40	Rs/Litre
Vehicular operating cost (VOC)		
Rail	1.41	Rs/t-km
IWT	1.15	Rs/t-km
Direct Employment Creation		
Rail	2.00	Per Million t-km
IWT	0.50	Per Million t-km
Employment cost	2.50	Rs Lakhs per Annum
Emission Reduction		
Rail	13.30	g CO2/t-km
IWT	6.00	g CO2/t-km
Shadow factor		
CAPEX/O&M Cost (Convert financial cost to economic cost)	0.85	-
Carbon Credits factors		
Carbon Shadow price	20.00	$/Tonne
Exchange rate	67.00	Rs/USD

All the essential assumptions with respect to fuel efficiency, direct employment multiplier, reduction in carbon emission, and carbon credit factors have been taken from the common industrial benchmarks.

Estimated impact of each factor at fairway development till FY65 is presented in the table below.

Table 15.289Economic IRR Calculation for Fairway developemnt (INR Crore)

Operation years	FY21	FY25	FY30	FY35	FY40	FY45	FY55	FY65
Accident Loss			6	6	6	6	6	6
Saving on fuel		0	20	48	288	325	340	340
Saving on account of VOC		0	34	79	481	543	569	569
Job creation		0	33	76	463	522	547	547
Reduction in Emissions		0	1	3	18	20	21	21
Total Revenue			99	170	588	641	662	662
Total Economic Impact	0	0	195	382	1,845	2,059	2,147	2,147

Operation years	FY21	FY25	FY30	FY35	FY40	FY45	FY55	FY65
O&M Expenditure	54	238	340	530	579	562	550	548
Economic Cash Outflow	-54	-238	-145	-147	1,266	1,497	1,596	1,599
Investment	837	837	767	1,026				
Net Cash Flow to Project	-891	-1,075	-912	-1,174	1,266	1,497	1,596	1,599
Project EIRR	**5.0%**							

15.5 PhasewiseFinancial Analysis for Terminals and Fairway (Cumulative)

The Financial Analysis is done for the combination of fairway and Terminals (Dirty Cargo, Multi- purpose and Passenger) in each Phase. This analysis would include both development and operation of terminals and fairway on NW 110.The combined Financial Analysis is done to realize whether the project could be viable by considering combined model for terminal and fairway on NW 110.

The Financial Analysis for terminals and fairway is done for three phases, Phase 1, Phase 2 and Phase 3. Development period of fairway in Phase 1 is FY 21- FY 25, Phase 2 is FY 27- FY 31 and Phase 3 is FY 32- FY 36.In the last two years of each phase, terminals would also be developed along with fairway. In Phase 1, terminal would be developed in FY 24 - FY 25; in Phase 2, terminal would be developed in FY 30 - FY 31 and in Phase 3 terminal would be developed in FY 35 - FY 36.Operational period for both terminal and fairway would be FY 26- FY 65 in Phase 1, FY 32- FY 65 in Phase 2 and FY 37- FY 65 in Phase 3.

In Phase 1, fairway would be developed in the river stretch of 0- 453 km. In Phase 1, three dirty cargo terminals (T3, T4 & T5), two Multi- purpose cargo terminals (T6 & T8) and seven passenger terminals (T12 - a, b, c, T13- a, b, c, d) would be developed.

In Phase 2, fairway would be developed in the river stretch of 453- 743 km. In this phase, two terminals would also be developed, i.e. one dirty cargo terminals (T2) and one passenger terminal (T10).

In Phase 3, fairway would be developed in the river stretch of 743- 1,051 km. Along with development of fairway, in Phase 3, one dirty cargo terminals (T1), one Multi-purpose cargo terminal (T7) and two passenger terminals (T9 & T11) would be developed.

15.5.1 Inputs for Financial AnalysisPhasewise

All the assumptions and inputs used in developing Financial Analysis for terminals and fairway on River Yamuna are discussed in this section.

All the Assumptions for Financial Analysis of Terminals and fairway are same as mentioned in Financial Analysis of Terminal Section (Dirty Cargo Terminal, Multi-purpose Terminal and Passenger Terminal) and Financial Analysis of Fairway Section. The Financial Models discussed in this section is prepared by combining the Financial Analysis of Terminal Section and Financial Analysis of Fairway Section. Hence, assumptions considered for the combined model would be same.

All the assumptions, related to Tariff, Handling Cost, O&M Cost, Loan Schedule andSalaryCalculationfor Terminals& Fairway are same, which are discussed above in Terminal Section (Dirty Cargo Terminal, Multi- purpose Terminal and Passenger terminal) and Fairway Section. Most of the tariff assumptions are based on industry inputs and current Tariff of IWAI. General Assumptions for this Financial Analysis would also be same as discussed above in Assumptions for Financial Analysis Section.

15.5.2 Phase 1

Financial Analysis of Phase 1 includes 453km of stretch and all the terminals being developed in Phase 1 i.e. T3, T4 T5, T6, T8, T12, T13 (a, b, c, & d).

Table 15.290 Development Schedule of Phase 1

Type	Fairway (km)	FY21	FY22	FY23	FY24	FY25	FY26 - FY65
Fairway	453	Development					Operational
Terminals					Construction		Operational

15.5.2.1 Traffic

These terminals in Phase 1 Model are proposed for handling dirty cargo, clean cargo and passengers. Traffic these terminals are projected for next 30 years in the table below.

Table 15.291 Traffic in Phase 1 Model ('000 T)

Terminal	Cargo	Fy 26	Fy 30	Fy 35	Fy 40	Fy 45	Fy 50	Fy 55	Fy 60	Fy 65
T3	Coal	1,340	1,583	1,871	2,169	2,514	2,667	2,667	2,667	2,667
	Fly Ash	292	325	349	366	385	393	393	393	393
T4	Coal	1,218	1,438	1,700	1,971	2,284	2,424	2,424	2,424	2,424
	Fly Ash	582	648	695	731	768	783	783	783	783
T 5	Coal	2,514	2,969	3,509	4,068	4,716	5,003	5,003	5,003	5,003
	Fly Ash	1,020	1,136	1,218	1,280	1,345	1,372	1,372	1,372	1,372
T 6	Fertilizer	470	510	551	568	568	568	568	568	568
T 8	Fertilizer	470	510	551	568	568	568	568	568	568
	Iron &Steel	83	92	105	113	120	122	122	122	122
T 12	Passenger ('000 Nos.)	147	153	161	170	178	182	182	182	182
T 13		2,502	2,604	2,737	2,876	3,023	3,084	3,084	3,084	3,084

15.5.2.2 Capital Cost

This section represents the total capital expenditure in an Investment phased manner for Phase 1 terminal modelling.

Table 15.292 Project Cost involed in Phase 1 (INR Crore)

Description	Total Investment	Investment Phase 1	Investment Phase 2

		FY21	FY22	FY23	FY24	FY25	Fy 35	Fy 36
Fairway + Terminal	3,697	592	592	592	739	690	294	196
Navigation Cost + Approach Road	523	11	11	11	38	29	53	35
Dredging + Supporting Infra	562	86	86	86	366	273	-	-
Mechanical	916	148	148	148	169	232	14	56
Others	1,501	-	-		751	751	-	-
Total CAPEX	**7,199**	**837**	**837**	**837**	**2,063**	**1,975**	**362**	**288**

Development of fairway would take 5 years; in last 2 years of this development period terminal construction would be done. Investment in construction of terminals is done in 2 phases, as need for additional jetties arise with increasing traffic. Entire model would start operating from FY26 till FY65.

15.5.2.3 Financing

Construction Phase 1 & Phase 2 has been assumed to be funded in an Equity-Debt ratio of 35:65. Details of the means of financing for both the investment phases are shown below.

Table 15.293 Equity-Debt Share Distribution for Terminal 1 (INR Crores)

Particulars	%	Investment Phase 1	Investment Phase 2
Equity	35%	2,292	227
Debt	65%	4,257	422

15.5.2.4 Financial Indicators

This section shows the financial indicator that leads to the generation of FIRR for Phase 1 model. Revenue, Depreciation, Cash Flow, P&L Statement & Balance Sheet helps on understanding the returns on investment made for this terminal.

Revenue from Phase 1 model of River Yamuna will be generated from core operations that include cargo handling at the jetty, Storage, Stackyard, Evacuation from yard to Rail, fairway usage charges, etc. The detailed breakup of revenue is shown in the table above.

Table 15.294 Revenue from Phase 1 Model (INR Crore)

Nos.	FY21	FY30	FY40	FY50	FY60	FY65
Terminals						
T3	-	72	96	116	116	116
T4	-	22	30	37	37	37
T5	-	135	180	217	217	217
T6	-	22	70	81	81	81
T8	-	53	88	99	99	99
T12	-	2	3	3	3	3
T13a	-	6	6	7	7	7
T13b	-	2	3	3	3	3
T13c	-	3	3	3	3	3
T13d	-	2	3	3	3	3

Fairway						
T3	-	5.6	6.5	9	9	9
T4	-	21.9	25.1	33.6	33.6	33.6
T5	-	0.4	0.4	0.6	0.6	0.6
T6	-	0.1	0.1	0.2	0.2	0.2
T8	-	6.3	6.9	17	17	17
T12	-	49.8	52.3	58.9	58.9	58.9
T13	-	15.2	16	18	18	18
Total	**-**	**418.3**	**589.3**	**706.3**	**706.3**	**706.3**

The following table indicates the operating and maintenance (O&M) cost involved in Phase 1 model. O&M cost includes operating cost i.e. cargo Handling charges, Storage cost, evacuation cost &stackyard handling cost and maintenance cost i.e. insurance, administration and others.

Table 15.295 O&M Cost in Phase 1 Model (INR Crores)

Nos.	FY21	FY30	FY35	FY40	FY45	FY50	FY55	FY60	FY65
Terminals									
T3		63	74	84	93	96	96	96	96
T4		19	21	25	27	27	27	27	27
T5		94	111	126	142	156	156	156	156
T6		42	46	62	64	65	64	64	64
T8		31	33	62	65	66	66	66	66
T12		3	3	3	3	3	3	3	3
T13a		3	3	3	3	3	3	3	3
T13b		1	1	1	1	1	1	1	1
T13c		1	1	1	1	1	1	1	1
T13d		1	1	1	1	1	1	1	1
Fairway									
0-453km	33	155	153	156	152	150	150	149	149
Total	**33**	**413**	**447**	**524**	**552**	**569**	**568**	**567**	**567**

The following table depicts the P/L statement for development of Phase 1 model on River Yamuna.

Table 15.296 Profit & Lost Statement for Phase 1 Model (INR Crores)

Particulars	Fy-21	Fy-30	Fy-35	Fy-40	Fy-45	Fy-50	Fy-55	Fy-60	Fy-65
PBDIT	-108	-110	-92	-47	-10	2	-2	-7	-12
Depreciation	0	320	342	210	0	0	0	0	0
Interest	60	299	197	86	15	3	0	0	0
PBT	-168	-728	-631	-343	-25	-1	-2	-7	-12
Tax	0	0	0	0	0	0	0	0	0
PAT	-168	-728	-631	-343	-25	-1	-2	-7	-12

Revenue, traffic and development cost are the major factors that heavily impacts commercial prospects of proposed terminal. As per the above table, till FY65 Phase 1 model is not generating sufficient profit even to cover day-today operational overheads.

Depreciation has been calculated using the Straight Line Method (SLM). Under this method, cost of asset is evenly distributed across its useful life. Straight Line Method (SLM) has been used to calculate depreciation for Phase 1 model, under which the cost of tangible and intangible assets are evenly distributed across its life.

Table 15.297 Depreciation for Phase 1 Model (INR Crores)

Depreciation & Amortization	Fy-21	Fy-30	Fy-35	Fy-40	Fy-45	Fy-50	Fy-55	Fy-60	Fy-65
Gross Block	837	6,549	6,911	7,199	7,199	7,199	7,199	7,199	7,199
Depreciation & Amortization	-	320	342	210	-	-	-	-	-
Cumulative Depreciation & Amortization	-	3,925	5,546	7,199	7,199	7,199	7,199	7,199	7,199
Net Block	837	2,624	1,365	-	-	-	-	-	-

The table below depicts the cash inflow & outflow in case of development of Terminal 2.

Table 15.298 Cash Flow for Phase 1 Model (INR Crores)

Particulars	Fy-21	Fy-22	Fy-23	Fy-24	Fy-25	Fy-35	Fy-36	Fy-65
Equity	293	293	293	722	691	127	101	0
Debt	544	544	544	1,341	1,283	235	187	0
Net Cash from Investment	837	837	837	2,063	1,975	362	288	0
PBDIT	-108	-140	-173	-223	-279	-92	-106	-12
(-) Taxes Paid	0	0	0	0	0	0	0	0
Net Cash from Operations	-108	-140	-173	-223	-279	-92	-106	-12
Total Cash Inflow	729	698	664	1,840	1,695	269	182	-12
Capital Investment	837	837	837	2,063	1,975	362	288	0
Long Term Debt	0	0	86	153	217	238	238	0
Interest	60	120	170	301	418	197	191	0
Total Cash Outflow	897	957	1,093	2,517	2,610	797	717	0
Net Cash Flow	-168	-259	-429	-677	-915	-527	-535	-12
Opening Balance of Cash	0	-168	-427	-857	-1,534	-7,998	-8,526	-11,986
Closing Balance Cash	**-168**	**-427**	**-857**	**-1,534**	**-2,448**	**-8,526**	**-9,061**	**-11,997**

Table 15.299 Balance Sheet for Phase 1 Model (INR Crores)

Sources of Funds	Fy-21	Fy-30	Fy-40	Fy-50	Fy-60	Fy-65
Shareholder's funds						
Capital	293	2,292	2,419	2,520	2,520	2,520
Reserves & Surplus	-168	-8,153	-11,367	-14,129	-14,417	-14,446
Borrowings						
Secured Loans	544	2,714	1,787	783	136	30
Total Funds	669	-3,147	-7,161	-10,827	-11,762	-11,896
Fixed Assets						
Gross Block	837	6,549	6,911	7,199	7,199	7,199
Less: Depreciation	0	3,925	5,546	7,199	7,199	7,199
Net Block	837	2,624	1,365	0	0	0
Net Current Assets	-168	-5,771	-8,526	-10,827	-11,762	-11,896
Total Assets	**669**	**-3,147**	**-7,161**	**-10,827**	**-11,762**	**-11,896**

15.5.2.5 Financial IRR

Financial FIRR presented below will help IWAI to measure the financial returns on investment and assist take a firm decision on the implementation of this development. Final viability assessment for developing coal handling terminal on this River Yamuna would be done based on this outcome.

Table 15.300 Financial IRR Calculation for Phase 1 Model (INR Crores)

Particulars	Fy-21	Fy-22	Fy-23	Fy-25	Fy-35	Fy-36	Fy-65
PBDIT	-108	-140	-173	-223	-279	-92	-106
Interest	60	120	170	301	418	197	191
Principal repayment	0	0	86	153	217	238	238
Equity	293	293	293	722	691	127	101
Debt	544	544	544	1,341	1,283	235	187
Total Investment	837	837	837	2,063	1,975	362	288
Tax	0	0	0	0	0	0	0
Cash flow to Equity(Pre-tax)	-461	-552	-722	-1,399	-1,606	-654	-636
Equity IRR(Pre-tax)	**N.A**						
Cash flow to Equity(Post-tax)	-461	-552	-722	-1,399	-1,606	-654	-636
Equity IRR(Post-tax)	**N.A**						
Project Cash flow(Pre-tax)	-945	-977	-1,010	-2,286	-2,254	-454	-394
Project IRR(Pre-tax)	**N.A**						
Project Cash flow(Post-tax)	-945	-977	-1,010	-2,286	-2,254	-454	-394
Project IRR(Post-tax)	**N.A**						

- **Economic IRR**

EIRR section evaluates the value addition that, this Phase 1 Model (Terminal + Fairway) induces in society and the impact on various social factors. Economic IRR (EIRR) comprises all financial and non-financial benefits of the project. It helps in investment decision from prospects of improving welfare of society. If any project is commercially unviable then its economic viability is considered. These impacts are transformed into financial gains which can bring the state and central government to fund resources for the implementation. Government undertake the detailed assessment at projects contribution to the betterment of society like employment generation, improvement in connectivity, pollution control, trade improvement, carbon emission, employment generation, reduction in congestion, less vehicle operating cost, saving on fuel, etc.

Assumptions considered for computing EIRR are for Phase 1 Model is listed below.

Table 15.301Assumptions for EIRR Calculations

Parameters Adopted	Value	Unit
Economic loss due to Road Accidents	0.03	of GDP
Value of economic loss due to road accidents	3.76	Rs Lakhs Crores
Safety Index (IWT as base)	5.00	times safer than rail

Parameters Adopted	Value	Unit
Accident Loss		
Rail	0.77	Rs Lakhs/KM
IWT	0.15	Rs Lakhs/KM
Fuel Cost		
Rail	85.00	t-km / per liter
IWT	105.00	t-km / per liter
Fuel price	69.40	Rs/Litre
Vehicular operating cost (VOC)		
Rail	1.41	Rs/t-km
IWT	1.15	Rs/t-km
Direct Employment Creation		
Rail	2.00	Per Million t-km
IWT	0.50	Per Million t-km
Employment cost	2.50	Rs Lakhs per Annum
Emission Reduction		
Rail	13.30	g CO2/t-km
IWT	6.00	g CO2/t-km
Shadow factor		
CAPEX/O&M Cost (Convert financial cost to economic cost)	0.85	-
Carbon Credits factors		
Carbon Shadow price	20.00	$/Tonne
Exchange rate	67.00	Rs/USD

All the essential assumptions with respect to fuel efficiency, direct employment multiplier, reduction in carbon emission, and carbon credit factors have been taken from the common industrial benchmarks.

Estimated impact of each factor at Phase 1 Model till FY65 is presented in the table below.

Table 15.302 Economic IRR Calculation for Phase 1 Model (INR Crore)

Operation years	**FY21**	**FY22**	**FY23**	**FY24**	**FY35**	**FY36**	**FY55**	**FY65**
Accident Loss						5	5	5
Saving on fuel			0	0	0	23	24	45
Saving on account of VOC			0	0	0	46	47	89
Job creation			0	0	0	37	38	72
Reduction in Emissions			0	0	0	1	1	3
Total Revenue						473	484	706
Total Economic Impact	0	0	0	0	0	586	599	920
O&M Expenditure	108	140	173	215	259	236	246	250
Economic Cash Outflow	-108	-140	-173	-215	-259	350	353	670
Investment	837	837	837	2,063	1,975	362	288	
Net Cash Flow to Project	-945	-977	-1,010	-2,278	-2,234	-12	65	670
Project EIRR	**4.6%**							

15.5.3 Phase 2

Financial Analysis of Phase 2 includes development of stretch from 453 km chainangeto 743km chainagei.e. from Kanpur to Agraalong with Terminals T2 and T10. Phase 2 can be developed after implementation of phase 1. Phase 2 cannot be developed in isolation on standalone basis.

Table 15.303 Development Schedule of Phase 2

Type	Fairway (km)	FY27	FY28	FY29	FY30	FY31	FY32 - FY65
Fairway	453 - 743	Development					Operational
Terminals					Construction		Operational

15.5.3.1 Traffic

These terminals in Phase 2 Model are proposed for handling dirty cargo and passengers. Traffic these terminals are projected for next 30 years in the table below.

Table 15.304 Traffic in Phase 2 Model ('000 T)

Terminal	Cargo	Chainage (km)	Fy 32	Fy 40	Fy 45	Fy 50	Fy 55	Fy 60	Fy 65
T2	Coal	731	1,451	1,838	2,131	2,260	2,260	2,260	2,260
	Fly Ash	731	544	589	619	632	632	632	632
T10	Passenger	742	66	72	75	77	77	77	77

15.5.3.2 Capital Cost

This section represents the total capital expenditure in an Investment phased manner for Phase 2 terminal modelling.

Table 15.305 Project Cost involed in Phase 2 (INR Crore)

Description	Total Investment	Investment Phase 1					Investment Phase 2	
		FY27	FY28	FY29	FY30	FY31	Fy 35	Fy 36
Fairway + Terminal	3,044	591	591	591	609	603	35	23
Navigation Cost + Approach Road	90	6	6	6	18	14	23	15
Dredging + Supporting Infra	168	22	22	22	58	46	0	0
Mechanical	760	148	148	148	151	160	1	4
Others	1,003	0	0	0	502	502	0	0
Total CAPEX	5,065	767	767	767	1,337	1,325	59	43

Development of fairway would take 5 years; in last 2 years of this development period terminal construction would be done. Investment in construction of terminals is done in 2 phases, as need for additional jetties arise with increasing traffic. Entire model would start operating from FY32 till FY65.

15.5.3.3 Financing

Construction Phase 1 & Phase 2 has been assumed to be funded in an Equity-Debt ratio of 35:65. Details of the means of financing for both the investment phases are shown below.

Table 15.306 Equity-Debt Share Distribution for Phase 2 Model (INR Crores)

Particulars	%	Investment Phase 1	Investment Phase 2
Equity	35%	1,737	36
Debt	65%	3,226	67

15.5.3.4 Financial Indicators

This section shows the financial indicator that leads to the generation of FIRR for Phase 1 model. Revenue, Depreciation, Cash Flow, P&L Statement & Balance Sheet helps on understanding the returns on investment made for this terminal.

Revenue from Phase 2 model of River Yamuna will be generated from core operations that include cargo handling at the jetty, Storage, Stackyard, Evacuation from yard to Rail, fairway usage charges, etc. The detailed breakup of revenue is shown in the table above.

Table 15.307 Revenue from Phase 2 Model (INR Crore)

Nos.	FY27	FY32	FY40	FY50	FY60	FY65
Terminals						
T2	-	64	80	94	94	94
T10	-	2	2	2	2	2
Fairway						
T2	-	44	53	63	63	63
T10	-	15	16	17	17	17
Total	**-**	125	151	176	176	176

The following table indicates the operating and maintenance (O&M) cost involved in Phase 2 model. O&M cost includes operating cost i.e. cargo Handling charges, Storage cost, evacuation cost &stackyard handling cost and maintenance cost i.e. insurance, administration and others.

Table 15.308 O&M Cost in Phase 2 Model (INR Crores)

Nos.	FY27	FY32	FY35	FY40	FY45	FY50	FY55	FY60	FY65
Terminals									
T2	-	53	57	64	70	72	72	72	72
T10	-	7	7	6	6	3	3	3	3
Fairway									
453-743km	29	118	110	101	96	94	98	103	107
Total	**29**	**171**	**163**	**158**	**159**	**154**	**158**	**163**	**167**

The following table depicts the P/L statement for development of Phase 2 model on River Yamuna.

Table 15.309 Profit & Lost Statement for Phase 2 Model (INR Crores)

Particulars	Fy-27	Fy-32	Fy-35	Fy-40	Fy-45	Fy-50	Fy-55	Fy-60	Fy-65
PBDIT	-29	-58	-45	-26	-9	0	-4	-8	-13
Depreciation	49	451	355	257	7	0	0	0	0
Interest	52	290	241	153	63	2	0	0	0
PBT	-129	-799	-641	-437	-79	-1	-4	-8	-13
Tax	0	0	0	0	0	0	0	0	0
PAT	**-129**	**-799**	**-641**	**-437**	**-79**	**-1**	**-4**	**-8**	**-13**

Revenue, traffic and development cost are the major factors that heavily impacts commercial prospects of proposed terminal. As per the above table, till FY65 Phase 2 model is not generating sufficient profit even to cover day-today operational overheads. Depreciation has been calculated using the Straight Line Method (SLM). Under this method, cost of asset is evenly distributed across its useful life. Straight Line Method (SLM) has been used to calculate depreciation for Phase 2 model, under which the cost of tangible and intangible assets are evenly distributed across its life.

Table 15.310 Depreciation for Phase 2 Model (INR Crores)

Depreciation & Amortization	FY27	FY32	FY35	FY40	FY45	FY50	FY55	FY60	FY65
Gross Block	767	4,963	5,022	5,065	5,065	5,065	5,065	5,065	5,065
Depreciation & Amortization	49	451	355	257	7	-	-	-	-
Cumulative Depreciation & Amortization	49	1,493	2,750	4,036	5,065	5,065	5,065	5,065	5,065
Net Block	719	3,470	2,272	1,030	-	-	-	-	-

The table below depicts the cash inflow & outflow in case of development of Terminal 2.

Table 15.311Cash Flow for Phase 2 Model (INR Crores)

Particulars	FY27	FY28	FY29	FY30	FY31	FY35	FY36	FY65
Equity	269	269	269	468	464	21	15	0
Debt	499	499	499	869	861	39	28	0
Net Cash from Investment	767	767	767	1,337	1,325	59	43	0
PBDIT	-29	-50	-70	-93	-119	-45	-43	-13
(-) Taxes Paid	0	0	0	0	0	0	0	0
Net Cash from Operations	-29	-50	-70	-93	-119	-45	-43	-13
Total Cash Inflow	739	717	697	1,244	1,206	14	0	-13
Capital Investment	767	767	767	1,337	1,325	59	43	0
Long Term Debt	25	50	75	118	161	163	165	0
Interest	52	101	148	231	308	241	226	0
Total Cash Outflow	844	919	990	1,686	1,793	463	433	0
Net Cash Flow	-106	-201	-293	-442	-588	-449	-433	-13

Opening Balance of Cash	-33	-139	-340	-633	-1,075	-3,124	-3,573	-7,679
Closing Balance Cash	-139	-340	-633	-1,075	-1,663	-3,573	-4,007	**-7,692**

Table 15.312 Balance Sheet for Phase 2 Model (INR Crores)

Sources of Funds	Fy-27	Fy-32	Fy-35	Fy-40	Fy-45	Fy-50	Fy-55	Fy-60	Fy-65
Shareholder's funds									
Capital	269	1,737	1,758	1,773	1,773	1,773	1,773	1,773	1,773
Reserves & Surplus	-163	-3,075	-5,247	-7,653	-9,257	-9,366	-9,378	-9,410	-9,464
Borrowings									
Secured Loans	474	2,635	2,188	1,393	570	15	0	0	0
Total Funds	**580**	**1,298**	**-1,301**	**-4,487**	**-6,914**	**-7,579**	**-7,606**	**-7,637**	**-7,692**
Fixed Assets									
Gross Block	767	4,963	5,022	5,065	5,065	5,065	5,065	5,065	5,065
Less: Depreciation	49	1,493	2,750	4,036	5,065	5,065	5,065	5,065	5,065
Net Block	719	3,470	2,272	1,030	0	0	0	0	0
Net Current Assets	-139	-2,172	-3,573	-5,516	-6,914	-7,579	-7,606	-7,637	-7,692
Total Assets	**580**	**1,298**	**-1,301**	**-4,487**	**-6,914**	**-7,579**	**-7,606**	**-7,637**	**-7,692**

15.5.3.5 Financial IRR

Financial FIRR presented below will help IWAI to measure the financial returns on investment and assist take a firm decision on the implementation of this development. Final viability assessment for developing coal handling terminal on this River Yamuna would be done based on this outcome.

Table 15.313 Financial IRR Calculation for Phase 2 Model (INR Crores)

	Fy-27	Fy-28	Fy-29	Fy-30	Fy-31	Fy-35	Fy-36	Fy-65
PBDIT	-29	-50	-70	-93	-119	-45	-43	-13
Interest	52	101	148	231	308	241	226	0
Principal repayment	25	50	75	118	161	163	165	0
Equity	269	269	269	468	464	21	15	0
Debt	499	499	499	869	861	39	28	0
Total Investment	767	767	767	1,337	1,325	59	43	0
Tax	0	0	0	0	0	0	0	0
Cash flow to Equity(Pre-tax)	-374	-470	-562	-909	-1,051	-470	-449	-13
Equity IRR(Pre-tax)	**N.A**							
Cash flow to Equity(Post-tax)	-374	-470	-562	-909	-1,051	-470	-449	-13
Equity IRR(Post-tax)	**N.A**							
Project Cash flow(Pre-tax)	-796	-817	-837	-1,429	-1,443	-105	-86	-13
Project IRR(Pre-tax)	**N.A**							
Project Cash flow(Post-tax)	-796	-817	-837	-1,429	-1,443	-105	-86	-13
Project IRR(Post-tax)	**N.A**							

- **Economic IRR**

EIRR section evaluates the value addition that, this Phase 2 Model (Terminal + Fairway) induces in society and the impact on various social factors. Economic IRR (EIRR) comprises all financial and non-financial benefits of the project. It helps in investment decision from prospects of improving welfare of society. If any project is commercially unviable then its economic viability is considered. These impacts are transformed into financial gains which can bring the state and central government to fund resources for the implementation. Government undertake the detailed assessment at projects contribution to the betterment of society like employment generation, improvement in connectivity, pollution control, trade improvement, carbon emission, employment generation, reduction in congestion, less vehicle operating cost, saving on fuel, etc.

Assumptions considered for computing EIRR are for Phase 2 Model is listed below.

Table 15.314Assumptions for EIRR Calculations

Parameters Adopted	Value	Unit
Economic loss due to Road Accidents	0.03	of GDP
Value of economic loss due to road accidents	3.76	Rs Lakhs Crores
Safety Index (IWT as base)	5.00	times safer than rail
Accident Loss		
Rail	0.77	Rs Lakhs/KM
IWT	0.15	Rs Lakhs/KM
Fuel Cost		
Rail	85.00	t-km / per liter
IWT	105.00	t-km / per liter
Fuel price	69.40	Rs/Litre
Vehicular operating cost (VOC)		
Rail	1.41	Rs/t-km
IWT	1.15	Rs/t-km
Direct Employment Creation		
Rail	2.00	Per Million t-km
IWT	0.50	Per Million t-km
Employment cost	2.50	Rs Lakhs per Annum
Emission Reduction		
Rail	13.30	g CO2/t-km
IWT	6.00	g CO2/t-km
Shadow factor		
CAPEX/O&M Cost (Convert financial cost to economic cost)	0.85	-
Carbon Credits factors		
Carbon Shadow price	20.00	$/Tonne
Exchange rate	67.00	Rs/USD

All the essential assumptions with respect to fuel efficiency, direct employment multiplier, reduction in carbon emission, and carbon credit factors have been taken from the common industrial benchmarks.

Estimated impact of each factor at Phase 2 Model till FY65 is presented in the table below.

Table 15.315Economic IRR Calculation for Phase 2 Model (INR Crore)

Operation years	FY27	FY28	FY29	FY30	FY35	FY36	FY55	FY65
Accident Loss					5	5	5	5
Saving on fuel			0	0	24	25	33	33
Saving on account of VOC			0	0	49	50	66	66
Job creation			0	0	39	40	53	53
Reduction in Emissions			0	0	2	2	2	2
Total Revenue					134	137	176	176
Total Economic Impact	0	0	0	0	252	258	334	334
O&M Expenditure	29	50	70	91	110	108	98	107
Economic Cash Outflow	-29	-50	-70	-91	142	150	236	227
Investment	767	767	767	1,337	59	43		
Net Cash Flow to Project	-796	-817	-837	-1,428	83	107	236	227
Project EIRR	**NA**							

15.5.4 Phase 3

Financial Analysis of Phase 3 includes development of stretch from 743 km chainange to 1,051 km chainagei.e. from Agra to Delhi along with Terminals T1, T7, T9 and T11.Phase 3 can be developed after implementation of Phase 1 and 2. Phase 3 cannot be developed in isolation on standalone basis.In this phase entire NW-110 will become operational.

Table 15.316 Development Schedule of Phase 3

Type	Fairway (km)	FY32	FY33	FY34	FY35	FY36	FY37 - FY65
Fairway	743-1,051	Development					Operational
Terminal					Construction		Operational

15.5.4.1 Traffic

This terminals in Phase 3 Model are proposed for handling dirty cargo, clean cargo and passengers. Traffic these terminals are projected for next 30 years in the table below.

Table 15.317 Traffic in Phase 3 Model ('000 T)

Terminal	Cargo Terminals	Chainage (km)	Fy 37	Fy 40	Fy 45	Fy 50	Fy 55	Fy 60	Fy 65
T1	Coal	1047.8	2,866	3,131	3,630	3,851	3,851	3,851	3,851
T7	Automobile ('000 Nos.)	1049	139	152	176	186	186	186	186
	Food Grains	1049	900	955	1,054	1,097	1,097	1,097	1,097
	Sugar	1049	546	563	592	604	604	604	604

Terminal	Cargo Terminals	Chainage (km)	Fy 37	Fy 40	Fy 45	Fy 50	Fy 55	Fy 60	Fy 65
	Iron & Steel	1049	257	280	323	285	285	285	285
	Containers (TEU)	1049	657	707	800	840	840	840	840
T9	Passenger ('000 Nos.)	1051.7	290	299	314	321	321	321	321
T11		858.5	447	461	484	494	494	494	494

15.5.4.2 Capital Cost

This section represents the total capital expenditure in an Investment phased manner for Phase 3 terminal modelling.

Table 15.318 Project Cost involed in Phase 3 (INR Crore)

Description	Total Investment	Investment				
		FY32	FY33	FY34	FY35	FY36
Fairway + Terminal	4,481	798.6	798.6	798.6	1,091.4	993.8
Navigation Cost + Approach Road	116	9.6	9.6	9.6	50.6	37.0
Dredging + Supporting Infra	169	18.5	18.5	18.5	64.1	48.9
Mechanical	1,112	199.6	199.6	199.6	222.4	290.6
Others	1,477	-	-	-	738.7	738.7
Total CAPEX	**7,355**	**1,026**	**1,026**	**1,026**	**2,167**	**2,109**

Development of fairway would take 5 years, in last 2 years of this development period terminal construction would be done. Entire model would start operating from FY37 till FY65.

15.5.4.3 Financing

Construction has been assumed to be funded in an Equity-Debt ratio of 35:65. Details of the means of financing for both the investment phases are shown below.

Table 15.319 Equity-Debt Share Distribution for Phase 3 Model (INR Crores)

Particulars	%	Investment
Equity	35%	2,574
Debt	65%	4,781

15.5.4.4 Financial Indicators

This section shows the financial indicator that leads to the generation of FIRR for Phase 3 model. Revenue, Depreciation, Cash Flow, P&L Statement & Balance Sheet helps on understanding the returns on investment made for this terminal.

Revenue from Phase 3 model of River Yamuna will be generated from core operations that include cargo handling at the jetty, Storage, Stackyard, Evacuation from yard to Rail, fairway usage charges, etc. The detailed breakup of revenue is shown in the table above.

Table 15.320 Revenue from Phase 3 Model (INR Crore)

Nos.	FY32	FY37	FY40	FY45	FY50	FY55	FY60	FY65
Terminals								
T1	-	107	117	136	144	144	144	144
T7	-	249	267	301	313	313	313	313
T9	-	8	8	9	9	9	9	9
T11	-	13	13	14	14	14	14	14
Fairway								
T1	-	90.1	98.4	121.1	121.1	121.1	121.1	90.1
T7	-	78.6	83.6	94.8	94.8	94.8	94.8	78.6
T9	-	91.6	94.4	101.2	101.2	101.2	101.2	91.6
T11	-	115.2	118.7	127.3	127.3	127.3	127.3	115.2
Total	-	752.5	800.1	904.4	924.4	924.4	924.4	855.5

The following table indicates the operating and maintenance (O&M) cost involved in Phase 3 model. O&M cost includes operating cost i.e. cargo Handling charges, Storage cost, evacuation cost &stackyard handling cost and maintenance cost i.e. insurance, administration and others.

Table 15.321 O&M Cost in Phase 3 Model (INR Crores)

Nos.	FY32	FY37	FY40	FY45	FY50	FY55	FY60	FY65
Terminals								
T1	-	87	92	104	108	108	108	108
T7	-	281	296	325	322	322	322	322
T9	-	3	3	3	3	3	3	3
T11	-	2	2	2	2	2	2	2
Fairway								
743-1,051km	189	446	432	424	419	416	415	414
Total	**189**	**819**	**825**	**858**	**854**	**851**	**850**	**849**

The following table depicts the P/L statement for development of Phase 2 model on River Yamuna.

Table 15.322 Profit & Lost Statement for Phase 3 Model (INR Crores)

Particulars	FY32	FY37	FY40	FY45	FY50	FY55	FY60	FY65
PBDIT	-189	-97	-57	-3	32	36	37	38
Depreciation	65	668	520	372	0	0	0	0
Interest	70	433	354	222	91	0	0	0
PBT	-324	-1,197	-930	-597	-58	36	37	38
Tax	0	0	0	0	0	11	11	11
PAT	**-324**	**-1,197**	**-930**	**-597**	**-58**	**25**	**26**	**26**

Revenue, traffic and development cost are the major factors that heavily impacts commercial prospects of proposed terminal. As per the above table, till FY65 Phase 3 model is not generating sufficient profit even to cover day-today operational overheads. Depreciation has been calculated using the Straight Line Method (SLM). Under this method, cost of asset is evenly distributed across its useful life. Straight Line Method (SLM) has been used to calculate depreciation for Phase 3 model, under which the cost of tangible and intangible assets are evenly distributed across its life.

Table 15.323 Depreciation for Phase 3 Model (INR Crores)

Depreciation & Amortization	FY32	FY37	FY40	FY45	FY50	FY55	FY60	FY65
Gross Block	1,026	7,355	7,355	7,355	7,355	7,355	7,355	7,355
Depreciation &Amortization	65	668	520	372	-	-	-	-
Cumulative Depreciation & Amortization	65	2,158	4,013	5,873	7,355	7,355	7,355	7,355
Net Block	961	5,197	3,343	1,482	-	-	-	-

The table below depicts the cash inflow & outflow in case of development of Phase 3.

Table 15.324 Cash Flow for Phase 3 Model (INR Crores)

Particulars	FY32	FY33	FY34	FY35	FY36	FY45	FY55	FY65
Equity	359	359	359	759	738	-	-	-
Debt	667	667	667	1,409	1,371	-	-	-
Net Cash from Investment	1,026	1,026	1,026	2,167	2,109	-	-	-
PBDIT	-189	-243	-282	-340	-440	-3	36	38
(-) Taxes Paid	-	-	-	-	-	-	11	11
Net Cash from Operations	-189	-243	-282	-340	-440	-3	25	26
Total Cash Inflow	837	783	744	1,827	1,669	-3	25	26
Capital Investment	1,026	1,026	1,026	2,167	2,109	0	0	0
Long Term Debt	33	67	100	171	239	239	69	0
Interest	70	136	198	334	459	222	0	0
Total Cash Outflow	1,129	1,229	1,325	2,672	2,807	461	69	0
Net Cash Flow	-292	-446	-580	-845	-1,138	-464	-44	26
Opening Balance of Cash	0	-292	-738	-1,318	-2,163	-8,359	-11,385	-11,196
Closing Balance Cash	**-292**	**-738**	**-1,318**	**-2,163**	**-3,301**	**-8,822**	**-11,429**	**-11,170**

Table 15.325 Balance Sheet for Phase 3 Model (INR Crores)

Sources of Funds	Fy-32	Fy-37	Fy-40	Fy-45	Fy-50	Fy-55	Fy-60	Fy-65
Shareholder's funds								
Capital	359	2,574	2,574	2,574	2,574	2,574	2,574	2,574
Reserves & Surplus	-324	-5,379	-8,582	-11,935	-14,016	-14,003	-13,876	-13,745
Borrowings								
Secured Loans	634	3,932	3,215	2,020	825	0	0	0
Total Funds	**669**	**1,128**	**-2,793**	**-7,340**	**-10,617**	**-11,429**	**-11,301**	**-11,170**
Fixed Assets								
Gross Block	1,026	7,355	7,355	7,355	7,355	7,355	7,355	7,355
Less: Depreciation	65	2,158	4,013	5,873	7,355	7,355	7,355	7,355
Net Block	961	5,197	3,343	1,482	0	0	0	0
Net Current Assets	-292	-4,070	-6,135	-8,822	-10,617	-11,429	-11,301	-11,170
Total Assets	**669**	**1,128**	**-2,793**	**-7,340**	**-10,617**	**-11,429**	**-11,301**	**-11,170**

15.5.4.5 Financial IRR

Financial FIRR presented below will help IWAI to measure the financial returns on investment and assist take a firm decision on the implementation of this development. Final viability assessment for developing coal handling terminal on this River Yamuna would be done based on this outcome.

Table 15.326Financial IRR Calculation for Phase 3 Model (INR Crores)

Particulars	FY32	FY33	FY34	FY35	FY36	FY45	FY55	FY65
PBDIT	-189	-243	-282	-340	-440	-3	36	38
Interest	70	136	198	334	459	222	0	0
Principal repayment	33	67	100	171	239	239	69	0
Equity	359	359	359	759	738	0	0	0
Debt	667	667	667	1,409	1,371	0	0	0
Total Investment	1,026	1,026	1,026	2,167	2,109	0	0	0
Tax	0	0	0	0	0	0	11	11
Cash flow to Equity(Pre-tax)	-651	-805	-940	-1,603	-1,876	-464	-33	38
Equity IRR(Pre-tax)	**N.A**							
Cash flow to Equity(Post-tax)	-651	-805	-940	-1,603	-1,876	-464	-44	26
Equity IRR(Post-tax)	**N.A**							
Project Cash flow(Pre-tax)	-1,215	-1,270	-1,309	-2,507	-2,549	-3	36	38
Project IRR(Pre-tax)	**N.A**							
Project Cash flow(Post-tax)	-1,215	-1,270	-1,309	-2,507	-2,549	-3	25	26
Project IRR(Post-tax)	**N.A**							

- **Economic IRR**

EIRR section evaluates the value addition that, this Phase 3 Model (Terminal + Fairway) induces in society and the impact on various social factors. Economic IRR (EIRR) comprises all financial and non-financial benefits of the project. It helps in investment decision from prospects of improving welfare of society. If any project is commercially unviable then its economic viability is considered. These impacts are transformed into financial gains which can bring the state and central government to fund resources for the implementation. Government undertake the detailed assessment at projects contribution to the betterment of society like employment generation, improvement in connectivity, pollution control, trade improvement, carbon emission, employment generation, reduction in congestion, less vehicle operating cost, saving on fuel, etc.

Assumptions considered for computing EIRR are for Phase 3 Model is listed below

Table 15.327Assumptions for EIRR Calculations

Parameters Adopted	**Value**	**Unit**
Economic loss due to Road Accidents	0.03	of GDP
Value of economic loss due to road accidents	3.76	Rs Lakhs Crores
Safety Index (IWT as base)	5.00	times safer than rail
Accident Loss		
Rail	0.77	Rs Lakhs/KM

Parameters Adopted	Value	Unit
IWT	0.15	Rs Lakhs/KM
Fuel Cost		
Rail	85.00	t-km / per liter
IWT	105.00	t-km / per liter
Fuel price	69.40	Rs/Litre
Vehicular operating cost (VOC)		
Rail	1.41	Rs/t-km
IWT	1.15	Rs/t-km
Direct Employment Creation		
Rail	2.00	Per Million t-km
IWT	0.50	Per Million t-km
Employment cost	2.50	Rs Lakhs per Annum
Emission Reduction		
Rail	13.30	g CO2/t-km
IWT	6.00	g CO2/t-km
Shadow factor		
CAPEX/O&M Cost (Convert financial cost to economic cost)	0.85	-
Carbon Credits factors		
Carbon Shadow price	20.00	$/Tonne
Exchange rate	67.00	Rs/USD

All the essential assumptions with respect to fuel efficiency, direct employment multiplier, reduction in carbon emission, and carbon credit factors have been taken from the common industrial benchmarks.

Estimated impact of each factor at Phase 3 Model till FY65 is presented in the table below.

Table 15.228Economic IRR Calculation for Phase 3 Model (INR Crore)

Operation years	FY32	FY33	FY34	FY35	FY36	FY45	FY55	FY65
Accident Loss						5	5	5
Saving on fuel			0	0	0	251	263	263
Saving on account of VOC			0	0	0	500	524	524
Job creation			0	0	0	403	422	422
Reduction in Emissions			0	0	0	16	17	17
Total Revenue						890	924	924
Total Economic Impact	0	0	0	0	0	2,064	2,154	2,154
O&M Expenditure	189	243	282	331	383	359	350	348
Economic Cash Outflow	-189	-243	-282	-331	-383	1,705	1,804	1,806
Investment	1,026	1,026	1,026	2,167	2,109			
Net Cash Flow to Project	-1,215	-1,270	-1,309	-2,498	-2,492	1,705	1,804	1,806
Project EIRR	**14.0%**							

15.6 Cumulative Financial Analysis of all Terminals and Entire Fairway

The Financial Analysis is done for the combination of fairway and Terminals (Dirty Cargo, Multi- purpose and Passenger) on NW 110. This analysis would include both development and operation of terminals and fairway on NW 110.The combined

Financial Analysis is done to realize whether the project could be viable by considering combined model for terminal and fairway on NW 110 (0 – 1051 Km).

15.6.1 Inputs for Cumulative Financial Analysis

All the assumptions and inputs used in developing Cumulative Financial Analysis for all terminals and fairway combining all phases on River Yamuna are discussed in this section.

All the Assumptions for Cumulative Financial Analysis of Terminals and fairway are same as mentioned in Financial Analysis of Terminal Section (Dirty Cargo Terminal, Multi- purpose Terminal and Passenger Terminal) and Financial Analysis of Fairway Section. The Financial Models discussed in this section is prepared by combining the Financial Analysis of Terminal Section and Financial Analysis of Fairway Section of all three phases. Hence, assumptions considered for the combined model would be same. Assumptions, related to Tariff, Handling Cost, O&M Cost, Loan Schedule and Salary Calculation for Terminals & Fairway are same, which are discussed above in Terminal Section (Dirty Cargo Terminal, Multi- purpose Terminal and Passenger terminal) and Fairway Section. Most of the tariff assumptions are based on industry inputs and current Tariff of IWAI. General Assumptions for this Cumulative Financial Analysis would also be same as discussed above in Assumptions for Financial Analysis Section.

Cumulative Financial Analysis of Fairway and all terminals include development of stretch from 0 km chainange to 1,051 km chainage i.e. from Allahabad to Delhi.

Table 15.329 Development Schedule of Cumulative Terminal & Fairway

Phases	Fy 21-25	Fy 27-31	Fy 32-36	FY45	FY65
I	Development	Operational			
II		Development	Operational		
III			Development	Operational	

15.6.1.1 Capital Cost

This section represents the total capital expenditure in an Investment phased manner for Cumulative Fairway & Terminal modelling.

Table 15.330 Project Cost involed in Cumulative Fairway & Terminal (INR Crore)

Description	Total Investment	Phase I	Phase II	Phase III
		FY21 - FY25, FY30 & FY31	FY27 - FY31	FY32 - FY36
Fairway + Terminal	11,223	3,206	2,986	5,030
Navigation Cost + Approach Road	729	100	51	244
Dredging + Supporting Infra	899	896	168	169
Mechanical	2,788	845	755	1,188
Others	3,982	1,501	1,003	1,477
Total CAPEX	**19,619**	**6,549**	**4,963**	**8,108**

Development of fairway would take 5 years and in last 2 years of of each phase, terminal construction would be done.

15.5.4.3 Financing

Construction has been assumed to be funded in an Equity-Debt ratio of 35:65. Details of the means of financing for both the investment phases are shown below.

Table 15.331 Equity-Debt Share Distribution (INR Crores)

Particulars	%	Phase 1	Phase 2	Phase 3
Equity	35%	2,292	1,737	2,838
Debt	65%	4,257	3,226	5,270

15.5.4.4 Financial Indicators

This section shows the financial indicator that leads to the generation of FIRR for Cumulative Fairway and Terminal model. Revenue, Depreciation, Cash Flow, P&L Statement & Balance Sheet helps on understanding the returns on investment made for Fairway and terminal.

Revenue from this model of River Yamuna will be generated from core operations that include cargo handling at the jetty, Storage, Stackyard, Evacuation from yard to Rail, fairway usage charges, etc. The detailed breakup of revenue is shown in the table above.

Table 15.332 Revenue from Cumulative Fairway & Terminal Model (INR Crore)

Nos.	Fy-21	Fy-26	Fy-35	Fy-45	Fy-55	Fy-65
Fairway						
Phase I	-	92	107	133	137	137
Phase II	-	-	62	77	81	81
Phase III	-	-	-	431	444	444
Total	**-**	**92**	**170**	**641**	**662**	**662**
Terminal						
Phase I	0	278	366	540	569	569
Phase II	0	0	71	93	96	96
Phase III	0	0	0	459	480	480
Total	**-**	**278**	**438**	**1,092**	**1,145**	**1,145**

The following table depicts the P/L statement for development of Cumulative Fairway and Terminal model on River Yamuna.

Table 15.333 Profit & Lost Statement for Cumulative Fairway & Terminals Model (INR Crores)

Particulars	Fy-21	Fy-26	Fy-35	Fy-45	Fy-55	Fy-65
PBDIT	0	370	607	1,734	1,807	1,807
Depreciation	54	436	953	1,662	1,678	1,675

Interest	-54	-66	-346	72	129	132
PBT	0	620	1,552	215	0	0
Tax	60	394	800	304	0	0
PAT	**-114**	**-1,080**	**-2,697**	**-447**	**129**	**132**

Revenue, traffic and development cost are the major factors that heavily impacts commercial prospects of proposed terminal. As per the above table, till FY45the project is not generating sufficient profit even to cover day-today operational overheads. Depreciation has been calculated using the Straight Line Method (SLM). Under this method, cost of asset is evenly distributed across its useful life. Straight Line Method (SLM) has been used to calculate depreciation for Cumulative Fairway and Terminal model, under which the cost of tangible and intangible assets are evenly distributed across its life.

Table 15.334 Depreciation for Cumulative Fairway and Terminal Model (INR Crores)

Depreciation & Amortization	FY21	FY26	FY30	FY40	FY50	FY60	FY65
Gross Block	837	6,549	10,187	19,619	19,619	19,619	19,619
Depreciation & Amortization	-	620	618	987	-	-	-
Cumulative Depreciation & Amortization	-	1,897	4,516	15,247	19,619	19,619	19,619
Net Block	837	4,652	5,672	4,372	-	-	-

15.5.4.5 Financial IRR

Financial FIRR presented below will help IWAI to measure the financial returns on investment and assist take a firm decision on the implementation of this development. Final viability assessment for developing whole Fairway and all proposed terminal on this River Yamuna would be done based on this outcome.

Table 15.335 Financial IRR Calculation for Cumulative Fairway and Terminal (INR Crores)

Particulars	Fy-21	Fy-26	Fy-35	Fy-45	Fy-55	Fy-65
PBDIT	-54	-66	-346	72	129	132
Interest	60	394	800	304	0	0
Equity	293	0	874	0	0	0
Debt	544	0	1,624	0	0	0
Tax	0	0	0	0	39	39
Cashflow to Equity(Pre-tax)	-407	-678	-2,594	-657	60	132
Equity IRR(Pre-tax)	**N.A**					
Project Cashflow(Pre-tax)	-891	-66	-2,845	72	129	132
Project IRR(Pre-tax)	**-8.0%**					
Project IRR(Post-tax)	**-9.0%**					

- **Economic IRR**

EIRR section evaluates the value addition that, this Cumulative Fairway & Terminal Model (all Terminals + entire Fairway) induces in society and the impact on various social factors. Economic IRR (EIRR) comprises all financial and non-financial benefits of the project. It helps in investment decision from prospects of improving welfare of society. If any project is commercially unviable then its economic viability is considered. These impacts are transformed into financial gains which can bring the state and central government to fund resources for the implementation. Government undertake the detailed assessment at projects contribution to the betterment of society like employment generation, improvement in connectivity, pollution control, trade improvement, carbon emission, employment generation, reduction in congestion, less vehicle operating cost, saving on fuel, etc.

Assumptions considered for computing EIRR are for Cumulative Fairway & Terminal Model is listed below.

Table 15.336 Assumptions for EIRR Calculations

Parameters Adopted	Value	Unit
Economic loss due to Road Accidents	0.03	of GDP
Value of economic loss due to road accidents	3.76	Rs Lakhs Crores
Safety Index (IWT as base)	5.00	times safer than rail
Accident Loss		
Rail	0.77	Rs Lakhs/KM
IWT	0.15	Rs Lakhs/KM
Fuel Cost		
Rail	85.00	t-km / per liter
IWT	105.00	t-km / per liter
Fuel price	69.40	Rs/Litre
Vehicular operating cost (VOC)		
Rail	1.41	Rs/t-km
IWT	1.15	Rs/t-km
Direct Employment Creation		
Rail	2.00	Per Million t-km
IWT	0.50	Per Million t-km
Employment cost	2.50	Rs Lakhs per Annum
Emission Reduction		
Rail	13.30	g CO2/t-km
IWT	6.00	g CO2/t-km
Shadow factor		
CAPEX/O&M Cost (Convert financial cost to economic cost)	0.85	-
Carbon Credits factors		
Carbon Shadow price	20.00	$/Tonne
Exchange rate	67.00	Rs/USD

All the essential assumptions with respect to fuel efficiency, direct employment multiplier, reduction in carbon emission, and carbon credit factors have been taken from the common industrial benchmarks.

Estimated impact of each factor at Cumulative Fairway & Terminal Model till FY65 is presented in the table below.

Table 15.337 Economic IRR Calculation for Cumulative Fairway and Terminal Model (INR Crore)

Particulars	FY21	FY26	FY30	FY40	FY50	FY60	FY65
Accident Loss		5	5	5	5	5	5
Saving on fuel		18	20	288	340	340	340
Saving on account of VOC		36	41	574	678	678	678
Job creation		29	33	463	547	547	547
Reduction in Emissions		1	1	18	21	21	21
Total Revenue		370	419	1,557	1,807	1,807	1,807
Total Economic Impact	0	459	519	2,905	3,399	3,399	3,399
O&M Expenditure	54	436	636	1,586	1,682	1,676	1,675
Economic Cash Outflow	-54	22	-117	1,319	1,717	1,723	1,723
Investment	837	0	1,337	0	0	0	0
Net Cash Flow to Project	-891	22	-1,454	1,319	1,717	1,723	1,723
Project EIRR	**1.6%**						

15.7 Financial Analysis for Combination of Phase 1 & 2

This section discussed about Financial Analysis for combination of Phase 1 & Phase 2 on NW 110. This analysis would include both development and operation of terminals and fairway of respective phases (1 & 2) on NW 110. The combined Financial Analysis is done to realize whether the project could be viable by considering combined model for terminal and fairway on NW 110 (0 – 743 Km).

15.7.1 Inputs for Combined Phases (1 & 2) Financial Analysis

All the assumptions and inputs used in developing Financial Analysis for combined phases on River Yamuna are discussed in this section.

All the Assumptions for this are same as mentioned in Financial Analysis of Terminal Section (Dirty Cargo Terminal, Multi- purpose Terminal and Passenger Terminal) and Financial Analysis of Fairway Section. The Financial Models discussed in this section is prepared by combining the Financial Analysis of Phase 1 & 2 (Fairway+Terminal). Hence, assumptions considered for the combined model would be same. Assumptions, related to Tariff, Handling Cost, O&M Cost, Loan Schedule and Salary Calculation for Terminals & Fairway are same, which are discussed above in Terminal Section (Dirty Cargo Terminal, Multi- purpose Terminal and Passenger terminal) and Fairway Section. Most of the tariff assumptions are based on industry inputs and current Tariff of IWAI. General Assumptions for this Cumulative Financial Analysis would also be same as discussed above in Assumptions for Financial Analysis Section.

Cumulative Financial Analysis of Fairway and all terminals of Phase 1 & 2 include development of stretch from 0 km chainange to 743 km chainage i.e. from Allahabad (Sangam) to Agra (Opposite side to TajMahal).

Table 15.329 Development Schedule of Combined Phase 1 & 2 (Terminal & Fairway)

Phases	Fy 21-25	Fy 27-31	Fy 32-36	FY45	FY65
I	Development	Operational			
II		Development	Operational		

15.7.2 Capital Cost

This section represents the total capital expenditure in an Investment phased manner for Cumulative Fairway & Terminal modelling.

Table 15.330 Project Cost involed in Combined Phase 1 & 2 (INR Crore)

Description	Total Investment	Phase I	Phase II
		FY21-FY25,FY34 & FY35	FY27-FY31, FY34 & FY35
Fairway + Terminal	6,742	3,697	3,044
Navigation Cost + Approach Road	612	189	90
Dredging + Supporting Infra	730	896	168
Mechanical	1,676	916	760
Others	2,504	1,501	1,003
Total CAPEX	**12,264**	**7,199**	**5,065**

Development of fairway would take 5 years and in last 2 years of of each phase, terminal construction would be done.

15.7.3 Financing

Construction has been assumed to be funded in an Equity-Debt ratio of 35:65. Details of the means of financing for both the phases are shown below.

Table 15.331 Equity-Debt Share Distribution (INR Crores)

Particulars	%	Phase 1	Phase 2
Equity	35%	2,520	1,773
Debt	65%	4,679	3,292

15.7.4 Financial Indicators

This section shows the financial indicator that leads to the generation of FIRR for Cumulative Fairway and Terminal model. Revenue, Depreciation, Cash Flow, P&L Statement & Balance Sheet helps on understanding the returns on investment made for Fairway and terminal. Revenue from this model of River Yamuna will be generated from core operations that include cargo handling at the jetty, Storage, Stackyard, Evacuation from yard to Rail, fairway usage charges, etc. The detailed breakup of revenue is shown in the table above.

Table 15.332 Revenue from Combined Phase 1 & 2 Model (INR Crore)

Nos.	Fy-21	Fy-26	Fy-31	Fy-40	Fy-50	Fy-60	Fy-65
Fairway							
Phase I	-	92	101	124	137	137	137

Phase II	-	-	-	69	81	81	81
Total	**-**	**92**	**101**	**193**	**218**	**218**	**218**
Terminal							
Phase I	0	278	330	482	569	569	569
Phase II	0	0	0	82	96	96	96
Total	**-**	**278**	**330**	**563**	**665**	**665**	**665**

The following table depicts the P/L statement for development of Cumulative Fairway and Terminal model on River Yamuna.

Table 15.333 Profit & Lost Statement for Combined Phase 1 & 2 Model (INR Crores)

Particulars	Fy-21	Fy-26	Fy-31	Fy-40	Fy-50	Fy-60	Fy-65
Total Revenue	0	370	431	757	883	883	883
O&M Cost	108	452	650	830	880	897	907
PBDIT	-108	-82	-220	-74	3	-15	-24
Depreciation	0	620	1,071	618	0	0	0
Interest	60	394	582	244	9	0	0
PBT	-168	-1,096	-1,873	-935	-7	-15	-24
Tax	0	0	0	0	0	0	0
PAT	**-168**	**-1,096**	**-1,873**	**-935**	**-7**	**-15**	**-24**

Revenue, traffic and development cost are the major factors that heavily impacts commercial prospects of proposed terminal. As per the above table, till FY65 the project is not generating sufficient profit even to cover day-today operational overheads. Depreciation has been calculated using the Straight Line Method (SLM). Under this method, cost of asset is evenly distributed across its useful life. Straight Line Method (SLM) has been used to calculate depreciation for Cumulative Fairway and Terminal model, under which the cost of tangible and intangible assets are evenly distributed across its life.

Table 15.334 Depreciation for Combined Phase 1 & 2Model (INR Crores)

Depreciation & Amortization	Fy-21	Fy-26	Fy-31	Fy-40	Fy-50	Fy-65
Gross Block	837	6,549	11,512	12,264	12,264	12,264
Depreciation & Amortization	-	620	1,071	618	-	-
Cumulative Depreciation & Amortization	-	1,897	5,887	11,433	12,264	12,264
Net Block	837	4,652	5,625	832	-	-

15.5.4.5 Financial IRR

Financial FIRR presented below will help IWAI to measure the financial returns on investment and assist take a firm decision on the implementation of this development. Final viability assessment for developing whole Fairway and all proposed terminal on this River Yamuna would be done based on this outcome.

Table 15.335 Financial IRR Calculation for Combined Phase 1 & 2Model (INR Crores)

Particulars	Fy-21	Fy-26	Fy-31	Fy-40	Fy-50	Fy-60	Fy-65
PBDIT	-108	-82	-220	-74	3	-15	-24
Interest	60	394	582	244	9	0	0
Equity	293	0	464	0	0	0	0

Particulars	Fy-21	Fy-26	Fy-31	Fy-40	Fy-50	Fy-60	Fy-65
Debt	544	0	861	0	0	0	0
Tax	0	0	0	0	0	0	0
Cashflow to Equity(Pre-tax)	-461	-693	-1,644	-720	-74	-15	-24
Equity IRR(Pre-tax)	**N.A**						
Project Cashflow(Pre-tax)	-945	-82	-1,544	-74	3	-15	-24
Project IRR(Pre-tax)	**N.A**						
Project IRR(Post-tax)	**N.A**						

- **Economic IRR**

EIRR section evaluates the value addition that, this Combined Phase 1 & 2 Fairway & Terminal Model in defined stretch (0-743 Km)induces in society and the impact on various social factors. Economic IRR (EIRR) comprises all financial and non-financial benefits of the project. It helps in investment decision from prospects of improving welfare of society. If any project is commercially unviable then its economic viability is considered. These impacts are transformed into financial gains which can bring the state and central government to fund resources for the implementation. Government undertake the detailed assessment at projects contribution to the betterment of society like employment generation, improvement in connectivity, pollution control, trade improvement, carbon emission, employment generation, reduction in congestion, less vehicle operating cost, saving on fuel, etc.

Assumptions considered for computing EIRR are for Combined Phase 1 & 2 Fairway & Terminal Model is listed below.

Table 15.336 Assumptions for EIRR Calculations

Parameters Adopted	Value	Unit
Economic loss due to Road Accidents	0.03	of GDP
Value of economic loss due to road accidents	3.76	Rs Lakhs Crores
Safety Index (IWT as base)	5.00	times safer than rail
Accident Loss		
Rail	0.77	Rs Lakhs/KM
IWT	0.15	Rs Lakhs/KM
Fuel Cost		
Rail	85.00	t-km / per liter
IWT	105.00	t-km / per liter
Fuel price	69.40	Rs/Litre
Vehicular operating cost (VOC)		
Rail	1.41	Rs/t-km
IWT	1.15	Rs/t-km
Direct Employment Creation		
Rail	2.00	Per Million t-km
IWT	0.50	Per Million t-km
Employment cost	2.50	Rs Lakhs per Annum
Emission Reduction		
Rail	13.30	g CO2/t-km

IWT	6.00	g CO2/t-km
Shadow factor		
CAPEX/O&M Cost (Convert financial cost to economic cost)	0.85	-
Carbon Credits factors		
Carbon Shadow price	20.00	$/Tonne
Exchange rate	67.00	Rs/USD

All the essential assumptions with respect to fuel efficiency, direct employment multiplier, reduction in carbon emission, and carbon credit factors have been taken from the common industrial benchmarks.

Estimated impact of each factor at Combined Phase 1 & 2 till FY65 is presented in the table below.

Table 15.437 Economic IRR Calculation for Combined Phase 1 & 2 Model (INR Crore)

Particulars	FY21	FY26	FY30	FY40	FY50	FY60	FY65
Accident Loss		5	5	5	5	5	5
Saving on fuel		18	20	288	340	340	340
Saving on account of VOC		36	41	574	678	678	678
Job creation		29	33	463	547	547	547
Reduction in Emissions		1	1	18	21	21	21
Total Revenue		5	5	5	5	5	5
Total Economic Impact		18	20	288	340	340	340
O&M Expenditure		36	41	574	678	678	678
Economic Cash Outflow		29	33	463	547	547	547
Investment		1	1	18	21	21	21
Net Cash Flow to Project		370	419	757	883	883	883
Project EIRR	**5.1%**						

15.6 Conclusion

The table below gives an overview of the project cost and viability signs for all the cargo and passenger terminals development in River Yamuna.

The projected revenue (based on the higher tariff rates) is sufficient enough to cover the development cost of the terminals. The development of these terminals on River Yamuna is anticipated to provide healthy returns. However, IWAI needs to take additional measures in order to keep these terminals operational on good returns.Abovepositive derived returns can only be expected under the following conditions,

- All the cost involved in the development of terminals on River Yamuna has to be borne by IWAI itself.
- The projected traffic for the terminals would only come over in the future if total logistics cost for IWT movement is less as compared to other existing modes of transportation. Therefore, in-order to attract traffic in River Yamuna, IWAI has to structure their tariff accordingly. At the same time, IWAI should also look that the tariff is not creating a negative impact on revenue and end up at bearing losses.

- The tariff rates considered, in this financial analysis, is higher than the actual scale of rates provided by IWAI. Under the actual scale of rates, this project does not generate any positive return. IWAI has to give subsidy to match the difference between cost and inflow of the project.

Table 15.338 Summary of Financial Analysis

Type of Infrastructure	Capital Investment	Financial Returns	Economic Returns	Project Period (Years)	Conclusion	Reasoning
Option 1						
Fairway + Terminal (0-1051 Km)	19,619	-9.0%	1.60%	45	Not Viable	Investment is very high
Option 2						
Fairway + Terminal (Phase 1)	7,199	Non-Existent	4.60%	45	Not Viable	Investment is very high
Fairway + Terminal (Phase 2)	5,065	Non-Existent	N.A	45	Not Viable	Investment is very high
Fairway + Terminal (Phase 3)	7,355	Non-Existent	14.00%	45	Not Viable	Investment is very high
Total Cumulative	19,619					
Option 3						
Combination of Phase 1 & 2	12,264	Non-Existent	5.1%	45	Not Viable	Investment is very high
Option 4						
Fairway	13,154	Non-Existent	5.0%	45	Not Viable	Investment is very high
Terminal 1	271	15.00%	77.90%	30	Viable on standalone basis	Coal Traffic is high.
Terminal 2	1,154	-2.80%	15.90%	30	Not Viable	Capital Investment is very high
Terminal 3	773	Non-Existent	10.10%	30	Not Viable	Capital Investment is very high
Terminal 4	422	Non-Existent	26.50%	30	Not Viable	Capital Investment is very high
Terminal 5	649	7.30%	19.00%	30	Viable on standalone basis	Coal Traffic is very high.
Terminal 6	459	Non-Existent	3.20%	30	Not Viable	Not fully operational till Phase 3 development of NW 110
Terminal 7	1,917	5.00%	31.70%	30	Viable on standalone basis	Multipurpose terminal with very high traffic
Terminal 8	454	1.30%	10.50%	30	Viable on standalone basis	Fertiliser/Iron & Steel traffic in Phase 1. Fully operational after development of Phase 3 NW 110
Terminal 9	18	0.10%	NA	30	Viable on standalone basis	Projected Traffic is very high due to Mathura & Agra

Type of Infrastructure	Capital Investme nt	Financial Returns	Economic Returns	Project Period (Years)	Conclusion	Reasoning
Terminal 10	76	N.A	NA	30	Not Viable	Traffic from Agra to Allahabad very low. It will be viable after development of Phase 3 for movement from Delhi to Agra
Terminal 11	16	6.00%	NA	30	Viable on standalone basis	Tourist Traffic is very high
Terminal 12 a	19	Non-Existent	NA	30	Not Viable	Very low Traffic due to availability of proper road transport
Terminal 12 b	18		NA	30		
Terminal 12 c	18		NA	30		
Terminal 13 a	75	Non-Existent	NA	30	Not Viable	Less traffic movement from Agra to Allahabad.
Terminal 13 b	39	-3.40%	NA	30	Not Viable	Investment Cost is high.
Terminal 13 c	39	-0.30%	NA	30	Not Viable	
Terminal 13 d	40	-3.60%	NA	30	Not Viable	
Total	19,619					

CHAPTER – 16

CONCLUSIONS AND RECOMMENDATIONS

16.1 Conclusions

16.1.1 River Yamuna, National Waterway (NW) – 110 has transportation potential. River Yamuna can be developed as alternate mode of transportation for cargo and passenger movement. This development would help to decongest traffic of road and railway by shifting it to waterway.Developing and maintaining NW – 110 is an opportunity to improve sustainable development of this waterway and the hinterland.

16.1.2 WAPCOS carried out the technical and financial study for development of NW 110. From the detailed technical studies and analysis carried out under this assignment it is found that

a) Minimum targeted depthfor navigationin River Yamuna NW 110, from Prayagraj Sangam at Ch. 0 Km up to u/s Kalpi at Ch. 371 km can be achieved with dredging only. The remaining portion of the NW110 above Ch. 371 up to New Delhi at Ch. 1052 Km can be made navigable by constructing 20 nos. barrages with navigation locks.

b) 45 nos. existing bridges falling in the stretch of River Yamuna NW 110 are not having requisite horizontal and vertical clearance as per IWAI guidelines and needs to be demolished and reconstructed.

c) Total 19 nos. of terminal are required for handling cargo and passengers including 8 Cargo terminals, 10 Passenger terminals and one Ro-Ro terminal.

d) Navigation on River Yamuna (NW – 110) could be made technically feasible after making large investments on creation of Infrastructure.

16.1.3 Navigation on River Yamuna faces very high competition from the existing modes of transport. The wandering nature of River makes distance of travel between two points at least 40% more than optimally planned man made railways and road ways. This makes it difficult for transportation on River Yamuna compete with existing modes of transportation such as Railways and Roadways. Hence, the commercial viability of River Yamuna for large scale cargo transportation would depend upon direct supports from Government till the time scale of time scale of operation becomes such that transportation cost is lower than existing modes.

16.1.4 The traffic projections likely to be transported using River Yamuna is based on the assumption that government will assist in matching the per ton transportation cost on River Yamuna at par with Railways. No cargo would shift from Railways to Waterways in the absence of the same. The project has been found to give no returns to very poor financial returns in all possible modes/structures of investments. Hence, the project has not been found to be financially viable on standalone basis.

16.1.5 This project will contribute in development of local / regional / national economy of the region. Also, the project will generate direct and indirect employment. Therefore, this project should be conceived for initiating the development of the region. In this sense, the project should not be confined to a merely profit-making concept rather the project should be financially self-sufficient. Hence, it is very much essential that the proposed developments be taken up. The envisaged developments are expected to achieve following targets

a) De-congestion of cargo traffic moving through roads/rails
b) Diversion of cargo from road/rail to Proposed Navigation Channel
c) Paving scope for development of channel front facilities along the entire stretch of the proposed navigational channel
d) Growth in employment avenues in respect of both direct and indirect sectors

16.1.6 The economic benefits that will accrue with the development of inland waterway on NW 110 are as follows:

- Employment Generation
- Fuel savings due to Inland waterway transportation
- Carbon credit earned
- Reduction of congestion on existing modes
- Other benefits such as reduction in accidents, noise etc.
- Less cost of development
- Less land occupancy
- Property Uplift and Regeneration
- Transportation of goods and passengers
- Ecosystem Services

16.1.7 Apart from being an alternate option of transportation, NW 110 would generate various economic activities such as tourism, boating, water taxi, vessel/boat building& repairs, dredging services, hydrographical survey, safety management etc. Apart from industries, NW 110 would be attractive to both local residents and to visitors/tourists. For both of these groups, planning and investment is required to maximize the level of engagement on river Yamuna.

16.1.8 The efficiency of NW 110 could be increased by providing training at local districts, located on the bank of Yamuna. This would increase their knowledge of Project Management, IWT development, Terminal operation etc. Economic & social benefits of NW 110 could be further increased by following points

- Providing support and encouragement for IWT development
- Proper integration of public & private sector to create profitable situation for involved parties
- By putting emphasis on urban & rural development
- By promoting waterways
- Supporting & preserving river bank protection & conservation

16.1.9 There exists a need to involve both public and private sector for development and operation of inland waterway on river Yamuna. Involvement of both the sectors would ensure that the waterway is developed with all required facilities& technologies and there would be smooth operation and maintenance of the waterway. Investors could provide services specifically designed to meet some particular needs of industries, like establishing terminal facilities, parking for trucks and trailers, providing warehousing and storage facilities, operating material handling equipment such as cranes & forklifts, loaders etc.There exists huge investment opportunities in IWT system in river Yamuna.

16.2 Recommendations

Government would have to provide large scale financial supports for cargo transportation.Some of the eminent support needed from the Government is as follow

- The cost of creating, maintaining and operating fairway involved in the development of River Yamuna has to be borne by IWAI.Transferring these costs to users or private developers would further increase already high cost of water transportation compared to Railways and deter them from shift to waterways.
- The projected traffic for the terminals would only come over in the future if total logistics cost for IWT movement is less as compared to other existing modes of transportation. Therefore, in-order to attract traffic in River Yamuna, IWAI has to provide direct subsidy equivalent to the transportation cost difference between River Yamuna and Railways. This would have to be facilitated till the time cost becomes competitive. It could happen either due to gain in economy of scale and deployment of larger vessels or technological advancement reducing cost of transportation on river.
- The tariff rates considered, in this financial analysis, is higher than the actual scale of rates provided by IWAI. Under the actual scale of rates, this project does not generate any positive return.
- There exists an urgent need to involve NW 110 development agenda under major Government policies and objectives to increase socio economic benefits offered by NW 110. By doing so, it would attain long-term sustainability and would gain a wider recognition as a waterway dedicated for transport and leisure.

* Government should promote carbon-sensitive policies to reduce sector emissions, which would encourage industries to opt inland waterways.
* Government needs to generate public interest, encouragement and involvement in the prospects and potential inherent in the inland waterways in river Yamuna. Government needs to be determined to provide an investment friendly climate and generate policy and incentives that will encourage new investors and investments in NW 110.