CONTENTS

0 EXECUTIVE SUMMARY OF DRAFT DPR

0.1 Background

National Capital Region (NCR) is a unique example for inter-state regional development planning for a region with Nation Capital at its core. It is one of the largest National Capital Region of the World and constitutes about 1.60% of the country's land area. NCR is the home of 371 lakhs people living in 108 towns of which 17 are class I cities and more than 7500 rural settlements.

The four constituent Sub-Regions of NCR are given below:

1) Haryana - 40% 13,413 sq. kms. -9 districts- Faridabad, Gurgaon, Mewat, Rohtak, Sonepat, Rewari, Jhajjhar, Panipat and Palwal

2) Uttar Pradesh - 32% 10,853 sq. kms. – 5 districts - Meerut, Ghaziabad, Gautam Budha Nagar, Bulandshahr, and Baghpat

3) Rajasthan - 23% - 7,829 sq. kms. –1 district - Alwar district

4) Delhi - 5% - 1,483 sq. kms.

The population of NCR is projected to be 641.38 lakhs by 2021. Based on the projections & policies given in the Regional Plan-2021 for NCR, it is expected that the population of NCT-Delhi Sub-region would be 225 lakhs by 2021 and 163.50 lakhs, 49.38 lakhs & 203.50 lakhs for Haryana, Rajasthan Sub-region & Uttar Pradesh Sub-regions respectively.

NCR Planning Board prepared a Regional Plan with the perspective for year 2021 for the National Capital Region which was notified on 17.9.2005 for implementation. The Plan aims at promoting growth and balanced development of the National Capital Region. In this endeavor the effort is to harness the spread of the developmental impulse and agglomeration economies generated by Delhi. The above objective is sought to be achieved through:

i.) By providing suitable economic base for future growth and by identification and development of regional settlements capable of absorbing the economic development impulse of Delhi.

ii.) To provide efficient and economic rail and road based transportation networks (including mass transport systems) well integrated with the land use patterns.

iii.) To minimize the adverse environmental impact that may occur in the process of development of the National Capital Region.

iv.) To develop selected urban settlements with urban infrastructural facilities such as transport, power, communication, drinking water, sewerage, drainage etc. comparable with Delhi.

v.) To provide a rational land use pattern in order to protect and preserve good agricultural land and utilize unproductive land for urban uses.

vi.) To promote sustainable development in the Region to improve quality of life.

vii.) To improve the efficiency of existing methods and adopt innovative methods of resource mobilization, and facilitate, attract and guide private investment in desired direction.

The proposed Regional Rapid Transit System (RRTS) corridor between Delhi, Sonepat and Panipat is envisaged as part of the National Capital Region Planning Board's Transport Mobility Plan 2021 for a Mass Rapid Transit System that could provide an effective, high-speed and world class solution to benefit ridership between the cities of Panipat, Sonepat and towns of Kundli, Rajeev Gandhi Educational University, Murthal, Samalkha and Ganaur with Delhi. The RRTS corridor has been proposed to create a cost-effective yet world class transportation solution to provide a much needed relief to the NCR commuters and to discourage congestion within Delhi, a city bursting at its seams with inflow of population and strained resources and infrastructure.

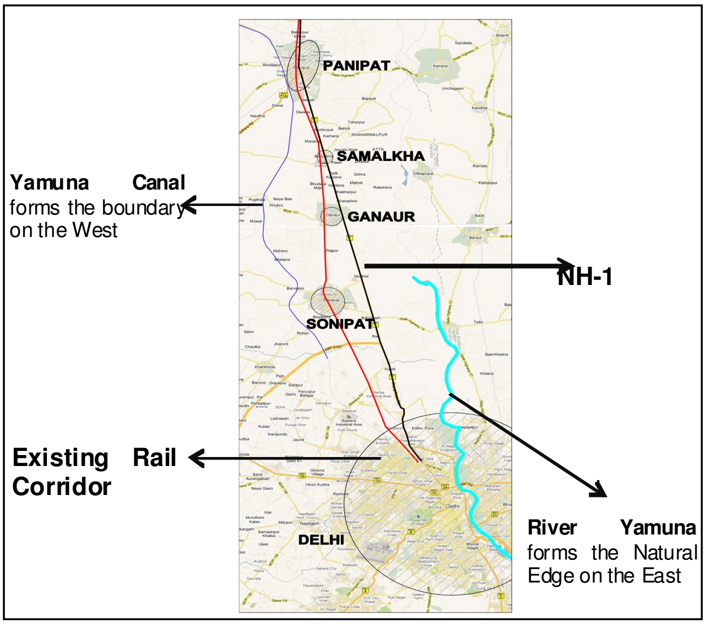
0.2 Agency

Delhi Integrated Multi Modal Transit Systems (DIMTS) has been awarded the work for development of Detailed Project Report for the proposed RRTS corridor by NCRPB. As a part of the ongoing assignment, this report "Draft Detailed Project Report" presents the financial and technical viability of the RRTS corridor.

0.3 Vision of RRTS

The Delhi-Sonepat-Panipat project corridor is in the states of Haryana and Delhi. The cities of Delhi and Panipat are connected through NH1 (6/8 lane highway) and Indian Railways trunk line. The cities and towns that lie in between Delhi and Panipat served by NH1 and the Indian Railway trunk line are Sonepat Ganaur, Samalkha, Kundli and Rai. It has been observed that most of the settlements/ development in these cities has taken place between the NH1 and Indian Railway corridor that provide connectivity between these cities as well as connectivity with Delhi and Panipat.

The project corridor is bound by the River Yamuna on the eastern fringe and the Western Yamuna Canal on the western side. It is generally observed that there is not much population to the east of NH-1, and almost all the city centres in Haryana state are located to the west of NH-1 upto Ambala. The YamunaRiver serves as the boundary between the states of Haryana and Uttar Pradesh. The western Yamuna Canal, NH-1 and the existing Indian Railway line are defined, continuous alignments between Delhi to Panipat and beyond.

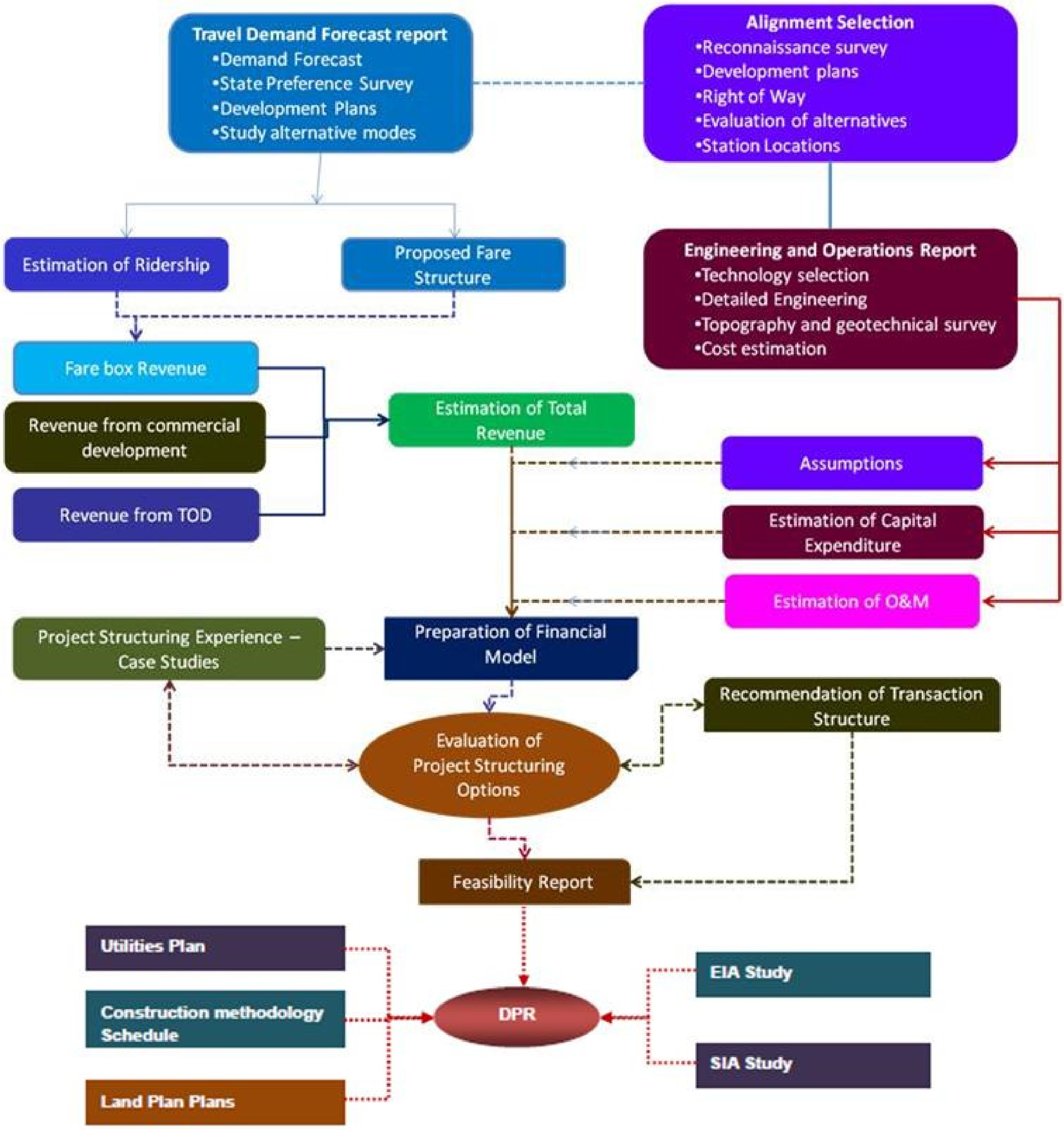


The vision of RRTS can be summarized in the following points:

- To create an an optimized hi-speed high quality transport system having predominantly seated accommodation and good comfort level for passengers
- The operating pattern may include both non-stop and stopping at all stations journeys. The non-stop journey between Delhi and Panipat to be in the order of 45-50 minutes for the RRTS corridor
- The Delhi terminus may be located for interchange with the existing Delhi Metro network or any other separate continuing link with other alignments in the RRTS
- Interchange with other MRTS corridors including the development of feeder systems to other MRTS corridors
- To use Broad gauge track and coaches must meet standard Indian structure profile
- Optimized locations of stations for ease of access to commuters and to serve maximum volume of ridership
- Optimize route, ridership and number of stops so as to achieve good operating speeds

0.4 Overall Approach for draft DPR

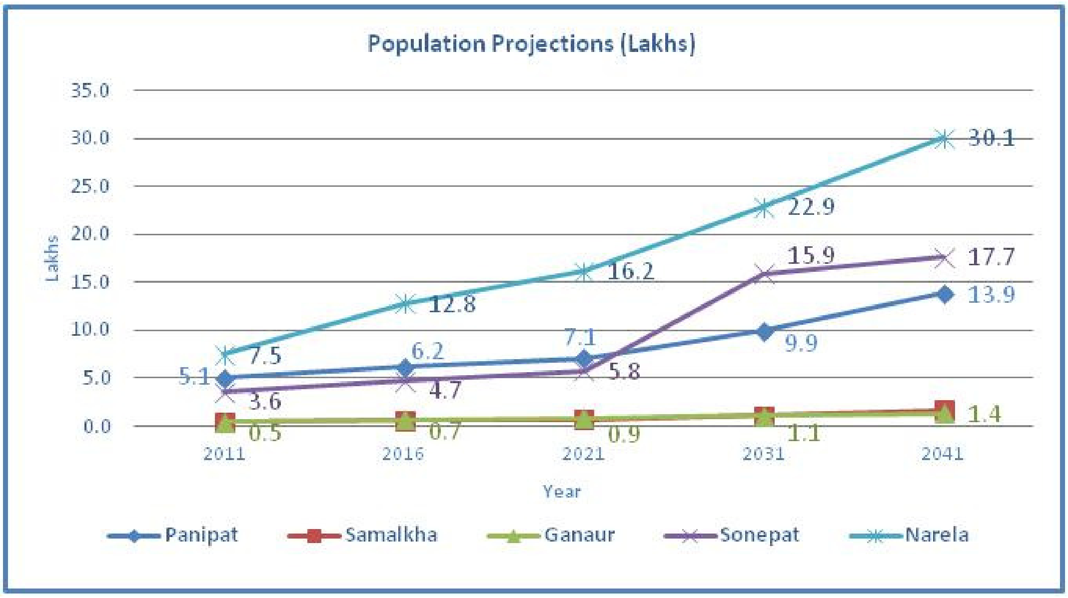
The figure below depicts the overall approach for preparation of the Viability Report for the RRTS Delhi Sonepat Panipat corridor.



0.5 Detailed Travel Demand Forecast Study

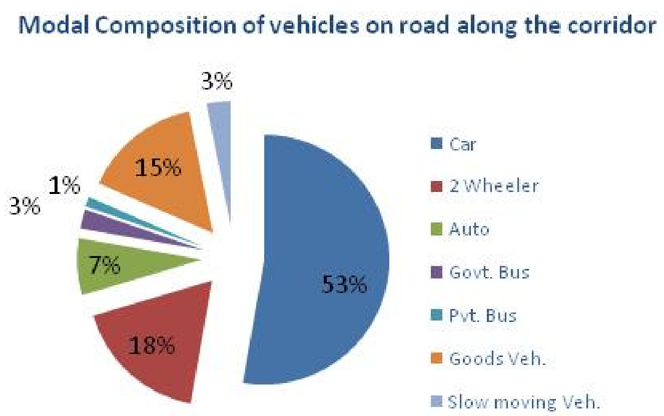
The development plans for main cities of Sonepat and Panipat along with Class-I and II towns of Ganaur and Samalkha have been studied. The development plans have projected the population for each of the towns for the year 2011 & 2021 in sync with the proposed development. Population is estimated for the horizon years 2031 and 2041 using Regression method. The demographics estimated are presented below.

Demographic profile along the corridor



0.6 Traffic Volume

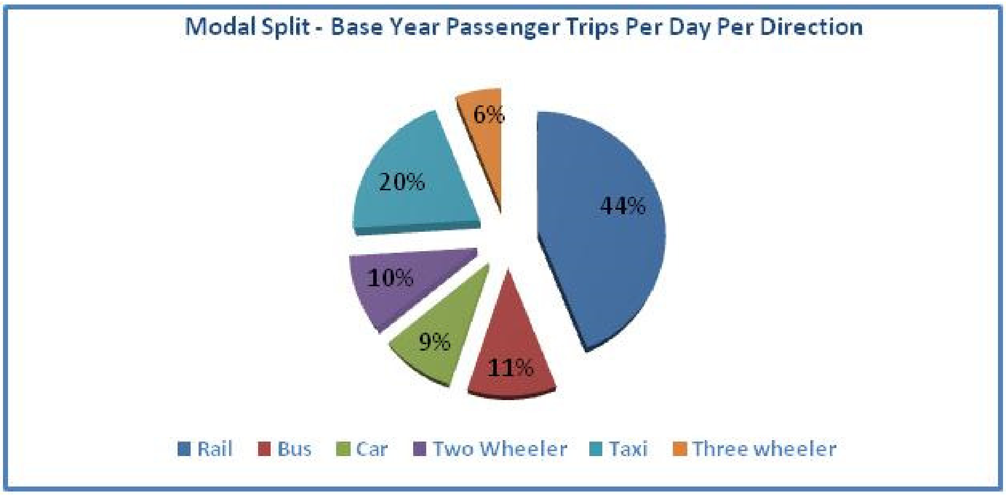
The average daily traffic and modal composition of vehicles on a typical week day in both the directions along the corridor is given below.



0.7 Travel characteristics of Base Year (2011) by Rail, Bus and Private Vehicles

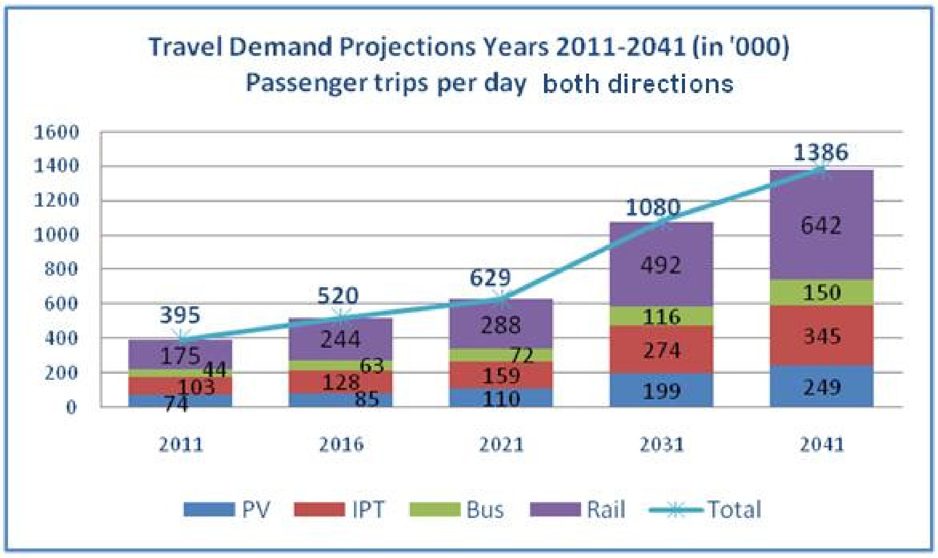
The total passenger movement from Delhi to Panipat along the study corridor is around 3.95 lakh passengers per day. The modal share shows that maximum (44%)

share of passengers is carried by rail, 11% by buses and rest by private (19%) and IPT (26%). The mode wise breakup of base year travel demand is presented in the following chart.



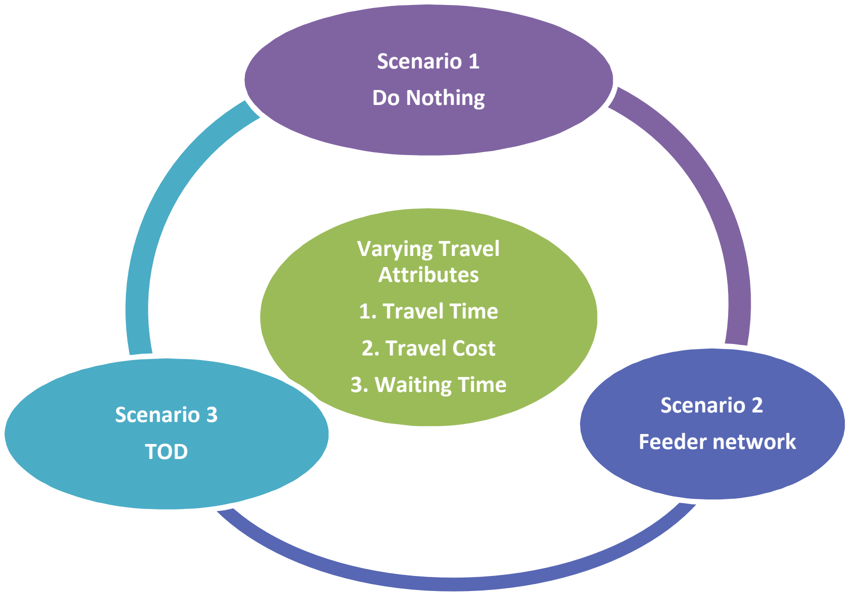
0.8 Travel Demand Forecast

Travel demand by various modes is forecasted for all the horizon years 2016, 2021, 2031, 2041.



0.9 Ridership Estimation for RRTS along the Delhi Sonepat Panipat Corridor

Stated preference surveys were conducted to arrive at binary logit mode choice model. The model is used to estimate shift from a given OD pair to RRTS based on the travel time, travel cost and waiting for that OD pair. This exercise of identifying the shift of travel from existing mode to RRTS is performed for each mode and the shift is calculated using the fares, travel time and waiting times of the existing mode to that of RRTS in the binary logit model obtained from analyzing stated preference data.



Demand has been estimated based on 74 minutes travel time between Delhi- Panipat, peak and off peak frequency as per operational plan and Rs1.1 per km fare as determined from Willingness To Pay. The fare between Delhi to Panipat City has been considered as Rs100 and the maximum fare from Delhi to IOCL Panipat has been extrapolated based on length to Rs 110. A concessional fare (monthly pass) has also been considered for the commuters. We have assumed that the concessional fare would be 25% less than the full fare for respective journeys for the consumers. It has been assumed that 75% of the passengers would be using the full fare and 25% would be using the concessional fare (monthly pass) for commuting between Delhi Panipat

In addition, a further analysis was conducted to delineate the TOD zones near to the various stations. The extra inducement of traffic from finalized TOD zones was accounted in revised forecasts.

The ridership is presented in table below

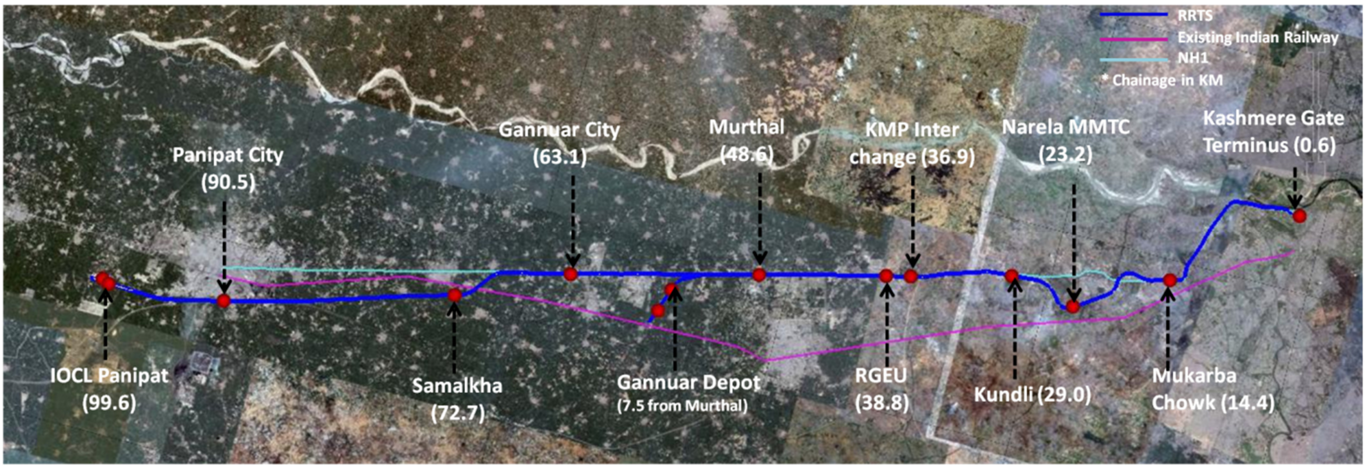
Daily ridership

Year	Total ridership (in lakhs per day)
2016	3.77
2018	4.38
2021	5.47
2031	7.79

2041	9.83

0.10 Proposed Alignment

he Delhi Sonepat Panipat RRTS alignment is proposed to start at Maharana Pratap Inter State Bus Terminus (referred to as Kasmere Gate Terminal in this report) in Delhi and ends at IOCL Panipat terminal in Haryana covering a total distance of 111.2 kms that includes a spur length of 10.6 kms at Gannaur Depot. The alignment consists of a mix of elevated (100.7 kms), underground (2.7 kms), and segregated At Grade (7.8 kms), sections across the length of the corridor. There are 12 stations and 2 depots proposed on the corridor.



The Delhi terminal of the RRTS corridor is proposed to be located underground at Kashmere Gate parallel to, and at the same level as that of new proposed phase III underground Delhi Metro station thus providing the commuters integration with Delhi Metro and Inter State Bus Terminus at Kashmere Gate. Exiting the Kashmere Gate terminus, the alignment remains underground to cross a park, residential areas and ring road and emerges on the east side of the ring road. Thereafter the alignment goes elevated and follows ring road to reach Mukarba Chowk station in Delhi and follows NH1 thereafter towards Narela Multi Modal Transit Centre. As a multimodal transit station is proposed in Delhi Master Plan at Narela, the alignment moves westward from NH1 to integrate with Narela MMTC and then again joins back NH1 alignment to proceed northwards to Haryana. In Haryana the alignment utilizes the greenbelt along the west side of NH1 with stops at Kundli, KMP interchange (Kundli Manesar Palwal Interchange), Rajeev Gandhi Education University, Murthal and Gannuar. At Gannaur, a spur of 10.6 km length has been proposed towards the west of the main alignment for RRTS depot and Gannaur Depot station that will serve the Transit Oriented Development Zone to be developed at Gannaur. Moving northwards from Gannuar city station, the elevated main alignment moves westward to cross the Indian Railway alignment to reach Samalkha station parallel to the Indian Railway station at Samalkha. From Samalkha the alignment moves northwards to reach Panipat City station and further terminates at Panipat IOCL terminal station. Depots are proposed at Panipat IOCL terminal and Gannaur. Along the alignment three Transit Oriented Zones are proposed at (1) IOCL Panipat, (2) Samalkha, and (3) Gannaur Depot.

The following table summarizes the location of stations along with other details.

Sr. No	Stations	Station location	Distance from Previous station (KM)	Total KM
1	Kashmere Gate Terminus	Underground		
2	Mukarba Chowk	Elevated	13.8	13.80
3	Narela MMTC	Elevated	8.8	22.60
4	Kundli Border	Elevated	5.8	28.40
5	KMP Expressway interchange	Elevated	7.9	36.30
6	Rajeev Gandhi Education City (Rai)	Elevated	1.9	38.20
7	Murthal (Sonepat)	Elevated	9.8	48.00
9	Gannaur (at NH1)*	Elevated	14.5	62.50
10	Samalkha	Elevated	9.6	72.10
11	Panipat City	Elevated	17.8	89.90
12	IOCL Panipat	At Grade	9.1	99.00
8	Gannaur Depot (along the spur)*	At Grade	7.5	106.5
	Additional Length of alignment			4.70
	Total Length			**111.2**

* distance from Murthal

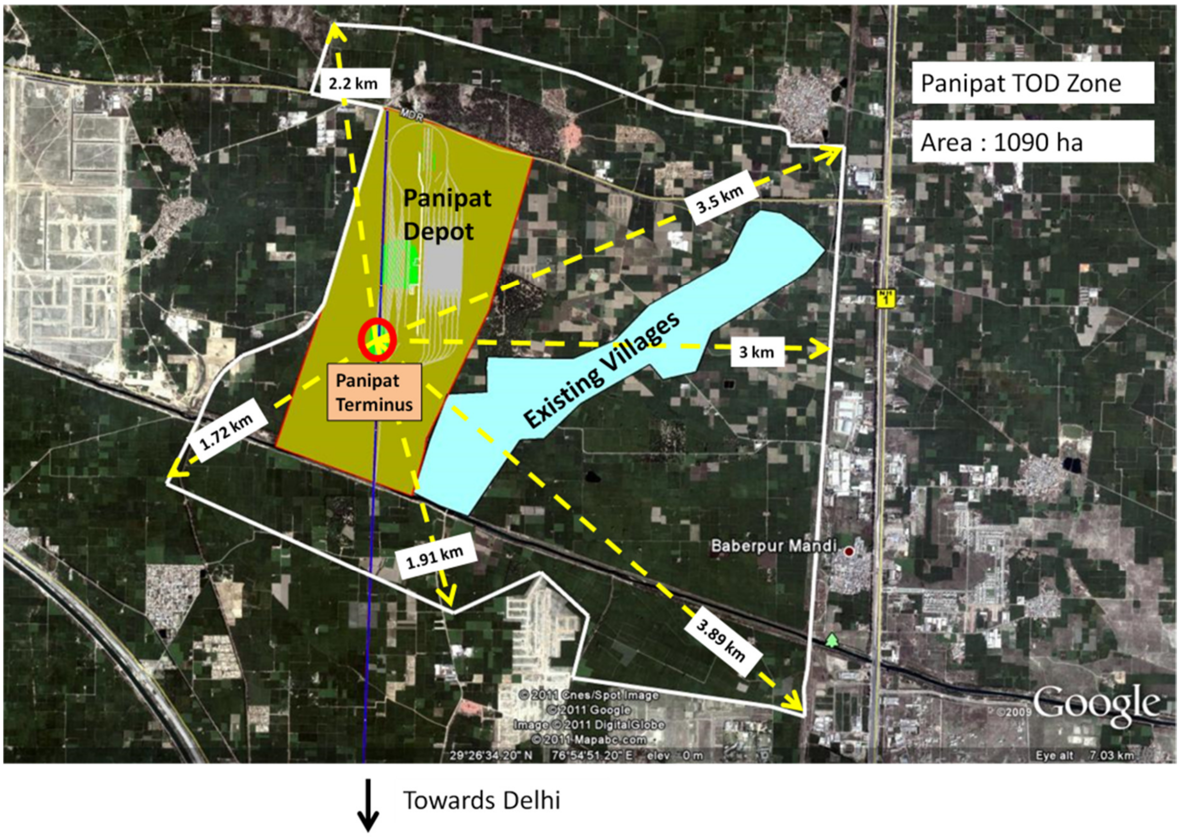
0.11 Transit Oriented Development Zones

A transit-oriented development (TOD) is a mixed-use residential or commercial area designed to maximize access to public transport, and often incorporates features to encourage transit ridership. A TOD neighborhood typically has a center with a transit station or stop (train station, metro station, or bus stop), surrounded by relatively high-density development with progressively lower-density development spreading outwards from the center.

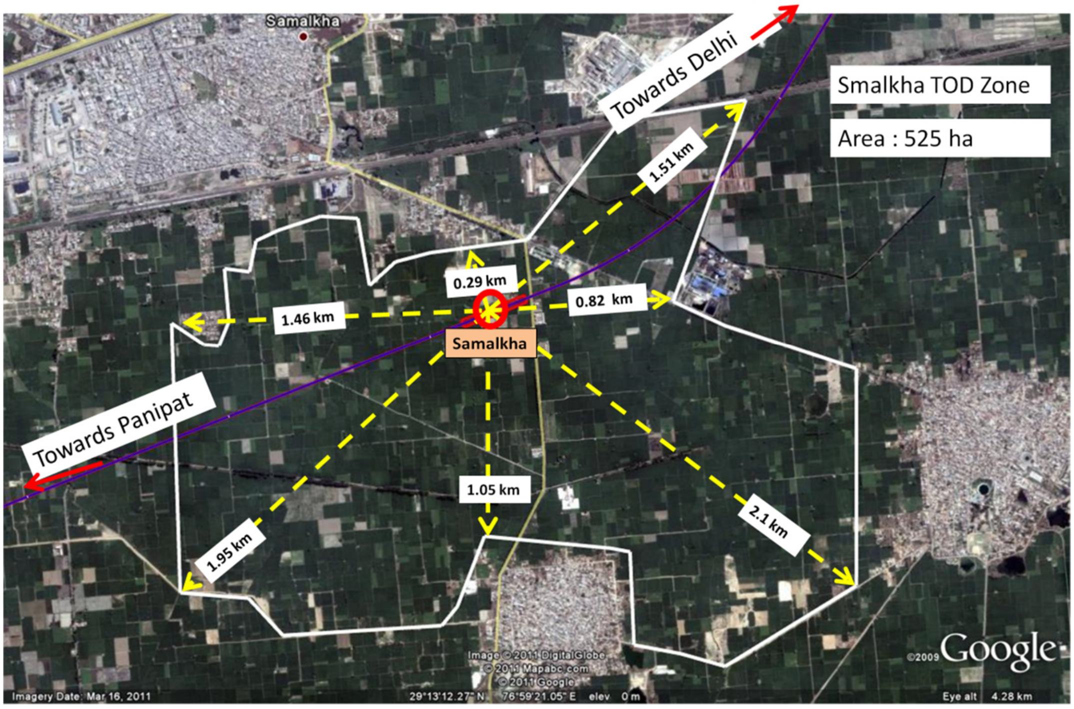
Potential TOD sites

Three potential TOD sites have been in vicinity of IOCL Panipat, Samalkha and Gannaur Depot Stations.

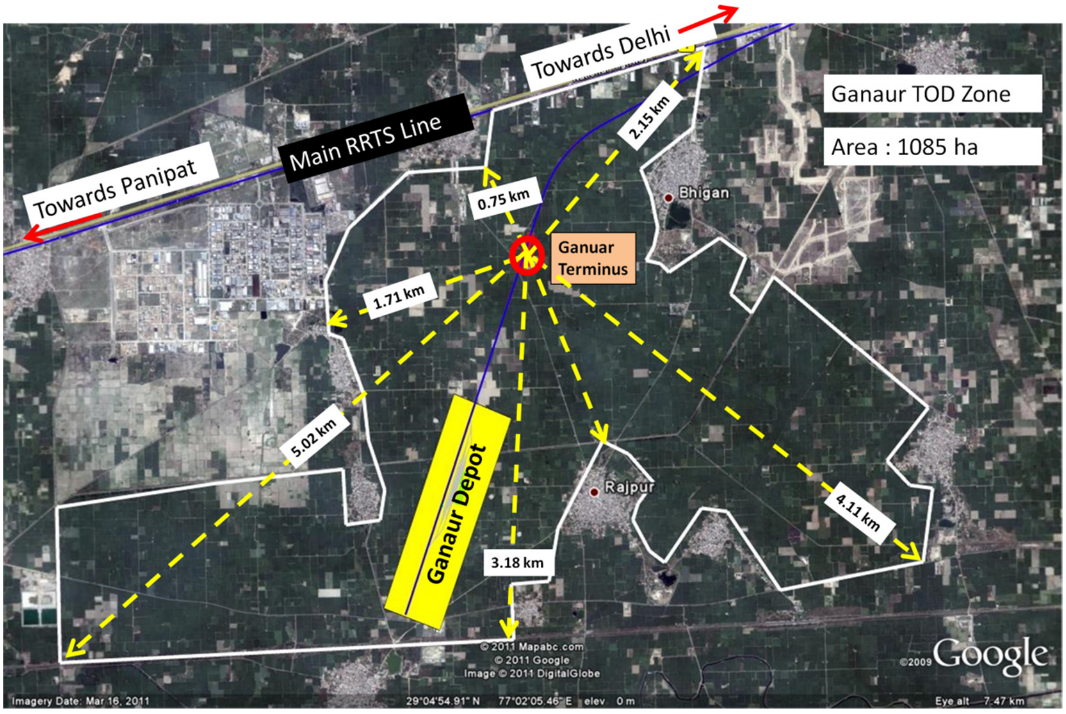
Potential area for TOD at IOCL Panipat Depot


Panipat TOD Zone
Area : 1090 ha
2.2 km
Panipat
Depot
3.5 km
3 km
Existing Villages
Panipat
Terminus
1.72 km
1.91 km
3.89 km
Baberpur Mandi
Google
Towards Delhi

Potential area for TOD at Samalkha



Potential area for TOD at Gannuar Depot



0.12 Rolling Stock Selection

Physical attributes derived from the demand for rolling stock are summarized below :

- operating headway of 3.5 minutes at Ultimate System Capacity (2041);
- operating headway of 4.5 minutes at Opening System Capacity (2021);
- cars of 3.7 metres external width;
- three double doorways per bodyside of 1.5 metres nominal width;
- one luggage stack per driving car;
- two luggage stacks per middle car;
- one wheelchair position per driving train;
- seat pitch of 800 mm arranged airline-style. Alternatively, the seats could be arranged front/rear facing;
- preferred maximum standing passenger density of 3 per square metre;
- no tables;
- no toilets;
- no catering facilities;
- no equipment cabinets within the saloons;
- no bicycle accommodation;
- no train crew accommodation (other than the drivers).

The parameters shown in Table below are those selected to provide the optimum train and train services:

Parameter	At Opening System Capacity	At Ultimate System Capacity
Peak Hour System Capacity, PHPDT	16,281	27,683
Operational Headway, minutes	4.5	3.5
Required Train Passenger Capacity	1,252	1,628
Nominal Car Length, metres	24	24
Nominal Car Width, metres	3.7	3.7
Rail Gauge, mm	1,676	1,676

Parameter	At Opening System Capacity	At Ultimate System Capacity
Seating Layout	2 + 3	2 + 3
Style of Seat Layout	Airline	Airline
Seat Pitch, mm	800	800
Density of Standing Passengers in Normal Service, per square metre	3	3
Number of Cars per Train	6	9
Train Length, metres (formed from 3-car units)	152	228
Train Stopping Accuracy at Stations, metres	10	10
Number of Doorways per Bodyside	3	3
Nominal Width of the Bodyside Doors, metres	1.5	1.5
Number of Luggage Stacks per Driving Car	1	1
Number of Luggage Stacks per Middle Car	2	2
Number of Wheelchair Positions per Driving Car	1	1
Number of Wheelchair Positions per Middle Car	0	0
Toilets on the Trains	No	No
Tables on the Trains	No	No
Catering Facilities on the Trains	No	No
Bicycle accommodation on the Trains	No	No
Train Crew Accommodation on the Trains (other than the drivers)	No	No
Train Type	25 kV EMU	25 kV EMU
Train Configuration	Fixed formation of 3-car units and 6-car units	Fixed formation of 3-car units and 6-car units
Nominal Laden Car Weight (heaviest car), tonne	77	77

Parameter	At Opening System Capacity	At Ultimate System Capacity
Extreme Car Weight, tonne	95	95
Train Power with 160 km/hr maximum speed, MW	1.90	3.00
Energy Consumption for Single Journey with 160 km/hr maximum speed, kWh	2,235	3,350
Regenerative Braking Required	Yes	Yes
Cab-end gangways with close-off doors	Yes	Yes
Passenger Saloons and Driving Cabs to be Air Conditioned	Yes	Yes
CCTV in the Trains	Yes	Yes
Maximum Train Speed, km/hr	160	160
Maximum Initial Train Acceleration, m/s^2	1.0	1.0
Initial Train Acceleration to be Independent of Train Weight	Yes	Yes
Maximum Braking Rate, m/s^2	1.0	1.0
Average Service Braking Rate, m/s^2	0.5	0.5
Stop-all-stations Journey Time from Kashmere Gate to Panipat IOCL, minutes	74	74
Stop-all-stations Journey Time from Kashmere Gate to Ganaur Terminus, minutes	41	41
Number of Trains to be Provisioned	34	44
Number of Cars to be Provisioned	204	396
Track Gauge	1676mm Indian Broad Gauge	
Track Structure	ballastless track structure on main running lines	
Rails	60kg/m flat bottom	
Signalling	CATC	

Parameter	At Opening System Capacity	At Ultimate System Capacity

The track cross section dimensions are built up as follows :

Element	Dimension	Comment
Emergency walkway	1000mm 700mm	Generally At OLE mast positions
OLE structure	300mm	
Structure clearance	2135mm	To track centreline
Track interval	4290mm	Straight track
Track interval on curves	4460mm	Minimum 400mR

0.13 Communications Systems

The Supervisory Control and Data Acquisition System (SCADA) will monitor and/or control equipment of the System including the fare collection equipment, CCTV, public and non-public Emergency Telephones (ET). It will display the alarms and will be able to control some functions of this equipment. The Remote Terminal Units (RTU) will be located in stations, substations and at the Depot

Other main components of the communications are :

- Fibre Optic Communication System
- Emergency Telephones
- Closed Circuit Television
- Passenger Information Display System
- Public Address System

0.14 Fare Collection System

For the fare collection system (FCS) a preventive maintenance schedule for each of the following system elements will be provided:

- automatic ticket vending machine (ATVM).
- automatic gate barriers (AGB).
- central and station computer system.

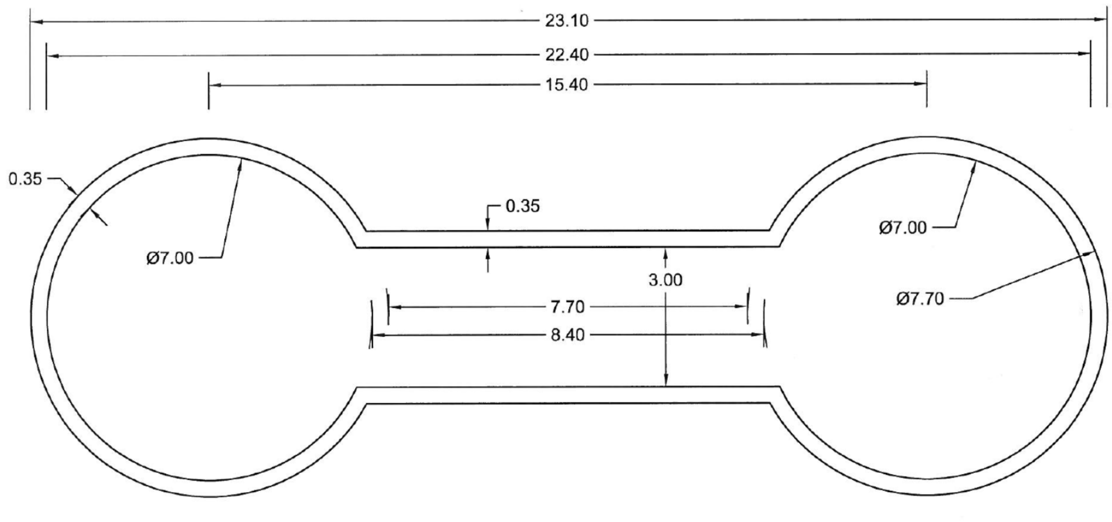
ATVMs, AGBs, station computers, central servers and computers will have self diagnostics. Preventive maintenance of the FCS consists mainly of visual inspection, cleaning and internal calibration.

0.15 Selection of Structural Form

The standard viaduct section will be formed from a precast post-tensioned concrete box girder, simply supported on single piers which are founded either on bedrock or a piled slab. The deck will carry the double track railway and will be completed by pre-cast parapets which will also form a continuous emergency walkway on both sides of the structure. Single track viaducts using similar features to the standard viaduct will be required on link lines and at stations with island platforms.

The Tunnel and Portals

For the first 2.5km length of the route out of Delhi is proposed to run underground, starting in a new station box near the existing DMRC Kashmere Gate station. Currently it is proposed that the RRTS tracks will run in twin bore tunnels with an external diameter of 7.70m.



Schematic of the Twin Bore Tunnel Section

0.16 Train operational Plan

In order to provide the required passenger capacity, the service headway could be 4.5 minutes and would be a nine minute interval service between IOCL Panipat and Kashmere Gate and a nine minute interval service between Ganaur Terminus and Kashmere Gate. Such a service will take 74 minutes between IOCL Panipat and Kashmere Gate, could be accommodated on a double track railway, and will require 29 train sets to operate. The total fleet will be 34 trains including standby trains and maintenance requirements.

0.17 Power

The RRTS: Delhi – Sonipat – Panipat railway will be a high power user. Supplies will be required for both traction and non traction systems supplied at high voltage.

Traction Power

The consumption of traction electrical power is closely related to the rolling stock characteristics, the service levels required and the permanent way geometry.

System Information	2021	2041
Estimated Energy Consumption per annum (MWh)	350,000	644,000

0.18 ASSUMPTIONS AND BOUNDARY CONDITIONS for Financial Analysis

Sr. No.	Particulars	Value
1	Base year for cost estimation	2013
2	Award of contract	October 2014
3	Years of construction	4
4	Commercial operation date (COD)	1st October 2018
5	Concession period/model period	30 years
6	End of concession period/model	30th September 2048

Sr. No.	Particulars	Rate (%)
1	Custom Duty	18.6%
2	Excise duty	8.2%
3	Value Added Tax	12.5%

Sr. No.	Particulars	Value
1	Inflation rate	5%
2	Discount rate	10%
3	Tax rate	32.45%
4	MAT	20.01%
5	80IA benefit taken from date	From COD

6	Tax holding in a block of 15 years	10 years
7(a)	Extent of Term Loan as a % of total project cost (Multilateral Funding) – In case the project is implemented by a Govt owned agency/ NCRTC	60%
7(b)	Extent of Term Loan as a % of total project cost (Multilateral Funding) – in case the project is implemented under PPP route	40%
8	Interest rate on term Loan	2%
9	Term period	20 years
10	Moratorium	Nil
11	Interest rate on future capital expenditure	10%
12	Debt equity structure for future capital expenditure	80:20
13	Repayment period for future capital expenditure	10 years

Standard taxation workings at the prevailing rates have been assumed for the financial analysis. Provision under section 80 I (A) has been considered as the project qualifies for such benefits.

0.19 Revenue Estimation

Fare Box Revenue

Mode wise Comparison of Existing Fare Structure (Year 2010)

Sr. No.	Mode	Delhi – Panipat fare (in Rs.)	Journey Time	Remarks
1	EMU – Passenger	Rs 15	2-2.5hrs	
2	Kalka Shatabdi (AC Chair Car)	Rs 285 (actual) Rs151 (Prorated)	70-80 mins	Rs 151 fare is prorated based on distance on Delhi Chandigarh full fare
3	Jan Shatabdi (AC Chair Car)	210	85 mins	
4	State Transport bus (Non AC)	65 (approx)	1.5 – 2 hrs	
5	State Transport AC Volvo Bus	200 (approx)	1.5 hrs	
6	RRTS	100	74 mins.	

Fares between the stations is based on telescopic fare structure with a minimum fare 25% of Delhi Panipat City Fare (Rs 100 for Year 2010). A rebate of 25% on the journey fare is considered for the commuters opting for the monthly pass.

Other Revenue

The revenue from other sources is estimated from the following sources:

- Commercial area/ complexes developed at the station complex
- Advertisement panels
- Betterment charges in Transit Oriented Development zones – Charges on transaction of land/ built up area

Proposed Betterment charges in TOD zones

Sr. No.	Description	Unit	Rate
			Rupees
1	Land /Site/Plot	Per sq.m / transaction	1,000
2	Developed Area		
a	Residential	Per sq.m/ transaction	1,000
b	Commercial	Per sq.m/ transaction	2,000
c	Office	Per sq.m/ transaction	1,500

Following table provides summary of revenue streams and total estimated project revenues for key years.

Sr. No.	Revenue Stream	FY2020	FY2021	FY2031	FY2041	FY2046
		Rs. Million /Year				
1	Fare box	7579	9825	28872	59445	84883
2	Revenues from station commercial	1088	1486	3259	5309	6776
3	Revenue from advertisement	76	98	289	594	849
4	TOD betterment charges post construction	6075	6075	4455	2956	2287
5	**Total Project Revenue**	**14819**	**17484**	**36875**	**68304**	**94795**

0.20 Land Pooling concept for TOD zones

In order to achieve orderly development at identified TOD Zones and along the proposed RRTS corridor, Government may pool or assemble lands and to reconstitute them in accordance with the proposed detailed development plan/scheme. The reconstituted plots of land are allotted to the owners.

Urban Development Plans Formulation & Implementation Guidelines (UDPFI), Government of India has incorporated such schemes, based on pooled land development either by the government entity or by the private owners.

Land could be assembled, on the basis of a detailed development plan/scheme, through voluntary pooling by its owners, which could be consolidated thereby permitting the local agency to develop infrastructure according to a layout plan. A portion of the land may be reserved for the provision of services including RRTS infrastructure facilities, open spaces and roads while the rest may be developed into plots to be distributed among the owners as per their share in the pooled land. The higher value of the developed plots would compensate the lesser area and payment of betterment charges.

However, this process needs to be promoted and augmented by providing appropriate policy framework in order to promote planned development and to make available land for public purposes without involving any compulsory acquisition of land.

0.21 Capital Cost Estimation

Estimated capital cost for base year 2013

Item	Description	Units	Quantity	Rate (Rs. Crore/ per Unit)	Sub-Total (Rs. Crore)	Total (Rs. Crore)	Total (Rs Mil)
1.0	**Land**					**2163**	**21,626**
1.1	Private Land, R&R & EIA	Hectare	329.3	-	2162.6		
1.2	Government land	Hectare	111.6	-			
2.0	**Civil works, Alignment and formation**					**3435**	**34,349**
2.1	Tunneling Work	R Km	2.240	168.5	377.5		
2.2	Ramp - underground	R Km	0.325	52.2	17.0		
2.3	Ramp - Elevated	R Km	0.975	20.4	19.9		
2.4	Elevated Viaduct	R Km	93.990	30.7	2881.7		
2.5	At grade Alignment	R Km	7.180	1.7	12.0		
2.6	Single Track Viaduct	R Km	2.800	-	-		
2.61	Single Track Viaduct	Total Km	5.000	25.4	126.8		
3.0	**Station Building**		12.0			**1623**	**16,229**
3.1	Underground Terminal Station	Nos.	1.0	292.2	292.2		
3.2	Elevated Stations	Nos.	9.0	124.6	1121.2		
3.3	At grade Terminal Station	Nos.	2.0	104.7	209.5		
4.0	**E&M Works**		12.0			**374**	**3,735**
4.1	Electro mechanical works including Lifts, Escalators, DG sets, UPS,ECS						

Item	Description	Units	Quantity	Rate (Rs. Crore/ per Unit)	Sub-Total (Rs. Crore)	Total (Rs. Crore)	Total (Rs Mil)
4.11	Underground station	Nos.	1.0	74.2	74.2		
4.12	Elevated station	Nos.	9.0	29.4	264.7		
4.13	At grade station	Nos.	2.0	14.7	29.4		
4.2	Tunnel Ventilation	R Km	1.5	3.5	5.1		
5.0	**Depot-cum-Workshop**		2.0			**227**	**2,267**
5.1	IOCL Panipat Depot						
5.11	Civil works, Track work, OHE	Nos.	1.0	93.3	93.3		
5.12	Plant and Machinery	Nos.	1.0	84.9	84.9		
5.2	Gannaur Depot						
5.21	Civil works, Track work, OHE	Nos.	1.0	26.5	26.5		
5.22	Plant and Machinery	Nos.	1.0	22.0	22.0		
6.0	**Permanent Way**					**796**	**7,964**
6.1	Ballastless track for elevated & underground alignment	R KM	104.1	7.1	743.4		
6.2	Ballasted/Embedded track for at grade allignment	R KM	17.2	3.1	53.0		
7.0	**Traction & Power Supply incl. OHE, ASS etc.**					**931**	**9,307**
7.1	Under Ground Section	R KM	2.57	9.6	24.6		
7.2	Elevated & At Grade Section	R KM	120.9	7.5	906.1		
8.0	**Signalling and Telecom.**					**926**	**9,264**
8.1	Signalling	R KM	121.2	7.0	847.0		
8.2	Telecom.	No. of Stations	12.0	7	79.4		
9.0	**Automatic fare collection**					**62**	**622**
9.1	Ticketed Stations	No. of Stations	12.0	5.2	62.2		
10.0	**Misc. Works**					**195**	**1,954**
10.1	Utilities Relocation	R KM	111.2	0.6	61.3		
10.2	Misc. civil works such as median, road signages	R KM	111.2	0.6	61.3		
10.3	Barracks for Security Staff including security equipments	Nos.	12.0	0.6	6.6		
10.4	Staff Quarters for O&M	Nos.	12.0	5.5	66.2		

Item	Description	Units	Quantity	Rate (Rs. Crore/ per Unit)	Sub-Total (Rs. Crore)	Total (Rs. Crore)	Total (Rs Mil)
11.0	**Rolling Stock**					**2362**	**23,616**
11.1	EMU Coaches	Nos.	204.0	11.6	2361.6		
12.0	**Miscellaneous Items**					**152**	**1,518**
12.1	Training	Nos.	1.0	11.0	11.0		
12.2	Spares (%of 7,8,9 & 11)	%	2%	4280.9	85.6		
12.3	Testing and Commissioning Costs	Nos.	1.0	55.1	55.1		
13.0	**Total**						
13.1	Total (Including Land Cost)	Sum (1 to 12)			**13245**		**132,451**
13.2	Total (Excluding Land Cost)	Item 13.1 Less 1			11082.5		
13.3	General Charges incl. Project Management, Design charges etc.	% of 13.2		5%	554.1		
13.4	Contingency	% of 13.1+13.3		5%	690		
	Estimated Construction Cost on Year 2013 Basis (Excluding Land)					**12,327**	**123,266**
	Estimated Construction Cost on Year 2013 Basis					**14,489**	**144,892**

Base capital cost with taxes and duties

Sr. No.	Components	Amount in Rs. Million
1	Land	21626
2	Base Construction Cost (excl. land cost & General Charges and Contingency)	110825
3	**Total Base Project Cost**	**132451**
4	Total Central Taxes	**12006**
a	Customs Duty	7893
b	Excise Duty	4113
5	Cost including Central Taxes (3+4a+4b)	144457
6	State Tax (VAT)	**6759**

7	Cost including State Tax (5+6)	151216
8	Project Management, design and Procurement Charges @5% on (7 -1)	6479
9	Contingency @5% on (7+8)	7885
10	**Total Cost (incl. taxes excl. IDC)**	**165580**

0.22 Operation & Maintenance Cost Estimation

The operations and maintenance cost of RRTS Delhi Panipat would consist of the following:

- Staff costs
- Energy cost
- Maintenance cost

Staff Cost

Actual staff cost for key years is presented below

Number of Staff	
Main Depot	615
Second Depot	63
Train Crew	326
Station Staff	1,308
Total Staff Number	**2,312**
Salary Cost, Rs Mil per year	**Rs Mil/year**
FY 2020	1589
FY2021	1717
FY2031	4484
FY2041	11714
FY2046	17212

Energy cost

The energy cost has been estimated based on per unit charges calculated by using weighted average of variable and fixed energy charges (at 2013 price levels) levied by the states of Haryana and Delhi for DMRC

Base energy costs (at 2013 cost levels) have been calculated for 4 blocks of years namely 2018 -2021, 2021-2034 and 2035-2044 & 2044+ The estimation of the energy cost has been done based on the energy consumption in the following areas

- Energy consumption in traction
- Energy consumption in station
- Energy consumption in depot

The base energy cost is provided in table below

Timeline	Total Consumption, kWh	Energy Cost per year, (Rs Cr)	Total Demand, kVA	Demand cost per year, (Rs Cr)	Total cost per year, (Rs Cr)
2018 to 2020	373,109,280	185.79	64,685	10.57	196.35
2021 to 2034	547,837,741	272.79	94,977	15.52	288.31
2035 to 2044	670,150,208	333.70	116,182	18.98	352.68
2044+	884,576,324	440.47	153,357	25.06	465.52

Maintenance Expenditure

For repair and maintenance of the RRTS assets, apart from staff, some material will also be used. This includes spare parts and consumables. The cost of such material which is consumed annually depends on a lot of factors such as the design of the equipment, the intensity of usage, the maintenance philosophy, the manufacturer's recommendations, renewal plans etc. The Base maintenance costs (at 2013 price levels) per annum have been estimated at a rate of 0.8% of total base capital expenditure (excluding land). The total actual O&M cost is provided in table below:

Financial Year	Maintenance cost (Rs Million)	Manpower cost (Rs Million)	Energy cost (Rs Million)
FY 2019	718	761	1177
FY 2020	1459	1589	2345
2021	1572	1717	2415
2022	1778	1854	3652
2023	1867	2002	3762
2024	1960	2379	3875
2025	2058	2569	3991
2026	2161	2774	4111
2027	2269	2996	4234
2028	2383	3236	4361
2029	2502	3844	4492
2030	2627	4152	4627

2031	2923	4484	4765
2032	3587	4843	4908
2033	3766	5230	5056
2034	3955	6214	5207
2035	4152	6711	5363
2036	4360	7248	6758
2037	4578	7827	6960
2038	4807	8454	7169
2039	5047	10043	7384
2040	5300	10846	7606
2041	5565	11714	7834
2042	5843	12651	8069
2043	6135	13663	8311
2044	6442	14756	8560
2045	6764	15937	11638
2046	7102	17212	11988
2047	7457	18589	12347
2048	7830	20076	12718

0.23 Project Structuring and Viability

State governments have taken an aggressive stand in these projects and such stand has been very well supported by the Central Government in pushing through these projects either by way of necessary legislation, land acquisition, equity commitments.

NCRPB has been instrumental in signing of MoUs with various states government, besides Ministry of Urban Development, Govt. of India (MoUD) and Ministry of Railways for making equity contribution to the RRTS projects. Further, equity contributions are expected to be made in a company referred to as NCR Transport Company or say (“NCRTC”).

NCRTC is expected to be the holding company of all RRTS projects and to our understanding is proposed have an initial corpus of Rs. 100 crores shared in the following manner:

Name of the Entity	Share in NCRTC(%)
Govt of India (MOUD + MoR + NCRPB)	50
Govt. of National Territory of Delhi	12.5
State Govt. of Uttar Pradesh	12.5
State Govt. of Haryana	12.5

State Govt. of Rajasthan	12.5
Total	**100**

NCRTC Panipat Delhi Structure

Each of the RRTS project can be developed through NCRTC where respective investments amongst state governments could be split based on project specific details. Therefore potential investments contributions could be as set out below:

Equity Contribution Structure of Delhi – Sonepat - Panipat Project

Name of Entity	Percentage (%)
Govt of India (MOUD + MoR + NCRPB)	50
Govt. of National Territory of Delhi, State and **Govt. of Haryana**	50
Total	100

The contribution of GNCTD and Govt of Haryana could be split in terms of:

a) Route length
b) Investment
c) Shareholding in the holding company

Role of Lenders

Multi-lateral funding agencies such as JICA, World Bank and ADB have shown keen interest in funding these projects. These projects are typically backed by central government guarantees towards repayment. Typically the loan repayment could be done from the project company, however, the exchange rate risk is taken on by the central government in such debt financing deals.

The project of this size would require, ideally soft loan from a multi lateral institution on attractive terms such as a loan paid of 20 to 30 years with interest rate less than 2%. We believe that the project could obtain 40% - 60% of the construction cost as soft loan from suitable multi lateral funding agency e.g. World Bank, JICA and ADB with exchange rate risk typically borne by Government of India.

As discussed in the chapter on Assumptions and Boundary Conditions, a soft loan 60% of the total project cost at 2% interest rate has been considered for the project in case the project is done by NCRTC/ Govt agency where as a soft loan of 40% of the total project cost at 2% interest rate has been considered for the project if it is done under a PPP structure.

0.24 Viability and Structuring of Project under implementation by Government

Total Project cost and phasing under project implementation by government

As discussed in section of Assumptions and boundary conditions, a soft loan of 60% of the total project cost @ 2% interest rate with 20 year repayment period has been considered in case the complete project is implemented by NCRTC/ under a government agency.
The total project cost including all taxes, escalation of cost during construction and the component of interest during construction is estimated at Rs 19038 Crs.

The table below specifies the year wise breakup of funds required for the total capital expenditure.

Year wise actual capital expenditure required for project under implementation by Government (including IDC and margin money)

Component (Cost in Rs Mil)	FY15	FY16	FY17	FY18	FY19	Total
Land, R&R and Utility shifting	7209	14418	0	0	0	21626
Civil works, Alignment and formation	5625	16089	21886	11731	0	55331
Overhead Station buildings	1976	6224	8714	4575	0	21489
Underground Station buildings	455	1435	2008	1054	0	4953
Depot-cum-Workshop	0	953	1540	566	0	3058
Power supply and substations	0	0	5428	6705	1056	13189
S&T (excluding onboard) and AFC	0	0	5458	7163	1504	14126
Miscellaneous	525	1102	1157	1215	638	4636
Rolling Stock	4831	10146	10815	5762	0	31554
Total	20622	50366	57005	38772	3198	169963
Other charges(contingency and project management)	1830	4693	5577	3983	345	16428
total capital cost without IDC	22452	55059	62582	42755	3543	186391
IDC	0	3	596	1916	1116	3632
Total Capital cost without Margin money	22452	55063	63178	44671	4659	190023

Margin money	0	0	0	0	361	361
Total capital cost	22452	55063	63178	44671	5020	190384

Suggested project structure and roles under NCRTC/ government implementation

NCRTC shall be responsible for undertaking project activities including initial civil mechanical and electrical construction, procurement of rolling stock and operations of the project as well as undertaking future expansion expenditure for the project.

The contributors to the funding for the project could be as set out below:

Name of Entity
MoUD, Govt. of India + NCRPB
Ministry of Railways + Govt. of India
Govt. of National Territory of Delhi, State Govt. of Haryana

Further, the NCRTC could borrow money from multi-lateral financial institutions with suitable government guarantees, since multi-lateral financial institutions typically request for such guarantees as well as the fact that they would find it more convenient to fund a 100% government owned company as compared to a company with private sector majority holding.

The revenue of NCRTC would include revenue from operations of RRTS, advertisement, revenues from commercial areas at stations and betterment charges from ToD areas. In turn NCRTC shall spend on day to day operations of the project and debt servicing for the soft loan taken for development of the project.

Funding pattern

Following the project structure as suggested above, the total investment breakup for the funds to be supplied by each entity including multilateral agencies is presented in the table below:

Sl. No.	Name of Entity	Investment Based on Length		Contribution Based on Initial Investment	
		%	Rs. Million	%	Rs. Million
1.	Govt of India (MOUD + MoR + NCRPB)	20%	38,077	20%	38,077
2	Govt. of National Territory of Delhi	5.1%	9,757	4.4%	8,329
3	State Govt. of Haryana	14.9%	28,320	15.6%	29,746
4	**Total by Govt**	**40%**	**76,154**	**40%**	**76,154**
6	Soft Loan	60%	114,230	60%	114,230
7	**Total investment**	**100%**	**190,384**	**100%**	**190,384**

The aforesaid excludes the project funding required for additional investments in future as well replacement costs associated with the project.

Profit and loss account for the Project

The project profit and loss statement for the project is presented below:

P&L Statement (Rs Mil)	FY20	FY21	FY26	FY31	FY36	FY41	FY46
Revenue							
Fare box revenue	**7579**	**9825**	**19258**	**28872**	**41630**	**59445**	**84883**
Revenue from commercial development	1088	1486	2554	3259	4160	5309	6776
Revenues from Advertisment Rights	76	98	193	289	416	594	849
Other Revenue (from ToD Betterment Charges)	6075	6075	5265	4455	3820	2956	2287
Total Revenue	***14819***	***17484***	***27269***	***36875***	***50026***	***68304***	***94795***
Expenses							
Maintenance cost	1459	1572	2161	2923	4360	5565	7102
Manpower cost	1589	1717	2774	4484	7248	11714	17212
power cost	2345	2415	4111	4765	6758	7834	11988
Rehabilitation Grant	335	352	450	574	732	935	1193
Total operating expenses	***5728***	***6056***	***9496***	***12746***	***19098***	***26047***	***37494***
EBITDA	9090	11428	17773	24129	30929	42257	57300
Depreciation	5020	5128	5453	5731	5865	1517	1517
EBIT	4071	6300	12320	18398	25064	40740	55784
Interest on long term loan	*2170*	*2090*	*1485*	*1004*	*446*	*49*	*0*
Interest on short term loan	*137*	*182*	*300*	*409*	*545*	*738*	*1014*
PBT	**1764**	**4027**	**10535**	**16985**	**24073**	**39953**	**54770**
Tax	353	806	2,108	5,580	7,735	11,828	17,528
PAT	**1411**	**3222**	**8427**	**11405**	**16338**	**28125**	**37242**

Cash flow, IRR and DSCR for the project

The Weighted Average Cost of Capital (WACC) under implementation of NCRTC has been estimated to be 5.51%. The estimation of the internal rate of return for the project is based on cash flow projected for the 30 year period of operations i.e. from FY2018 to FY2048.

The IRR for the project are as follows:

- Project IRR (Post Tax) 6.97%
- Project IRR (Pre Tax) 8.43%
- Equity IRR (at 60% soft loan @2%) 8.11%
- Average DSCR 3.0

0.25 Viability and Structuring of Project under PPP framework

Role of Private Sector

Private sector as the concessionaire has been fairly active in the Indian market in being part of these projects on reasonable commercial terms. Some of the projects have been successfully bid out using land banks provided as part of the project, such as Hyderabad Metro project. Other projects have used the distinction of basic infrastructure costs and rolling stock required for the project in order to enable the private sector participation, besides use of some commercial development.

We have carried out analysis for structuring the project under the PPP frame work, wherein the project can be developed under a suitable PPP frame work.

As per our estimation done under the financial analysis, private sector would be in a position to contribute 25-40% of the initial cost of construction, besides undertaking several other project responsibilities

Role Division Between Private Sector and NCRTC

Based on technical analysis carried out, the project element which could be split between government and private sector are as follows:

Project Components – Government and Private Sector (at base cost of year 2013)

Item	Description	Total (Rs. Million)	Government Sector (NCRTC)	Private Sector
1.0	Government Contribution (land, R&R, Utility shifting)	23,580	23,580	-
2.0	Civil works, Alignment and formation	34,349	34,349	-
3.0	Station Building	16,229	2,922	13,307
4.0	E&M Works	3,735	794	2,941

5.0	Depot-cum-Workshop	2,267	1,198	1,069
6.0	Permanent Way	7,964	7,964	-
7.0	Traction & Power Supply incl. OHE, ASS etc.	9,307	9,307	-
8.0	Signalling and Telecom.	9,264	9,264	-
9.0	Automatic fare collection	622	-	622
10.0	Rolling Stock	23,616	-	23,616
11.0	Miscellaneous Items	1,518	-	1,518
12.0	General Charges incl. Design charge	5,541	3,388	2,154
13.0	Contingency	6,900	4,638	2,261
14.0	**Total Base Construction Cost**	**144,892**	**97,404**	**47,488**
	% of Initial Investment		**67%**	**33%**
	% of Total Lifecycle Investment		**50%**	**50%**

From the above analysis we suggest that about 67% of the initial construction cost would need to be contributed by the government or multilateral financial institutions. It would be prudent to, therefore split the project to deliver optimum project structuring wherein a government entity could raise fund from Financial Institutions and its own sources with about 33% of project cost from private sector investment.

Total Project Cost and phasing under PPP structure

As discussed in section of Assumptions and boundary conditions, a soft loan of 40% of the total project cost @ 2% interest rate with 20 year repayment period has been considered in case the project gets implemented under suggested PPP structure.
The total project cost including all taxes, escalation of cost during construction and the component of interest during construction is estimated at Rs 18,904 Crs.

The table below specifies the year wise breakup of funds required for the total capital expenditure.

Year wise actual capital expenditure required for project under PPP structure (including IDC and margin money)

Component (Cost in Rs Mil)	FY15	FY16	FY17	FY18	FY19	Total
Land, R&R and utility shifting	7209	14418	0	0	0	21626
Civil works, Alignment and formation	5625	16089	21886	11731	0	55331
Overhead Station buildings	1976	6224	8714	4575	0	21489

Underground Station buildings	455	1435	2008	1054	0	4953
Depot-cum-Workshop	0	953	1540	566	0	3058
Power supply and substations	0	0	5428	6705	1056	13189
S&T (excluding onboard) and AFC	0	0	5458	7163	1504	14126
Miscellaneous	525	1102	1157	1215	638	4636
Rolling Stock	4831	10146	10815	5762	0	31554
Total	20622	50366	57005	38772	3198	169963
Other charges(contingency and project management)	1830	4693	5577	3983	345	16428
total capital cost without IDC	22452	55059	62582	42755	3543	186391
IDC	0	0	305	1246	737	2288
Total Capital cost without Margin money	22452	55059	62887	44001	4280	188679
Margin money	0	0	0	0	361	361
Total capital cost	22452	55059	62887	44001	4641	189040

Funding Pattern

The table below presents the actual funding required upto project commissioning for the project considering the central and state govt taxes, escalation in capital cost during construction period, IDC and margin money

Total Investment breakup for project implementation under PPP structure (Capital cost including taxes, escalation, IDC and margin money)

Sl. No.	Name of Entity	Investment Based on Length		Contribution Based on Initial Investment	
		%	Rs. Million	%	Rs. Million
	Investments by DP Infraco				
1.	Govt of India (MOUD + MoR + NCRPB)	13.5%	25,536	13.5%	25,536
2	Govt. of National Territory of Delhi	3.5%	6,544	3.0%	5,586
3	State Govt. of Haryana	10.0%	18,992	10.5%	19,949

4	**Total by DP Infraco**	**27%**	**51,071**	**27%**	**51,071**
6	Soft Loan	40%	75,607	40%	75,607
	Investments by DP Rollco				
7	DP Rollco	33%	62,362	33%	62,362
8	**Total investment**	**100%**	**189,040**	**100%**	**189,040**

The aforesaid excludes the project funding required for additional investments in future as well replacement costs associated with the project. These costs shall be required to be incurred by the DP Rollco.

Profit and Loss Account for the Project under PPP structure

Profit and Loss Account for key years is presented below:

P&L Statement (Rs Mil)	FY20	FY21	FY26	FY31	FY36	FY41	FY46
Revenue							
Fare box revenue	**7579**	**9825**	**19258**	**28872**	**41630**	**59445**	**84883**
Revenue from commercial development	1088	1486	2554	3259	4160	5309	6776
Revenues from Advertisment Rights	76	98	193	289	416	594	849
Other Revenue (from ToD Betterment Charges)	6075	6075	5265	4455	3820	2956	2287
Total Revenue	***14819***	***17484***	***27269***	***36875***	***50026***	***68304***	***94795***
Expenses							
Maintenance cost	1459	1572	2161	2923	4360	5565	7102
Manpower cost	1589	1717	2774	4484	7248	11714	17212
power cost	2345	2415	4111	4765	6758	7834	11988
Rehabilitation Grant	335	352	450	574	732	935	1193
Total operating expenses	***5728***	***6056***	***9496***	***12746***	***19098***	***26047***	***37494***
EBITDA	9090	11428	17773	24129	30929	42257	57300
Depreciation	4976	5084	5409	5687	5832	1506	1506
EBIT	4115	6344	12364	18442	25096	40751	55795
Interest on long term loan	*1437*	*1395*	*983*	*695*	*330*	*49*	*0*
Interest on short term loan	*137*	*182*	*300*	*409*	*545*	*738*	*1014*

P&L Statement (Rs Mil)	FY20	FY21	FY26	FY31	FY36	FY41	FY46
PBT	2542	4767	11081	17338	24221	39964	54781
Tax	509	954	2217	5689	7776	11830	17529
PAT	**2033**	**3813**	**8864**	**11650**	**16444**	**28134**	**37252**

Cash flow project IRR & DSCR

The Weighted Average Cost of Capital (WACC) under PPP has been estimated to be 6.82%. The estimation of the internal rate of return for the project is based on cash flow projected for the 30 year period of operations i.e. from FY2018 to FY2048.

The project IRR for the project are as follows:

- Project IRR (Post Tax) 6.93%
- Project IRR (Pre Tax) 8.43%
- Average DSCR 3.72

Equity IRR for DP Rollco

As presented in the **Error! Reference source not found.**, the private partner DP Rollco, shall be investing 33% of the total project cost in the project.

NCRTC shall select the private partner DP Rollco based on the Capital grant (positive or negative) required by the private investor for investing the 33% of the funds.

For the suggested structure, the Equity IRR for the private investor DP Rollco has been estimated based on the following assumptions:

Parameter	Unit
Debt Equity structure of Private partner (after reduction of Capital Grant)	70:30
Interest Rate	10%
Moratorium Period/ Repayment Period	3Years/ 20Years
Capital Grant for Initial investment	20% (Rs 12663 mil)

The Equity IRR estimated for the private investor is 14.02%. In this scenario, the Government shall have to pitch in an additional grant of Rs 12663 million.

In case of a positive grant required by DP Rollco, the funding from the government for the project would increase to the extent of the amount of grant provided. The table below presents the various scenarios of grant and the respective total funds required from the government including the grant for DP Rollco

Scenarios for Grant (%)	Grant (Rs Mil)	Investment from DP Infraco (Rs Mil)*	Total from Government (Rs

			Mil)
0%	0	51071	51,071
5%	3166	51071	54,237
10%	6331	51071	57,402
15%	9497	51071	60,568
20%	12663	51071	63,734

*As presented in Table **Error! Reference source not found.**

0.26 Economic Internal Rate of Return (EIRR)

The benefits vehicle operating cost savings, time savings due to increased speed and environmental benefits with improved environment are added together to get the total savings.

For the proposed project, benefits from following were assessed:

- Savings in Fuel Consumption
- Savings in Vehicle Capital Costs
- Savings due to reduced Environmental Pollution
- Savings in Travel Time
- Savings in Road Construction costs
- Accident cost

The rate of return considered desirable for the transport infrastructure project in India is 12 percent. As EIRR of proposed RRTS facility is 26.92 %, which is above 12 percent cut-off rate, the project is economically viable.

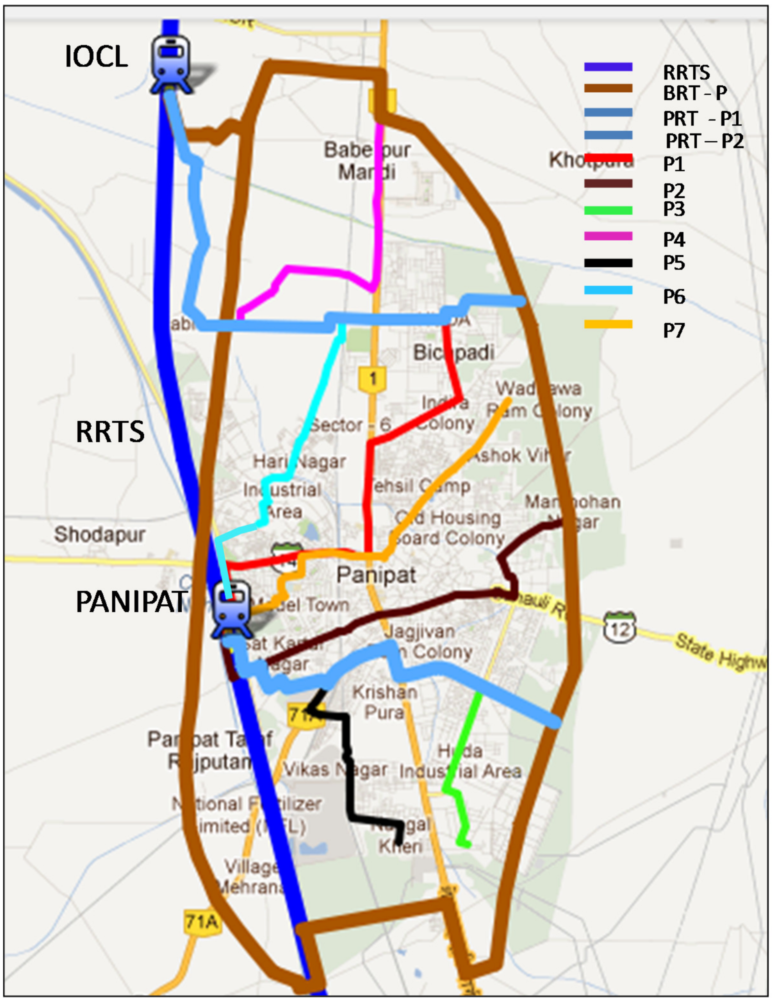
0.27 Feeder Network and Traffic Integration

This study identifies passenger's desire pattern's, distribution of residential and economic centre's in the influence area of each RRT station and define potential feeder services that could be provided to connect these nodes efficiently in conjunction with the RRT services. The Study has following components:

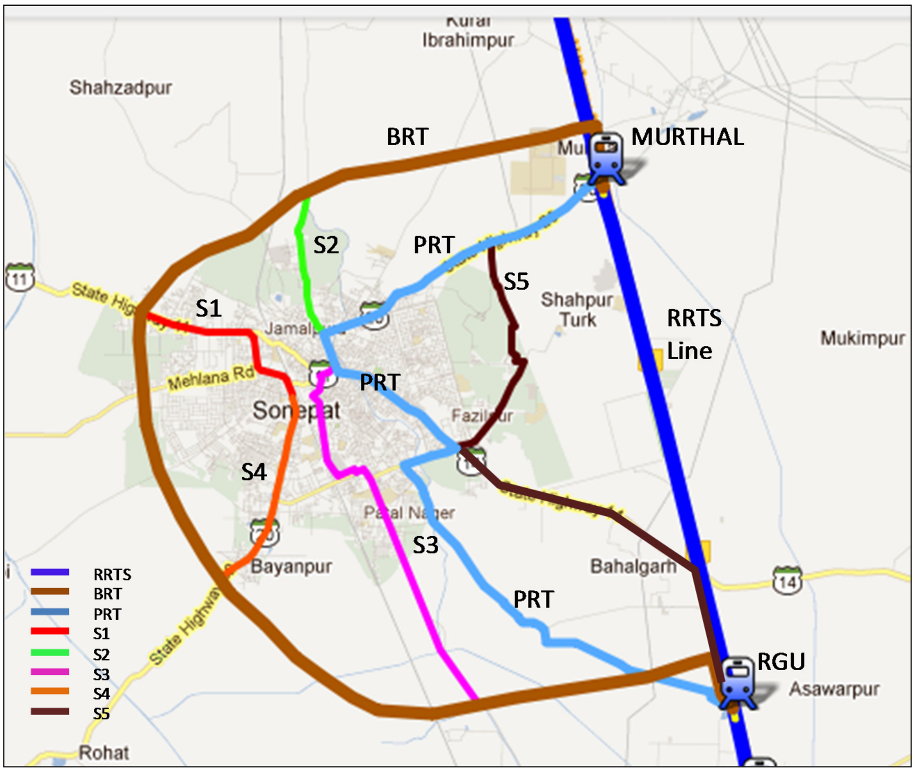
1. Review of RRT station connectivity's and identification of catchment area for major stations
2. Review and identifications of major traffic production/attraction centre's in catchment area
3. Review of Existing and proposed Bus Routes in catchment area
4. Suggest new Feeder Routes connecting major catchment area nodes not covered by existing system

5. Suggest any new system if required for integrating feeder services to the RRT station
6. Plan for complete Integrated Public Transport Network for Panipat and Sonepat region.

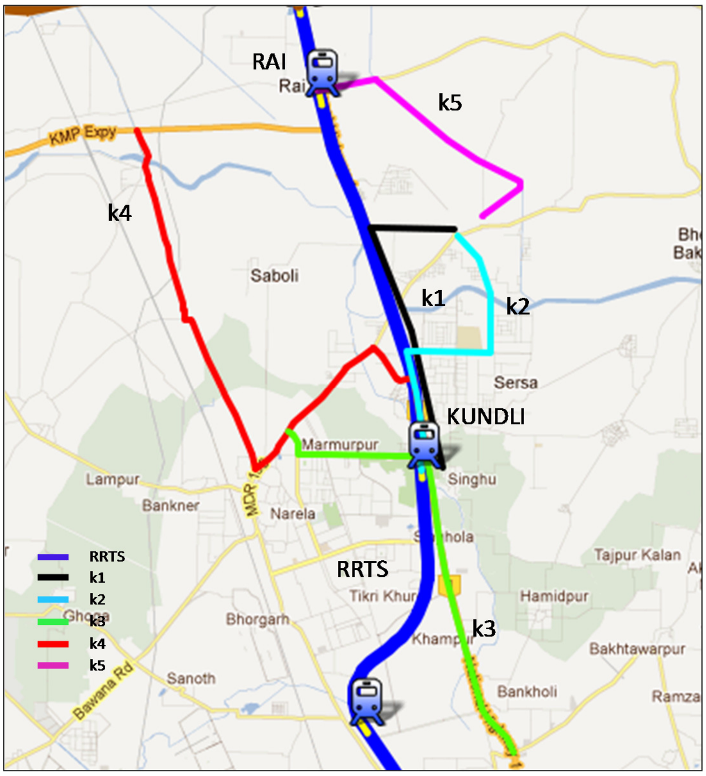
Proposed integrated network for Panipat is presented below



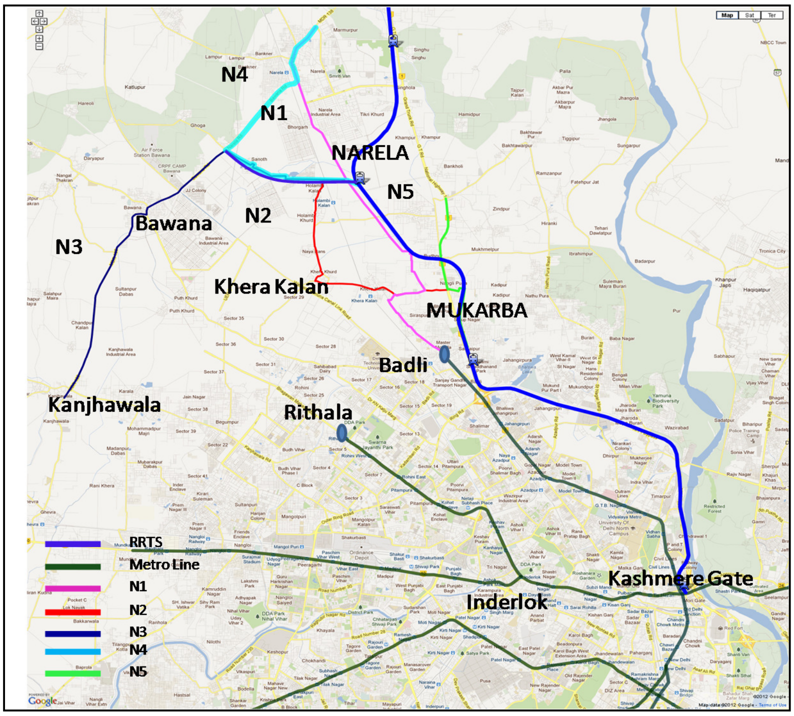
Proposed network for Sonepat is presented in figure below



Proposed network for Kundli region is presented below



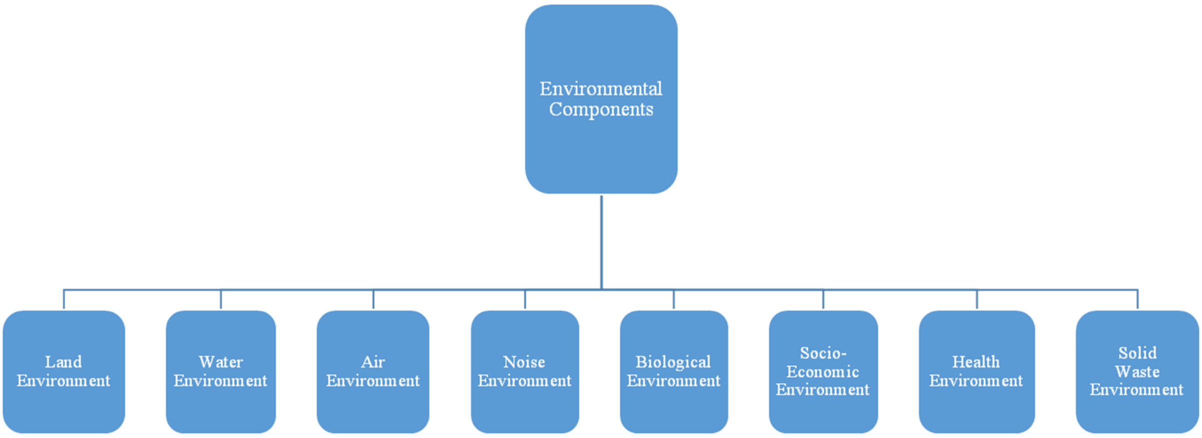
Proposed feeder network for Delhi region is presented below



The main thrust has been that providing feeder system to the main trunk line of RRT system cannot, by itself lead to a more efficient transit system. Integrating different types of modes, increases the seat-miles offered as a result of employing the most adapted and effective mode in each segment of the network. Transit modes should be made more attractive to choice-riders. Therefore, planning a feeder system to serve a RRTS can only be viewed as one component of a comprehensive transportation policy designed to shift the modal- split in favor of transit. The formulation and implementation of similar plans require the cooperation and coordination between various departments and agencies in each city/towns.

A good, easy access to the RRT system and an efficient dispersal system for the passengers at the station is crucial for choice of the commuter to ride the RRTS. The integrated multi modal transport feeder system proposed for Panipat includes at grade BRT System of 42km, elevated BRT/ PRT for 17.0km length and the rest with 40.5 km of feeder bus system. The total block cost for the infrastructure required is expected to be Rs 1730 crores. The block cost estimates for the infrastructure required for Sonepat is expected to be Rs 1413 crores. A total of Rs 3143 crores will be required to build the new infrastructure in the two regions of Panipat and Sonepat.

0.28 Environmental Impact Assessment



Environmental Management Plan

With the objective of minimizing the negative impacts and optimizing the positive benefits of the RRTS project, a comprehensive **Environmental Management System (EMS)**is drawn up. For details the detailed report on EIA may be referred to.

An environmental management system (EMS) should have various basic elements ascertaining the concern of the proponent namely,

- Commitment and Policy
- Planning,
- Implementation,
- Measurement and Evaluation,
- Review and Improvement.

Design Phase

- Land Acquisition
- Green Cover Management Plan
- Air Pollution
- Noise Management Plan
- Water Management Plan
- Avoidance of Nuisance
- Soil Management Plan
- Public Utility Management Plan
- Traffic Diversions
- Labour Management Plan

Operation Phase

- Water Quality
- Vibration Management Plan
- Safety Management
- Fire Management Plan
- On-Site Emergency Plan
- Off-Site Emergency Plan

Environmental Monitoring Programme

Monitoring of environmental factors and constraints will enable agencies to identify the changes in the environmental impacts at particular locations, application of mitigative measures and utilization of standard design guidelines for finalization of alignment design. Monitoring will also ensure that actions taken are in accordance with the construction contract and specifications. It provides a basis for evaluating the efficiency of mitigation and enhancement measures, and suggests further actions needed to be taken to achieve the desired effect.

To ensure the effective implementation of the EMP it is essential that an effective monitoring program be designed and carried out.

The monitoring includes:

- visual observations
- selection of environmental parameters at specific locations
- sampling and regular testing of these parameters

0.29 Social Impact Assessment and R&R

Land acquisition details

S No.	Impacts		No.
1	Land Acquisition Ha (including depot area)		**440.98**
2	Total Residential structure affected	249	
3	Total commercial structures affected	50	
4	Total Residential cum commercial structures affected	32	**331**
5	Total community (CPRs)		**106**
6	Total no. of DP		**1324**

Budget

S. No	Item	Amount (Crore)	Amount (Rs Mil)
1	Private Land Acquisition Cost	2144.31	21443
2	Government Land Cost	1183.46	11835
3	Structure Cost	5.14	51
4.	Community Structure Cost	2.48	24
5	R&R Assistance Cost	9.07	91
6	**Total**	**3344.46**	**33445**

0.30 Construction Method and Commissioning schedule

The programme assumes that the Award of Contract in is April 2014 with a Commercial Operating Date (COD) (Railway Opening) in October 2018.

The detailed commissioning schedule is presented along with draft DPR as an Annexure.

0.31 Identification of Utilities to be diverted

Utilities that are falling on the alignment have been identified and mapped on the alignment. The following utilities have been identified and mapped:

- Crude Gas Pipeline
- Electric Lines
- Sewage Lines
- Telecommunications Network
- Water Pipelines & Tubewell/wells

The detailed drawings are submitted as separate volumes/ reports along with this draft DPR.

0.32 Discussion with Stakeholders

As per the Minutes of Meeting issued on 02.05.13 of Consultancy Review Committee (CRC)/ Sub-committee to Task Force meeting held on 17.04.13, it has been decided and conveyed to the consultants that the milestone for Stakeholder Workshop for the project has been shifted after the submission of Draft DPR. Thus the report on discussion with stakeholders would be delivered after the Stakeholder Consultation during the submission of Final DPR stage.

0.33 Station yard Plan and changes

The RRTS Delhi Panipat alignment has been designed as a separate alignment. The utilization of existing railway land/ tracks were found to be not feasible during the course of the study.

Since the RRTS is designed as a new system separate from the existing Indian Railway system, a detailed station plan study including Urban Design has been conducted and a separate report “Urban Design Study” has been submitted during the feasibility stage. This report may be referred to for any further information.

0.34 Recommendations and Way Forward

The project is expected to be taken forward by NCRTC for implementation and operations. However, the role envisaged for NCRTC is not limited to Delhi-Panipat RRTS and is far wider in terms of development of transit infrastructure in NCR besides development of all RRTS projects.

Team for NCRTC would need to have following professionals:

- Finance professionals for implementation and operation phase
- Planning professionals for development of RRTS corridor
- Engineering professionals for implementation of RRTS projects
- Operations professionals from Engineering and other backgrounds

Apart from this there would be requirement of expertise and personnel related to areas such as transaction advisory, design and project management mainly during the project implementation phase.

Equity Contribution by Stakeholders

Based on structure of NCRTC, it is understood that the contribution between the Centre and State Governments shall be in the proportion of 50:50 to finance the government’s equity contribution for the project cost.

To decide the basis of equity contribution from each state in a project, alternatives evaluated were based on (a) equal percentage (50% each), (b) route length passing through each state and (c) investment on RRTS project in each state.

Route length does not always reflect the extent of investment required, since the number of stations, alignment location (at grade, underground, elevated), land cost are also an important criteria. Typically a heavily built up area requires an underground system.

In case route length is used as the sole criteria, the states may decide to push in more length underground through their respective areas, which may reduce the overall viability of the project. Similarly, the states may demand additional number of stations since cost sharing is based on route length.

Based on aforesaid argument, we recommend that equity contribution could be made by states in the terms of estimated investment. The present report provides on the estimate of investment in each state and this could be further refined during the construction stage.

Options for Project Structure

Based on the scope of work envisaged, NCRTC could:

(A) Either deliver the entire scope of work on its own or

(B) Seek participation in delivery of the projects.

The former is not the most recommended option even though it has its advantages as described in the following paragraph.

The advantage of NCRTC taking up RRTS projects on its own would be a clear command and control wherein based on stakeholders decision and funds availability, the projects could be implemented swiftly. NCRPB / NCRTC could therefore explore the possibility of delivering the first project as a pilot project under the aforesaid model as adopted by DMRC.

However, as a long term option PPP structure would need to be explored, where part of the work responsibility financing and risks are shared with a suitable private developer.

Possible Options under PPP Structure

NCRTC could invite private investors either at the implementation stage or at the operations stage of the projects. Since it would be possible to invite the private operators at any point during the project operations phase, the advantages of involving private investors at project implementation stage are being discussed in this report.

For Rail based Urban Transit Project, the basic philosophy of separation of civil construction and other infrastructure development from Rolling Stock and Operation remains strong for PPP projects.

The options available with NCRTC for structuring the project under PPP mode are:

- Option 1 - NCRTC to undertake construction of civil structures under EPC contracts with rolling stock brought in by the Concessionaire (DP Rollco) or
- Option 2 - The Concessionaire (DP Rollco) undertakes the entire project on its own.

Option 2 can be implemented wherein DP Rollco is initially paid for civil construction based on predetermined milestones. Structuring the project under Option 2 would have advantages in terms of involvement of the private partner right through design and construction and thus reducing these risks that could cause irreparable damage to the project.

However for this project considering the amount of investment required, considering the risks related to construction, financing, land acquisition and administration issues, whether the market has sufficient depth to deliver such a project may be doubtful.

The Option 1 which would even though increase the requirement of coordination between NCRTC and DP Rollco would be better for comparatively less risk taking developers/ conservative developers.

Also in case of option 1, the bidding criteria would be far easier to define and understand since the cost of rolling stock and operations can be estimated and the construction cost and time related risks would be passed on to NCRTC.

Based on inputs from potential developers, NCTRC could take appropriate decision on the matter. In our opinion, Option 1 i.e. NCRTC undertaking civil and other infrastructure related implementation may be more feasible option as compared to the option 2 i.e. DP Rollco implementing the entire project on its own.

As a bidding tool, the 10% stake in DPRollco by NCRTC could be used by way of positive or negative valuation for nominal 10% of DPRollco.

Raising of Financial Resources

To raise financial resources three pronged strategy needs to be followed:

- Commencement of negotiations with financial institutions and Government of India for obtaining soft loan.
- Finalizing equity contribution plans with state governments
- Implementation of Transit Oriented Development Zones

Declaration of Transit Oriented Development zones and Land Availability

The actions which need to be taken related to ToD are:

a. Preparation of Development Plans based on ToD Areas within a timeframe say 3 months
    - Conduct Survey to mark land boundary, existing physical features - topography, slope, plot boundaries, existing structures.
    - Establish ownership of land by using revenue records.
    - Prepare detailed Development Plans including recommendations on FAR.
    - Superimpose Development Plan on Survey Maps.
    - Make provisions for RRTS infrastructure facilities, roads, dedicated bus corridors, subways, water, electricity, sewage, drainage, solid waste management, green areas, social areas and other special requirements.
    - Calculate total area required for infrastructure.
    - Reconstitute the remaining area.

b. Legislation for collection of TOD Betterment Charges/levies cess from ToD areas.

c. Land acquisition where required for the project infrastructure area.

d. Identification and marking of alignment on the green belt in Haryana.

e. Land pooling activities as defined below:
    - Respective State Government identifies area for Land Pooling
    - State Government nominate an Agency (A development authority, corporation, any other agency)
    - Agency appoints a Development Officer
    - Development Officer prepares detailed layout plan
    - Development Officer invites objections from land owners

- Development Officer, based on review of objections, makes necessary revisions
- Authority, recommends to the state government for notification
- Develop major infrastructure

Financial compensation/ collection from land owners done by the Authority

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1 INTRODUCTION

1.1 National Capital Region

National Capital Region (“NCR”) is a multi-state region with Nation Capital as its centre. It covers an area of 33,578 sq km spreading over four constituent States of Delhi, Haryana, Rajasthan & Uttar Pradesh.

The National Capital Region Planning Board was constituted under the National Capital Region Planning Board Act, 1985 with the concurrence of the State legislatures of the participating States of Haryana, Uttar Pradesh and Rajasthan, (Delhi being a Union Territory at that time). It has the mandate for preparation of a Plan for the development of the National Capital Region and for coordinating and monitoring the implementation of such plan and for evolving the harmonized policies for the control of land uses and development of infrastructure in the National Capital Region comprises an area of 33,578 square kilometers and covers eight districts of Haryana, five districts of Uttar Pradesh, one district of Rajasthan and the entire National Capital Territory of Delhi. The National Capital Region also has five Counter-magnet Areas outside the Region, namely, Hissar (Haryana), Bareilly (Uttar Pradesh), Kota (Rajasthan), Patiala (Punjab) and Gwalior (Madhya Pradesh).

NCR Planning Board prepared a Regional Plan with the perspective for year 2021 for the National Capital Region which was notified on 17.9.2005 for implementation. The Plan aims at promoting growth and balanced development of the National Capital Region. In this endeavor the effort is to harness the spread of the developmental impulse and agglomeration economies generated by Delhi. The above objective is sought to be achieved through:

i.) By providing suitable economic base for future growth and by identification and development of regional settlements capable of absorbing the economic development impulse of Delhi.

ii.) To provide efficient and economic rail and road based transportation networks (including mass transport systems) well integrated with the land use patterns.

iii.) To minimize the adverse environmental impact that may occur in the process of development of the National Capital Region.

iv.) To develop selected urban settlements with urban infrastructural facilities such as transport, power, communication, drinking water, sewerage, drainage etc. comparable with Delhi.

v.) To provide a rational land use pattern in order to protect and preserve good agricultural land and utilize unproductive land for urban uses.

vi.) To promote sustainable development in the Region to improve quality of life.

vii.) To improve the efficiency of existing methods and adopt innovative methods of resource mobilization, and facilitate, attract and guide private investment in desired direction.

National Capital Region (NCR) is a unique example for inter-state regional development planning for a region with Nation Capital at its core. It is one of the largest National Capital Region of the World and constitutes about 1.60% of the country's land area. NCR is the home of 371 lakhs people living in 108 towns of which 17 are class I cities and more than 7500 rural settlements.

The four constituent Sub-Regions of NCR are given below:

1) The Haryana Sub-Region comprising of nine districts, that is, Faridabad, Gurgaon, Mewat, Rohtak, Sonepat, Rewari, Jhajjhar, Panipat and Palwal together constituting about 40% (13,413 sq. kms.) of the Region;
2) The Uttar Pradesh Sub-Region comprising of five districts, that is, Meerut, Ghaziabad, Gautam Budha Nagar, Bulandshahr, and Baghpat together constituting about 32% (10,853 sq. kms.) of the Region;
3) The Rajasthan Sub-Region comprising of Alwar district constituting about 23% (7,829 sq. kms.) of the Region ; &
4) The NCT of Delhi constituting about 5% (1,483 sq. kms.) of the Region.

Figure 1-1 National Capital Region

The population of NCR is projected to be 641.38 lakhs by 2021. Based on the projections & policies given in the Regional Plan-2021 for NCR, it is expected that the population of NCT-Delhi Sub-region would be 225 lakhs by 2021 and 163.50 lakhs, 49.38 lakhs & 203.50 lakhs for Haryana, Rajasthan Sub-region & Uttar Pradesh Sub-regions respectively.

The thrust areas of the Regional Plan – 2021 for NCR mainly includes:

1. Lays down Land Uses at the Regional level in terms of a harmonious pattern emerging from a careful examination of natural features including susceptibility to natural disasters and socio-economic activities
2. Proposes Development of Metro and Regional Centres as powerful growth nodes to attract major activities
3. Provide regional transport linkages and Mass Commuter System
4. Construction of peripheral expressways and orbital rail corridor around Delhi
5. Development of core urban infrastructure (transport, power, water supply, sewerage, drainage) in NCR towns
6. Development of the region's economy through Model Industrial Estates, Special Economic Zones outside NCT-Delhi

The Regional Plan-2021 for NCR has proposed a six tier Settlement System consisting of Metro Centres, Regional Centres, Sub-Regional Centres, Service Centres, Central Villages and Basic Villages. The urban agglomerates selected consist of 7 Metro Centres/ Complexes outside NCT of Delhi with a population of one million and above consisting of Gurgaon-Manesar, Faridabad-Ballabhgarh, Ghaziabad-Loni, Noida, Greater Noida, Meerut and Sonepat-Kundli; and 11 Regional Centres/Complexes namely Bahadurgarh, Panipat, Rohtak, Palwal, Rewari-Dharuhera-Bawal, Hapur-Pilakhua, Bulandshahr-Khurja, Baghpat-Baraut, Alwar, Greater Bhiwadi & Shahjahanpur-Neemrana-Behror.

Delhi has a limited area of 1482 sq km out of which approximately half the area is already urbanized. As per IRS IC LISS III Satellite Data (1999) the developed area in Delhi was approximately 47.31 percent where as total urbanisable area is only 65.94 percent. In the last decade, Delhi has seen substantial development (like, development at Dwarka, Rohini, Jasola) and there is limited space available for further land use growth in Delhi.

1.2 Background of the Study

As part of the initiative of NCRPB, it has prepared a Transport Plan as part of the 'NCR Regional Plan - 2021' with an objective to "promote and support the economic development of the region and relieve the Capital of excessive pressure on the infrastructure including traffic congestion. It is to provide accessibility to all parts of the region and discourage the transit of passengers and goods through the core area of NCT – Delhi by providing bypasses and there by opening areas for economic development of the rest of the region". The Transport Plan 2031 emphasizes the need for development of settlements outside NCT – Delhi and providing inter-connection between Delhi and settlements, the 'NCR Transport Plan 2031' has proposed to:

- Develop activities keeping in view rail and road linkages in Central NCR having better accessibility and at the same time relieving pressure on the existing transport routes converging at NCT-Delhi.

- Unrestricted movement of buses, taxis and auto-rickshaws within NCR. Focus on certain inter-state issues (e.g. land acquisition) for workable coordination and evolve an institutional mechanism on priority basis to encourage private participation.

- Execution without further delays of the Regional Plan-2001 proposals of Integrated Mass Rapid Transport System (MRTS), Regional Rapid Transport System (RRTS), Expressways and Bypasses.

Delhi has an impressive public transport system with about 192.7 km of Metro system supported by a fleet of more than 6500 buses which is expected to increase to 10,000 by 2015. The Delhi Metro network is also expected to double over the next five years to more than 400kms.

NCRPB has developed an NCR Plan 2031 wherein eight Regional Rapid Transit corridors (RRTS) (with an average speed of 200 km/hr) have been proposed for development to achieve fast and seamless connectivity for the satellite towns with Delhi. Out of the aforesaid eight corridors, three RRTS corridors have been chosen for implementation initially viz.

- Panipat-Sonepat-Delhi (Length-111 km)
- Meerut-Ghaziabad-Delhi (length 90 km) and
- Delhi-Alwar (Length 180 km).

To undertake the development of these projects relevant studies have been commissioned and these have reached advance stages. Development of Detailed Project Reports (DPR's) for two of the above mentioned corridors I,e, Delhi Panipat corridor and Delhi Meerut corridor is being undertaken by Delhi Integrated Multi Modal Transit Systems (DIMTS), a joint venture of Govt. of Delhi and IDFC (a financial institution promoted by Government of India).

1.3 Vision of RRTS

- An optimized hi-speed link to suit transport demand requirements
- A high quality transport system having predominantly seated accommodation and good comfort level for passengers
- Broad gauge track for wider coaches for interoperability with existing railway networks
- Coaches must meet standard Indian structure profile

- Optimized locations of stations for ease of access to commuters and to serve maximum volume of ridership
- Optimize route and ridership needs so as to achieve good operating speeds
- Optimize the number of stops in concordance with the desired operating speed
- The operating pattern may include both non-stop and stopping at all stations journeys. The non-stop journey to be in the order of 45-50 minutes for the RRTS corridor
- The Delhi terminus may be located for interchange with the existing Delhi Metro network or any other separate continuing link with other alignments in the RRTS
- Interchange with other MRTS corridors including the development of feeder systems to other MRTS corridors

The project corridor has the potential to serve a substantial volume and diverse commuter spectrum, while connecting the major cities and towns along the project stretch. The proposed RRTS system is to be designed as a controlled access system with a Design Speed in range of 180-200 km/hr. It has been suggested by NCRPB that the corridor is expected to serve the commuter traffic at comparatively speeds higher than that of the existing MRTS systems such as Delhi Metro. The RRTS as suggested is to be designed on the Indian Railways Broad Gauge system in order to accommodate substantial commuter traffic.

1.4 Content of Draft Detailed Project Report

1.4.1 Reference to earlier reports submitted under the assignment

DIMTS has been awarded the work for preparation of feasibility report followed by Detailed Project Report for the proposed Delhi Sonepat Panipat RRTS corridor by NCRPB. During the course of the assignment, we have delivered various reports based on the milestones as per the Terms of Reference. These reports have been presented to and approved by the Consultative Review Committee and Task Force constituted by Planning Commission for RRTS under the Chairmanship of Secretary, MoUD. The reports that have been submitted and approved by the Task Force constitute the building blocks for development of this draft Detailed Project Report. The draft DPR integrates all the following previous reports:

1. Travel Demand Forecast Report
2. Existing Condition Analysis Report
3. Alignment Options and Proposed Alignment Report
4. Feasibility Report constituting the following:
    i. Feasibility Report
    ii. Engineering and Operations Report
    iii. Topographical Survey Report
    iv. Topographical Survey – Proposed Plan and Profile of alignment

v. Geotechnical Report

vi. Urban Design Study Report

5. Dispersal Study Report

1.4.2 Reports being submitted under draft Detailed Project Report

1. Draft Detailed Project Report
2. Financial and Economic Viability Report
3. Environmental Impact Assessment Report
4. Social Impact Assessment and Resettlement and Rehabilitation Report
5. Detailed Alignment Drawings for the Project: Proposed Plan and Profile
6. Utility Location Plan Report Volume 1 & Volume 2
7. Land Acquisition Plans

1.4.3 Structure of draft Detailed Project Report

This report is laid out into Chapters; a summary of each section is detailed below:

Chapter 1: Introduction: The current section provides the background and objectives of the project, scope of work, deliverables and milestones achieved under the project and report structure.

Chapter 2: Approach and Methodology - This section provides the overall approach and methodology of development of draft Detailed Project Report.

Chapter 3: Recommendations from Travel Demand Forecast study - This section provides a summary of the travel demand forecast study conducted under the assignment along with estimated ridership figures. The detailed report of Travel Demand Forecast has already been submitted and approved.

Chapter 4 – Review of present railway and NH1 alignment:- This section provides the summary of Existing Condition Analysis report submitted and approved earlier as a part of this Assignment

Chapter 5: Proposed Alignment - This section provides an overview of the methodology followed to finalize the alignment, the proposed alignment & station locations. This Chapter summarizes the Proposed Alignment Report submitted and approved earlier as a part of this assignment. The chapter also describes the station locations along the corridor alongwith the Transit Oriented Development strategy and requirement for the project.

Chapter 6: Key Inputs from Engineering and Operations Study - This section provides an overview of the detailed engineering study conducted for the establishing the technical viability of the project. This chapter summarizes the key technical parameters related to requirement of rolling stock, signaling systems, civil works, station design, power systems that have been finalized for the project. This Chapter summarizes the Engineering and Operations Report submitted and approved earlier as a part of this assignment.

Chapter 7: Financial and Economic Viability – The Financial and Economic Viability report is being submitted alongwith the draft DPR. The separate Financial & Economic Viability report contains the following:

- Executive Summary of the draft DPR
- Details of assumption and inputs taken for the financial model
- Details of revenue estimates from farebox and other revenue sources identified for the project.
- Capital cost estimation for the project and information on the basis for estimation of capital cost.
- Operations and Maintenance cost estimation
- Project Structuring and Viability - This section provides a detailed analysis of the financial viability of the project under various input scenarios and assumptions. This chapter calculates Internal Rate of Return for the project. The chapter also provides various options of structuring the project including PPP alternatives. Also the chapter gives an overview of project structures and funding mechanisms of similar urban transport rail based PPP projects across the country. The section also tries to identify the potential funding sources for the project. The role of government support in terms of administrative support, policy interventions for the project has also been explained.
- Details the economic viability of the project calculating the EIRR for the project.
- Way Forward and Recommendations

Chapter 8: Feeder Network and Traffic Integration: This chapter describes the feeder network suggested for the cities of Delhi, panipat and Sonepat along with the cost of establishing the feeder network and suitable modes of transport.

Chapter 9: Environmental Impact Assessment: This chapter summarizes the EIA study conducted as a part of the assignment. A separate detailed Environmental Impact Assessment Report is being submitted along with the draft DPR.

Chapter 10: Social Impact Assessment & R&R: This chapter summarizes the SIA and R&R study conducted as a part of the assignment. A separate detailed Social Impact Assessment Report is being submitted along with the draft DPR.

Chapter 11: Construction Method and Commissioning Schedule: This Chapter describes in detail the construction methodology and details out the construction programme along with the commissioning schedule for the project

Chapter 12: Identification of Utilities to be diverted: A separate report is being submitted along with draft DPR providing the detailed drawings for the utilities falling in RRTS route.

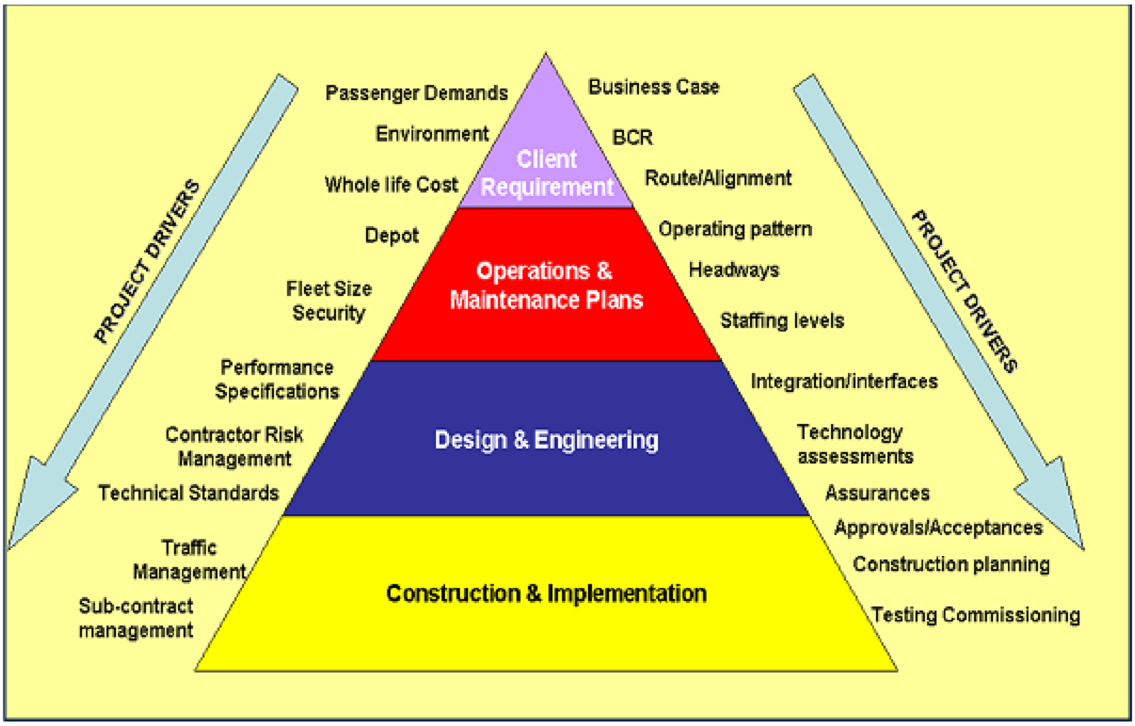
Chapter 13: Discussion with stakeholders

Chapter 14: Station yard plans and changes in existing layout: The chapter refers to the Urban Design Study report already submitted and approved during the feasibility stage of the project wherein the necessary details have been provided.

2 APPROACH AND METHODOLOGY

2.1 Overall Approach for draft Detailed Project Report

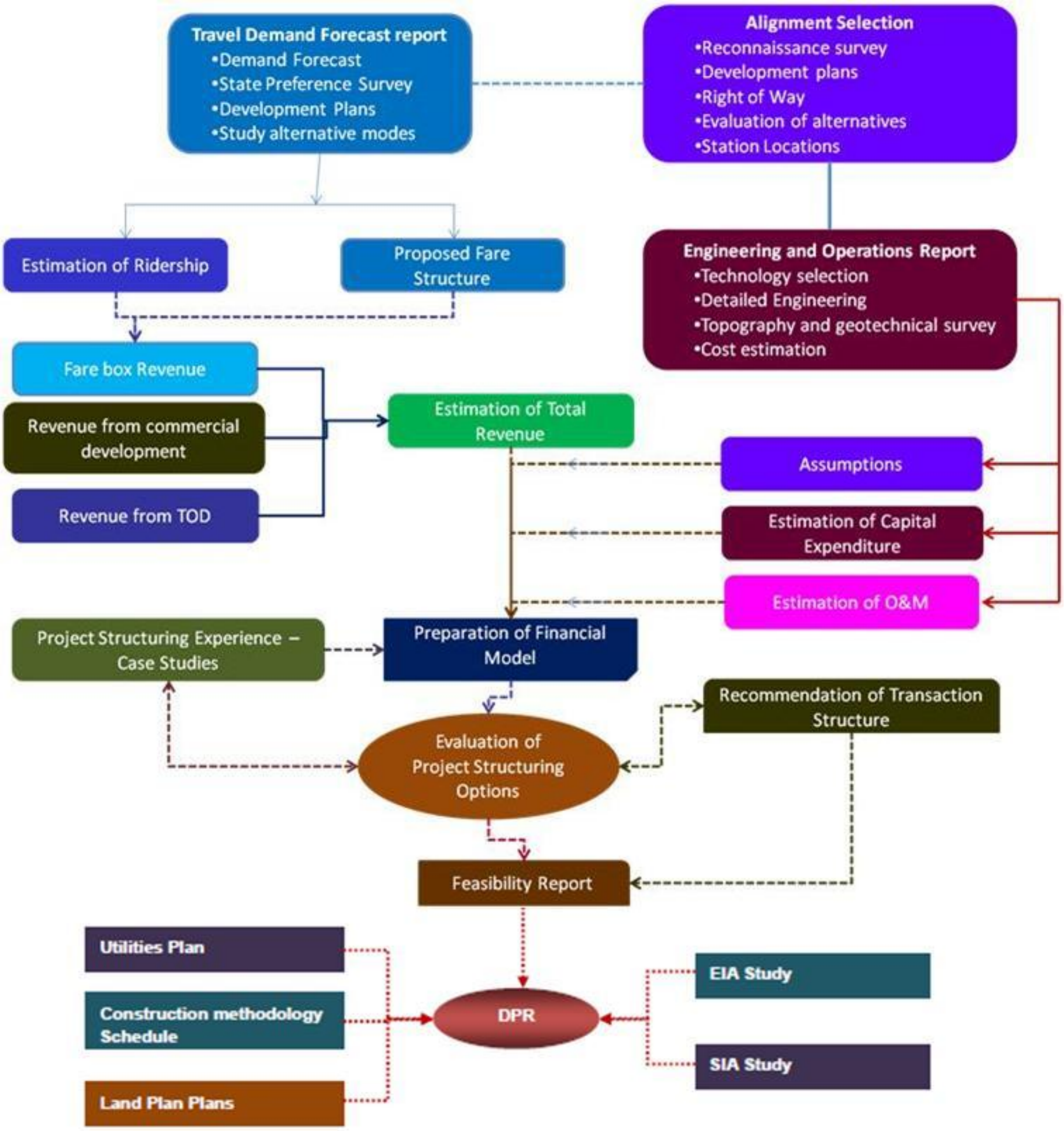
For setting up any new railway system a top down approach is adopted. The first step in this is to determine whether there is a demand for the railway and then prepare a business case for it. These along with the client requirements constitute the starting points that determine the type of railway service which must be run in order to meet the client requirements. The system design and engineering is then chosen to meet the operating parameters. Finally, the construction and implementation of the project is undertaken. These steps along with the different project drivers are pictorially represented in Figure below.



Similar approach has been adopted for this DPR study. The passenger traffic demand and need for the RRTS have been assessed through a traffic demand study. Based on this, various alignment options for the RRTS have been considered and the most suitable one chosen. Next an operations study has been done to determine the frequency and size of trains which are needed to be run in order to carry the projected traffic. Thereafter, options for the different systems like rolling stock, signal, and power supply are evaluated and the most appropriate design which can meet the operational requirements is chosen. Due consideration is given at this stage to the client's aspirations and requirements for standardization of systems. Operation and Maintenance plan for the system and cost estimates are then determined.

The figure below depicts the overall approach for preparation of the draft Detailed Project Report for the RRTS Delhi Sonepat Panipat corridor.

Figure 2-1 Detailed Approach and Methodology for DPR



2.1.1 Development of Financial Model

DIMTS has developed a detailed financial model that integrates the financial inputs related to investments and estimates of revenue from ridership and other sources based on the Engineering and Operations Report and Travel Demand Forecast Report undertaken as a part of this assignment. Based on estimates from the aforesaid traffic study, estimates of ridership over the horizon period of 30 years have been prepared. Suitable fare structure has been prepared enabling calculation of the potential revenues from passengers. Further revenue from commercial development, an essential part of the station complex and from development of Transit Oriented Development has been assessed and incorporated in the revenue projections. The financial model has been used to develop various scenarios related to variations in capital cost, phasing of expenditure, sensitivity related to fare structure etc.

2.1.2 Project Structuring and Viability

DIMTS has developed suitable options on project structure and based on such project structure identified the project viability covering the following:

- Financial projections and assessment of financial viability.
- Identifying the possible sources of funding for the project along with options for phasing of the project.
- Identifying viability enhancing measures required such as capital grants, guarantees, and/or potential revenue from commercial development and TOD.
- Potential PPP structure that can be explored for encouraging the private investment in the project.
- Policy level interventions

3 RECOMMENDATIONS FROM TRAVEL DEMAND FORECAST STUDY

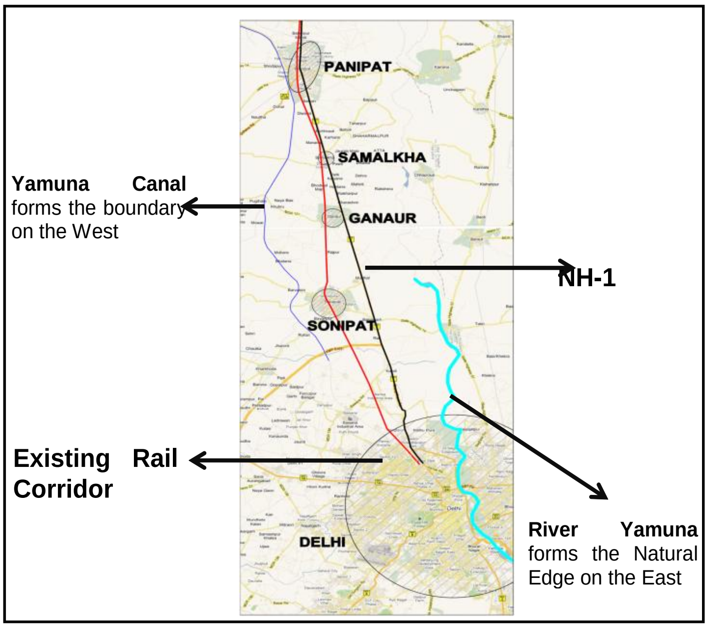
3.1 Detailed Travel Demand Forecast Study

The Travel Demand Forecast Study has been conducted as a part of the preparation of the Feasibility Report followed by Detailed Project Report for development of Regional Rapid Transit System (RRTS) for Delhi – Sonepat – Panipat Corridor for a rail based transportation system integrated with multi modal transport infrastructure for NCR. This chapter presents the synopsis of the Travel Demand Forecast Study conducted under the assignment. A detailed report on the Travel Demand Forecast Study has already been submitted and may be referred to for any further details required.

3.2 Existing Connectivity on the Project Corridor

The Delhi-Sonepat-Panipat project corridor is in the states of Haryana and Delhi. The cities of Delhi and Panipat are connected through NH1 (6/8 lane highway) and Indian Railways trunk line. The cities and towns that lie in between Delhi and Panipat served by NH1 and the Indian Railway trunk line are Sonepat Ganaur, Samalkha, Kundli and Rai. It has been observed that most of the settlements/ development in these cities has taken place between the NH1 and Indian Railway corridor that provide connectivity between these cities as well as connectivity with Delhi and Panipat.

Figure 3-1 Project Location Map



The project corridor is bound by the River Yamuna on the eastern fringe and the Western Yamuna Canal on the western side. It is generally observed that there is not much population to the east of NH-1, and almost all the city centres in Haryana state are located to the west of NH-1 upto Ambala. The Yamuna River serves as the boundary between the states of Haryana and Uttar Pradesh. The western Yamuna Canal, NH-1 and the existing Indian Railway line are defined, continuous alignments between Delhi to Panipat and beyond.

3.3 Surveys and Studies

Extensive and in-depth surveys and studies have been carried out to appreciate the traffic and travel characteristics along the corridor. The various surveys conducted are given below.

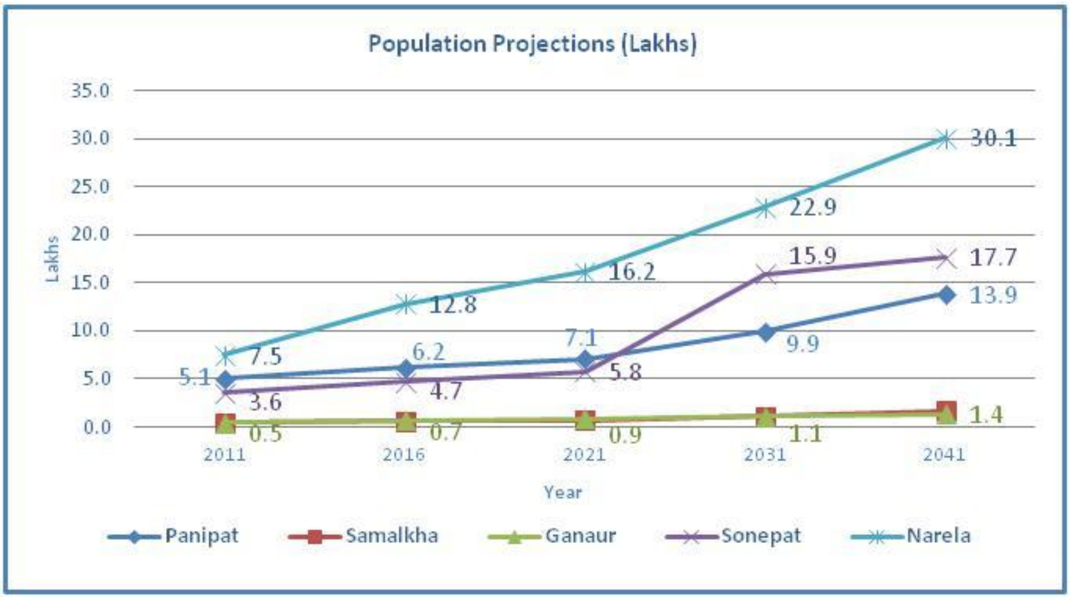
Table 3-1 : Details of Traffic Surveys

Sl. No.	Survey Title	Days	Quantum
1	Origin Destination Surveys	2 week days & 1 week end	21 locations including rail and bus stations
2	Passenger Head Count surveys	2 week days & 1 week end	16 locations including rail and bus stations)
3	Classified Traffic Volume Count Survey	16 hours	6 locations (mid block)
4	Occupancy Survey	-	6 locations
5	Stated Preference Survey	-	Conducted about 12500 enumerations among various modes

3.4 Demographic Profile along the Corridor

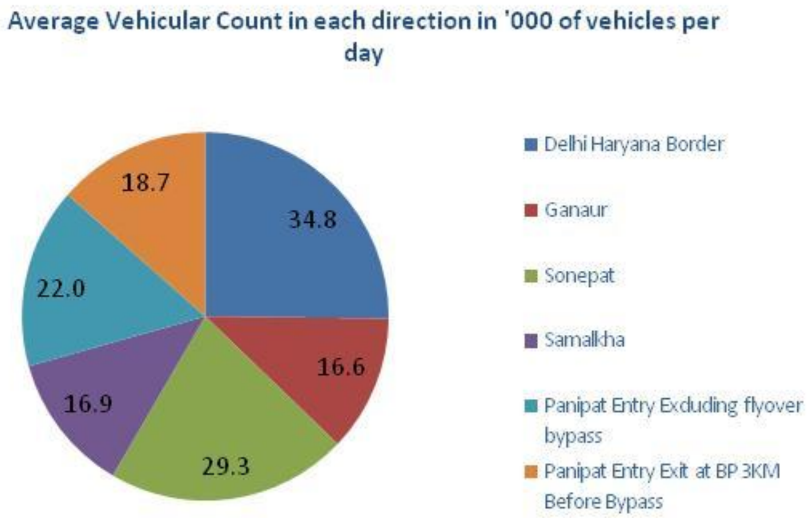
The development plans for main cities of Sonepat and Panipat along with Class-I and II towns of Ganaur and Samalkha have been studied. The development plans have projected the population for each of the towns for the year 2011 & 2021 in sync with the proposed development. Population is estimated for the horizon years 2031 and 2041 using Regression method. The demographics estimated are presented below.

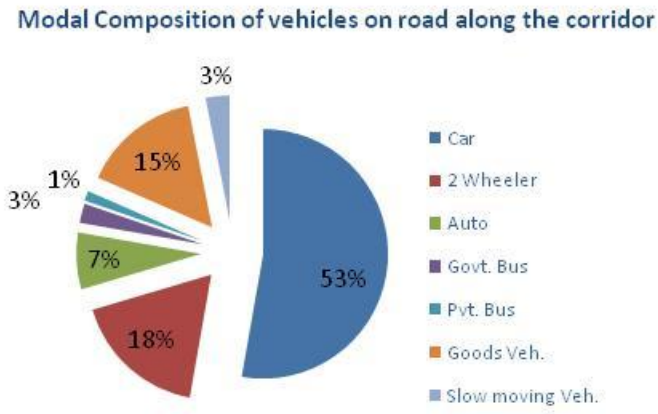
Figure 3-2 Demographic profile along the corridor



3.5 Traffic Volume

The average daily traffic and modal composition of vehicles on a typical week day in both the directions along the corridor is given below.

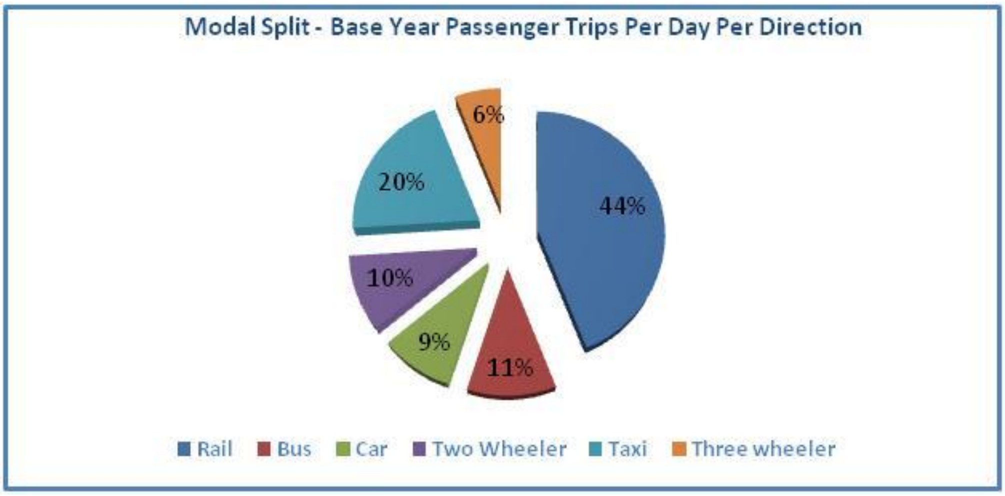




3.5.1 Travel characteristics of Base Year (2011) by Rail, Bus and Private Vehicles

Based on the analysis presented in the earlier sections on rail, bus and private vehicles travel pattern, potential trips for each probable station is estimated. The total passenger movement from Delhi to Panipat along the study corridor is 395437 passengers per day. The modal share shows that maximum (44%) share of passengers is carried by rail, 11% by buses and rest by private (19%) and IPT (26%) modes. The potential trips estimated in above analysis were utilized for estimating station-wise ridership based on willingness to shift estimated from Stated Preference Surveys. The mode wise breakup of base year travel demand is presented in the following chart.

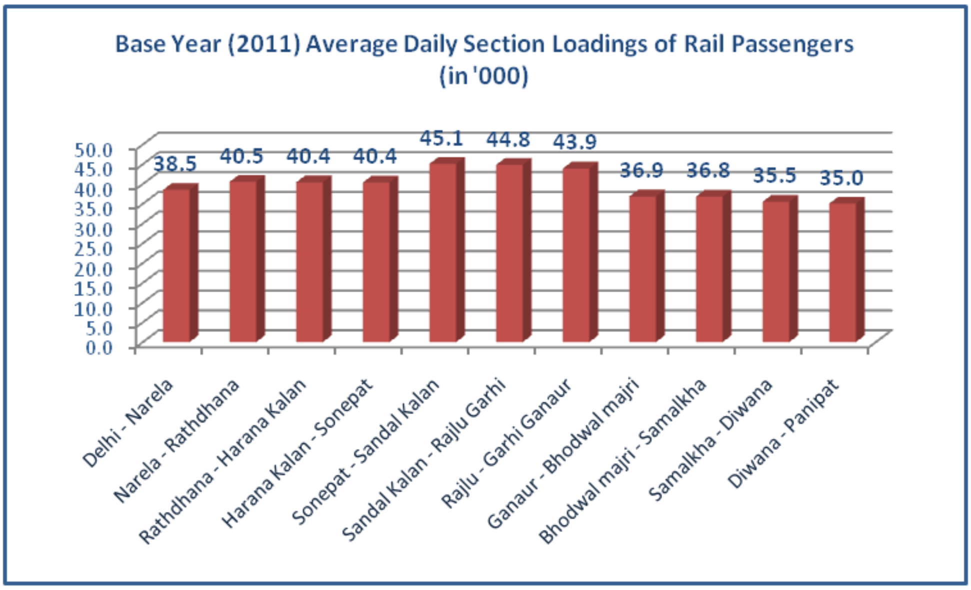
Figure 3-3: Modal Split for Year 2011



The detailed breakup of the passenger movement along various sections of Railway and Road along the Delhi – Sonepat – Panipat corridor are presented in the following paragraphs.

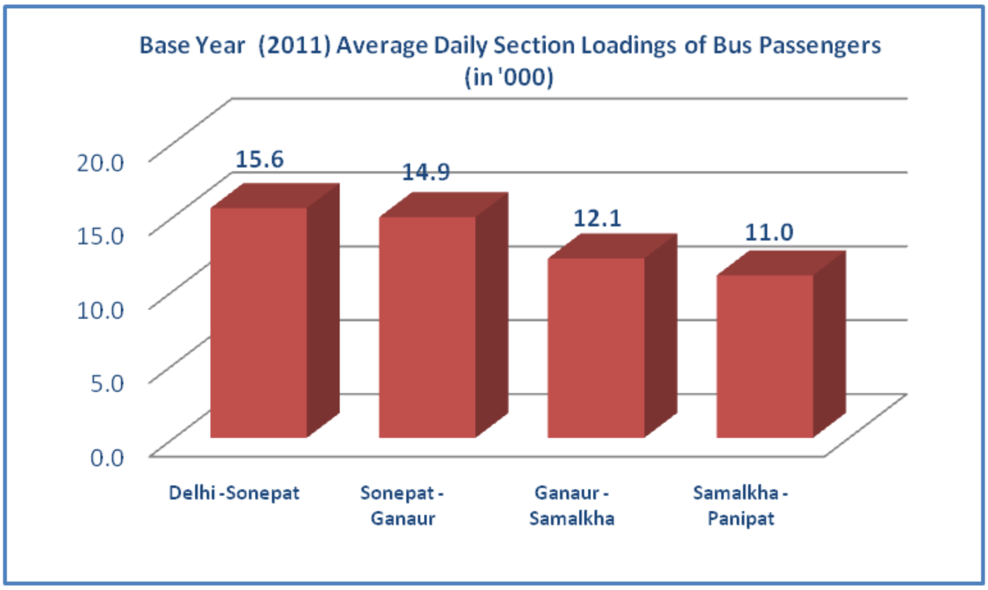
3.5.2 Railway Passengers

As part of commuter OD survey a total of nearly 11,000 rail passenger were interviewed for two week days and one week end at railway stations along the corridor. Based on this, the OD Matrix of daily rail passengers (commuters) along the corridor has been estimated. Sectional loadings are presented.



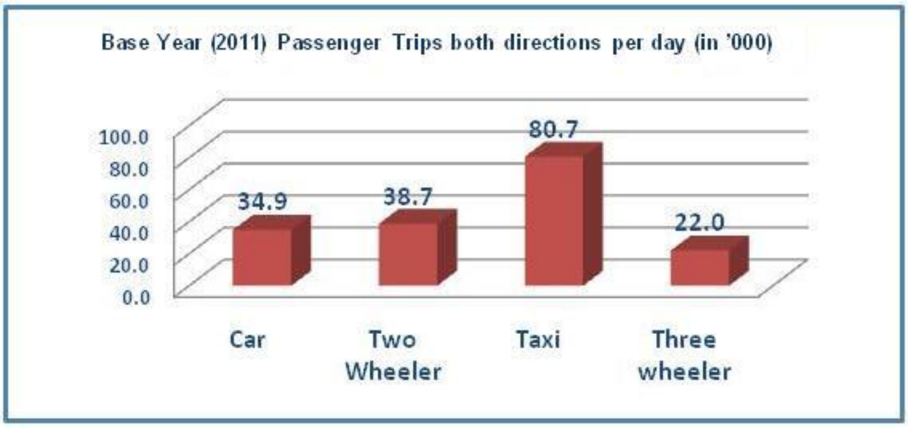
3.5.3 Bus Passengers

As part of commuter survey a total of nearly 5,000 bus passengers were interviewed for two week days and one week end at Delhi, Sonepat and Panipat ISBT's respectively along the corridor. Based on this, the O-D Matrix of daily bus passengers along the corridor has been constructed. Sectional loadings are presented in the following chart.



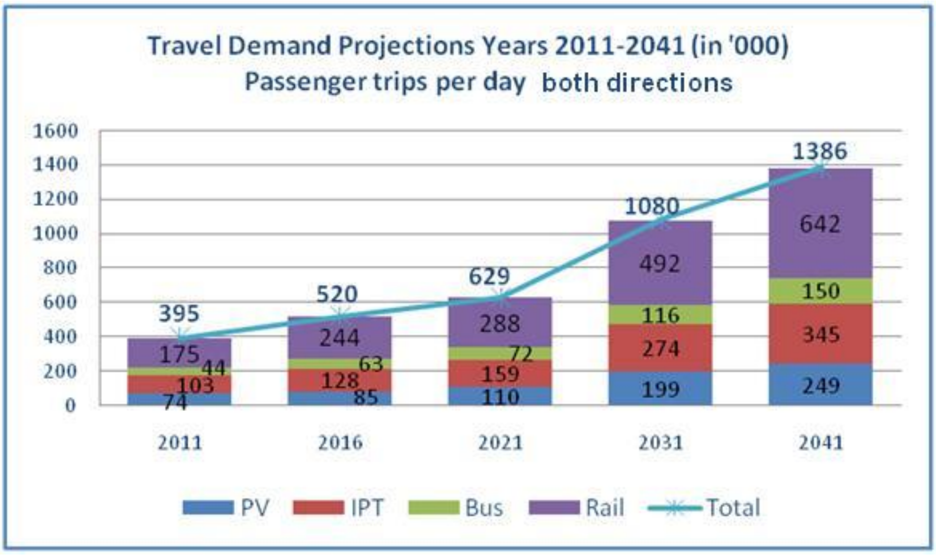
3.5.4 Private Vehicles (PV) and Intermediate Public Transport (IPT) Passengers

The private vehicle O-D survey was conducted on highway at various locations along the Sonepat and Panipat study corridor. As part of private vehicle survey a total of nearly 3,200 cars, two wheeler, three wheeler and taxi passenger were interviewed. Based on that survey, the OD pattern of car, two wheeler and IPT passengers has been constructed and presented below.



3.6 Travel Demand Forecast

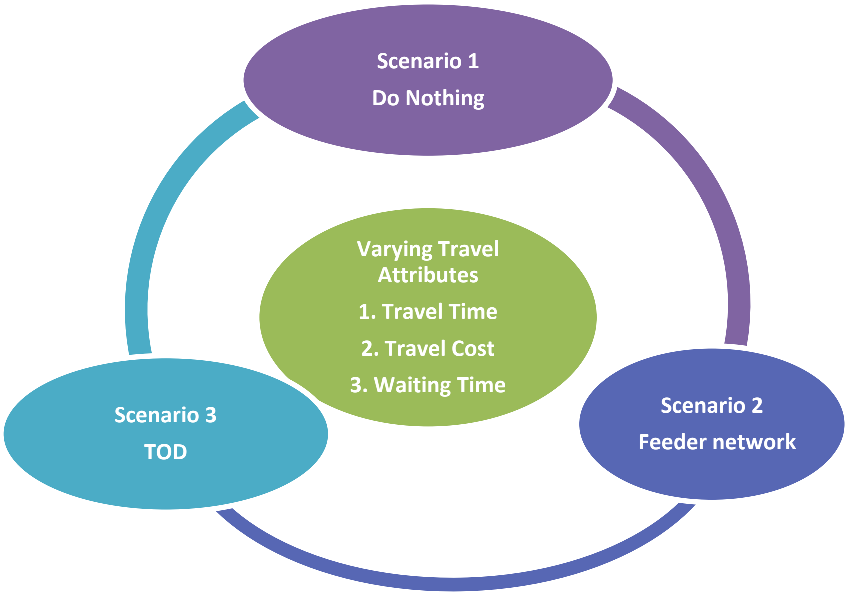
Travel demand by various modes is forecasted for all the horizon years 2016, 2021, 2031, 2041.



3.7 Ridership Estimation for RRTS along the Delhi Sonepat Panipat Corridor:

Stated preference surveys were conducted to arrive at binary logit mode choice model. The model is used to estimate shift from a given OD pair to RRTS based on the travel time, travel cost and waiting for that OD pair. This exercise of identifying the shift of travel from existing mode to RRTS is performed for each mode and the shift is calculated using the fares, travel time and waiting times of the existing mode to that of RRTS in the binary logit model obtained from analyzing stated preference data.

To understand the proposed shift of passengers from the current mode of transport to the new RRTS three scenario's were built:



3.7.1 Travel Demand Forecast Scenarios

Travel Demand Forecasts were developed as part of ridership study based on aforementioned scenarios. These scenarios cover passenger usage from the foreseen opening of the railway in 2016 with the influence of three growth types as follows:

- "Do Nothing" where passengers move naturally from the existing alternative transport methods to the railway;
- "Feeder" where bus feeder services are provided to a number of the railway stations;
- "Feeder and TOD" where, in addition to the feeder services, the additional passenger usage due to Transit Oriented Development (TOD) is included. A number of TOD zones have been investigated along the railway route.

In addition to these scenarios, the Travel Demand Forecast Study examines 12 Cases of travel attributes for travel time, travel cost and waiting time. Case 1 uses short travel time, low travel cost and short waiting time and hence produces the highest passenger numbers. At the other extreme, Case 12 uses long travel time, high travel cost and long waiting time and hence produces the lower passenger numbers.

3.8 RRTS Parameters and Estimates of Ridership

While the scenarios explained above provided a range of forecasts under various parameters, the ridership used for estimating revenue was based on fare levels (travel cost) derived from revenue optimization and willingness to pay of users. The travel time and frequency was also adopted from finalized operational plan in which RRTS simulations were conducted. The impacts of providing concessional fares were also accounted while finalizing ridership. The final ridership is presented in the table below.

This is based on 74 minutes travel time between Delhi- Panipat, peak and off peak frequency as per operational plan and Rs1.1 per km fare as determined from Willingness To Pay. The fare between Delhi to Panipat City has been considered as

Rs100 (for FY 2011) and the maximum fare from Delhi to IOCL Panipat has been extrapolated based on length to Rs 110. A concessional fare (monthly pass) has also been considered for the commuters. We have assumed that the concessional fare would be 25% less than the full fare for respective journeys for the consumers. It has been assumed that 75% of the passengers would be using the full fare and 25% would be using the concessional fare (monthly pass) for commuting between Delhi Panipat

In addition, a further analysis was conducted to delineate the TOD zones near to the various stations. The extra inducement of traffic from finalized TOD zones was accounted in revised forecasts.

Based on above, the ridership is presented in table below

Table 3-2 : Daily ridership

Year	Total ridership (in lakhs per day)
2016	3.77
2018	4.38
2021	5.47
2031	7.79
2041	9.83

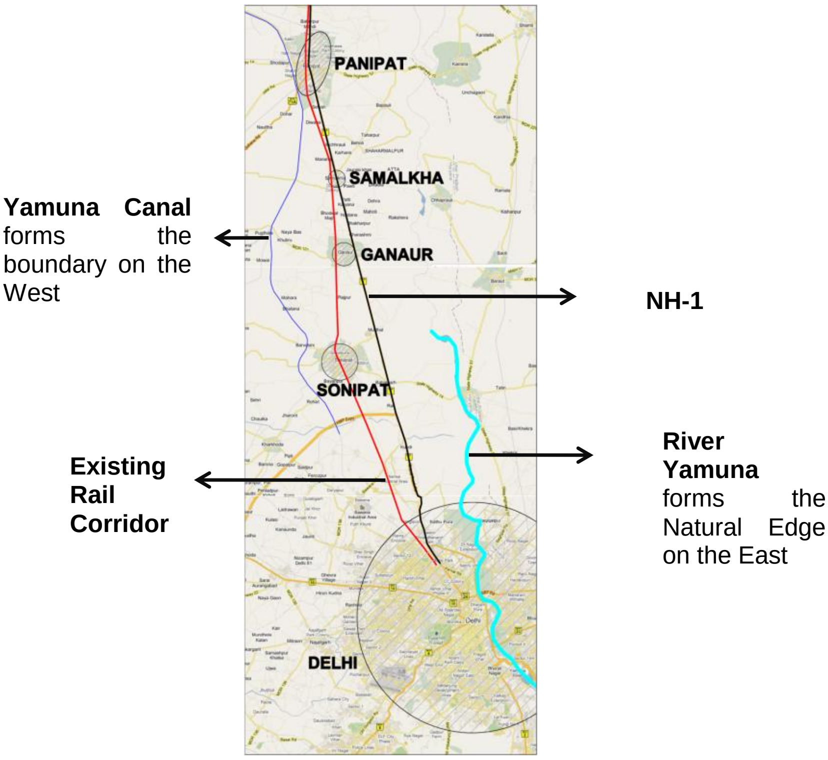
4 REVIEW OF PRESENT RAILWAY AND NH1 ALIGNMENT

4.1 Introduction

The Existing Condition Analysis report has been submitted as a deliverable as a part of this assignment. This chapter presents a summary of the Existing Condition Analysis report wherein the present Indian Railway alignment and the NH1 alignment have been evaluated for suitability for RRTS Delhi Panipat link.

4.2 Background

There are two major existing transport corridors linking Panipat and Sonepat with Delhi; (i) Indian Railway from Old Delhi to Ambala and (2) National Highway NH-1. Both these alignments generally follow flat or gently undulating landform at-grade, with grade separation at some important intersections with side roads. Survey for existing condition analysis was undertaken to investigate the feasibility of utilizing either of these existing corridors as the basis for the RRTS alignment.



4.3 Use of existing Indian Railway Alignment

The existing railway corridor is predominantly two track, running at-grade from Old Delhi Station up to Panipat. runs generally at-grade through flat or gently undulating topography. It is approximately 89 km long with a total of 16 stations throughout its entirety. A number of the existing stations have four tracks to enable passing loops within the platform areas. The existing journey time from Old Delhi to Panipat Junction averages in the region of 2 hours due to stopping at all the intermediate stations.

Detailed information regarding number of stations, level crossings, bridges, road overbridges, underbridges etc and curves along the existing Indian Railway Delhi Panipat corridor has been studied and collated. This information is summarized below:

Number of stations: 16

Number of level crossings – 48

Number of Major Bridges – 19

Between the comparatively large settlements, the railway network passes through open countryside where manually operated level crossings exist at intersections with side roads. On the existing railway corridor, RRTS alignment can be developed on the eastern side to take advantage of the direction of existing track curvature. However, at Delhi, Sonepat and Panipat, acquisition of land would be required. Large construction work adjacent to the existing railway network could also potentially cause major disruption to the operation of the railway during construction. Further, slewing of the existing track and/or demolition of adjacent property would also be required to provide land for RRTS. Also the RRTS would travel at comparatively high speed as compared to Indian Railway. This may require overhaul in the signaling system that is currently being used.

4.4 Use of existing NH1 Alignment

The NH-1 road has 6 lanes and some improvements (mainly grade separation at existing intersections) are currently under construction. NH 1, similar to existing railway network, passes through large urban settlements and also has sharp curves. Both the aforesaid factors are not amenable to development of high speed rail network.

Further at Panipat, Samalkha and Gannaur, overhead bypass (flyovers) over the city have been developed, with parallel connector roads providing access to the local network. The aforesaid developments significantly reduces the option of construction of RRTS along this alignment.

However, in certain areas, where right of way is available, as indicated by Government of Haryana, option of RRTS development along NH 1 could be undertaken.

4.5 Conclusions

4.5.1 Existing Railway Alignment

- The existing railway corridor passes through the outskirts of Delhi and the densely urbanized areas of Sonepat, Ganuar, Samalkha and Panipat. In between these settlements it passes through open countryside where manually operated level crossings exist at intersections with side roads.
- On the existing railway corridor, RRTS alignment can be developed on the eastern side to take advantage of the direction of existing track curvature. However, at Delhi conurbation significant works would be required to accommodate a new line adjacent to the existing, causing potential major

disruption to the operation of the railway during construction and would require slewing of the existing track and/or demolition of adjacent property.

- Similarly ROW issues would arise at Sonepat, Ganuar and Panipat where the existing stations may have to be relocated to accommodate the new RRTS alignment.
- The rationale behind the RRTS is to provide a high-speed, non-stop service between Delhi and Panipat whereas the existing railway generally operates at lower line speeds. It would seem incongruous to combine these two alignments running at-grade as the RRTS corridor needs to be fully contained on both sides to prevent people and animal trespassing onto the tracks.
- Indian Railways may find it difficult to release operational railway land for the construction of the RRTS as they have future plans to expand and enhance their network between Delhi and Amritsar. This would entail further encroachment into the densely populated areas lying adjacent to the existing railway in the urban conurbations.

For these reasons the direct use of the existing railway corridor for the RRTS alignment cannot be recommended.

4.5.2 Existing NH 1 Alignment

- The NH-1 route runs to the east and generally parallel to the existing railway line from the Mukarba Chowk interchange northwards and connects Sonepat, Ganuar, Samalkha and Panipat with Delhi. The road generally comprises 6 lanes and some improvements (mainly grade separation at existing intersections) are currently under construction.
- To the south and east of Mukarba Chowk, NH-1 forms a connection with the Delhi Outer Ring Road and insufficient ROW is available to provide the RRTS along the existing road corridor up to Kashmiri Gate.
- Immediately north of Mukarba Chowk, NH-1 passes through densely urban development up to Krishna Nagar and fitting in an acceptable alignment for the RRTS would be very difficult without major demolition of property.
- At Sonepat the road passes directly through the conurbation at-grade, with priority junctions at the intersections with routes SH-14 and SH-20 at Bahalgarh and Murthal respectively. Dense development in close proximity to the highway limits availability of ROW for the RRTS alignment.
- At Ganuar, Samalkha and Panipat, NH-1 passes through these conurbations on varying sections of viaduct, with parallel connector roads providing access to the local network. There is insufficient ROW available to locate the RRTS alongside these major viaducts.
- In between these settlements the NH-1 corridor passes through open countryside and ROW for the RRTS would be available on one side of the road or the other. However, continuous ROW throughout the full highway corridor is unavailable without bypassing the settlements in some form and the tightness of curvature required for the RRTS on these sections would not meet required standards.
- The National Highway Authority has future plans to expand the NH-1 corridor from its present 6 lanes and may not like to release operational land for the construction of a parallel RRTS.

For these reasons the direct use of the existing national highway corridor for the RRTS alignment cannot be recommended for the entire alignment of RRTS.

However, in certain areas, where right of way through the green belt as indicated by Government of Haryana, is available, such option has been explored and incorporated in the proposed alignment route as explained in later chapters.

5 PROPOSED ALIGNMENT

5.1 Alignment Finalization Process

The Alignment for Delhi Sonepat Panipat RRTS corridor has been finalized after detailed evaluation of the project corridor through collection of relevant data and analysis of various alternative alignments chosen for the study along the corridor. This chapter presents a summary of the findings of the alignment finalization process along with details of the finalized alignment. A detailed report "Evaluation of Alternatives and Proposed Alignment Report" has already been submitted as a part of deliverables for the project that may be referred to for any further details.

The figure below presents the alignment finalization process followed:

Travel Demand forecast	•Traffic survey and Stated Preference Survey •Inputs from Development Plans of various cities •Study alternative modes •Demand forecast for 2011 – 2041 including projections for modal shift
Detailed Analysis of Present Development along the corridor	Present and future development plans of the region developed by state government of Delhi and Haryana have been collected from relevant agencies for analysis so that the selected alignment caters to the future development plans of the region
Division of Corridor into Blocks and Identification of Alternative routes/ alignments for each Block	The entire corridor was divided into 9 blocks to understand and evaluate various sections. Alternative alignment paths in each block were analysed to be suitable for a RRTS alignment
Field Survey and analysis	The alternative alignments for each block has been analyzed by conducting detailed field surveys providing inputs on critical issues such as land acquisition, travel time, Cost, Ease of construction, Connectivity and TOD etc. for defining an alignment suitable for RRTS.
Study of Potential for Transit Oriented Development (TOD)	Identify TOD zone along RRTS alignment Revenue from TOD zones can be utilized as source of funding for the project.
Detailed Topographic Survey	Perform a detailed topographic survey of the finalized alignment

5.2 Alignment Contours

The Delhi Sonepat Panipat RRTS alignment is proposed to start at Maharana Pratap Inter State Bus Terminus (referred to as Kasmere Gate Terminal in this report) in Delhi and ends at IOCL Panipat terminal in Haryana covering a total distance of 111.2 kms that includes a spur length of 10.6 kms at Gannaur Depot. The alignment consists of a mix of elevated (100.7 kms), underground (2.7 kms), and segregated At Grade (7.8 kms), sections across the length of the corridor. There are 12 stations and 2 depots proposed on the corridor.

The Delhi terminal of the RRTS corridor is proposed to be located underground at Kashmere Gate parallel to, and at the same level as that of new proposed phase III underground Delhi Metro station thus providing the commuters integration with Delhi Metro and Inter State Bus Terminus at Kashmere Gate. Exiting the Kashmere Gate terminus, the alignment remains underground to cross a park, residential areas and ring road and emerges on the east side of the ring road. Thereafter the alignment goes elevated and follows ring road to reach Mukarba Chowk station in Delhi and follows NH1 thereafter towards Narela Multi Modal Transit Centre. As a multimodal transit station is proposed in Delhi Master Plan at Narela, the alignment moves westward from NH1 to integrate with Narela MMTC and then again joins back NH1 alignment to proceed northwards to Haryana. In Haryana the alignment utilizes the greenbelt along the west side of NH1 with stops at Kundli, KMP interchange (Kundli Manesar Palwal Interchange), Rajeev Gandhi Education University, Murthal and Gannuar. At Gannaur, a spur of 10.6 km length has been proposed towards the west of the main alignment for RRTS depot and Gannaur Depot station that will serve the Transit Oriented Development Zone to be developed at Gannaur. Moving northwards from Gannuar city station, the elevated main alignment moves westward to cross the Indian Railway alignment to reach Samalkha station parallel to the Indian Railway station at Samalkha. From Samalkha the alignment moves northwards to reach Panipat City station and further terminates at Panipat IOCL terminal station. Depots are proposed at Panipat IOCL terminal and Gannaur. Along the alignment three Transit Oriented Zones are proposed at (1) IOCL Panipat, (2) Samalkha, and (3) Gannaur Depot.

Figure 5-1 RRTS Delhi Sonepat Panipat Alignment

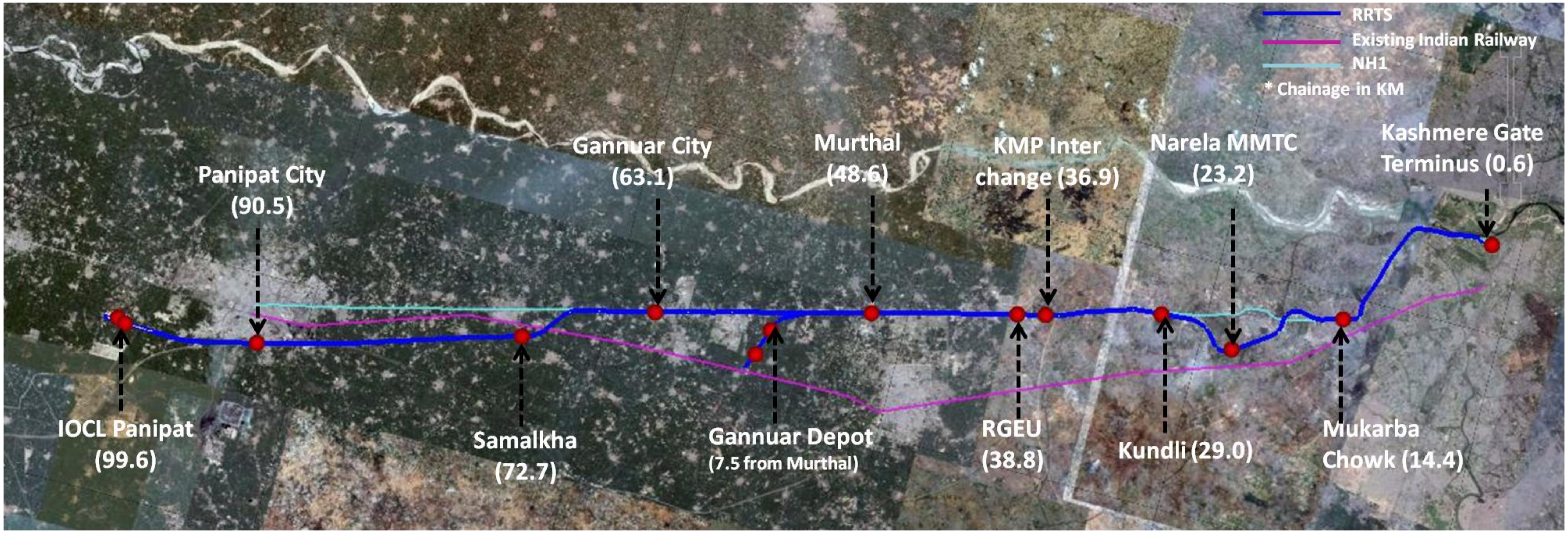
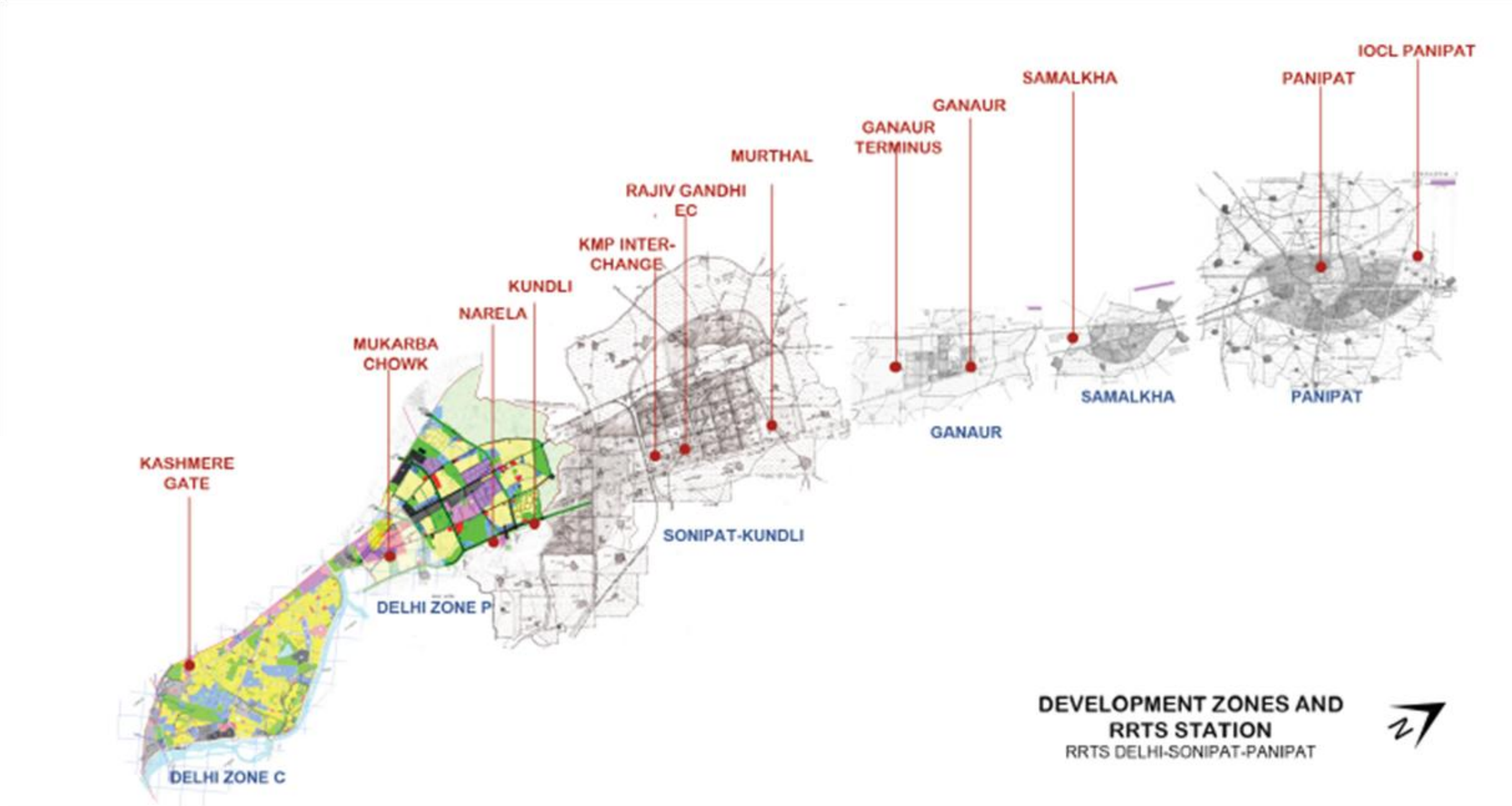


Figure 5-2 RRTS Delhi Sonepat Panipat stations and development zones



5.3 Stations Along the Alignment

The following table summarizes the location of stations along with other details.

Table 5-1 : Proposed Stations along the Corridor

Sr. No	Stations	Station location	Distance from Previous station (KM)	Total KM
1	Kashmere Gate Terminus	Underground		
2	Mukarba Chowk	Elevated	13.8	13.80
3	Narela MMTC	Elevated	8.8	22.60
4	Kundli Border	Elevated	5.8	28.40
5	KMP Expressway interchange	Elevated	7.9	36.30
6	Rajeev Gandhi Education City (Rai)	Elevated	1.9	38.20
7	Murthal (Sonepat)	Elevated	9.8	48.00
9	Gannaur (at NH1)*	Elevated	14.5	62.50
10	Samalkha	Elevated	9.6	72.10
11	Panipat City	Elevated	17.8	89.90
12	IOCL Panipat	At Grade	9.1	99.00
8	Gannaur Depot (along the spur)*	At Grade	7.5	106.5
	Additional Length of alignment			4.70
	Total Length			111.2

* distance from Murthal

The figure below describes the development zones in the cities along the alignment and shows the location of stations.

5.4 Transit Oriented Development Zones

A transit-oriented development (TOD) is a mixed-use residential or commercial area designed to maximize access to public transport, and often incorporates features to encourage transit ridership. A TOD neighborhood typically has a center with a transit station or stop (train station, metro station, or bus stop), surrounded by relatively high-density development with progressively lower-density development spreading outwards from the center.

5.4.1 Potential TOD sites

Three potential TOD sites have been in vicinity of IOCL Panipat, Samalkha and Gannaur Depot Stations. It is proposed that these areas be notified by the state Govt as the TOD zones allowing mix land use in the area. The figures below show a potential/ tentative areas at the three locations where a TOD zone can be developed. The exact areas can be refined subject to further discussions with respective authorities and agencies.

The potential areas for TOD have been identified based on availability of open land and by avoiding the inhabited areas and villages.

Figure 5-3:Potential area for TOD at IOCL Panipat

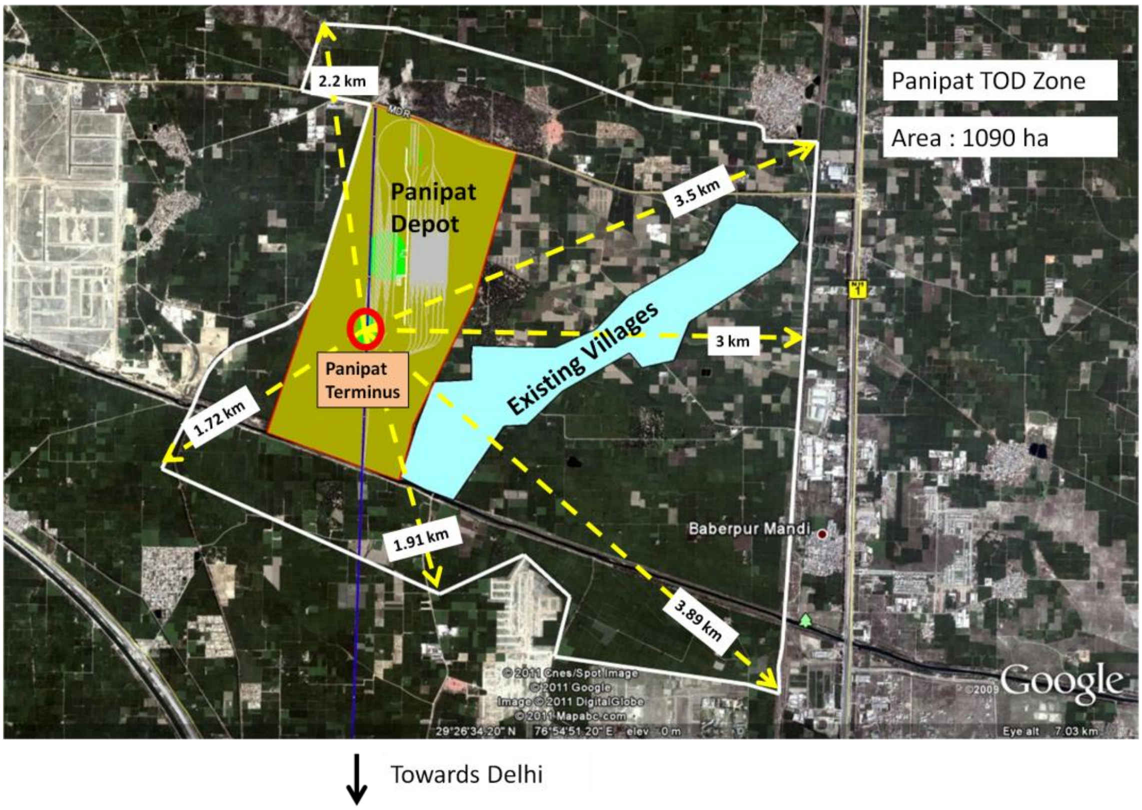


Figure 5-4: Potential area for TOD at Samalkha

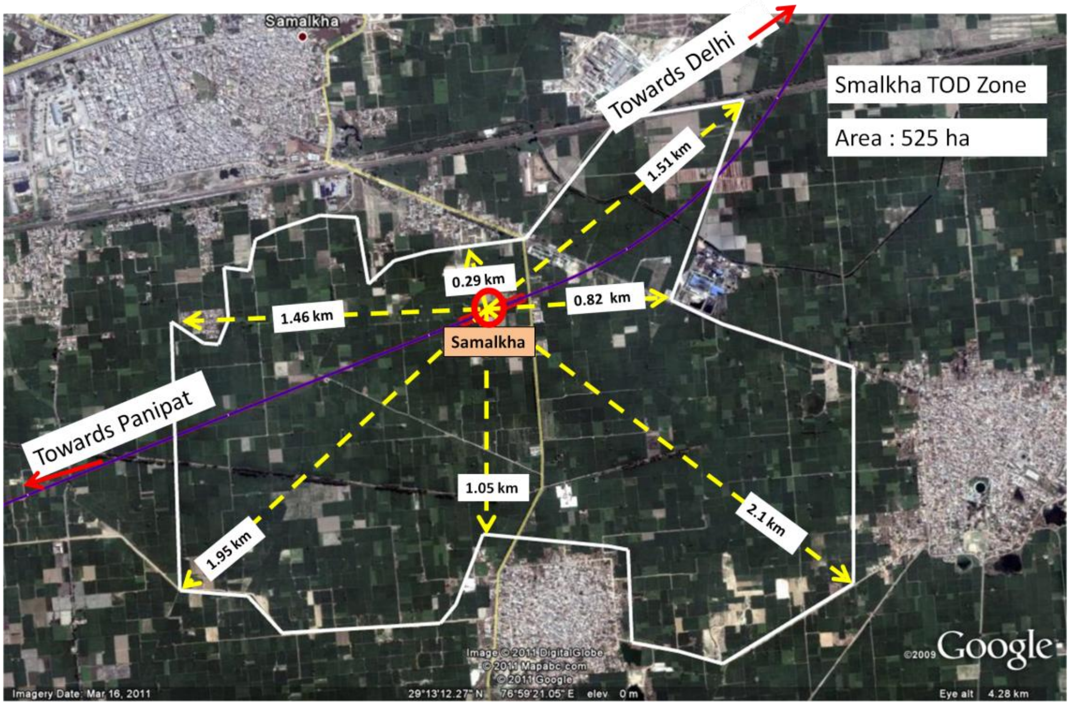
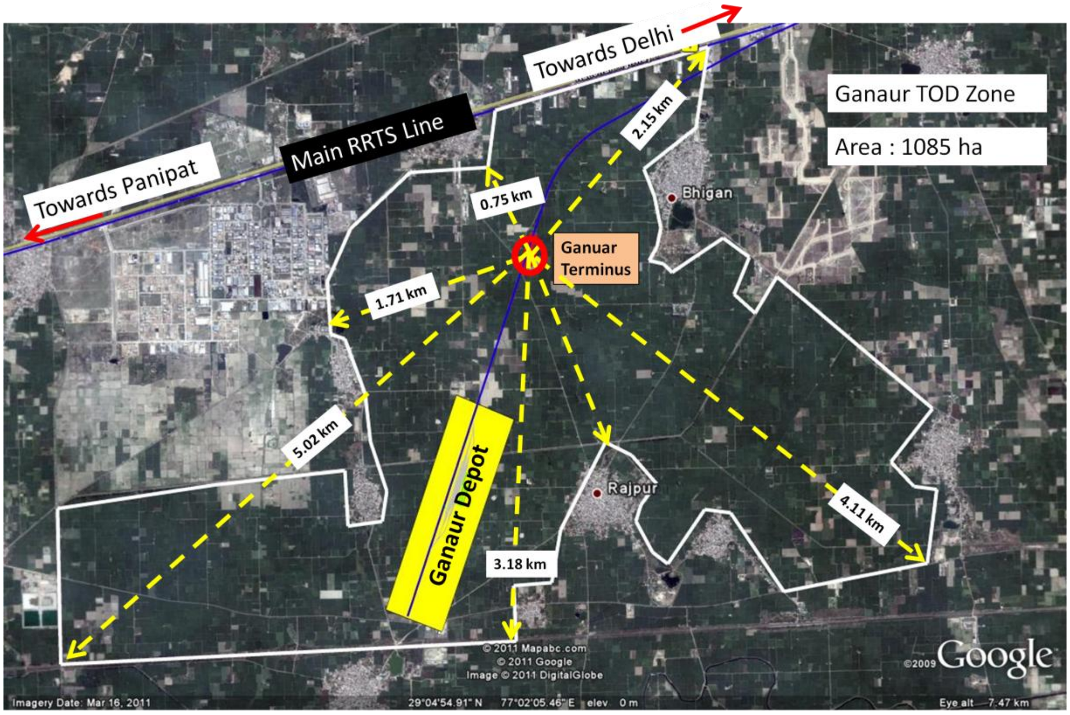


Figure 5-5: Potential area for TOD at Gannuar Depot



6 KEY INPUTS OF ENGINEERING AND OPERATIONS REPORT

6.1 Introduction

A detailed engineering study along with topography survey and geo-technical investigation has been conducted to understand the engineering viability of the project and establish various engineering parameters for the project. A separate detailed report is being submitted along with the Business Plan report that may be referred to for additional details. This chapter summarizes some of the key elements of the engineering study.

6.2 Rolling Stock Demand

Based on estimates of the demand made, the rolling stock requirement has been estimated for the years 2018, 2021, 2031, 2041 and subsequent years. The rolling stock in the intermediate years shall be based on actual demand achieved.

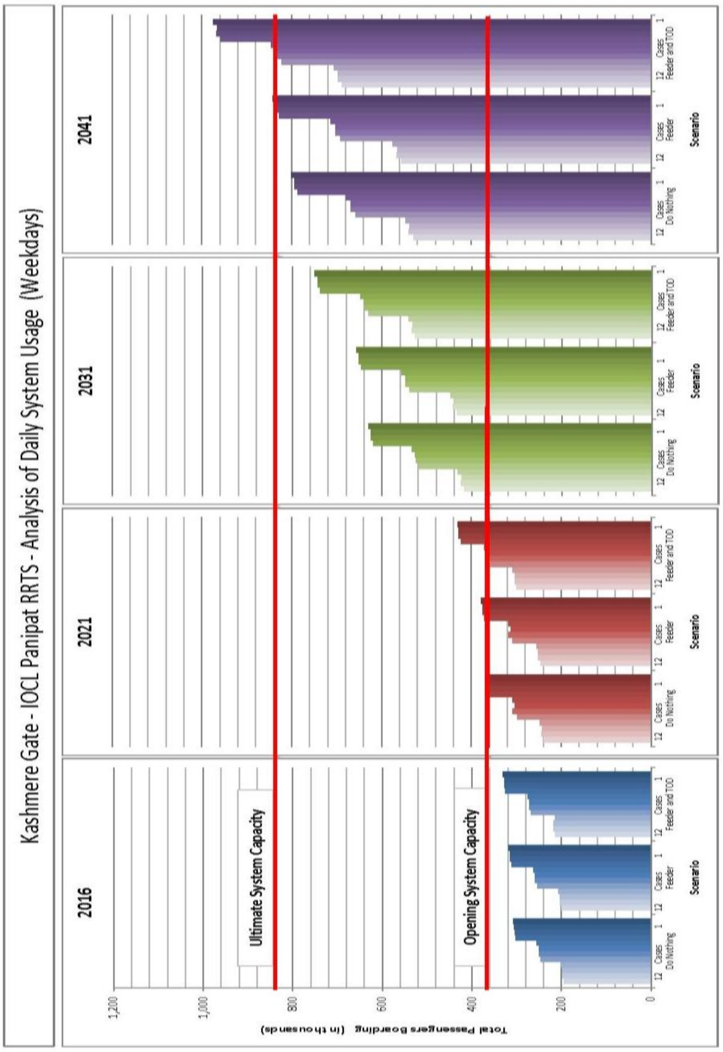


Figure 6-1 Analysis of detailed system usage

6.3 Rolling Stock Selection

Physical attributes derived from the demand for rolling stock are summarized below :

- Operating headway of 3.5 minutes at Ultimate System Capacity (2041);
- Operating headway of 4.5 minutes at Opening System Capacity (2021);
- Cars of 3.7 metres external width;
- Three double doorways per bodyside of 1.5 metres nominal width;
- One luggage stack per driving car;
- Two luggage stacks per middle car;
- One wheelchair position per driving train;
- Seat pitch of 800 mm arranged airline-style. Alternatively, the seats could be arranged front/rear facing;
- Preferred maximum standing passenger density of 3 per square metre;

- No tables;
- No toilets;
- No catering facilities;
- No equipment cabinets within the saloons;
- No bicycle accommodation;
- No train crew accommodation (other than the drivers).

The 2 + 3 seating layout gives less luxurious accommodation than the 2 + 2 layout but it significantly reduces the number of cars and the length of the trains. However, with wider cars (3.7 metres) and the 2 + 3 seating layout the degree of luxury will still be relatively high and is expected to be comparable to cars such as BART SFO (the airline-style seating sections of the car).

System Capacity Timeline	Nominal Car Length, (metres)	Seating Arrang-ement	No. of Cars per Train	Length of Fixed-Formation Trains, (metres)	No. of Trains Requir ed	No. of Cars Required
Ultimate System Capacity (2041)	24	2 + 3	9	220	44	396
Opening System Capacity (2021)	24	2 + 3	6	148	34	204

Table 6-1: Train and fleet sizes for 24 m long, 3.7 m wide cars with 2 + 3 seating layout and with standing passengers at 3 per square metre

The train fleet sizes include additional trains for hot-standby and maintenance purposes. For the Ultimate Capacity fleet, further trains are included for the necessary turn round procedures at the terminal stations.

Typical train configuration for 3 and 6 car train could be as follows:

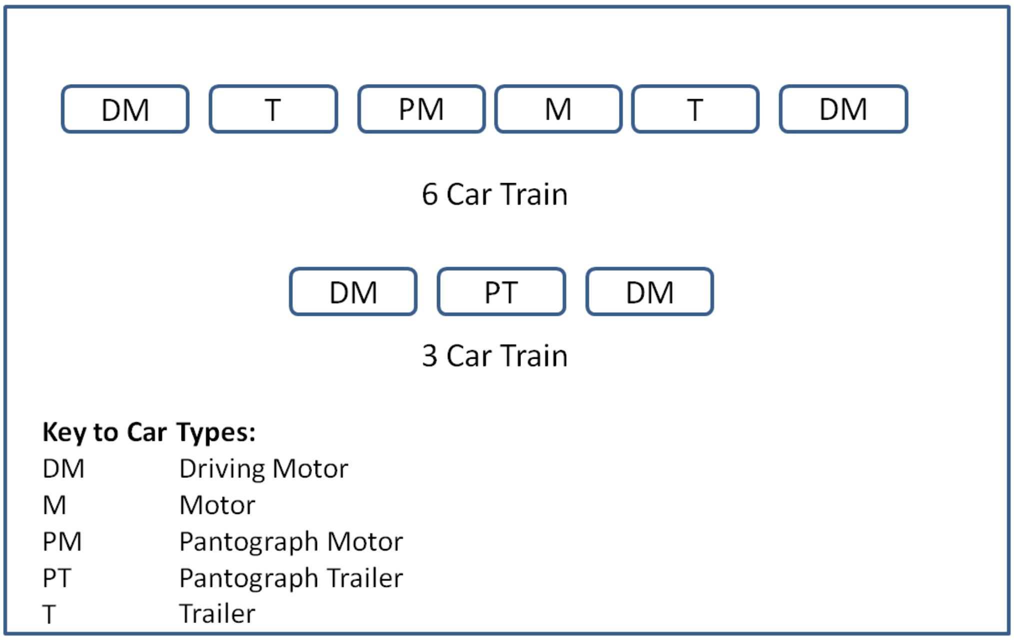


Figure 6-2 Possible train configurations

The options for the steps of fleet expansion have been analysed and are setout below :

Step	System Capacity Timeline	System Capacity PHPDT	Operating Headway, minutes	Number of Cars per Train	Number of Trains Required	Number of 3-car Units	Number of 6-car Units	Total Number of Cars Required
1	Opening (2018 to 2021)	15,028 (16,367*)	4.5	6	34	34	17	204
2	Increment (between 2021 to 2034)	22,737	4.5	9	34	46	28	306
3	Ultimate (2035 to 2043)	29,733**	3.5	9	44	56	38	396
4	Post 2041 (2044 to 2056)	39,831	3.5	12	44	96	40	528

* Increased standing density to 3.6/m^2 to achieve required capacity for 2021.

** Actual capacity exceeds 2041 required capacity.

Table 6-7: Train Fleet Expansion Steps

Figure below shows these expansion steps graphically.

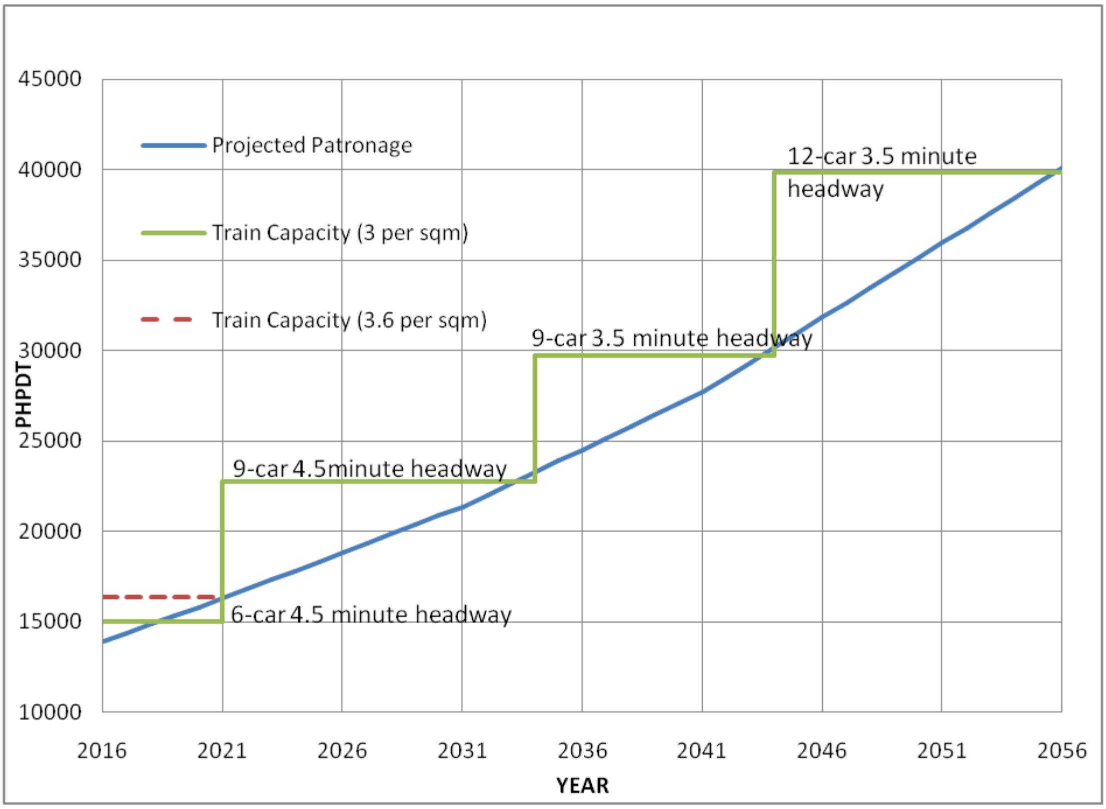


Figure 6-3 Planned fleet expansion profile

6.3.1 Train Requirements

For the envisaged rail system with optimised journey times, electric multiple-unit (EMU) trains are the most appropriate because the acceleration performance can be significantly better than locomotive-hauled trains.

6.3.2 Journey Time Simulations

Journey time analyses have been carried out using MTrain professional simulation software which has been assessed and verified on both UK and Australian national railway systems.

Figure 6-4 Gradient Profile and Line Speed Limits for stop-all-stations run from Kashmere Gate to IOCL Panipat

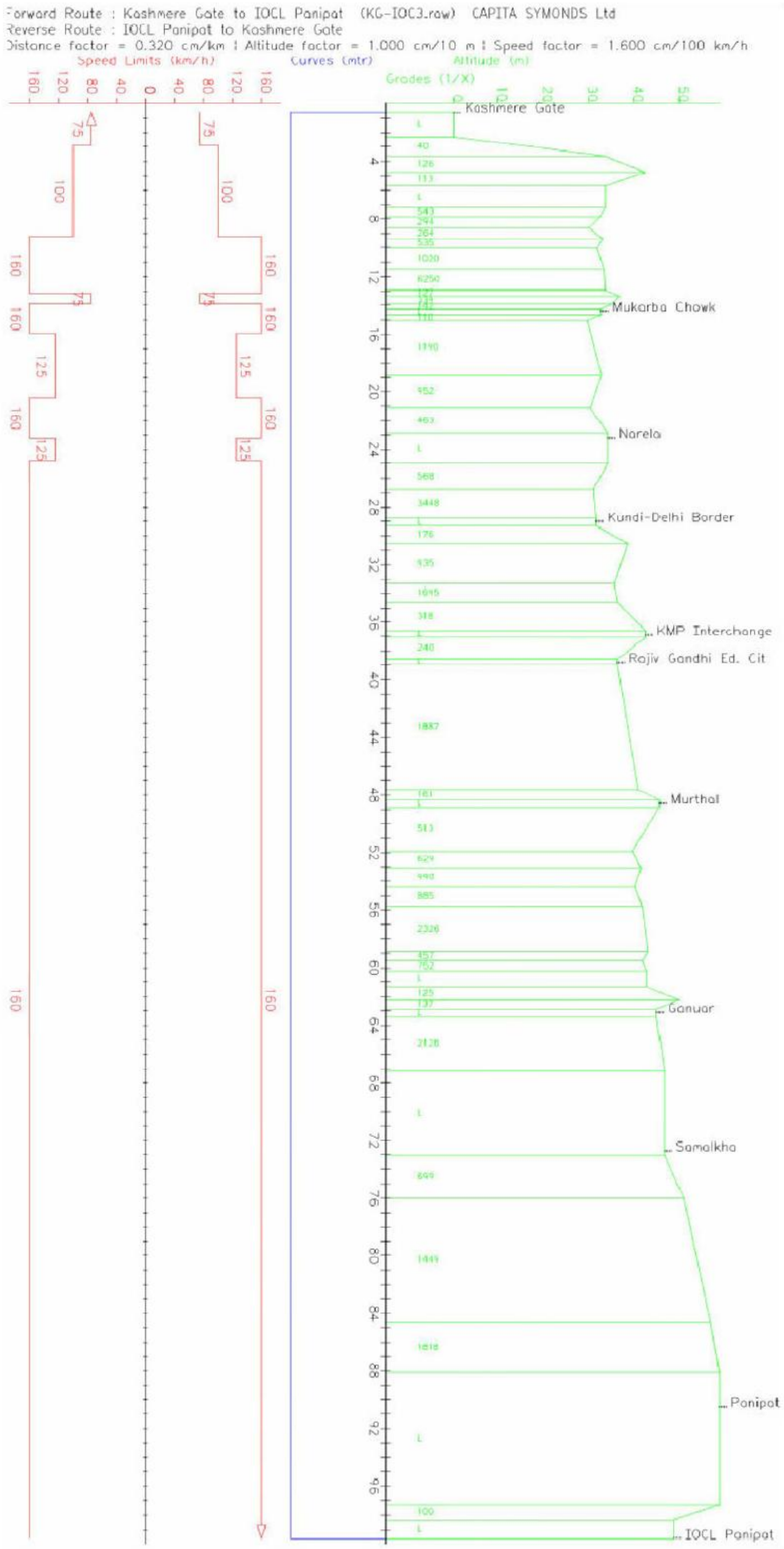
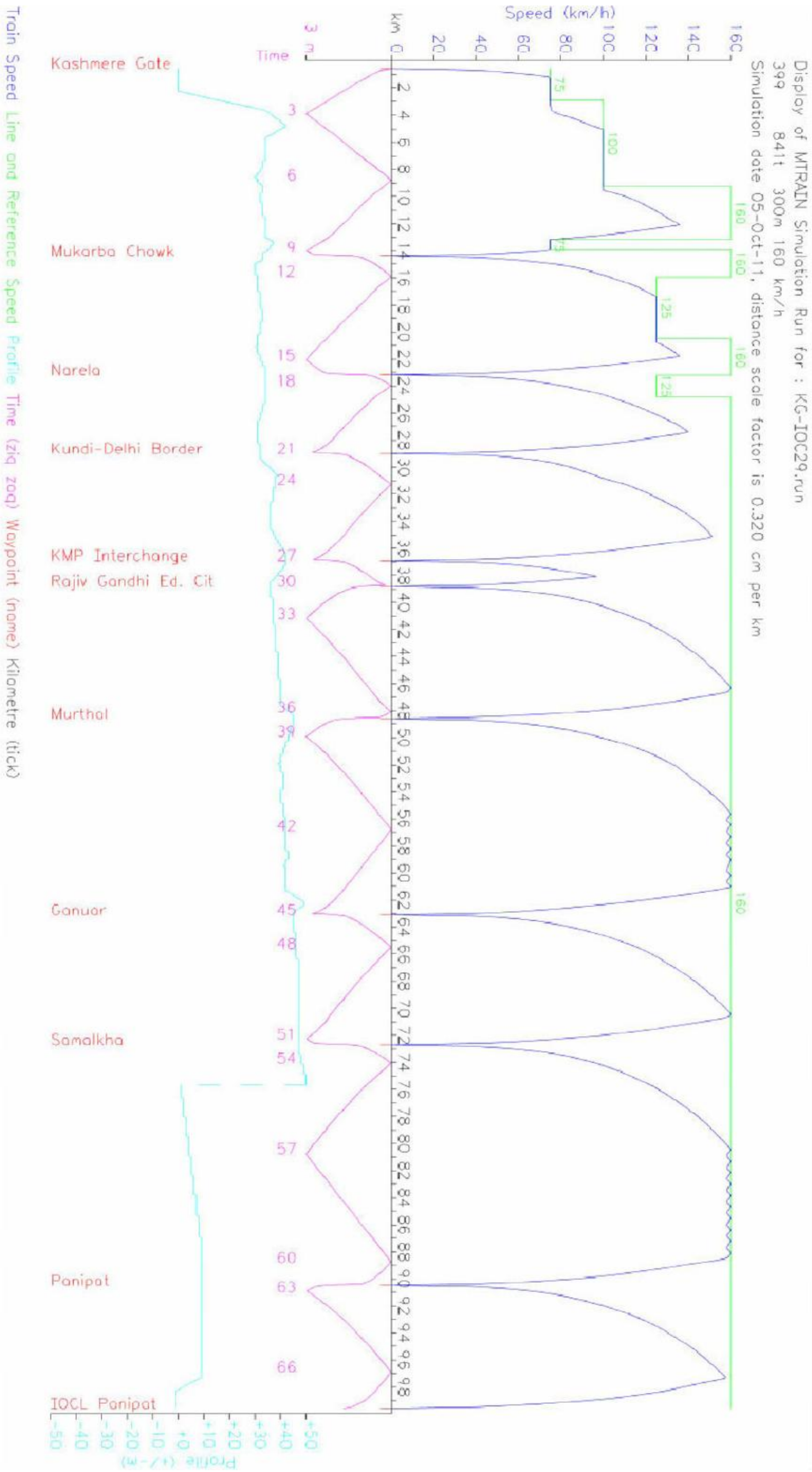


Figure 6-5 Speed profile for stop all stations run from Kashmere Gate to IOCL Panipat



6.3.3 Summary of Parameters of the Selected Trains

The parameters shown in Table below are those selected to provide the optimum train and train services:

Parameter	At Opening System Capacity	At Ultimate System Capacity
Peak Hour System Capacity, PHPDT	16,281	27,683
Operational Headway, minutes	4.5	3.5
Required Train Passenger Capacity	1,252	1,628
Nominal Car Length, metres	24	24
Nominal Car Width, metres	3.7	3.7
Rail Gauge, mm	1,676	1,676
Seating Layout	2 + 3	2 + 3
Style of Seat Layout	Airline	Airline
Seat Pitch, mm	800	800
Density of Standing Passengers in Normal Service, per square metre	3	3
Number of Cars per Train	6	9
Train Length, metres (formed from 3-car units)	152	228
Train Stopping Accuracy at Stations, metres	10	10
Number of Doorways per Bodyside	3	3
Nominal Width of the Bodyside Doors, metres	1.5	1.5
Number of Luggage Stacks per Driving Car	1	1
Number of Luggage Stacks per Middle Car	2	2
Number of Wheelchair Positions per Driving Car	1	1
Number of Wheelchair Positions per Middle Car	0	0

Parameter	At Opening System Capacity	At Ultimate System Capacity
Toilets on the Trains	No	No
Tables on the Trains	No	No
Catering Facilities on the Trains	No	No
Bicycle accommodation on the Trains	No	No
Train Crew Accommodation on the Trains (other than the drivers)	No	No
Train Type	25 kV EMU	25 kV EMU
Train Configuration	Fixed formation of 3-car units and 6-car units	Fixed formation of 3-car units and 6-car units
Nominal Laden Car Weight (heaviest car), tonne	77	77
Extreme Car Weight, tonne	95	95
Train Power with 160 km/hr maximum speed, MW	1.90	3.00
Energy Consumption for Single Journey with 160 km/hr maximum speed, kWh	2,235	3,350
Regenerative Braking Required	Yes	Yes
Cab-end gangways with close-off doors	Yes	Yes
Passenger Saloons and Driving Cabs to be Air Conditioned	Yes	Yes
CCTV in the Trains	Yes	Yes
Maximum Train Speed, km/hr	160	160
Maximum Initial Train Acceleration, m/s²	1.0	1.0
Initial Train Acceleration to be Independent of Train Weight	Yes	Yes
Maximum Braking Rate, m/s²	1.0	1.0
Average Service Braking Rate, m/s²	0.5	0.5

Parameter	At Opening System Capacity	At Ultimate System Capacity
Stop-all-stations Journey Time from Kashmere Gate to Panipat IOCL, minutes	74	74
Stop-all-stations Journey Time from Kashmere Gate to Ganaur Terminus, minutes	41	41
Number of Trains to be Provisioned	34	44
Number of Cars to be Provisioned	204	396

Table 6-2: Summary of Parameters of the Selected Trains

6.3.4 Route Length

The report is based on a route length defined between Kashmere Gate and IOCL Panipat/Panipat Depot of 89km. However, following final agreement of the southern tunnelled alignment into Kashmere Gate and production of the topographic survey it is apparent that the route length is actually longer than this. The complete route length is made up as follows:

- Kashmere Gate to Panipat Depot 100.6 km
- Ganaur Junction to Ganaur Depot 10.6 km
- Total Route Length 111.2 km

A detailed listing of the proposed route alignment is given in Table below.

No.	Type	Length (m)	Radius (m)	Start Chainage (m)	End Chainage (m)	Proposed Linespeed (km/hr)	Cant for 160 km/hr	Cant Def for 160km/hr
Kashmere Gate to IOCL Panipat								
1	Line	412.469		560.943	973.413		Kashmere Gate	
2.1	T-C-T	69.000		973.413	1,042.413			
2.2	T-C-T	405.628	450.000	1,042.413	1,448.040	75	115	56
2.3	T-C-T	69.000		1,448.040	1,517.040			
3	Line	332.032		1,517.040	1,849.073	75		
4.1	T-C-T	72.000		1,849.073	1,921.073			
4.2	T-C-T	231.942	435.000	1,921.073	2,153.015	75	120	57
4.3	T-C-T	72.000		2,153.015	2,225.015			
5	Line	733.550		2,225.015	2,958.565	100		
6.1	T-C-T	36.000		2,958.565	2,994.565			
6.2	T-C-T	131.670	2,100.000	2,994.565	3,126.235	100	45	20
6.3	T-C-T	36.000		3,126.235	3,162.235			
7	Line	697.686		3,162.235	3,859.921	100		

No.	Type	Length (m)	Radius (m)	Start Chainage (m)	End Chainage (m)	Proposed Linespeed (km/hr)	Cant for 160 km/hr	Cant Def for 160km/hr
8.1	T-C-T	88.000		3,859.921	3,947.921			
8.2	T-C-T	143.781	850.000	3,947.921	4,091.702	100	110	51
8.3	T-C-T	88.000		4,091.702	4,179.702			
9	Line	108.465		4,179.702	4,288.167	100		
10.1	T-C-T	36.000		4,288.167	4,324.167			
10.2	T-C-T	197.710	2,100.000	4,324.167	4,521.877	100	45	20
10.3	T-C-T	36.000		4,521.877	4,557.877			
11	Line	462.495		4,557.877	5,020.372	100		
12.1	T-C-T	52.000		5,020.372	5,072.372			
12.2	T-C-T	175.962	1,350.000	5,072.372	5,248.334	100	65	37
12.3	T-C-T	52.000		5,248.334	5,300.334			
13	Line	157.852		5,300.334	5,458.186	100		
14.1	T-C-T	111.000		5,458.186	5,569.186			
14.2	T-C-T	1.837	600.000	5,569.186	5,571.023	100	150	79
14.3	T-C-T	100.000		5,571.023	5,671.023			
15	Line	168.324		5,671.023	5,839.347	100	≈Signature Bridge	
16.1	T-C-T	92.000		5,839.347	5,931.347			
16.2	T-C-T	824.913	802.000	5,931.347	6,756.260	100	115	56
16.3	T-C-T	92.000		6,756.260	6,848.260			
17	Line	1,960.556		6,848.260	8,808.816	100		
18.1	T-C-T	36.000		8,808.816	8,844.816			
18.2	T-C-T	245.533	2,100.000	8,844.816	9,090.349	160	45	20
18.3	T-C-T	36.000		9,090.349	9,126.349			
19	Line	1,331.609		9,126.349	10,457.958	160		
20.1	T-C-T	51.200		10,457.958	10,509.158			
20.2	T-C-T	704.684	6,000.000	10,509.158	11,213.843	160	40	19
20.3	T-C-T	51.200		11,213.843	11,265.043			
21	Line	827.552		11,265.043	12,092.595	160		
22.1	T-C-T	211.200		12,092.595	12,303.795			
22.2	T-C-T	346.392	1,200.000	12,303.795	12,650.186	160	165	128
22.3	T-C-T	211.200		12,650.186	12,861.386			
23	Line	326.368		12,861.386	13,187.754	160		
24.1	T-C-T	69.000		13,187.754	13,256.754			
24.2	T-C-T	546.640	450.000	13,256.754	13,803.394	75	115	56
24.3	T-C-T	69.000		13,803.394	13,872.394			
25	Line	2,069.571		13,872.394	15,941.964	160	≈Mukarba Chowk	
26.1	T-C-T	120.000		15,941.964	16,061.964			
26.2	T-C-T	426.490	1,200.000	16,061.964	16,488.454	125	120	59
26.3	T-C-T	120.000		16,488.454	16,608.454			
27	Line	778.258		16,608.454	17,386.712	125		
28.1	T-C-T	150.000		17,386.712	17,536.712			

No.	Type	Length (m)	Radius (m)	Start Chainage (m)	End Chainage (m)	Proposed Linespeed (km/hr)	Cant for 160 km/hr	Cant Def for 160km/hr
28.2	T-C-T	1,450.777	950.000	17,536.712	18,987.490	125	150	76
28.3	T-C-T	150.000		18,987.490	19,137.490			
29	Line	175.040		19,137.490	19,312.530	125		
30.1	T-C-T	130.000		19,312.530	19,442.530			
30.2	T-C-T	876.182	1,120.000	19,442.530	20,318.711	125	130	61
30.3	T-C-T	130.000		20,318.711	20,448.711			
31	Line	2,751.576		20,448.711	23,200.287	125		≈Narela
32.1	T-C-T	150.000		23,200.287	23,350.287			
32.2	T-C-T	1,338.619	950.000	23,350.287	24,688.906	125	150	76
32.3	T-C-T	150.000		24,688.906	24,838.906			
33	Line	151.496		24,838.906	24,990.402	160		
34.1	T-C-T	140.800		24,990.402	25,131.202			
34.2	T-C-T	2,034.029	2,100.000	25,131.202	27,165.231	160	110	57
34.3	T-C-T	140.800		27,165.231	27,306.031			
35	Line	3,243.757		27,306.031	30,549.788	160		≈Kundli
36.1	T-C-T	140.800		30,549.788	30,690.588			
36.2	T-C-T	341.337	2,100.000	30,690.588	31,031.926	160	110	57
36.3	T-C-T	140.800		31,031.926	31,172.726			
37	Line	2,963.069		31,172.726	34,135.795	160		
38.1	T-C-T	57.600		34,135.795	34,193.395			
38.2	T-C-T	476.064	5,000.000	34,193.395	34,669.459	160	45	25
38.3	T-C-T	57.600		34,669.459	34,727.059			
39	Line	840.290		34,727.059	35,567.350	160		
40.1	T-C-T	140.800		35,567.350	35,708.150			
40.2	T-C-T	234.838	2,100.000	35,708.150	35,942.988	160	110	57
40.3	T-C-T	140.800		35,942.988	36,083.788			
41	Line	1,193.717		36,083.788	37,277.505	160		≈KMP Interchange
42.1	T-C-T-T-C-T	32.000		37,277.505	37,309.505			
42.2	T-C-T-T-C-T	464.391	10,000.000	37,309.505	37,773.895	160	25	10
42.3	T-C-T-T-C-T	32.000		37,773.895	37,805.895			
42.4	T-C-T-T-C-T	32.000		37,805.895	37,837.895			
42.5	T-C-T-T-C-T	359.878	10,000.000	37,837.895	38,197.773	160	25	10
42.6	T-C-T-T-C-T	223.000		38,197.773	38,420.773			
43	Line	4,334.944		38,420.773	42,755.717	160		≈Rajiv Gandhi EC
44.1	T-C-T	30.000		42,755.717	42,785.717			
44.2	T-C-T	331.124	38,000.000	42,785.717	43,116.842	160	0	9
44.3	T-C-T	30.000		43,116.842	43,146.842			
45	Line	3,899.979		43,146.842	47,046.820	160		
46.1	T-C-T-T-C-T	57.600		47,046.820	47,104.420			
46.2	T-C-T-T-C-T	296.730	5,000.000	47,104.420	47,401.150	160	45	25
46.3	T-C-T-T-C-T	57.600		47,401.150	47,458.750			

No.	Type	Length (m)	Radius (m)	Start Chainage (m)	End Chainage (m)	Proposed Linespeed (km/hr)	Cant for 160 km/hr	Cant Def for 160km/hr
46.4	T-C-T-T-C-T	57.600		47,458.750	47,516.350			
46.5	T-C-T-T-C-T	217.764	5,000.000	47,516.350	47,734.114	160	45	25
46.6	T-C-T-T-C-T	223.000		47,734.114	47,957.114			
47	Line	1,234.377		47,957.114	49,191.491	160		≈Murthal
48.1	T-C-T-T-C-T	57.600		49,191.491	49,249.091			
48.2	T-C-T-T-C-T	286.410	5,000.000	49,249.091	49,535.501	160	45	25
48.3	T-C-T-T-C-T	57.600		49,535.501	49,593.101			
48.4	T-C-T-T-C-T	57.600		49,593.101	49,650.701			
48.5	T-C-T-T-C-T	209.443	5,000.000	49,650.701	49,860.144	160	45	25
48.6	T-C-T-T-C-T	219.000		49,860.144	50,079.144			
49	Line	1,518.870		50,079.144	51,598.013	160		
50.1	T-C	223.000		51,598.013	51,821.013			
50.2	T-C	2,422.079	200,000.000	51,821.013	54,243.092	160	0	2
50.3	T-C	0.000						
51	Line	1,487.136		54,243.092	55,730.228	160		
52.1	T-C-T-T-C-T	219.000		55,730.228	55,949.228			
52.2	T-C-T-T-C-T	298.690	5,000.000	55,949.228	56,247.919	160	45	25
52.3	T-C-T-T-C-T	57.600		56,247.919	56,305.519			
52.4	T-C-T-T-C-T	57.600		56,305.519	56,363.119			
52.5	T-C-T-T-C-T	340.212	5,000.000	56,363.119	56,703.331	160	45	25
52.6	T-C-T-T-C-T	219.000		56,703.331	56,922.331			
53	Line	2,093.332		56,922.331	59,015.662	160		
54.1	T-C-T	30.000		59,015.662	59,045.662			
54.2	T-C-T	301.160	15,000.000	59,045.662	59,346.822	160	15	8
54.3	T-C-T	30.000		59,346.822	59,376.822			
55	Line	258.662		59,376.822	59,635.484	160		
56.1	T-C-T	30.000		59,635.484	59,665.484			
56.2	T-C-T	217.563	15,000.000	59,665.484	59,883.047	160	15	8
56.3	T-C-T	30.000		59,883.047	59,913.047			
57	Line	565.237		59,913.047	60,478.284	160		
58.1	T-C-T	30.000		60,478.284	60,508.284			
58.2	T-C-T	608.457	20,000.000	60,508.284	61,116.741	160	0	18
58.3	T-C-T	30.000		61,116.741	61,146.741			
59	Line	3,570.215		61,146.741	64,716.956	160		≈Ganaur
60.1	T-C-T	57.600		64,716.956	64,774.556			
60.2	T-C-T	356.711	5,000.000	64,774.556	65,131.266	160	45	25
60.3	T-C-T	57.600		65,131.266	65,188.866			
61	Line	351.132		65,188.866	65,539.999	160		
62.1	T-C-T	57.600		65,539.999	65,597.599			
62.2	T-C-T	182.681	5,000.000	65,597.599	65,780.280	160	45	25
62.3	T-C-T	57.600		65,780.280	65,837.880			

No.	Type	Length (m)	Radius (m)	Start Chainage (m)	End Chainage (m)	Proposed Linespeed (km/hr)	Cant for 160 km/hr	Cant Def for 160km/hr
63	Line	707.389		65,837.880	66,545.269	160		
64.1	T-C-T	32.000		66,545.269	66,577.269			
64.2	T-C-T	375.457	10,000.000	66,577.269	66,952.726	160	25	10
64.3	T-C-T	32.000		66,952.726	66,984.726			
65	Line	530.480		66,984.726	67,515.206	160		
66.1	T-C-T	57.600		67,515.206	67,572.806			
66.2	T-C-T	361.891	5,000.000	67,572.806	67,934.697	160	45	25
66.3	T-C-T	57.600		67,934.697	67,992.297			
67	Line	189.895		67,992.297	68,182.192	160		
68.1	T-C-T	140.800		68,182.192	68,322.992			
68.2	T-C-T	1,239.386	2,100.000	68,322.992	69,562.378	160	110	57
68.3	T-C-T	140.800		69,562.378	69,703.178			
69	Line	1,230.213		69,703.178	70,933.391	160		
70.1	T-C-T	140.800		70,933.391	71,074.191			
70.2	T-C-T	1,216.600	2,100.000	71,074.191	72,290.791	160	110	57
70.3	T-C-T	140.800		72,290.791	72,431.591			
71	Line	4,073.543		72,431.591	76,505.134	160	≈Samalkha	
72.1	T-C-T	32.000		76,505.134	76,537.134			
72.2	T-C-T	202.440	10,000.000	76,537.134	76,739.574	160	25	10
72.3	T-C-T	32.000		76,739.574	76,771.574			
73	Line	8,070.533		76,771.574	84,842.107	160		
74.1	T-C-T	32.000		84,842.107	84,874.107			
74.2	T-C-T	574.113	10,000.000	84,874.107	85,448.220	160	25	10
74.3	T-C-T	32.000		85,448.220	85,480.220			
75	Line	7,806.903		85,480.220	93,287.123	160	≈Panipat	
76.1	T-C-T	32.000		93,287.123	93,319.123			
76.2	T-C-T	563.842	10,000.000	93,319.123	93,882.965	160	25	10
76.3	T-C-T	32.000		93,882.965	93,914.965			
77	Line	1,104.488		93,914.965	95,019.452	160		
78.1	T-C-T	57.600		95,019.452	95,077.052			
78.2	T-C-T	1,178.983	5,550.000	95,077.052	96,256.035	160	45	18
78.3	T-C-T	57.600		96,256.035	96,313.635			
79	Line	4,898.016		96,313.635	101,211.651	160	≈IOCL Panipat	
Murthal to Ganaur Terminus								
1	Curve	23.017	185.000	0.000	23.017	60		
2	Line	69.585		23.017	92.602	75		
3	Curve	62.208	500.000	92.602	154.810	75	115	56
4	Line	382.062		154.810	536.872	75	≈Murthal Station	
5	Curve	37.090	450.000	536.872	573.962	75	115	56
6	Line	61.274		573.962	635.236	75		
7	Curve	37.090	450.000	635.236	672.326	75	115	56

No.	Type	Length (m)	Radius (m)	Start Chainage (m)	End Chainage (m)	Proposed Linespeed (km/hr)	Cant for 160 km/hr	Cant Def for 160km/hr
8	Line	520.142		672.326	1,192.469	125		
9	Curve	34.454	1,000.000	1,192.469	1,226.922	125	130	61
10	Line	134.789		1,226.922	1,361.712	125		
11	Curve	34.454	1,000.000	1,361.712	1,396.165	125	130	61
12	Line	813.073		1,396.165	2,209.238	160		
13.1	T-C-T-T-C-T	57.600		2,209.238	2,266.838			
13.2	T-C-T-T-C-T	301.904	5,000.000	2,266.838	2,568.743	160	45	25
13.3	T-C-T-T-C-T	57.600		2,568.743	2,626.343			
13.4	T-C-T-T-C-T	57.600		2,626.343	2,683.943			
13.5	T-C-T-T-C-T	305.871	5,000.000	2,683.943	2,989.814	160	45	25
13.6	T-C-T-T-C-T	57.600		2,989.814	3,047.414			
14	Line	900.844		3,047.414	3,948.258	160		
15.1	T-C-T	57.600		3,948.258	4,005.858			
15.2	T-C-T	1,063.185	5,000.000	4,005.858	5,069.043	160	45	25
15.3	T-C-T	57.600		5,069.043	5,126.643			
16	Line	1,026.362		5,126.643	6,153.005	160		
17.1	T-C-T	120.000		6,153.005	6,273.005			
17.2	T-C-T	776.805	1,200.000	6,273.005	7,049.810	125	130	61
17.3	T-C-T	120.000		7,049.810	7,169.810			
18	Line	3,470.943		7,169.810	10,640.753	20	Ganaur Terminus Station and Depot	
T-C-T: Transition-Curve-Transition								

Table 6-3: Kashmere Gate to Panipat Route Details for Elevated Alignment

6.3.5 Track Gauge

Two track gauges are in common usage within India for fast railways, 1435mm (standard gauge) and 1676mm (Indian Broad gauge). Both gauges would be suitable for 160km/hr operational running or higher speeds. The 1435mm gauge is the most used gauge throughout the world; components are therefore less expensive and more readily available. However 1676mm gauge does have advantages in that the rolling stock can accommodate more passengers but this is countered by the fact that state-of-the art broad gauge rolling stock for 200km/hr railways will have to be specially designed and procurement will cost more and take longer. Inter running with other Broad Gauge railways will not be possible unless the signalling and control systems are similar.

For the RRTS: Delhi – Sonipat - Panipat the client has instructed that 1676mm Indian Broad Gauge will be used. This is acceptable due to estimated higher traffic volumes, shorter train lengths and bulk purchase for RRTS projects.

6.3.6 Track Structure

The railway will be subject to intensive train movements with little time for day to day maintenance. The track structure should therefore be designed to be long lasting with minimal maintenance. It should maintain a constant line and level commensurate with 200km/h running, passenger comfort levels and minimal noise and vibration.

Track will generally take one of two forms dependent on location. Within depots and stabling facilities the track will be ballasted using a traditional sleeper system. Sleepers may be formed of concrete, steel or timber but in the case of timber a separate baseplate will be required. These areas have low speed running and regular maintenance is possible. The main running lines will use a ballastless track structure. It is proposed to locate the rails on a resilient fastening system such as that manufactured by Pandrol, Clouth, Vossloh or other suitable company. The resilient fastening system will be fixed to concrete plinths incorporating derailment guard upstands.

6.3.7 Rails

It is envisaged that the rail type will be 60kg/m flat bottom. However, with the gentle curvature necessary for high speed lines it is not considered necessary to head harden the rail (although the railway operator/owner may decide to do this to increase rail life).

Rail will be continuously welded (CWR) throughout with de-stressing taking place if local conditions dictate. Long welded rail (LWR) and jointed track may be used in the depot/stabling areas.

Rails will be laid at an inclination of 1:20 with the rolling stock wheel profile machined for compatibility with the rail.

6.3.8 Cross Section Dimensions

The track cross section dimensions are built up as follows:-

Element	Dimension	Comment
Emergency walkway	1000mm 700mm	Generally At OLE mast positions
OLE structure	300mm	
Structure clearance	2135mm	To track centreline
Track interval	4290mm	Straight track
Track interval on curves	4460mm	Minimum 400mR

Table 6-4: Cross Section Dimensions

6.3.9 Vehicle Gauge

The proposed trains have an external body width of 3,700mm. To obtain the kinematic envelope a number of factors must be added, these include speed, suspension performance, vehicle build tolerance and track quality. The actual kinematic envelope will be determined after the design and construction of the vehicles.

For areas of the alignment where there are significant curves the swept envelope will be significantly different from the kinematic envelope since the swept envelope makes allowances for end and centre throws. For the purposes of this report a maximum swept envelope width of 4,009mm has been assessed based on a 24m vehicle length and a minimum radius of 400m.

Indian Standards do not mention kinematic envelope but do specify 5,300mm between track centres. This is applicable to ballasted track on a mixed traffic route that will include freight and passenger vehicles with opening windows. Given the vehicle width of 3,700mm, this would give a static clearance between trains of 1,600mm. However, the railway is a new line, separated from the rest of the railway system and designed as a passenger only system using modern sealed rolling stock. Given that the proposed route is on viaduct it is appropriate that the proposed track interval is reviewed to minimise overall structure size and therefore provide an economically efficient design.

In the UK, guidance on the infrastructure is provided by the Health & Safety Inspectorate[1]. It provides guidance for line speeds up to 165km/hr. Given that the maximum design line speed for the railway is likely to be 160km/hr it is considered prudent to adopt the guidance until such time as technical workshops have been undertaken to look at the detailed issues involved and more detailed information is available from prospective train manufacturers. It suggests a passing clearance of 450mm between the swept envelopes of adjacent trains.

For a straight track, a static envelope of 3,700mm and a clearance of 450mm will give a minimum interval between the centreline of tracks of 4,150mm. This will increase once the detailed kinematic information is provided by the vehicle builders. For the purposes of this report a preliminary kinematic envelope of 3,840mm has been adopted giving an inter-track spacing of 4,290mm.

The track interval will need to be increased appropriately on curves. Based on the kinematic envelope of 3,840mm, increasing for centre and end throws and clearance of 450mm the inter-track spacing on the tightest curve on the system will be 4,460mm.

6.4 Signalling

6.4.1 Signalling System and the Timetable

From the information now available it transpires that the appropriate frequencies for ETCS Level 2 are unobtainable. Given this situation the most likely option would be to use ETCS Level 1 or an equivalent system such as CATC technology, as used on the Delhi Metro. The Delhi Metro operates at max speeds of 80km/hr, with averages of 30km/hr and at headways of 90 – 120 seconds. However, there are no apparent reasons to suppose that the CATC technology cannot be extended to this application. However it needs to be understood that with the increased line speeds of up to 160km/hr, there will be a consequent increase in the headways to a minimum of 210 seconds (3.5 minutes).

CATC provides similar Automatic Train Protection and Control as ETCS Level 1 but uses Audio Frequency Track Circuit overlays for system track to train communications.

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[1] Railway Safety Principles and Guidance, Part 2, Section A, Guidance on the Infrastructure. Health & Safety Executive (Her Majesty's Railway Inspectorate)

The proposed signalling system should be reviewed at the time of bidding in favour of communication based system to see if an appropriate system has been implemented successfully somewhere in the world and has been running for a reasonable time.

The signalling system is based on discrete track sections to define the position of the tail of a train. The accuracy of this depends on the length of the section. Shorter sections increase the accuracy to which the tail of a train is known but increase the number required and hence increases the cost.

The system does not generally require visual line-side signals as the continuously up-dated speed profile is presented to the driver on an in-cab display. On the clearance of a section behind a train and subject to a system propagation time delay, the interlocking is up-dated and new data transmitted to the train to compute a new speed profile. Therefore the tail of a train is operating a fixed block function, with the system then keeping the cab of the following train as close to that point as possible yet at a safe distance. The ATP function enforces the correct speed/braking profile and provides the final defence in the event of a misjudgement by the driver. Appendix 4.1 gives pictorial details of a typical signalling system using this type of Control.

In normal operation therefore the signalling system should be transparent to the timetable and provide the safety back-stop when perturbations arise in operational service.

For reliable operation a margin of 30 to 60 seconds should also be taken in to consideration. There are measures that can increase this clearance time, but as noted previously, train characteristics and Line speeds are taken as fixed. The most efficient way identified for the project to achieve improved performance is through Shortening track sections in station areas – possible savings overall 10 secs as it provides a clearance time of 23 seconds. It is concluded that it is possible to operate a reliable 3.5 minute service.

6.4.2 Recovery Strategies

This is a line where operational difficulties due to equipment failure or more general operating events can have a serious effect on the service. Consideration should be given to generating such strategies either as a 'soft' solution using ATR and ATO and/or a 'hardware' solution by the use of additional equipment and lineside signals at strategic locations. Neither the technical details nor the costs have been investigated and most likely would form part of a study during the detailed design stage as the recovery strategy would necessarily be prepared by the D&B Contractor.

In the management of perturbations a number of factors can affect return to normal service. The adoption of statistical based real-time learning models based on a reasonably accurate dynamic model of the railway can improve performance on a continuous basis.

6.4.3 Rolling Stock Integration

Integration of the signalling equipment in to the rolling stock is only viable with vehicles specifically designed with the appropriate interfaces. Retro-fitting in practice has been shown to be technically difficult with high cost implications and uncertain performance.

6.4.4 Track Layouts

The proposed system provides a means of optimising timetable operation particularly on the running lines. Whilst it is technically feasible to control every train movement by automated signalling, in termini, consideration should be given to the use of additional visual signals at strategic locations. These would improve efficiency in the movement of stock within the station limits.

Train protection would still be provided by the system. The installation would need to remain compatible with the signalling system.

6.4.5 Train Detection

As the primary method of train detection will be track circuits in the interests of safety an overlay dead-locking system for points should be provided.

6.5 Communications Systems

6.5.1 SCADA

The Supervisory Control and Data Acquisition System (SCADA) will monitor and/or control equipment of the System including the fare collection equipment, CCTV, public and non-public Emergency Telephones (ET). It will display the alarms and will be able to control some functions of this equipment. The Remote Terminal Units (RTU) will be located in stations, substations and at the Depot

The station equipment will consist of Remote Terminal Units (RTU's) located in the Electrical Equipment Rooms (EER), fed by the UPS. The RTU's contain Programmable Logic Controllers (PLC), terminal blocks, power supplies, relay contacts, digital inputs and outputs and equipment cabinets.

Preventive maintenance of the SCADA hardware consists of inspection with periodic checking and testing to keep the equipment in healthy condition. All RTUs and the central computers are equipped with diagnostic capabilities for performance testing. Due to the high reliability of the components used in the system, routine maintenance is not recommended. In the rare event that there is a failure of such components, it is sudden rather than gradual. Therefore, unnecessary handling can only encourage failures.

6.5.2 Fibre Optic Communication System

The Fibre Optic Communication System (FOCS) will provide audio and data circuits between the depot and the passenger stations. Communications will be achieved by use of a redundant fibre optic ring to interconnect Network Elements (NE). The Network Management Subsystem (NMS) will use a graphical user interface to centrally manage and control the network. Status alarms, link performance data, and configuration information from remote sites will be available. Maintenance personnel will be able to use the NMS to diagnose major faults from any NE.

The maintenance operation is a real time fault detection system of transmission equipment; complete with alarms, graphic displays and diagnostics for determining specific components failure and for routine checks of the FOCS.

6.5.3 Emergency Telephones

Emergency telephones will be located throughout all passenger stations to provide immediate access to the Operations Control Centre (OCC). A computer facility will routinely poll each emergency telephone to perform diagnostics and confirm functionality. Preventive maintenance consists of a visual check of the telephone case, cord, and handset; followed by a test confirming swift response and good speech quality with the OCC.

6.5.4 Closed Circuit Television

The Closed Circuit Television (CCTV) system provides visual monitoring of selected areas. All station cameras are transmitted to the OCC via Ethernet over the FOCS. Maintenance is primarily referred to as users' maintenance. The determining factor is video quality i.e. meeting the user's requirements aided by adjusting the monitor's contrast and brightness controls. Video quality is confirmed by the users' during the performance of their normal daily duties.

6.5.5 Passenger Information Display System

The Passenger Information Display System (PID) provides centralized and station control of dynamic displays throughout the passenger stations. Preventive maintenance includes cleaning and inspection. Maintenance and repair of this system is by the replacement of LRUs.

6.5.6 Public Address System

The Public Address system (PAS) system provides coverage, for pre-recorded and other announcements, in passenger stations and passenger concourses. Preventive maintenance includes cleaning and inspection. Sound quality is confirmed by the Station Attendant during the performance of their normal daily duties. All deficiencies are reported to the Operations Control Centre.

6.5.7 Fare Collection System

The fare collection system is a key interface between a transit agency and its passengers. It directly affects the way in which passengers experience and perceive the transit agency and its services. In general, the transit passenger expects a fare system that:

- Is fast, easy to understand and use, with reliable fare transactions;
- Offers payment options that suit their particular travel needs (frequent, infrequent, weekly, daily, short-distance, etc);
- Allows easy transfers between modes and different transit providers; and
- Provides easy access to fare media.

Automatic fare collection system (AFCS) meets the requirements of an efficient, reliable and convenient ticketing system for a transit agency. In an AFCS, the fare is paid through an electronic payment media like a smart card or token. In case of gated systems (or closed systems), the passenger taps the payment media on a smart card reader at entry and exit gates and the appropriate fare is automatically debited from the smart card. In case of open system, the passenger taps the payment media on-board the vehicles.

The major components of the AFCS for RRTS will be as follows:

(i) Smart Card and Tokens – the payment media will be contactless smart cards and tokens. The smart cards will be anonymous cards and will be issued against a refundable deposit. The tokens will be issued for single journey and will be collected back at exit gates.

(ii) Ticket Office Machines (TOM) – The Ticket Office Machines will be used for issuing smart cards and tokens and topping-up of smart cards. The TOMs will be installed at all stations of the RRTS.

(i) Entry/exit Gates with smart card reader – The stations will have unpaid and paid areas, segregated by automated gates. The gates will have smart card readers built-in for validating and debiting fare from smart cards and tokens. On presenting a valid smart card/token, the gate will open allowing a single passenger to pass through. The passengers with tokens will have to insert token in a slot on the gate at the time of exit.

(ii) Station Computer – The station computer will be a server class machine, which shall manage all the gates on the local area network. The Station Computer shall communicate with the Central System over a secured link.

(iii) Central System – The Central System will be a key component of the AFC System, comprising of high-end servers (application servers, database servers, communication servers, web servers, etc.), storage, printers, UPS, networking, connectivity, power backup, third party software (RDBMS, operating system, firewall, antivirus software, etc.) and AFCS backend application software. Sufficient redundancy will be built in at various levels to ensure high uptime of the system. The AFCS backend application software will be a highly scalable, reliable, secure and flexible system.

(iv) Customer Care/Helpdesk system – The AFCS will include a Customer Care/Helpdesk which will facilitate answering customers' queries and resolving their grievances through various modes including IVRS, website, e-mail, etc.

6.6 Selection of Structural Form

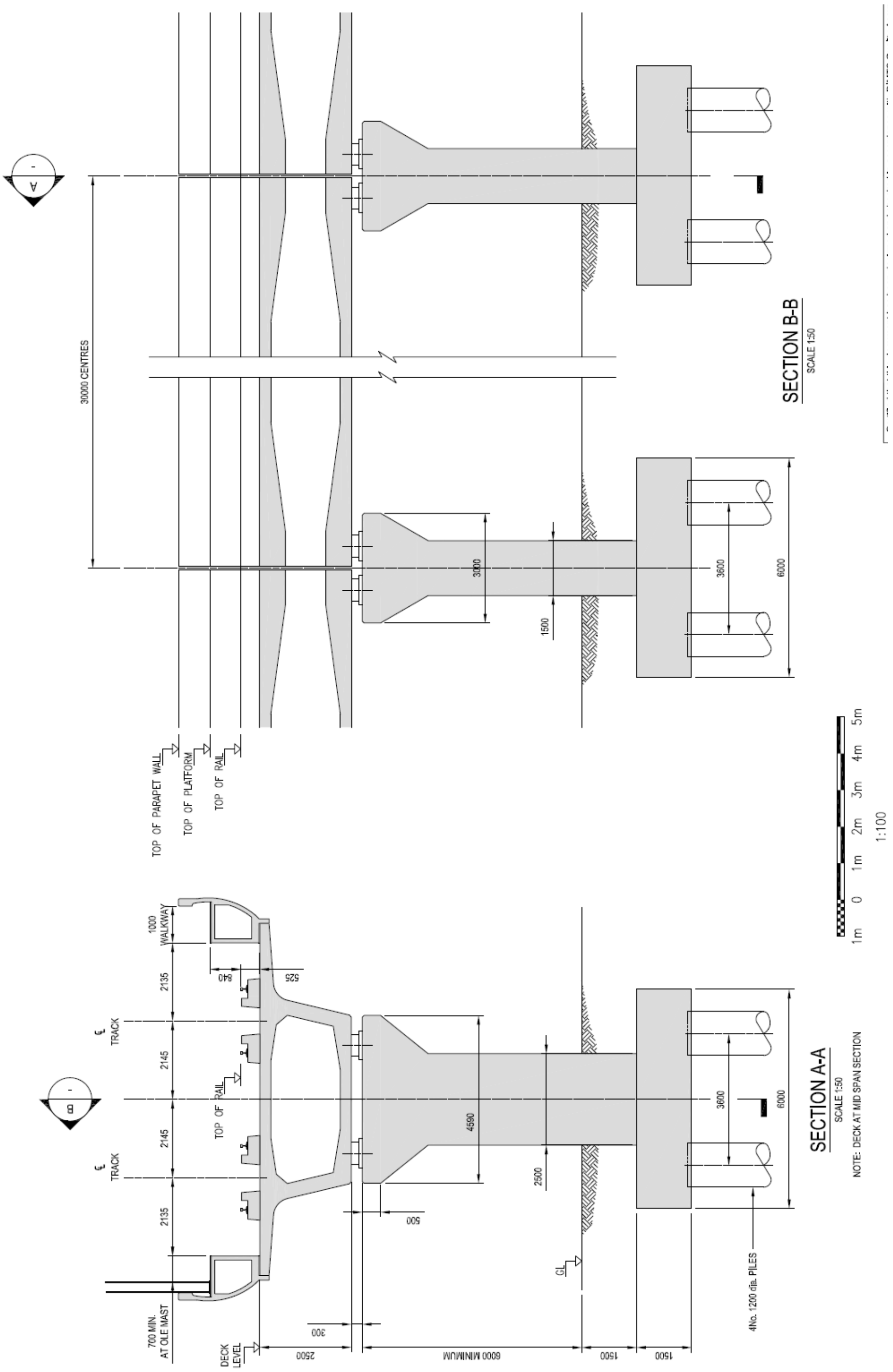
The proposed railway between Delhi and Panipat will be 100.6km long, excluding the branch to Ganaur; nearly all to be constructed on viaduct. Based on the geotechnical information available during the study, a pier spacing of 30m was chosen as a compromise between span length and possible substructure complexity. The design span of 28.8m is at the lower end for economic box girder construction.

Assuming the railway length of 100.6 km and a span of 30m then a guide to the total number of spans is:- 100.6 x 1000 / 30 = 3353 spans

The standard viaduct section will be formed from a precast post-tensioned concrete box girder, simply supported on single piers which are founded either on bedrock or a piled slab. The deck will carry the double track railway and will be completed by pre-cast parapets which will also form a continuous emergency walkway on both sides of the structure. Single track viaducts using similar features to the standard viaduct will be required on link lines and at stations with island platforms.

Comparison with the Taiwan High Speed Rail project with 157km of continuous viaduct shows that the viaduct is made up of 35m long precast post-tensioned concrete box girders simply supported on single columns. The deck units have free sliding mechanical pot bearings at each corner. Shear keys at either end of the span provide transverse restraint with one end fixed longitudinally.

Figure 6-6 Precast Post Tensioned Box Girder



The end rotation of a bridge deck due to the passage of trains is also an important factor for determining satisfactory rail / structure interaction. Preliminary calculations suggest that rotations should be acceptable for the 2,500 mm thick deck under full Load Model 71 loading.

Each substructure for the standard double track viaduct will be formed from a single reinforced concrete pier rising from a foundation slab supported on piles or bedrock according to the soil conditions. The engineering viability study considered a minimum height of 6m from ground level to viaduct soffit with 1.5m cover to the ground slab. Preliminary calculations suggest that a pier 2.5m wide by 1.5m thick will be sufficient to resist the horizontal loads imposed from the railway or by seismic loads. The bearings will be placed on a cross-head which will be dimensioned so that bearing replacement can be carried out without additional temporary works.

Clearance to the deck soffit will be a minimum of 6m. At pier positions the cross-head will reduce this to around 4.5m. The appearance of the pier and cross-head will harmonise with the deck and parapets to give an aesthetically pleasing finish.

6.6.1 The Tunnel and Portals

For the first 2.5km length of the route out of Delhi is proposed to run underground, starting in a new station box near the existing DMRC Kashmere Gate station. This solution has been proposed as a measure to overcome the problems of bringing the track above ground through heavily congested area around Kashmere gate and also to enable the RRTS to link in with the current and proposed Delhi metro located approximately 20m below ground level at Kashmere Gate.

6.6.2 Tunnel Geometry

Currently it is proposed that the RRTS tracks will run in twin bore tunnels with an external diameter of 7.70m.

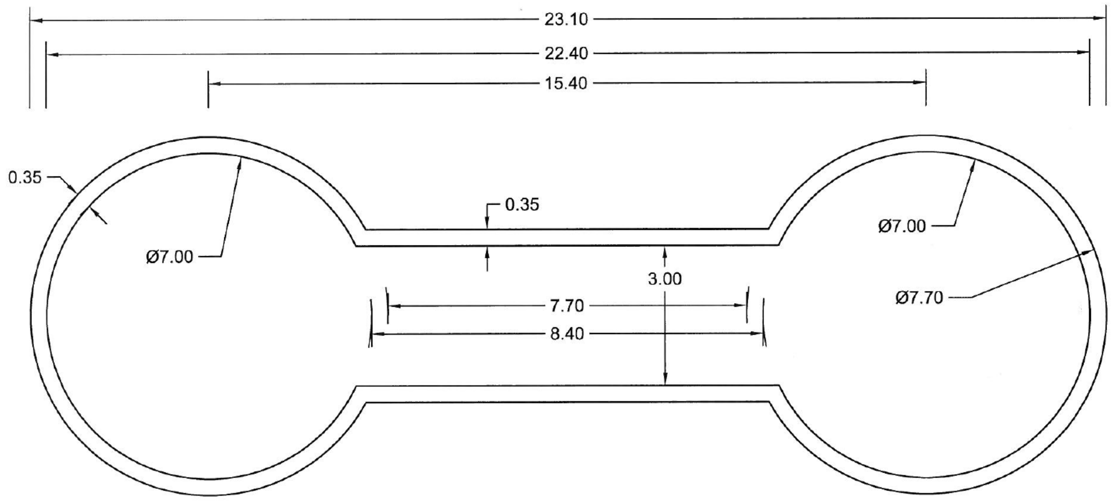


Figure 6-7 Schematic of the Twin Bore Tunnel Section

6.6.3 Previous Tunnelling in New Delhi

The following information is based on a study by Izumi. C and Lovelock. C et al[2]. which details the experience gained from the tunnelling works undertaken to facilitate the Delhi Metro Phase-II project.

Construction of the Delhi Metro Phase-II commenced in 2006 with the project comprising 94km of viaduct section and 30km of underground works. A total of 14 EPB TBMs have been used to complete the tunnelling works.

The tunnels were formed in southern New Delhi area, approximately 7km south of Kashmere Gate station. The ground conditions encountered consisted of predominately the Delhi Silts, specifically dense sandy silts and silty sands. The groundwater level in the area typically ranged from 10m to 35m bgl. In certain locations, the tunnel drives encountered localised outcrops of quartzite, in various stages of decomposition.

Tunnel progress was generally good with an average daily progress rate of 8.0m and a maximum daily progress of 34m. The TBMs were fitted with cutting discs on the periphery of the cutter head to assist with breaking through diaphragm walls at the portal areas and to cope with the localised outcrops of weathered quartzite.

Ground settlements were recorded in the range of 5mm to 20mm and volume loss was generally 0.3 – 0.8%. The main reason for the low settlement values was predominately down to the proper management of the TBMs operational procedures including face pressures and mucking rates.

[2] Izumi.C, Lovelock.C, Tyagi.J and Kumar Gupta.S (2009). A Review of Delhi Metro Tunnel Construction with 14 EPB Shield TBMS. WTC 2009.

6.7 Train operational Plan

The number of passengers per day is taken for 2021, which includes for TOD and feeder services. From the *Travel Demand Forecast Study* the likely passenger numbers on an hourly basis were calculated for the existing four stations which will have a station on the high speed line: Panipat, Samalkha, Ganaur and Narela.

Timetable for selected options is provided in Annexure 3.

6.7.1 Selected Option : All Stations Services to Panipat

For this option it was proposed that the daytime service would be a ten minute interval service between IOCL Panipat and Kashmere Gate and a ten minute interval service between Ganaur Terminus and Kashmere Gate. This would then provide a five minute interval service between Murthal and Kashmere Gate.

Subsequently and in order to provide the required passenger capacity, the service headway was reduced to 4.5 minutes and hence this option would be a nine minute interval service between IOCL Panipat and Kashmere Gate and a nine minute interval service between Ganaur Terminus and Kashmere Gate. Such a service will take 74 minutes between IOCL Panipat and Kashmere Gate, could be accommodated on a double track railway, and will require 29 train sets to operate. The total fleet will be 34 trains including standby trains and maintenance requirements.

6.7.2 Number of Train Sets

The basic “all-stations” 2021 timetable (Option A) requires 29 train sets to cover all services. Additional trains must be allowed for “hot standby” and maintenance purposes, necessitating a requirement for 34 train sets (all-stations service). The actual configuration of the trains will be decided in the subsequent phases of the project and will depend on actual service requirements. For the purposes of this report it is assumed that trains are identical and are a single set of cars (ie there are no internal cabs within the configuration to allow trains to be subdivided).

6.7.3 Provision for Engineering Work

It should be noted that provision will need to be made for engineering work to be carried out. Generally, there are three options:

- replace trains with buses/coaches when the line needs to be closed for engineering work.
- run services over one line of the railway allowing engineering work to be carried out on the other (bidirectional working);
- do not run any services at night;

Decisions regarding the type of night service provided will depend on further detailed review of safe access to the viaduct for maintenance of the railway through hazard studies during the detailed design stage of the project. The initial proposal is that no services run during the night so that access can be provided for maintenance and engineering staff.

6.7.4 Notes on the Timetable

At some stations, such as Murthal, separate arrival and departure times are shown. Where this is not the case and just one time is shown, this is the departure time. In such cases the station dwell time (i.e. the time the train is stationary at the station platform) is 1 minute, except at Kundli, Rajiv Gandhi EC and Samalkha stations, where the dwell time is reduced to 30 seconds due to the limited patronage.

It will be noted that a grade separated junction is required at Murthal to avoid conflict between northbound Kashmere Gate to IOCL Panipat services and southbound Ganaur Terminus to Kashmere Gate services.

6.7.5 Service Recovery Plan / Emergency Plan

It is essential that service recovery and emergency plans are developed during the detailed design stage to address recovery of the service level after perturbations have disrupted the service.

6.8 Users Safety

During normal operation this safety is addressed by keeping passengers within defined areas within the station building or on the trains themselves. As the System is on a viaduct the rails will be securely fixed to the structure and it will be possible to minimise the platform edge gap and the difference in levels between the train and the platform to minimise the risk to passengers. Access to the viaduct is not available to passengers except in emergency scenarios. The use of CCTV and other security systems will assist in providing a safe environment for passengers.

During degraded operations this is addressed in the same manner as during normal operations although additional information may need to be provided to keep passengers informed of events, prevent them from entering stations, or directing them from the stations as required.

During emergency scenarios the emergency plan would be used to clear the system of passengers and evacuate them to a place of safety. One scenario the emergency plan will need to consider is the evacuation of passengers from a failed train on the viaduct. Evacuation routes shall be considered at the detailed engineering stage to ensure suitable and sufficient provision is included.

6.8.1 Workers

During normal operations the safety of staff and workers is governed by the security and maintenance protocols that prevent access to dangerous areas of the system until it is safe to do so. Staff and maintenance workers will need to be trained in the safe operation and maintenance of the System with access to specific areas allowed only to those that are suitably qualified. Although Indian Railways have existing safety systems, an enhanced qualification will need to be developed to cover the railway due to the limited access available and line specific technology.

The railway operations plan will need to include protocols for various scenarios of degraded and emergency operation so that all staff and maintenance workers have a clear understanding of options available to them for operating the System in a safe and effective manner.

A safe means of access to all areas of the System shall be provided for all staff and maintenance workers.

6.8.2 Non-Users

The safety of non-users adjacent to the railway will need to be considered during the design, construction, operation and maintenance of the System. The design will need to include consideration of noise and vibration impacts during the construction, operation and maintenance of the System.

In order to maintain the safety and integrity of the System it may be necessary to provide alternative access for people affected by the system. The design will need to consider any alterations necessary to maintain highway access etc to areas adjacent to the railway.

Process will need to be reviewed as part of the design and construction process to ensure that the railway systems do not affect adjacent systems and that the adjacent systems do not affect the railway systems.

6.8.3 Plant and Machinery

A safe means of access to all plant and machinery shall be provided for all staff and maintenance workers.

The detailed design consultant will ensure that plant and machinery is adequately sized to perform its function correctly and that moving clearances are adequate to prevent collisions occurring.

Maintenance protocols shall be developed as part of the detailed maintenance plan to ensure that adequate systems are in place for the safe operation and maintenance of the System.

6.8.4 Emergency Planning

The requirement for tie-ups with Police, Hospitals, Voluntary organizations, Fire-fighting stations/organizations etc. en route will need to be developed so as to obviate the need for permanent staff for the purpose. The details of the interface with such organisations will be developed during the operational planning stage as part of the service recovery and emergency plan. It will be necessary for the design, build and operating contractors to include for developing these requirements.

6.8.5 Scenarios

Typical scenarios which the above plans should address are:

- timetable delays caused by minor perturbations.
- Passenger taken sick on train
- failed train at station.
- failed train on viaduct
- train on fire at station
- train on fire on viaduct

- highway vehicle collision with viaduct/pier
- building or vehicle on fire near or under a viaduct or pier
- signalling failure
- power failure

6.8.6 Train Evacuation Plan

An outline of a typical train evacuation plan is as follows:

1. The safest location for passengers in the event of an emergency is either on the train or in a station. Accordingly subject to the nature of the emergency passengers will always be advised by the train driver/conductor or operations control to remain in that place of safety. An emergency on board the train such as passenger sickness should be reported to the driver or conductor who will radio ahead to the emergency services to meet the train at the next station where aid can be given.
2. If a train fails but is able to be moved then it should be coupled to the following train and shunted to the nearest station where passengers will detrain and wait to continue their journey. The failed vehicle will be taken to the nearest depot for inspection/repair.
3. If a train fails but cannot be moved due to brakes locking on for example, the following train shall temporarily couple to the failed train and the passengers will transfer to the following train via the trackside walkway on the viaduct. Bidirectional working will be initiated to allow services to by-pass the failure and passengers from the failed train will be taken to the nearest station.
4. If an emergency occurs which will require removal of passengers from the train, for example fire on board, then the passengers in the alight carriage will be asked to proceed to the trackside using the emergency detraining instructions which will be posted by each door. The passengers will move from the train to the walkway at the side of the viaduct parapet and walk calmly to the nearest exit staircase. Viaduct exit staircases will be provided at 2 – 3 km intervals. At no time will passengers be encouraged to walk along the track itself.

6.9 Maintenance Plans

The core railway system maintenance tasks shall cover the following :

- trains
- workshop equipment including maintenance of lineside equipment
- signalling/communication systems
- traction power supply and distribution including OLE system
- fare collection system, and
- permanent way including tracks, switches, sleepers, ballast
- This is followed by a description of the non-core railway system maintenance tasks covering the following:
- maintenance of safety-related equipment in stations

- facilities/infrastructure maintenance
- civil works maintenance
- cleaning services

Level 1 Maintenance

This level of maintenance is preventive in nature and consists of regularly planned inspections performed at various time intervals. During these inspections, in addition to the basic and routine servicing of equipment, tasks are performed to check and verify functions and operating characteristics to ensure maximum performance during full service operation. On board data collection and portable diagnostic tools will be required to collect performance data and provide a thorough diagnosis of the systems and support trends and root cause failure analysis.

Level 2 Maintenance

This level of maintenance is corrective or emergency in nature and can be carried out at site in the case of fixed installations or at the maintenance depot in the case of the trainsets. This often involves rapid interventions performed by maintenance staff to ensure minimum disruption and downtime to service operations.

Level 3 Maintenance

Level 3 Maintenance is the repair and scheduled general overhauls of equipment. Provisions are made in the workshop design and equipment supply to carry out repairs as required to most system elements. While some of this work will be performed in-house, many tasks will be subcontracted offsite to suppliers or specialised workshops.

6.9.1 General Duration per Main System Components

The life span (design life) and residual life of major subsystems are presented in the following table. Achievement of the residual life will be largely dependent on implementation of the regular (short term) preventive maintenance schedules for the Core and non-Core railway subsystems, as well as the long term preventive maintenance tasks discussed in this section.

To ensure that the life span and residual life is achieved, all Core and non-Core Railway System equipment and civil infrastructures will be serviced at long term intervals as well. Most of these intervals and associated tasks are repetitive in nature. These types of preventive maintenance tasks are usually referred to as either overhauls, replacements or renewals.

Asset Group	Design Life Required (Years)	Major Upgrade/ Refurbish needed
Rolling stock	25-30	15
Permanent Way	30	15
OLE Contact Wire	15-20	Partial
OLE Support Structures	40	No
Sub Station Equipment	40	No
Signalling System	25	No
Communications Equipment	10-15	Yes

Asset Group	Design Life Required (Years)	Major Upgrade/ Refurbish needed
CCTV	15	Yes
Fare Collection	20	No
Escalators, lifts, etc.	20	No
Depot Equipment	25	No
Cabling	30	No
Earthworks	>50	No
Structures/ Bridges	>50	No
Roads and Paving	20	No
Park and Ride Infrastructure	20	Yes
Park and Ride Equipment	10	Yes
Buildings	40	No
Station Structures	40	No
Station E&M Systems	25	No
Fire Detection and Suppression Systems	25	No

Table 6-5: Asset Design Life

6.10 Power

The RRTS: Delhi – Sonipat – Panipat railway will be a high power user. Supplies will be required for both traction and non traction systems supplied at high voltage.

6.10.1 Non-Traction Power

Non-traction power is required for both railway infrastructure and for commercial or retail opportunities located at stations. Due to the need to maintain the rail system resilience, it is recommended that the rail power infrastructure is provided separately from the commercial supplies wherever possible. This power is excluding the power required for commercial areas.

Location	Non traction Power (kVA)	Commercial Power (kVA)
Depot (Panipat)	973/1,720**	0
IOCL Panipat	490*	375
Panipat	490*	375
Samalkha	490*	375
Ganaur	490*	375
Ganaur Terminus	490*	375
Ganaur Depot	567	-

Murthal	490*	375
Rajiv Gandhi Educational City	490*	375
KMP Interchange	490*	375
Kundli	490*	375
Narela	490*	375
Mukarba Chowk	490*	375
Kashmere Gate	725	440
System losses 0.85 PF & 10% uplift allowance	8,420	457
Typical System Load	9,263	5,681
*Based on typical station layout. **Panipat Depot load 2035 onwards.		

Table 6-6: Non Traction Power Preliminary Load Assessment

6.10.2 Traction Power

The consumption of traction electrical power is closely related to the rolling stock characteristics, the service levels required and the permanent way geometry.

(Based on rolling stock configurations)		
System Information	**2021**	**2041**
No of Cars	6	9
Headway, minutes	4.5	3.5
No of trains/hr/direction	13	17
Train Load at 160 km/hr maximum speed (MW)	1.90	3.00
Estimated Traction Power (MVA)	76	140
System With Regeneration (MVA)	61	112
Estimated Energy Consumption per annum (MWh)	350,000	644,000

Table 6-7: Traction Power Preliminary Load Assessment

6.10.3 Electricity Supply Quality

The recommended Negative Phase Sequence (NPS) levels of 1.5% for short term 'one minute average' and 0.75% for longer term 'half hour average' shall be applied to the traction power design.

The incoming grid power supplier shall use these NPS levels to decide on the optimum supply voltage e.g.132kV, 230kV or 400kV.

At this stage it should be envisaged that there are no reactors and or filters required at the substation.

The Total Harmonic Distortion (THD) level for harmonics at the point of common coupling shall be within agreed limits with the supply authority or in accordance with Engineering Recommendation G5/4 "Planning Levels for Harmonic Voltage Distortion and connection of Non-linear Equipment to Transmission Systems and Distribution Networks as used in the UK".

6.10.4 Approximate Site Areas

The approximate land area required for the for the traction system electrical supplies required along the route of the railway are as follows:

- 2 no BSP Grid Feeder stations – each of approximately(*) 700m^2
- 2 no ATFS Auto Transformer Feeder Stations each approximately 2,300m^2 adjacent to the BSP's above.
- ATS Auto Transformer Stations along the route as indicated on Figure 10.2 each- approximately- 1,500m^2.

(*) Subject to supply authority confirmation

6.11 Overhead Line Equipment (OLE)

Due to the type and nature of the rolling stock envisaged, a 25kV ac overhead catenary system with train mounted pantograph collectors provides the most suitable system to power the rolling stock.

6.11.1 Depot Feeding Arrangements

Power requirements for train stabling shall take into account the auxiliary load specified per train and the number of trains to be stabled simultaneously.

6.11.2 Spare Capacity

It is recommended a spare capacity of 10% shall be provided in the traction power supply system to allow for the recovery from a perturbed train service, following a degraded mode situation or system failure, within a timescale which is acceptable to the operator.

6.11.3 Auto Transformer Sites

Auto transformers are designed to provide parallel current paths to the trains under normal feeding conditions and reduce voltage sags on the system. The (ATS) sites can be utilised to provide sectioning and disconnection under first emergency, second emergency and degraded feeding arrangements, and where appropriate for midpoint sectioning, all are recommended to be remotely controlled from the SCADA system.

The traction supply system is based on the signaling system operating on the following for train detection:-

- axle-counters
- joint less track circuits

- transmission based system

Therefore both the running rails of each track are available as paths for the fault current and traction current return to the feeder stations.

6.11.4 Earthing & Bonding

The earthing and bonding system is recommended to ensure that the short time touch voltages/potentials for the entire route under fault conditions shall be compliant with Indian Railways safety standards and always be less than the EN 50122-1 and CCITT limits, for any practical rail to-earth resistance values, e.g. 2Ω.km (wet condition), 10Ω.km (dry condition) and 100 Ω.km (very dry condition).

The temporary accessible voltages for the entire route under all normal and degraded operations (but not fault conditions) shall conform to the EN 50122-1 limits.

The permanent accessible voltages for the entire route under all normal and degraded operations (but not fault conditions) shall always be less than the EN 50122-1 limit of 60V RMS, except in workshops and similar locations where it shall be less than 25V RMS for any practical rail-to-earth resistance values, e.g. 2Ω.km (wet condition), 10Ω.km (dry condition) and 100 Ω.km (very dry condition).

It may be necessary to cross-bond the two tracks of the system, to be compliant with the permissible touch and accessible voltages specified in EN50122-1.

The following assumptions have been made during the preparation of this document:-

- accessible voltage in stations, depot and workshop shall be limited to 25 V RMS under normal operating conditions.
- the accessible voltage in locations other than above shall be limited to 60V RMS maximum.
- the touch voltage in stations, depot and workshop shall be limited to 430 V RMS under fault conditions.

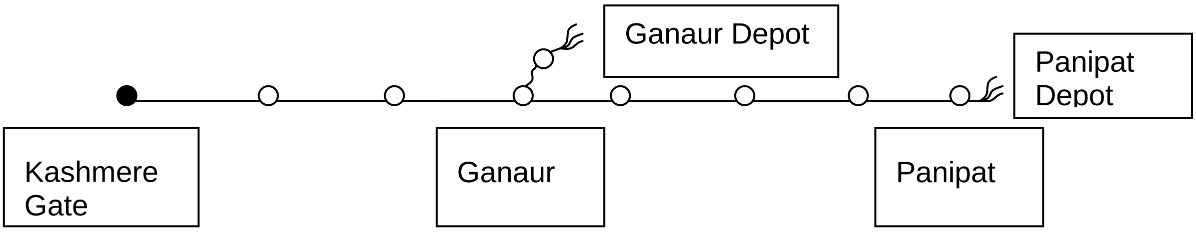
The typical OLE system architecture is indicated in Figure 10.3 below:

6.12 Train Maintenance Depot and Stabling

The train maintenance depots will provide all the necessary facilities for maintenance, operations and stabling for the railway. The depots will also provide the human requirements such as changing areas for maintenance staff and office space for the rail administration staff. It is proposed that there will be two depots one located at Ganaur and one at Panipat. Panipat will be the primary depot location and the Ganaur site will provide limited stabling for early morning services and light maintenance facilities. Ganaur will also provide some back up facilities such as a slave operations control room.

6.12.1 General Background and Design Process

The new railway requires stabling, maintenance, administration and the Operations Control centre near Panipat at the north end of the proposed alignment. Further stabling will be provided near Ganaur to service early morning and Ganaur – Kashmere Gate services. Ganaur depot will also provide backup resources in case of any requirement to shut down the Panipat site.



The key requirements for the depot were identified following an assessment of passenger flows against capacity of rolling stock. This was based on existing rolling stock configurations which are available in the market. Recent depot projects were also reviewed. The depot was then sized based on the provisional fleet size and the facilities required in the depot in order to develop a design schedule and layout to meet the predicted requirements

6.12.2 Depot Capability Summary

Based on the need to provide a more intense service between Kashmere Gate and Ganaur, a small depot is proposed at Ganaur to reduce ongoing revenue costs associated with empty coaching moves to Panipat depot and support the early services from Kashmere Gate. Panipat depot is proposed as the main depot and the facilities provided at each depot will be based on the following:

Ganaur

- all daily inspections and daily cleaning
- all minor repairs (light bulbs, window wipers etc)
- stabling for early morning services.

Panipat

- all daily inspections of all other rolling stock
- all “A” service checks (5,000km intervals)
- all “B” service checks (15,000km intervals)
- all minor repairs of all other rolling stock
- all intermediate overhauls (IOH) of all rolling stock (400,000km intervals)
- all periodic overhauls (POH) of all rolling stock (800,000km intervals)
- all stabling of all other rolling stock
- all heavy repairs (bogie change etc)

6.12.3 Stabling Requirements

Based on the provisional fleet size of 34 trains provided and the provisional timetable provided in the detailed Engineering & Operations Report the depot requirements for 2021 were assessed as follows.

	Panipat Depot		Ganaur Depot	
	2021	2041	2021	2041
Service Fleet	23	29*	6	8
Hot Standby	1	2	1	1
Maintenance	3	4	0	0
Total	27	35	7	9

Table 6-8: Fleet Size Breakdown (2021)

In order to support the early/late services in to and out of Kashmere Gate and reduce the extent of empty stock moves between Panipat and Delhi it is estimated that 6 trains will require stabling at Ganaur Depot with an additional hot spare provided to support service recovery.

The required 2021 capacity at Panipat Depot will therefore be a total of 27 trains.

From Chapter 2 of the detailed Engineering and Operations Report the maximum train length provided at the depot has been assumed as 238m to allow for possible future expansion from 6-car to 9-car in order to achieve the 2041 Ultimate System Capacity. This gives a maximum length of siding of 308m assuming a 15m stopping tolerance at each end and a straight length of 20m at each end to allow each car to align before entering the tight confines of the siding. Based on the above, preliminary depot layouts have been prepared for both Panipat and Ganaur and are shown in Figures 11.1 and 11.2 respectively in the detailed Engineering and Operations Report that has already been submitted.

7 FINANCIAL AND ECONOMIC VIABILITY

7.1 Financial and Economic Viability

As per the directions of NCRPB, the Financial and Economic Viability of the project has been presented in a separate report "Financial and Economic Viability Report" being submitted along with the draft Detailed Project Report.

8 FEEDER NETWORK AND TRAFFIC INTEGRATION

8.1 Introduction

For sustainable development of any region, it is imperative to have a good transport system which serves as a strong backbone to city's travel needs. Such system provides an efficient public transit system in the city for commuters to use daily for their work, education, business or social trips. Generally it is seen that about 75%- 80% of the daily trips in a city account for work and education trips. A well Integrated - transport system provides major share of daily trips, the growth of private vehicles can be restricted to a large extent. A brief description of all the alternate mass transit systems options are given in further sections which have been proposed as part of the public transport alternatives for the Panipat and Sonepat Region. Since both the cities are medium sized in terms of population, only light systems have been proposed as part of the integrated feeder transport network strategy.

8.2 Multimodal transport system alternatives

8.2.1 Public Transport System Options

Public transport systems include buses, trolleybuses, trams and trains, Ropeways, rapid transit (metro/subways/undergrounds etc) and ferries.

Most public transport run to a scheduled timetable with the frequent services running to a head way. Urban public transport may be provided by one or more private transport operators or by a transit authority. Public transport services require subsidy since fares charged to passengers may not meet the costs.

When it comes to public transit, design of vehicles must match the travel length and need. For destinations within a few miles, a bus is preferred mode, since the buses, can travel on most public roads and can serve large number of destinations. High population density and large number of riders might require a light rail or underground metro that stops every 1km or so.

Light rail meet a similar transportation requirement as a local bus, so they are generally a choice for distances of upto 10km or so.

In number cities around the world, we'll find multiple forms of public transit in the same city. People living in those cities intuitively understand that each mode has its place, and that certain modes and vehicles serve a specific transportation requirement. There are a number of examples in the world where alternate modes of public transportation are available based on the need and one such city is of Vienna. This city has an amalgam of rail systems, trams, buses, trolley buses, cycles and extremely good network for pedestrians.

8.2.2 Capacities of various mass transport systems

The comparative capacity of the main transport modes used in developing cities is reported in a TRRL-UK study (1995) and World Bank study (2000). As per these studies, the capacity of various modes may be taken as follows;

Bus Rapid Transit (BRT) System (with overtaking lanes)	10000 to 20000 phpdt
Personal Rapid Transit (PRT)	7200 phpdt
Light Rail Transit (LRT) System	2000 to 20000 phpdt
Metro/ Suburban Rail	30000 to 80000 phpdt

However capacity of LRT and monorail can be stretched up to 30,000 phpdt. Thus, it appears that BRT, Monorail and LRT, can be used when the demand on a corridor is not expected to exceed 20000 phpdt. Beyond the demand level of about 20000/30000 phpdt, a metro appears to be the only choice.

Of the above mentioned system medium capacity system such as PRT, LRT, Monorail etc can be regarded as a light metro system. These can be provided where road widths are limited and turning radius is also not adequate for heavy metro and thus only such systems have been considered in our proposed feeder network.

8.2.3 Right of way requirements

All medium capacity modes normally lie within the road right of way and hence require a share in the road space. At-grade modes however require more space than elevated modes. For at-grade BRT (with one lane each side), the desirable right of way requirement is 35-45 m. The minimum right of way for BRT, as prescribed in the Toolkit (Module 2 – Bus Rapid transit: Toolkit for Feasibility Studies) by Ministry of Urban Development (MoUD) is 30m. The latter allows for two- lane sub-standard carriageways each way.

If minimum ROW is not available, elevated modes become necessary. For elevated Monorail or LRT, minimum of 20 m road is required because at ground level space is required only for a column and its protective measures. Elevated BRT system may be provided on roads where road ROW is about 20-21 meters. A PRT system could be built on even much narrower roads because of the light infrastructure. A PRT system or elevated BRT is the preferred choice because the cost per km for Monorail/ LRT goes much higher. A BRT system would typically cost 4 to 20 times less than a LRT system and 10 to 100 times less than a metro system.

8.2.4 Public transport technology options

BRT is not the only mass transit option available for any city. Metro rail, Light rail transit (LRT), monorail, suburban rail, BRT and standard bus systems are all the options available. There is no one single right or wrong technology since much depends on the local circumstances. The factors affecting the technology choice include capital costs (infrastructure and land costs), operational costs, design and implementation considerations, performance and economical, social and environmental impacts.

It is well said by Freeman Dyson (1923) that "*The technologies that have most profound effect on human life are usually simple".* Out of all the modes of public transport that are available BRT is one of the best solutions for Indian cities with limited funding options for public transport systems.

8.2.5 Bus Rapid Transit

Bus Rapid Transit (BRT) is a busbased high quality, high capacity rapid transit system that aims to deliver fast, comfortable and cost effective urban mobility. BRT combines similar performance and operating characteristics of a metro system with the flexibility and infrastructure cost advantages of a road based, bus based system. The goal of these systems is to approach the service quality of rail transit while still enjoying the cost savings and flexibility of bus transit. The BRT has the advantages of rail with higher operating speeds and by being bus based is able to gain higher levels of accessibility. This system can often be the first step towards a MRT system for a smaller city.

It is a high-capacity urban public-transit system with its own dedicatedright-of-way, multiple-car trains at short headways, and longer stop spacing than traditional streetcars and buses. BRT, however, uses buses on a wide variety of rights-of-way, including mixed traffic, dedicated lanes on surface streets, and busways completely separated from traffic.

International best practice for the infrastructure, operation and its marketing and branding have been established for the Bus Rapid Transit system that allows it to achieve the high level performance characteristics and distinctive image that define it and distinguish it from regular bus based systems.

The various advantages of BRT systems are

- High System Flexibility
- High capacity
- Relatively Rapid Implementation Time- System can be implemented quickly and incrementally.
- Cost effective: Relatively less costly to implement than a rail transit line while providing similar benefits.
- BRT corridors can be on arterial streets, expressways, railroads and other separate rights-of-way, on aerial structures and on underground roads (in tunnels).
- Reduced Environmental Impact -BRT can be effectively integrated into the surrounding environment and generate significant urban development benefits.
- Safety and Security

In order to obtain the high level operating performance characteristics that define a BRT system, it is necessary to implement the key features of the system that allow this level of performance. These include

- Physically segregated bus ways-Usually located in the roadway median to avoid impacts of traffic congestion and vehicle conflicts

- High Capacity Vehicles -Usually articulated or bi-articulated vehicles, Often using clean fuels such as biodiesel, natural gas, hydrogen, etc

- Closed Station Design - Enclosed stations that are generally located in the median that function similar to a metro station , Access is controlled via turn stiles with p pre-payment outside the station, Passing lanes are a desirable feature

- High Frequency -Service frequency is akin to that of a metro system, that is, usually less than 5 minutes and potentially less than 1 minute

- Rapid boarding and alighting at stations - This is possible due to level boarding and off-board payment at closed stations. Large high capacity buses with 3 to 4 wide doorways also facilitate rapid boarding. This allows for low dwell times at stations, increasing journey speed are reducing congestion at stations

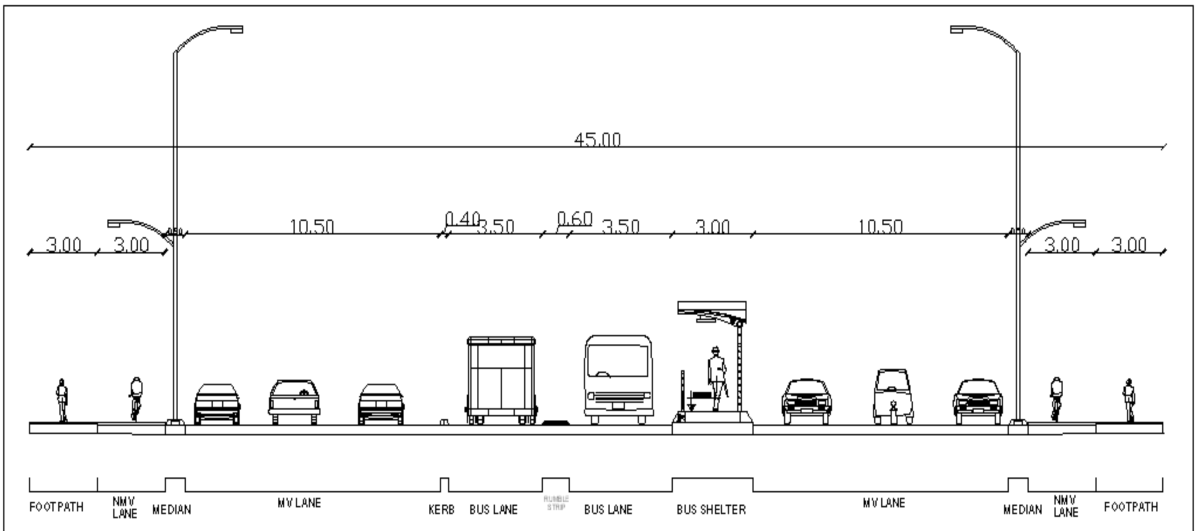
- High Capacity System - Peak hour peak direction capacities range from 3,000 passengers per hour and can go up to 45,000 passengers per hour. This is made possible due to the combination of all of the above features

- Operational Control and Fleet Management System-To achieve very high frequency and capacity, a centralized control centre is required via GPA or RFID radio in order to harmonize frequency and provide passenger and driver information

- Fare Integration

- Permit faster transfers and therefore reduced journey times through integrated ticketing and Automatic Fare Collection

A typical cross section for BRT on a 45 m wide road is given below.

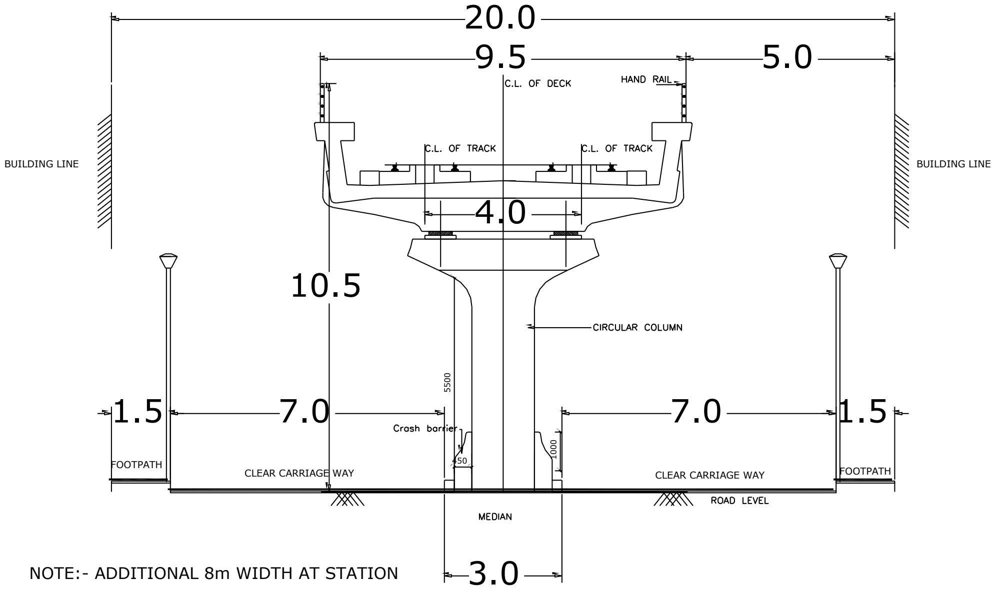


PROPOSED BRT SECTION - MID BLOCK BUS STOP (45 M)

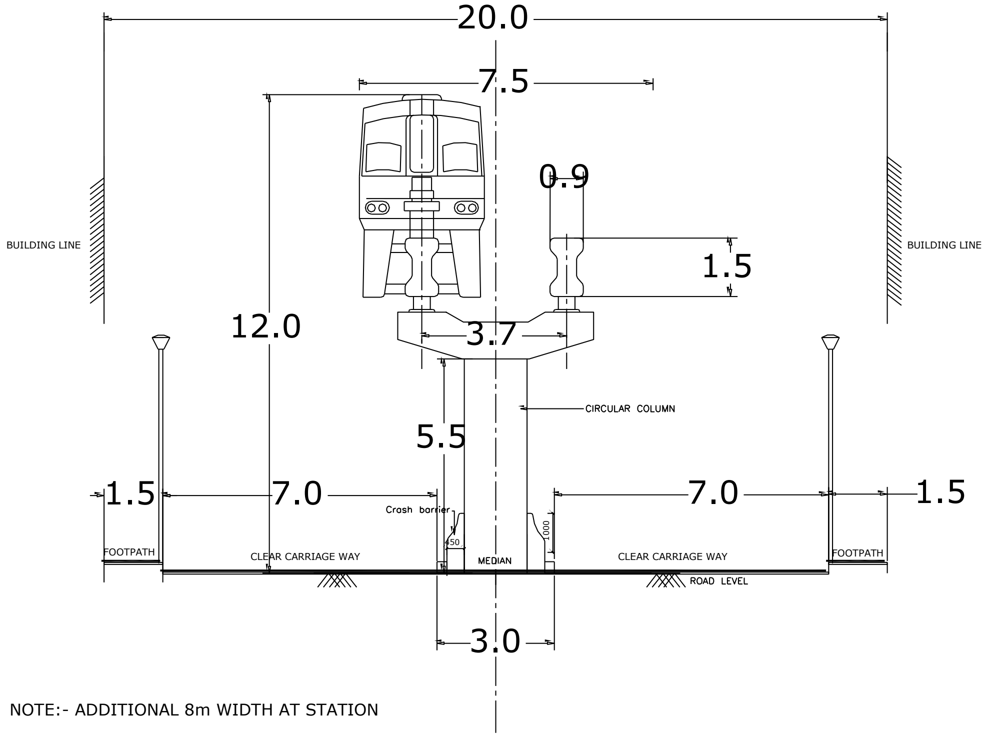
8.2.6 Light Rail Transit (LRT)

The light metro system can be Light Rail Transit (LRT), Monorail or Maglev etc. Light metro system are characterized by exclusive right of way, advanced train control systems, short headway capability, and floor level boarding. These systems approach the passenger capacity of full metro system, but can be easily constructed by using the ability of light metro system vehicles to turn tighter curves and climb steeper grades than standard metro system vehicle. These all system are high quality, ultra modern, customer oriented transit option that could deliver fast and comfortable urban mobility quite similar to Metro Rail. Light metro incorporates most of the high-quality aspects of metro systems with less ROW requirement. The elevated light metro does not occupy any space on the road surface.

In some parts of the world, light rail has been designed with long distances between stops and functions more like a regional rail service. However, light rail vehicles are designed to operate at lower speeds and have less comfortable seating than regional rail vehicles. Light rail generally has a maximum speed of 45 - 65 mph and an average operating speed (including stops) of about 15 mph. A typical cross section of LRT / Monorail is shown below.



ELEVATED LRT



ELEVATED MONORAIL

8.2.7 Personal Rapid Transit (PRT)

Personal Rapid Transit (PRT) is a public transport concept that offers passengers an on demand and non-stop service, using automated vehicles. PRT systems typically consist of 4-6 people, electric powered vehicles, with a central control system, running on either ground level or elevated guide ways.

PRT offers personal transportation with limited waiting time, and takes passengers non-stop to their chosen destination. This is a transit system which is as convenient as, or in congested environments more convenient than, the car, but due to its lightweight structural requirements its environmental impact can be minimized.

The PRT's benefits in terms of infrastructure consist of the following; reductions in vehicle emissions in the City, improved transport service, improved landside processes, more efficient use of space, solve critical problems of congestion both for travelers, a Standard implementable structural form available, it can be varied to suit architectural needs, low visual intrusion (17.5 inch side profile), lighter than an equal footbridge, when elevated it has a lower cost than an equal footbridge, when at-grade it has a lower cost than an equal footpath, Capacity equal to motorway lane, 0.45m depth to minimize visual intrusion and ease of installation

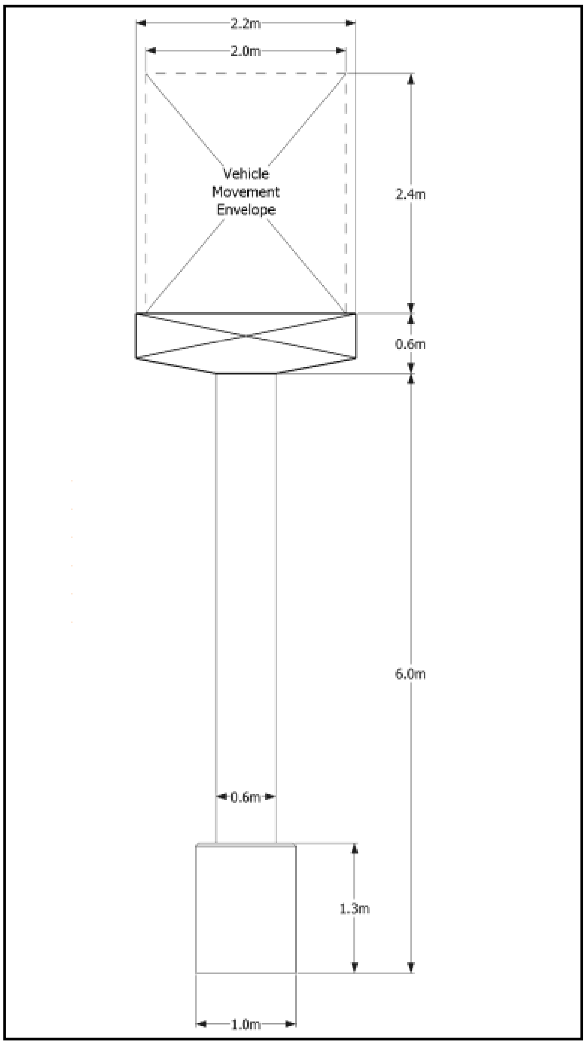
A PRT system can operate at-grade or elevated either within or external to buildings, offering the opportunity for significant benefits to the passenger.

Low loading footprint means that the system can be carried by conventional building structures with no need for structural strengthening.

The vehicle has a small (5 m) turning radius and readily copes with grades of 20%, although operating routes are limited to 10% to ensure passenger comfort.

Most PRT systems are highly adaptable. Modular design and construction techniques make addition of further routes straightforward.

Lightweight vehicles permit light infrastructure: Automated control allows high utilization. Small vehicles and guideways imply less land take. A typical cross section of PRT system is given below with an extra areaof about 7.5km for station.



Typical cross section of PRT

A typical PRT vehicle weighs no more than 500 Kg and it carries a maximum of 6 people. Its average speed is 40 Km/h and it is electricity-powered (2 KW). The line capacity of PRT can go up to 7200 persons.

A PRT system can operate at-grade or elevated either within or external to buildings, offering the opportunity for significant benefits to the passenger.

Low loading footprint means that the system can be carried by conventional building structures with no need for structural strengthening.

The vehicle has a small (5 m) turning radius and readily copes with grades of 20%, although operating routes are limited to 10% to ensure passenger comfort.

Most PRT systems are highly adaptable. Modular design and construction techniques make addition of further routes straightforward.

8.3 Proposed Feeder Network

8.3.1 Introduction

It has been seen globally that to enhance ridership of any transit facility a good feeder network needs to be designed for the city. With reference to our RRTS corridor the feeder system being viewed is basically a bus based system. The provision of feeder service to RRTS can be viewed as the process for designing new bus routes serving the whole city,for the purpose of achieving a more efficient and a better integrated multimodal transit system. Redesigning the bus system to serve a rail line is unusually based on savings in travel time and on effective utilization of rail's high capacity

8.3.2 Study Approach

This study identifies passenger's desire pattern's, distribution of residential and economic centre's in the influence area of each RRT station and define potential feeder services that could be provided to connect these nodes efficiently in conjunction with the RRT services. The Study has following components:

1. Review of RRT station connectivity's and identification of catchment area formajor stations
2. Review and identifications of major traffic production/attraction centre's in catchment area
3. Review of Existing and proposed Bus Routes in catchment area
4. Suggest new Feeder Routes connecting major catchment area nodes not covered by existing system
5. Suggest any new system if required for integrating feeder servicesto the RRT station
6. Plan for complete Integrated Public Transport Network for Panipat and Sonepat region.

8.3.3 Design of feeder services

The design of such new feeder system is guided by the Origin-destinations pattern within the city. The choice of the right type of feeder system whether rail, bus or IPT based is very critical for the commuter's choice of mode that is given and should match his preference as this affects the ridership on the RRTS. At the outset every commuter wants efficient, comfortable and quick transfers.

The transport feeder system for all the three regions namely Panipat, Sonepat and Delhi have been tailored keeping in view the catchment area, average trip length of the commuter, traffic demand, the local road widths available and lastly on the alternative public transit systems most suitable for each region.

Saving in travel time is possible as a result of rail systems' high speed over a long distance. But if the last mile connectivity for any commuter is not planned and designed properly it may increase the total travel time from end- end and hence affect the choice of the mode of RRTS. Thus providing a good feeder network enhances the ridership of any mainline system.

Therefore, the restructuring of the bus system and the provision of new feeder buses depend on distinct criteria. The two main determinant factors of the feeder service design/structuring process are to serve the RRTS lines based on the proposed development plans for the region and the following:

- Central Business District (CBD)-core area mobility
- Modal integration policy

Feeder systems main function is to improve the mobility within the city through the provision of an efficient trip circulator and distributor system. Mobility within the core city can be enhanced by reducing traffic volumes in peak hours. Buses add disproportionately to traffic problems. Automobile traffic in the core city area can be reduced by restricting access to the core areas, limiting parking spaces, or by implementing other traffic restrictions schemes.

The second important criterion of the designing process is the level of modal integration favored by the commuters'. In a highly integrated multimodal system, duplications of service have to be reduced to a minimum. This implies that most bus routes should be intercepted, split into two segments, or extended to the nearest RRTS station. Furthermore, in order to improve the efficiency of the system, the most cost-effective mode should be employed in each segment of the network.

A special bus feeder system can most efficiently meet the region's mobility needs, and can effectively link the CBD core area of the city to RRTS station.

In all the towns along the RRT corridor special feeder services are perceived to be provide by small to medium size buses since maneuvering is restrained on narrow roads and operating at low headways on short routes, preferably configured in a loop shape.

Feeder buses offer a high-quality service intended to be attractive to riders from all social backgrounds. The exterior look and colors of the buses, the logo and the quality of service (eg, operational, courtesy of drivers, cleanness) should be modeled along RRTS high-quality service so that riders will associate the feeder service with the RRTS instead of with the local buses, and regard them as an integral extension to the RRTS alignment (extension legs). Thereby, feeder buses will minimize the negative connotation usually associated with bus systems, and will improve their attractiveness to potential riders who previously relied on their cars.

While it is preferable to structure the existing bus network all at once, the implementation of the special feeder bus routes is inherently more flexible because they are an add-on new service. Special feeder bus lines should be gradually implemented on a priority basis.

Because special feeder services use small size vehicles, feeder buses are more maneuverable and better adapted to operate on high traffic local routes. They quickly and efficiently connect the dense residential areas near the CBD, and can quickly access RRTS stations by using the main arterials in the inner zone. Thereby, the implementation of special feeder routes will allow local buses to operate at a higher speed and service frequency, to reduce the number of service stops, and to avoid circulating on high-traffic local streets of the inner zone.

The feeder system for all major cities of Panipat, Sonepat and Kundli Complex and Delhi is developed specially keeping the above points in to consideration.

8.3.4 Proposed integrated transport feeder network for Panipat

Panipat is a point of congruence of roads from Delhi, Gohana, Karnal and Assandh in Haryana and Kairana from Uttar Pradesh.The Panipat area has two proposed RRT stations namely Panipat IOCL and the other Panipat City near between state highway 14 and Jatal road near model town.This station is located in the south western side of Panipat.It is proposed that the Panipat IOCL RRT station shall also have Transit oriented development (TOD) zone. The proposed developments in the Panipat region are shown in the DP-2021 for Panipat given in figure below.

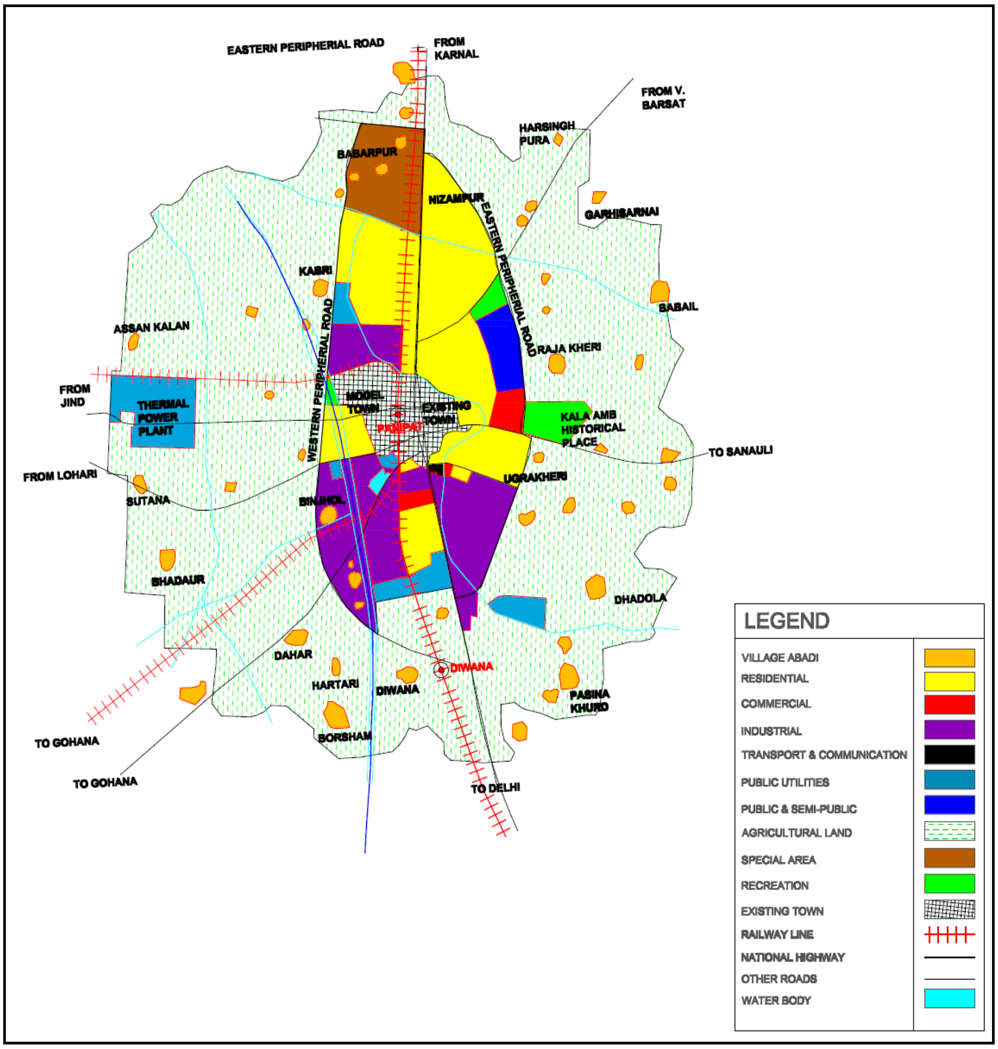


Figure 8-1: Development Plan (2021) –Panipat

The population of Panipat as per 2011 census is 506866. As per the revised Draft Development Plan, Panipat has anticipated a population of 7 lakhs up to the year 2021 and about 9.93 lakh for 2031, while the population of Town in the base year 2001 was 3.6 lakhs. The plan proposes a linear form of development along the national highway spread over an area of 7011 Ha. There is the Special Area Zone (SAZ) which would include land use such as special commercial, institutional recreational and sport complexes, etc. The Special Zone covers an area of 477 Ha in the northern part of the town. The first RRT station is located at IOCL Panipat. The IOCL complex is also located near the SAZ and there is vacant agricultural land surrounding the IOCL which has been identified for yard and terminal station facility as well.

The second proposed station is to be located at a distance of about 3-4 km from the existing town centre and located insouth Panipat near the proposed residential and industrial area. This will cater to the work force engaged in the surrounding HUDA industrial areas, NFL townships and areas of Sewah. The two stations within the Panipat region shall facilitate the transportation needs of the whole supported population and also the proposed land uses in the city by maintaining an efficient commuting distance.

Looking at the growth of the region and the locations of the activity centers it is important to have a good transport infrastructure development for the benefit of the commuters in the city so that RRTS is more easily accessible. A holistic view of the transport infrastructure needs to be taken while designing and planning of public transport facilities for the commuters. The idea of providing feeder services with small vehicles is to increase the catchment area. Panipat has limited road widths (ROW) and the infrastructure for the pedestrians is also poor in the city. The city needs an alternative mode of transport and also requires good public transport infrastructure schemes which will be beneficial for all types of road users and will integrate the feeder bus system to the proposed RRTS. The figure below shows all the proposed integrated feeder transport network for Panipat area which has been detailed in further sections.

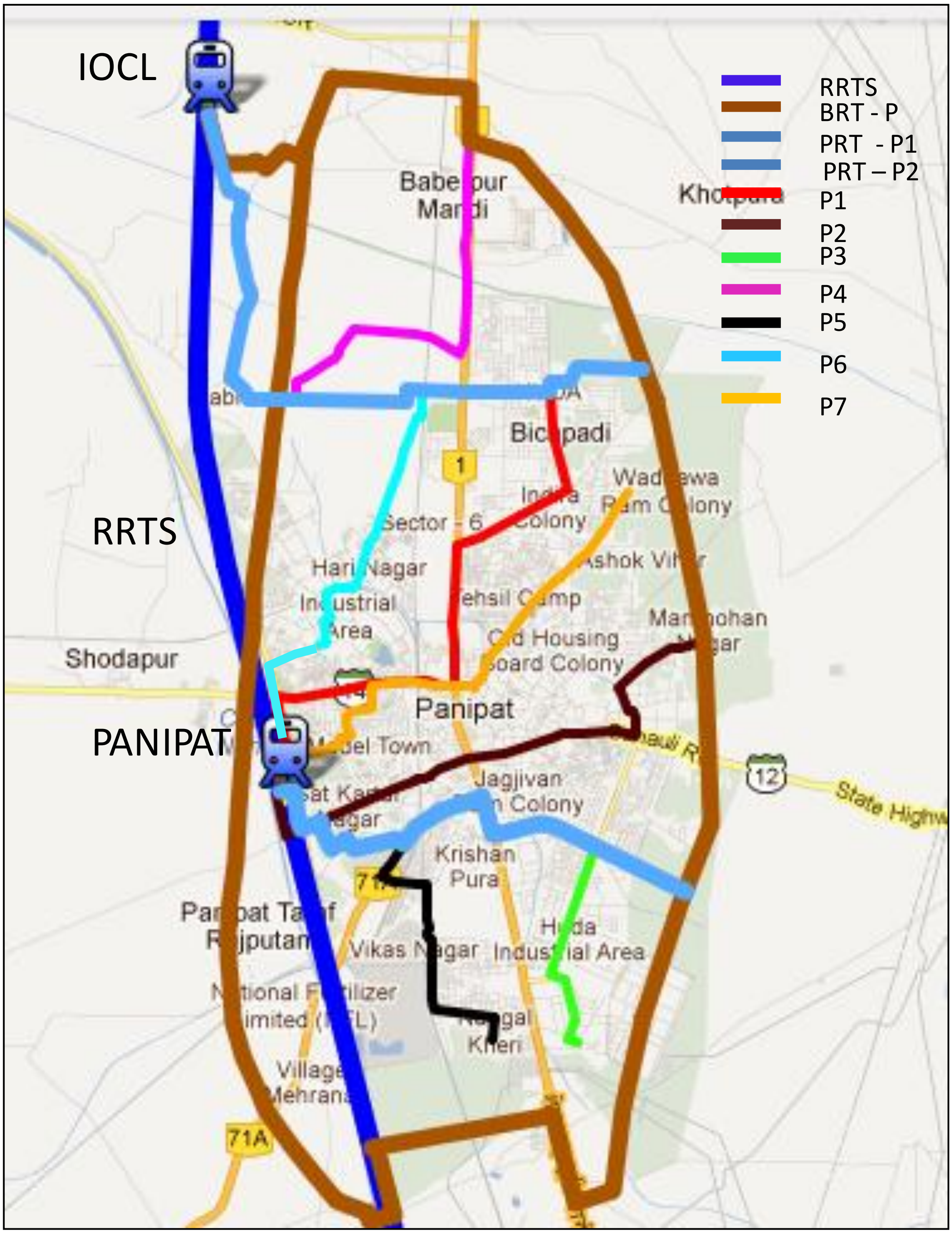


Figure 8-2: Proposed Integrated Multi Modal Transit system for Panipat

In choosing a mode for a potential public transit corridor, first priority should be given to at-grade services. It offers convenience to commuters to access the system. Commuters do not have to walk up/down to access the system and also the construction cost is low. It offers the best financial sustainability as well. If road width (ROW) is inadequate and it cannot be widened and/or the route is congested, an elevated mode needs to be proposed.

Currently the analysis of the Origin-Destination pattern of the public transport commuters in the Panipat area shows about 27% trips originate within 1 km, 32%

within 2 km and 21% within 3km the existing railway station and the bus station. Thus if the feeder network can be spread up to 3 km it will be able to cater to a 81% of the total public transport feeder trips within the city. The remaining 20% trips originate within 4-5 km range of the existing rail and bus stations. The desire pattern for Panipat city shows that major trip ends are seen in the eastern Panipat area covering areas of Babarpur, Diwana, Jhattipur, Manana,Kabri, Ghodar, Gaha etc.

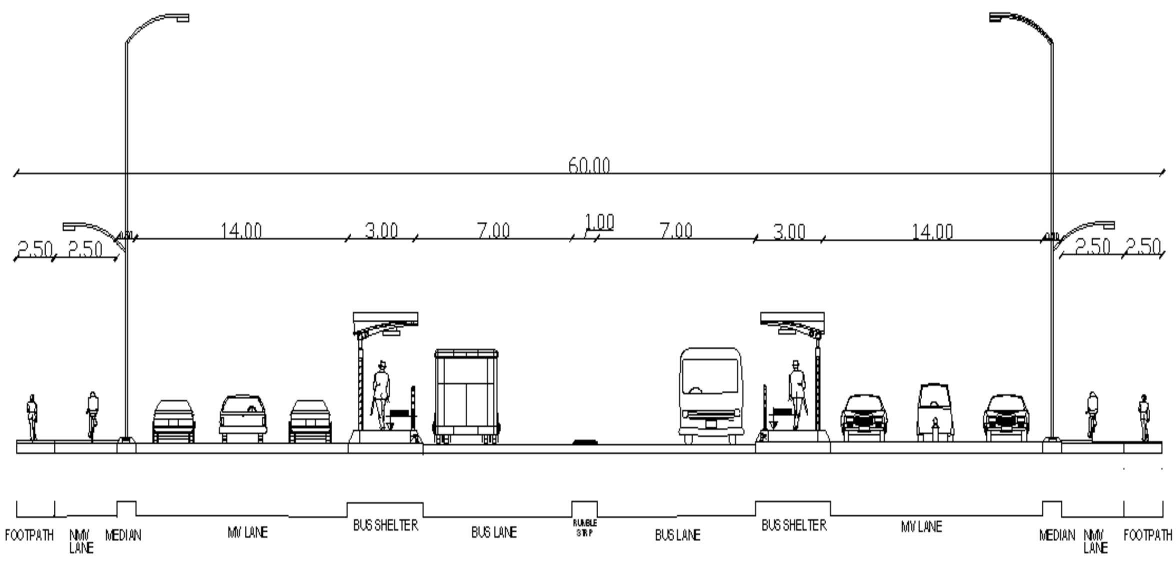
Both the RRT stations in Panipat district need to be well connected by bus feeder network due to the limitation of the physical location of the RRT station. The current Origin-Destination pattern and the Value of time (VOT) analysis were studied in detail to work out the modal split of passengers. The modal spilt of the passengers boarding the RRT IOCL station shows that about 14% would walk to the station, 31% would use intermediate public transport, 8% would use private vehicles and about 28% are expected to use the feeder bus system and the rest would use NMT. The average trip length for the city is 2.4km.The entire feeder system for Panipat district has been designed keeping in mind the future development plan of the area.

All the feeder bus routes are proposed to cover the entire city of Panipat and the Panipat IOCL station area.

- The proposed route P1 shall start from HUDA, then passing through Wadhawa Ram colony, Hari Nagar, Diwan Nagar and terminating at Panipat City RRT station. Route P1 shall cover the nearby areas of Indira Colony, Vikas Nagar,Prakash Nagar, Indira colony, Preet vihar, Ashok Vihar, New Ramesh Nagar, Bishon Swaroop colony, Geeta colony, Kacha camp, Aggrasen colony and Shanti Nagar. The length of the proposed route is 8.7km.
- The proposed feeder P2 bus route shall start from Panipat city RRT station following the Ashram Road, Sanauli Road, Babali Road and covering parts of Netaji colony, Amar Bhawan Chowk area, new HB colony, Chawla Colony and terminating at the Balaji Nagar. The length of the proposed route is 7.6km.
- The proposed feeder P3 bus route of length 3km which will connect the HUDA industrial area to the LRT P2 line.
- The proposed feeder P4 bus route shall start from Ansal's Sushant City, HUDA sector-18 via Parsvanth Paliwal city and terminating at the proposed RRTS station near IOCL. Length of this route is 5.7 Km.
- The proposed feeder P5 from Nangal Kheri, Azad nagar and connect to LRT-P2 line. P5 shell feed the areas of NHFL Township, Vikas Nagar, Krishna Pura and HUDA industrial area. The length of the proposed route is 4.0 km.
- The proposed feeder P6 bus route of length 4.1 km shall start from Kaccha camp, Haribagh colony, passing through HariNagar industrial areas and connecting to the LRT P1 line.
- The proposed feeder P7 bus route of length 7.5km to start from Wadhawa Ram colony, Hanuman Colony, via Insaari bazaar Road, on to Assandh Road, Model Town, Shanti Nagar and terminating at Paniapt City RRT station.

A total of about 52 mini buses shall be required for all the 7 suggested bus routes covering about41km of total length. These shall provide a 5minute frequency feeder service.

Based on the pre-feasibility of the ROW of the potential corridors in Panipat it is proposed to enhance the feeder network with an at-grade Bus Rapid Transit System (BRTS) system on the western Peripheral Road and the Eastern Peripheral Road and completing a Ring road of about 42km length with a spur of about 2km connecting to IOCL RRT station. As per the Proposed Development Plan this road would have right of way of 60m. The 60 m wide road width can be utilized to provide a good at grade BRT system which will not only improve the movement for buses (regular and feeder bus) but also would improve the infrastructure for pedestrians and non motorized vehicles like the cycles & cycle rickshaws which are the key sustainable modes of transport. All the three modes account for 33% - 38% share in the total access trips to the RRT stations. The bus station on ring BRT near the Panipat city RRT station shall be connected by a skywalk for ease of commuters to use the BRT system once they alight from the RRT station. A total of more than 60% of commuters accessing the RRT stations shall directly benefit from investments done in building such infrastructure. A typical cross section of a BRT which is proposed on the western and eastern peripheral DP road is given in figure below.



PROPOSED BRT CROSS SECTION FOR 60 METER RIGHT OF WAY

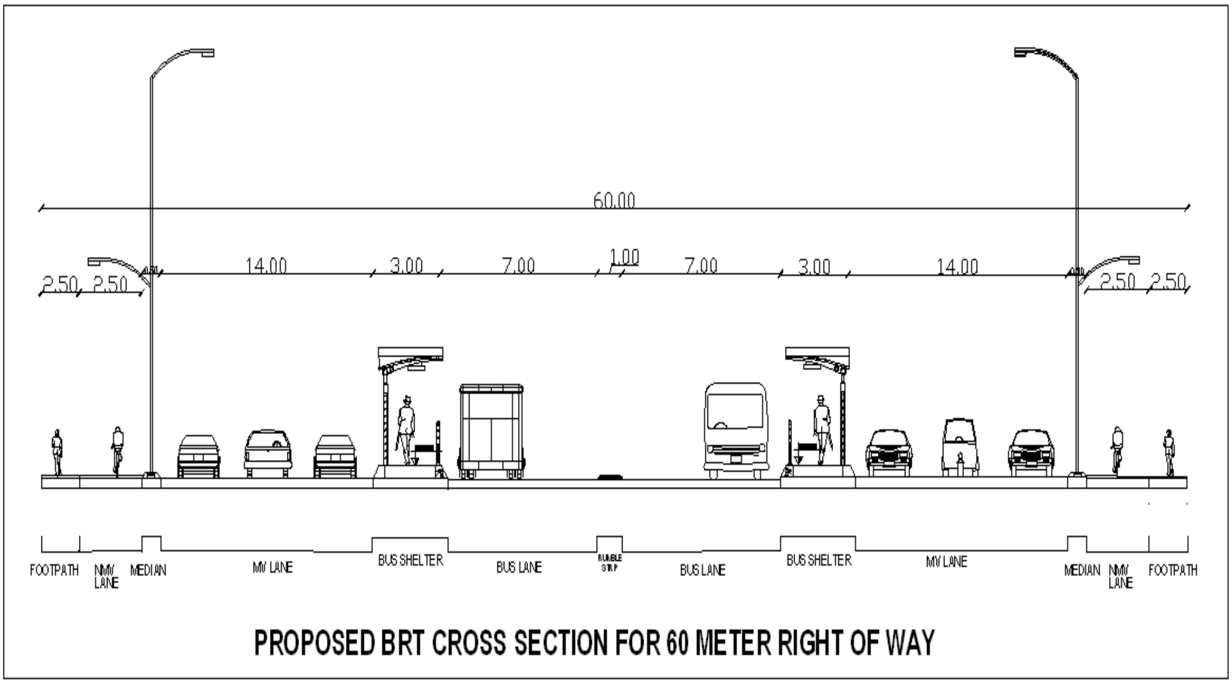


Figure 8-3: Typical Cross-Section of Ring BRT on 60 M (ROW)

Further to enhance the network apart from the feeder buses and BRT, it is proposed to build two more public transit corridors which could be elevated BRT/ PRT line covering the dense areas of Panipat. These light systems can be built in densely populated areas. Due to the paucity of road widths it is proposed that such light systems needs to be built on the dedicated elevated structures so as to leave the ground road space for other road users. Both the identified potential public transit corridors have limited ROW of less than 25m. These two elevated BRT/PRT lines shall connect the commuters to the two RRT stations with high frequency reliable services.

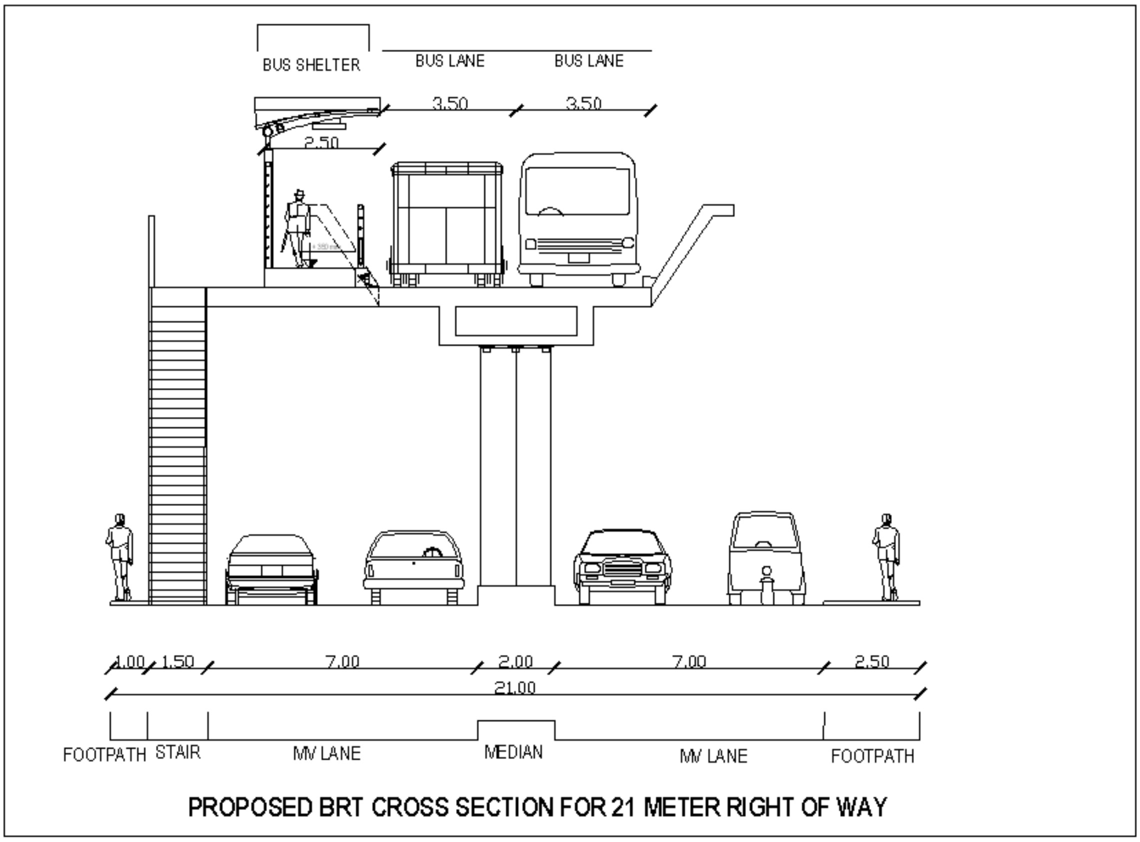


Figure 8-4: Typical Cross-Section of BRT with 21 M (ROW)

The first line PRT-P1 shall pass through the thickly populated residential areas of HUDA andSushant city via Kabrito the terminal RRT station at IOCL. The other PRT-P2 shall connect the easily populated HUDA industrial areas and residential areas of sector 12 Panipat city, Jagjeevan ram colony, Gohana Road, dense commercial areas of Sat Kartar Nagar and finally connecting to the RRT station at Panipat city. The typical cross section of an elevated BRT on limited 20m ROW is given in figure above.

These two elevated BRT/PRT lines shall also be connected to the ring BRT as well making the network more flexible and accessible for quick transfers and hence saving time for the commuters. This dedicated feeder system would enhance the transport network in the city and at the same time provide multi modal choices to the daily traveler. This entire integrated public transport system would act as added catalyst to the main trunk line of RRTS in Panipat region.

8.3.5 Proposed Integrated Transport Network for Sonepat and Kundli Complex

The last biggest area along the corridor before entering Delhi is the Sonepat –Kundli Urban Complex. The NCR Plan 2001 has recognized Kundli area to be developed as a Delhi Metropolitan Area (DMA) town. The current population of Sonepatis357990 and is expected to rise up to 576364 by 2021 and 1589762 by 2031.The proposed development plan for Sonepat and Kundli Urban Complex-2021 is given below.

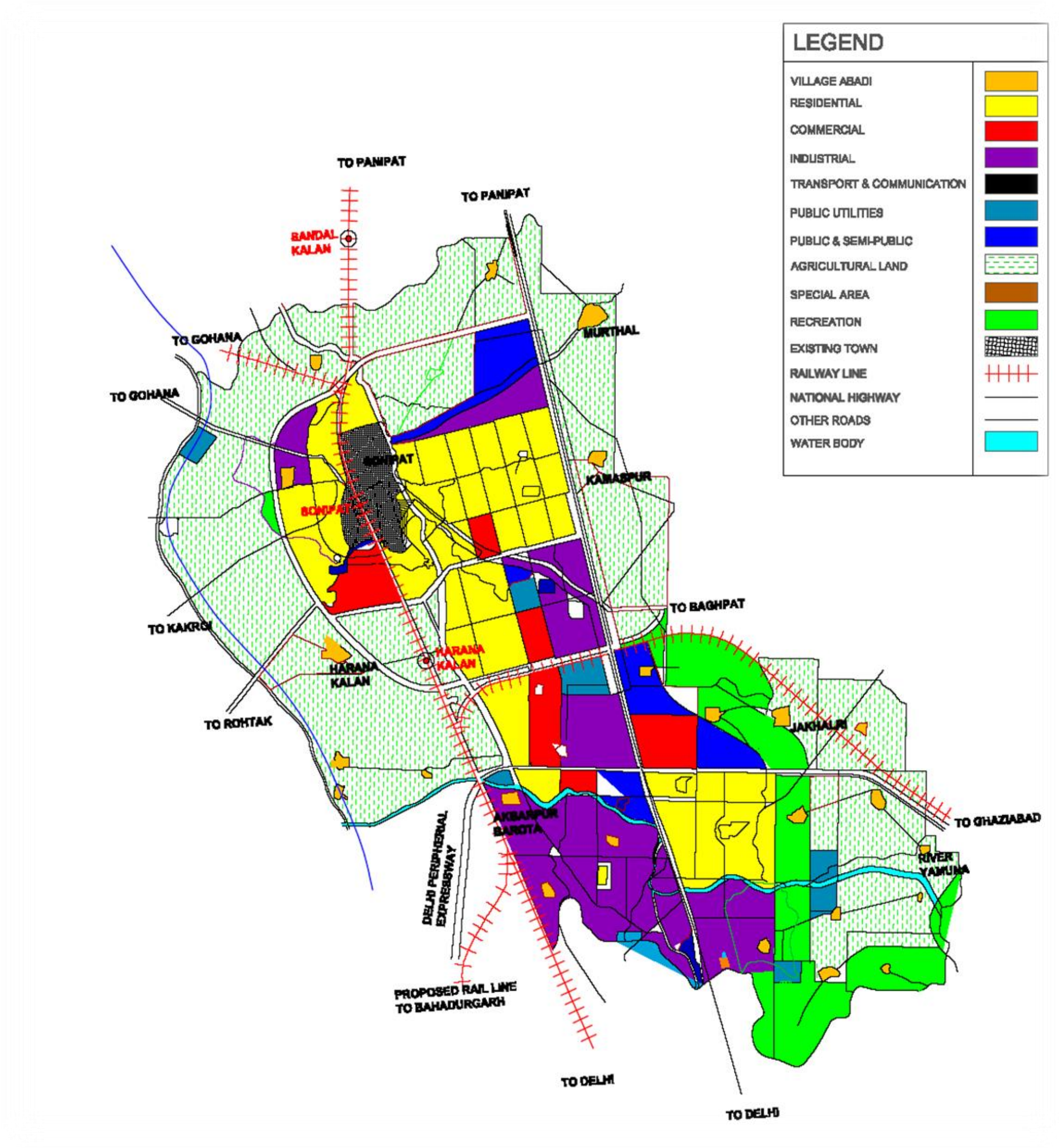


Figure 8-5: Development Plan for Sonepat, Kundli Urban Complex

Considering the relevance of the town in NCR framework, to cover area of Sonepat it is proposed to have stations at Murthal, Rajeev Gandhi University, KMP Interchange and Kundli. Sonepat shall be connected to the above mentioned stations by feeder network.

Like Panipat even Sonepat is a medium sized city which does not have very wide roads. Due to the limitation of the width of roads in the city and also the population is not very high, the traffic demand in the region does not warrant for high capacity rail based mass transit systems. As such light mass transit systems such as BRT/PRT are more sustainable. To enhance the ridership on to RRTS it is further proposed that multi modal transit options are provided to the commuter to travel within the Sonepat and Kundli Complex. Figure below shows the proposed integrated feeder transport network for the region keeping in view the Development Plan-2021 for the Sonepat region. The choice of the proposed feeder system has been based on the traffic demand, proposed activity centers and the existing& proposed road network in the city.

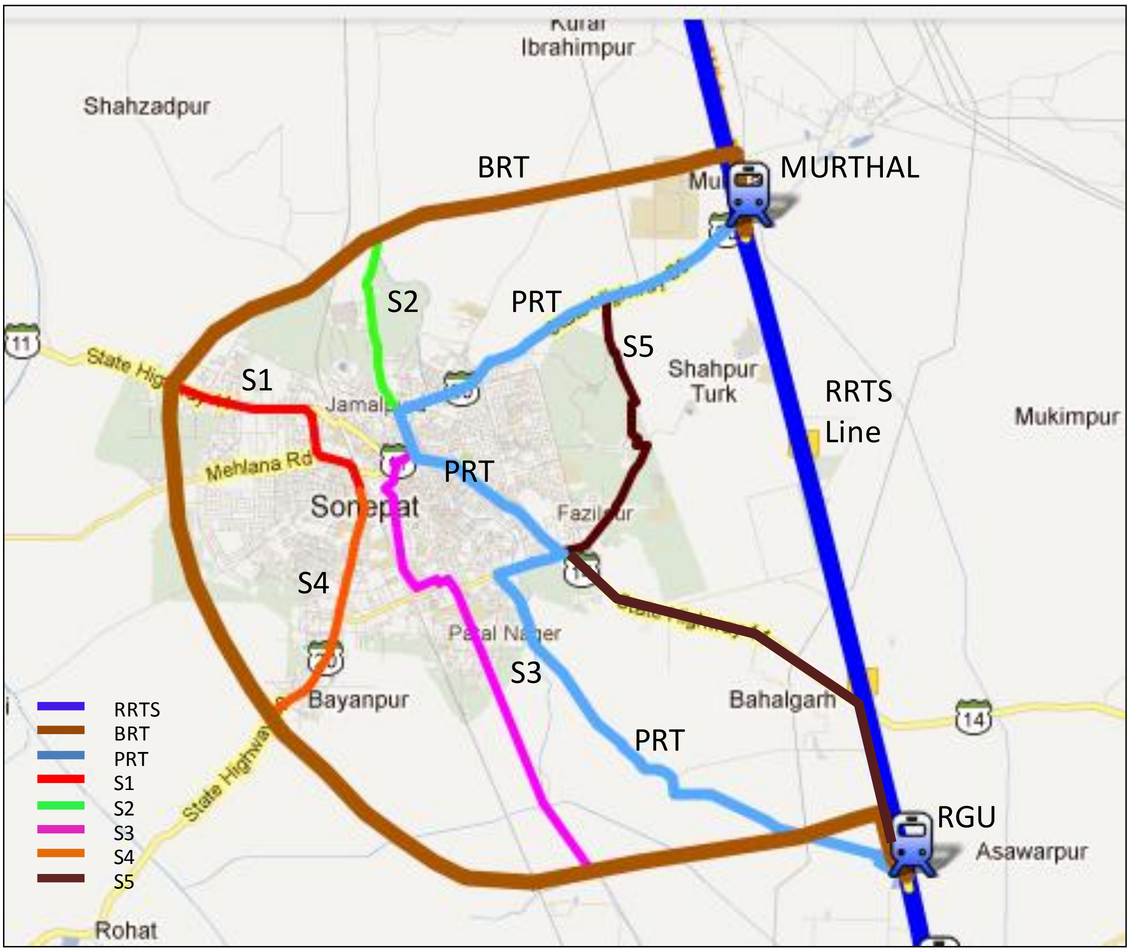


Figure 8-6: Integrated Feeder Network for Sonepat Region

It is proposed to have a Ring BRT system which will be built at grade on the 60M peripheral road which is a planned road as per the Development Plan -2021. Due to limited road widths 21m we propose to have an elevated PRT/LRT system along the East-West and North- South corridors in Sonepat. This system shall compliment the connectivity to the ring BRTS and complete integrated network with the proposed bus feeder network. A total of 32 regular buses will be required to operate the BRT system in Sonepat.

The Sonepat and Kundli Complex spread over a larger area as compared to Panipat. The O-D pattern of the public transport users shows that about 25% trips originate within 1 km, 23% within 2 km,18% within 3km and 13%within 4km of the existing railway station and the bus station. If the feeder network is spread up to 4 km it shall cater to 80% of the total public transport feeder trips. The average trip length in Sonepat is about 2.5km.

The proposed bus feeder system in Sonepat region shall help complete the network connectivity gaps from all areas inner areas to the RRT stations. The rail alignment is proposed to run from Murthal to Rai and along the national highway's green belt. In such case the Sonepat city needs to be well connected by a good feeder system with high frequencies to Murthal, RGU and KMP RRTS stations for greater catchment area.

- The proposed feeder S1 starts from Sonepat Main railway station passing through part of state highway-20, via SH-11 and connecting to Ring BRT station. Length of the proposed route is 3.6 Km.
- The proposed feeder route S2 of route length 2.7km shall start from Sonepat Bus station via Jamalpura and connecting to the DP Road.
- A third feeder route S3 is proposed to start from Sonepat ISBT , passing from the main road of Sonepat and further moving towards state highway 20 and passing through Patal Nagar and terminating at KMP RRT station. The length of the proposed route is 16.14 Km.
- The fourth feeder bus route S4 is proposed to start from Nahara area and passing through the Kundli industrial area and further running on MDR -138 and passing through Narela industrial area and terminating at Kundli RRT station. The length of the proposed route is expected to be 14.16 km.
- The fifth proposed route S5of route length 12.2km shall connect from Fazilpur to BRT on SH-20 and shall traverse through the institutional areas of that region connecting to Bahalgarh industrial area and terminating at RGU RRT station.

A total of 32 mini buses shall be required to operate the feeder services on all the above five routes. In Sonepat it is proposed to have a ring of elevated BRT/PRT to run from Murthal to Sonepat bus station via State Highway-20, further continuing on State Highway- 14 passing through the residential plots ofSonepat sector-12, Fazilpur, Patal Nagar and final connecting to RGU RRT station. A total of about 14km of elevated BRT/PRT system is proposed. The typical cross sections for such an elevated BRT/PRT system have already been detailed in the earlier section of the report.

Kundli is also coming up as an important activity centre in this urban complex of Sonepat region. The proposed Kundli RRT station shall cater to the trips destining in the industrial areas. A total of five feeder bus routes have been proposed for the Kundli region. There are four feeder routes proposed to be connected to Kundli and one for KMP RRT station.

- The proposed feeder routes K1 and K2 shall cover the residential areas of Bdh Khalsha Giri and covering the industrial areas of Kundli and Rai. The lengths of the proposed bus routes K1 will be about 5km and K2 would be about 7km.
- The third feeder route K3 of length 9.5 km is proposed to start from Bankholi, Hamidpur, Singhola and terminating at Kundli RRT station.
- Proposed feeder route K4 of length 14.2km to start from Nahara, passing through MDR-138 Narela and connecting to Kundli RRT station.
- Route K5 of length 6km is proposed to start from Khalsha Giri residential area and passing through the institutional and commercial areas and connecting to KMP RRT station.

A total of 61 small feeder buses will be required for operating the above said routes in the Kundli and Rai area. The entire proposed integrated Transport network for Kundli areas is given below.

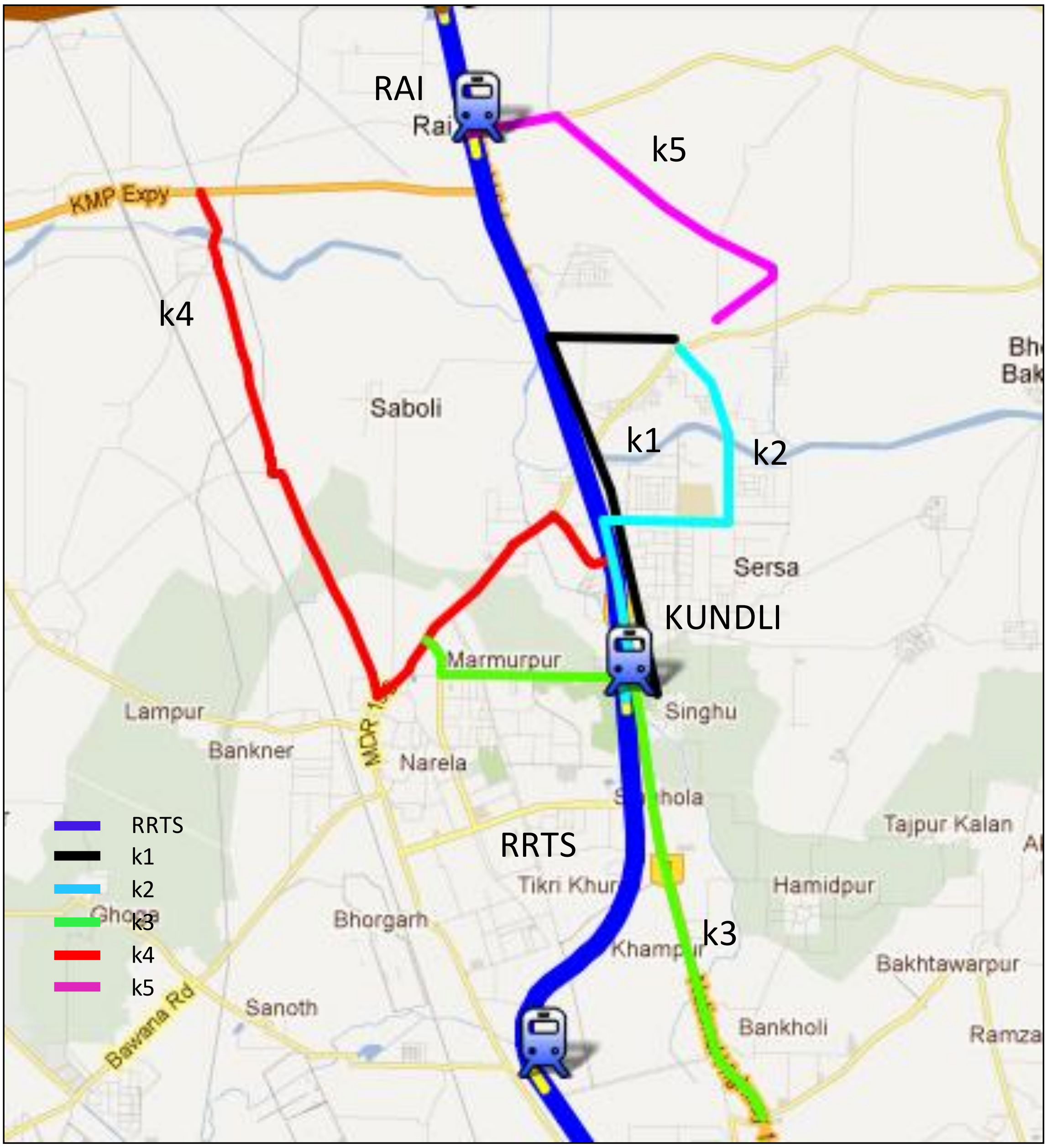


Figure 8-7: Integrated Transport Network in Kundli Region

8.3.6 Delhi Feeder Network

After Kundli RRT station, there are three proposed RRT stations in Delhi namely Narela MMTC, Mukarba chowk and terminating at Kashmere gate. The alignment of RRTS while entering GNCTD area has been governed by the traffic generating and terminating points in Delhi. The industrial areas of Bawana shall be served by providing connectivity to Narela MMTC station by an efficient feeder network. This shall help in providing inter modal integration of RRTS with other modes such as bus, metro and para transit modes.

The origin destination survey shows that destinations to Delhi are seen 52.3%tocentral Delhi near Kashmere gate, old city, New Delhi railway station and civil lines. Major destinations of 30% are also seen to North West Delhi including Azadpur, Badli industrial area and Bawana and 12% to Narela alone.

Narela and Mukarba Chowk RRT stations are not connected by any of the Delhi Metro lines and as such the dispersal is majorly dependent on existing city bus services and para transit facilities. The choice of para transit may not be the obvious choice for the commuter as this involves higher costs for the short last mile connectivity. In view of this we have also designed feeder bus services which would make the efficient dispersal of the commuters at this station. The bus feeder services shall play a vital role for the commuter's ease of travel.

A total of five feeder bus routes have been designed to serve this area.

- Narela RRT station to Badli (N1) –This proposed bus route starts from Badli and shall cover the residential and industrial areas of Rana Park, Khera Kalan, Nangli Puna, Bankholi and terminating at Narela MMTC RRT station. The length of the proposed route is 16.2km.
- Narela RRT station to Nangli Puna (N2) - The second feeder route N2 of about 10km length is proposed to start from Nahara industrial area, Saboli via MDR-138 Narela and connecting to Kundli RRT station.
- Narela RRT station to Khanjawala (N3) - This route shall cover areas of Khanjawala, Bawana industrial areas and terminating at Narela MMTC station. The length of the proposed route is about 17km.
- Narela RRT station to Bawana (N4) - This proposed route of route length of about 11.2km shall connect the residential areas of Narela, Holambi Kalan to Narela RRT station.
- Mukarba RRT station to Bankholi (N5) – This proposed route of length of 7.5km shall cover the industrial area of Bankholi, Budhpur, Namgli Puna and via the Pushta Road shall terminate at Mukarba Chowk RRT station.

The station at Narela and Mukarba Chowk shall serve the commuters coming to Bawana industrial area. The Bawana area is also proposed to be served by a bus feeder routeN3 of 17 km connecting to Narela MMTC station. A total of 88 small feeder buses will be required to operate the entire Narela and Bawana feeder services. Figure below shows the feeder routes for Delhi.

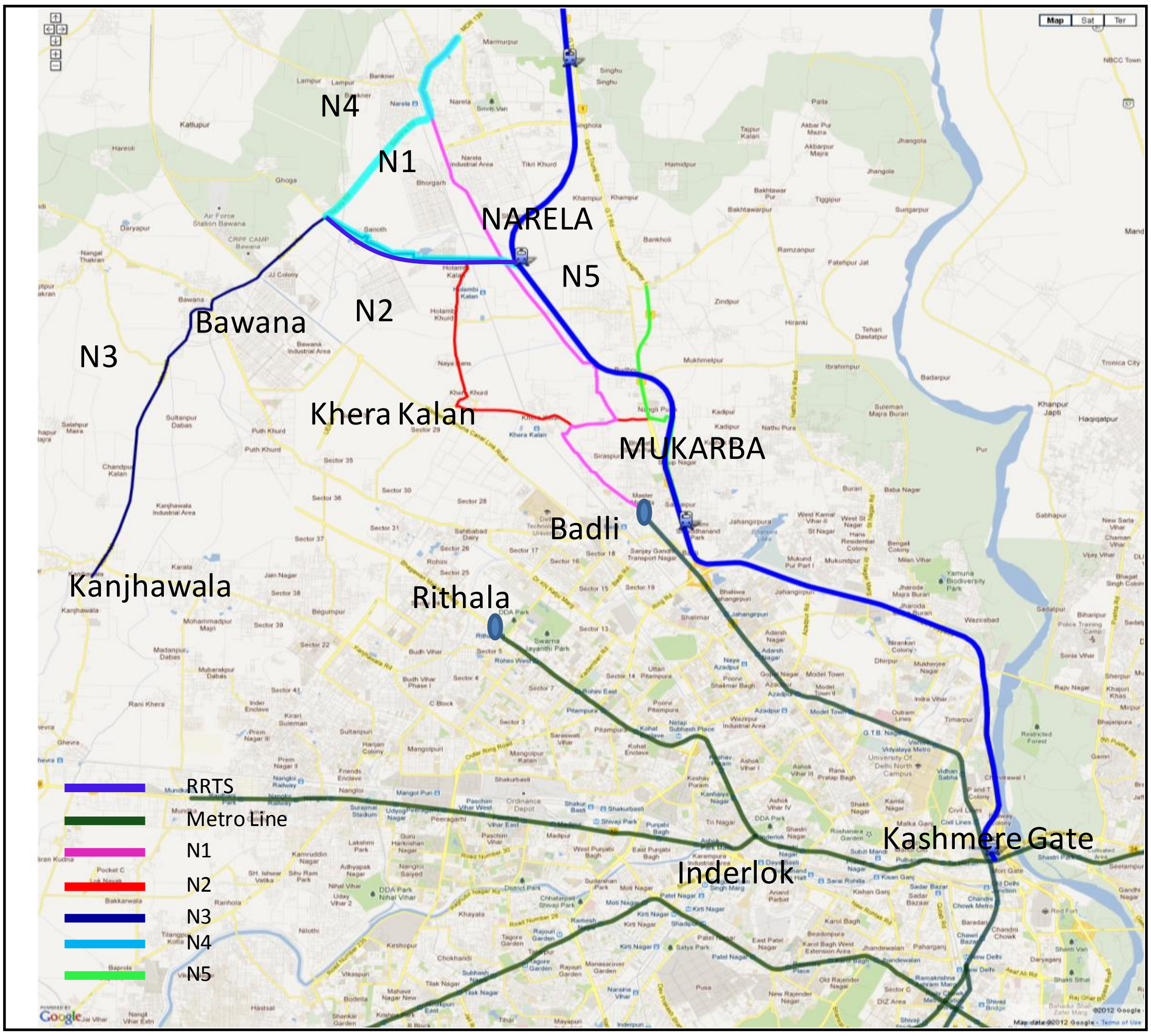


Figure 8-8:Feeder Network in Delhi

The connectivity at the Kashmere Gate RRT station is very crucial as in the coming years a lot of infrastructure development is expected near Kashmere Gate. This area is expected to grow into a big multi modal transportation hub and as such it is vital for integrating all transport systems for seamless travel of the commuter. Wherein we have existing two metro lines intersecting, two future RRTS lines, Metro Phase -3 and future BRT lines and all are to conjugate at Kashmere gate as shown in figure below. Looking at the O-D pattern of the RRTS passengers it is vital that RRTS is terminated at this place since 62% of the total destinations in Delhi happen to be at Kashmere gate.

Apart from providing the area specific feeder network, each RRT station shall be provided by a conjugate park and ride facility that is integrated into the entire multi-modal hub as shown. Each RRT station shall be provided with drop-off bays which have been designed to take into consideration that no stacking occurs which may hinder the station area circulation. For smooth dispersal of passengers, IPT facilities such as auto, taxi and cycle rickshaws have also been proposed to be strengthened at each of the RRT station. As part of station area planning proper provision of IPT parking stands and drop off bays have also been proposed.

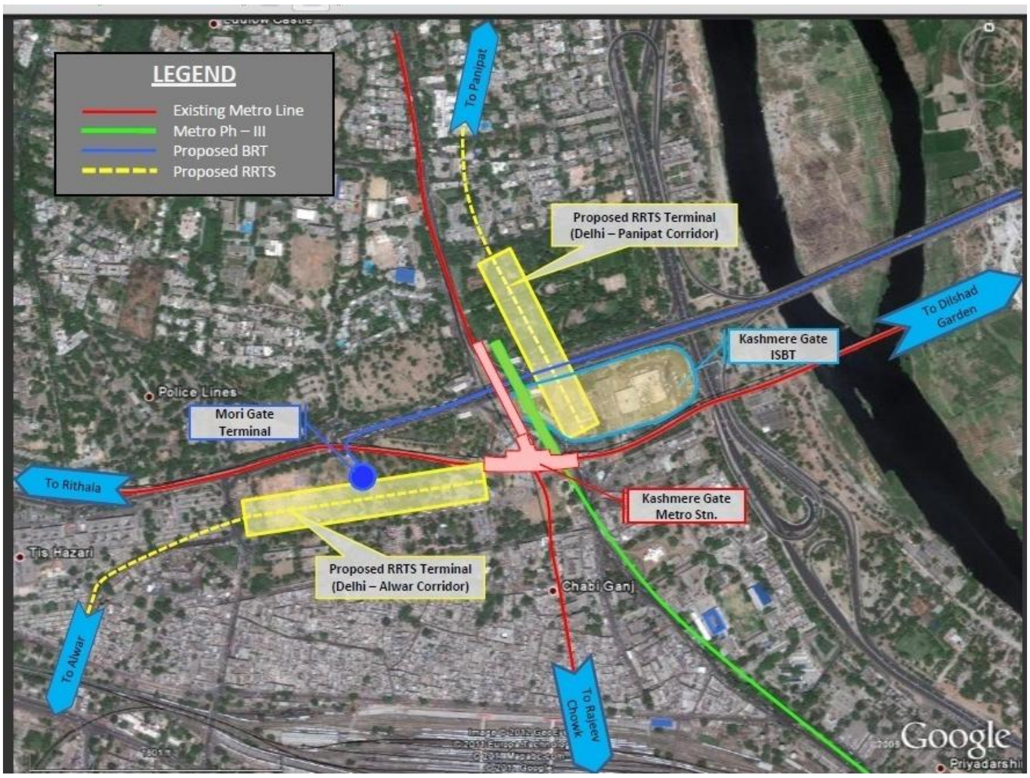


Figure 8-9: Kashmere Gate a Transport Hub

The feeder system which is proposed in all the three main regions of Panipat, Sonepat and Delhi along the corridor shall have high quality, high frequency buses which could be operated by a Special Purpose Vehicle (SPV) running the RRTS system so as to maintain the schedule of buses to match with the RRTS train timings, only then the feeder shall be successful. Globally the increase in ridership of the main mass rapid transit system due to feeder network varies from 15%-25% as seen in European case cities.

8.4 Conclusions

The main thrust has been that providing feeder system to the main trunk line of RRT system cannot, by itself lead to a more efficient transit system. Integrating different types of modes, increases the seat-miles offered as a result of employing the most adapted and effective mode in each segment of the network. Transit modes should be made more attractive to choice-riders. Therefore, planning a feeder system to serve a RRTS can only be viewed as one component of a comprehensive transportation policy designed to shift the modal- split in favor of transit. The formulation and implementation of similar plans require the cooperation and coordination between various departments and agencies in each city/towns.

A good, easy access to the RRT system and an efficient dispersal system for the passengers at the station is crucial for choice of the commuter to ride the RRTS. The integrated multi modal transport feeder system proposed for Panipat includes at grade BRT System of 42km, elevated BRT/ PRT for 17.0km length and the rest with 40.5 km of feeder bus system. The total block cost for the infrastructure required is expected to be Rs 1730 crores. The block cost estimates for the infrastructure required for Sonepat is expected to be Rs 1413 crores. A total of Rs 3143 crores will be required to build the new infrastructure in the two regions of Panipat and Sonepat.

Table 8-1: Total Cost to build new infrastructure

Region	Length of At grade BRT (km)	Cost per km (Rs. Crs.)	Length of Elevated BRT/PRT	Cost per km (Rs. Crs.)	Total Cost (Rs Crs)
Panipat	42	25	17	40	1730
Sonepat	26.6	25	18.7	40	1413
Grand Total Cost					3143

The entire integrated public transport system could be made attractive for the passengers by providing automatic fare collection system (AFCS) cards between designated RRTS stations, bus station, BRT or PRT stations. The passengers couldbe given incentives to buy smart cards such as, enjoy free interchange from the RRTS to the bus/BRT/PRT. If a passenger transfers from the bus to the RRTS, the interchange offer should be the bus fare or the rail fare, whichever is lower. Such schemes could be improvised and applied for inducing increased ridership due to better feeder network for the RRTS.

9 ENVIRONMENTAL IMPACT ASSESSMENT

9.1 Introduction

The Environmental Impact Assessment Study has been conducted as a part of the preparation of the Feasibility Report followed by Detailed Project Report for development of Regional Rapid Transit System (RRTS) for Delhi – Sonepat – Panipat Corridor for a rail based transportation system integrated with multi modal transport infrastructure for NCR. This chapter presents the synopsis of the EIA Study conducted under the assignment. A detailed report on the Environmental Impact Assessment Study is being submitted along with the Draft DPR and may be referred to for any further details required.

9.2 Methodology

9.2.1 Purpose and Objectives

The environmental impact assessment study determined the environmental sensitivity of the project route. That in turn helps the level of planning in terms of time, budget and effort required to take up the particular project for development.

EIA of the study area has the following major objectives:

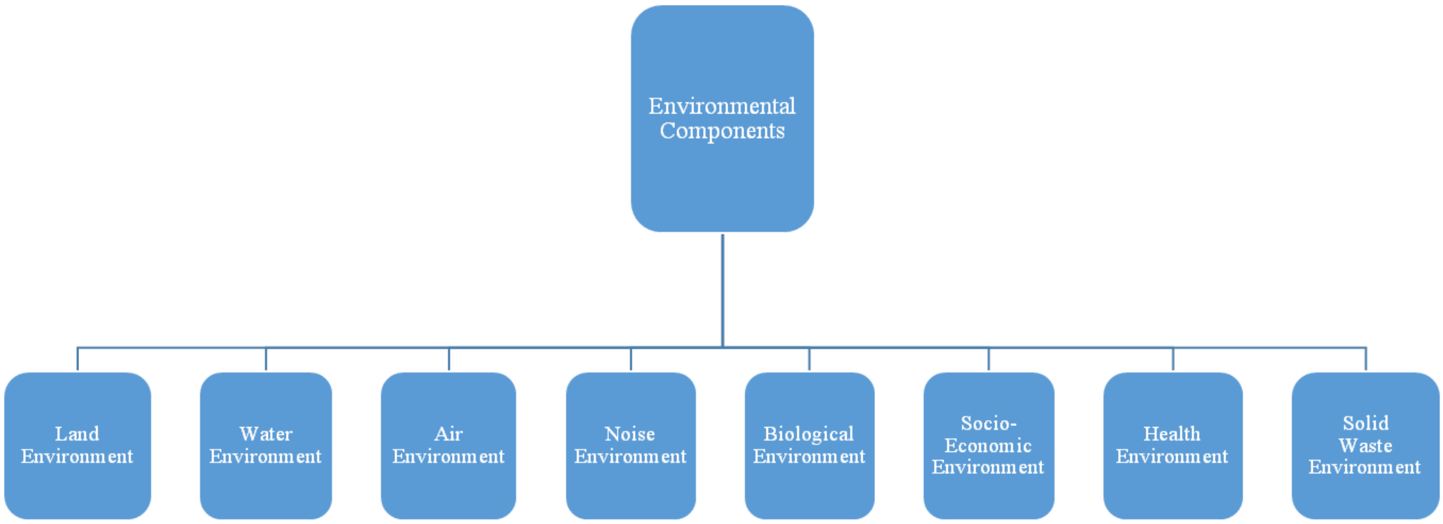
- preparation of Baseline
- identification and assessment of Impacts, Policy, legal and institutional issues for planning for Implementation of EMP during Design, Construction and Operational phases
- identification of environmental sensitive receptors.
- scoping and future course of work for Environmental Assessment process.

Environmental Screening process requires a thorough understanding of various environmental parameters and its effect on the project planning and implementation.

The screening process involved the following steps.

- Preparation for various surveys
- Reconnaissance site visit
- Preparation of all background data relating to the project roads that are to be
- screened
- Preparation of base maps to plot the project roads accurately as far as possible
- Identification of the valued ecosystem components (VEC) that are important for the project
- Devising or Preparation of formats for recording these parameters
- Identification of an environmental screening survey team
- Training of the survey team to record the data in the survey formats

- Actual ground surveys to collect or record the data in the relevant sheets
- Analysis of the data collected by qualitative and quantitative techniques



The Valued Environmental Components (VEC) are defined as social or bio physical component of an environment which is of value (for any reason) within a project influence area. In the case of rail projects, it is a zone covering 50 m on both sides from the centre line of the project route. This could be water pollution or air pollution that can be carried out to far distances. In some other cases, this is even more as in the case of wildlife, debris disposal and for material sources.

Based on the environmental studies, primary data on following Valued Environmental Components (VECs) shall be collected as follows:

Physical environment

• Disposal of debris/materials resources

• Water resources (Surface and Ground water)

• Soil erosion

• Air/Water/Noise pollution

Bio-Environment

• Number of trees within the ROW

• Wildlife/nesting places/mud holes and other habitats

• Forests

• Reserved Forests (RFs)

• National parks and sanctuaries

• Wetlands

Socio-Economic Environment

• Drinking water sources

• Schools/hospitals/college (declared silence zones)

• Cultural properties such as temples/shrines and other religious and archaeological monuments and properties

• Residential properties

• Commercial properties

• Tourism locations

9.2.2 Project Influence Area

The areas of direct influence will be confined in a linear fashion along the corridor, where the construction activities take place. For the stretch of alignment adjacent to NH-1, the area of direct influence is 10 m towards the east side of the central line of the proposed RRTS corridor and 20 m towards the west side of the proposed centre-line. For open areas, area of 15 m on either side of the centre line will be influenced by the project.

9.2.3 Types and sources of data collection

Environmental experts have undertaken a reconnaissance survey of the project corridor. During survey, the existing baseline environmental conditions along the corridor have been assessed and significant environmental issues have been identified. The reconnaissance survey has been supplemented by detailed field investigations.

9.2.4 Secondary data collection

Secondary data pertaining to the significant environmental issues are collected from various governmental, quasi-governmental, research institutions,& non-governmental organizations. Some of the likely sources of the secondary data are:

• India Meteorological Department (IMD)

• Directorate of Agriculture

• District Statistical Office (s)

• Forest Department

• Department of Town and Country Planning

• State Pollution Control Board

• Irrigation Department

• Soil and Land use Planning Boards

• Department of Geology and Mines

• Department of Archeology

Apart from these published data, additional relevant environment data was collected from individual research works; either published or unpublished. The source of the data has been documented in the report as reference. The data collected has been broadly subjected to the ground truth verification during detailed field investigations and modifications necessary to the database have been carried out.

9.2.5 Primary data generation

After the completion of the secondary data collation, primary data has been generated for the relevant attributes. Some of the attributes are ambient air quality, ambient noise, water quality, ecological studies, soil investigations, etc. The test procedures for generating the primary data conform to the guidelines stipulated by the Central/ State Pollution Control Board, Ministry of Environment & Forests and relevant Indian Standards. The samples were analyzed at laboratories recognized by State/ Central Pollution Board and/ or Ministry of Environmental and Forest, Government of India.

9.3 Baseline environmental conditions

9.3.1 General

With rapid strides in economic development, particularly in urban areas, the need for rationalizing and upgrading the transport system is imperative. In the process of development, there has been intensive use of natural resources. Very often the process of development has adversely affected the environment, leading to ecological imbalances. The importance of conserving and enhancing the environmental assets has assumed urgency. Apart from land use, conservation of flora and fauna and planning urban transportation is an important aspect of eco-development.

The development/ compilation of environmental baseline data are essential to assess the impact on environment due to the project. Climatologically data is collected from meteorological office. The majority of data on water quality, vegetation, air and noise quality has been collected during field studies.

9.3.2 Physical Environment

Data related to temperature, seasons, rains, visibility(fog) etc. was collected for Delhi, Panipat and Sonipat.

9.3.3 Seismic Profile of the Area

The entire project corridor falls in Zone IV of the seismic Zonation Map (Hazard Map) Seismicity. The seismic risk in Zone IV indicates high vulnerability to earthquakes according to the Seismic Zoning Map of India (BIS 2000, zones). Seismic zones are rated from I to Zone V, in which Zone V has the highest risk seismic zone. Most earthquakes in this region are shallow, though a few earthquakes of intermediate depth have been recorded in Haryana. The alluvial cover of the Indo-Gangetic plain makes even distant earthquake felt here quite strongly.

9.3.4 Air Quality

No secondary data of the ambient air quality in the proposed project area was available. Consequently air quality monitoring has been done. This has been compared with National Ambient Air Quality Standards.

9.3.5 Noise

Noise level has been measured at different locations along project corridor. At various places, 24 hours noise recorded data shows that the values were higher than the prescribed permissible limits of 65 dBA (day) and 55 dBA (night) in commercial area and higher than permissible limits of 55 dBA (day) and 45 dBA (night) in residential areas.

Table 9-1: Summary of Air & Noise monitoring locations

Site 1	Kashmiri Gate,
Site 2	Libaspur, Landfill at Mukarba Chowk
Site 3	Bhogarh, Narela
Site 4	Kundli
Site 5	KMP Interchange
Site 6	Rajeev Gandhi Education City
Site 7	Murthal
Site8	Gannaur
Site 9	Samalkha
Site 10	Panipat, near NFL
Site 11	Asand Road,Panipat
Site 12	Rajapura Panipat, Depot Terminus

9.3.6 Water environment

The project traverses along Yamuna River and the Supplementary Drain of Irrigation & flood control dept, govt. of Delhi. The names of the channels with their respective Chainages are given in Table below

Table 9-2: Water bodies along the project route

Sl. No.	Name of river or water body	Chainage
1	Yamuna river	1.9 km to 4.00 km
2	Supplementary drain ,dept. of Irrigation &Flood Control Dept	6. 4km to 23.7 km

Water pollution impacts and possible sedimentation during construction of rail would be carefully controlled and monitored. In spite of the irrigation facilities in the districts, especially along the project area canals are the major source of water supply.

9.3.7 Water Quality

Water quality can be expressed in terms of physical, chemical and biological characterization of water. Environmental survey was conducted and sampling locations for ground water were selected along the project corridor.

Parameters analyzed, based on data from 20 locations, for water pollution are :

- pH
- Sulphate
- Total Dissolved Solids
- Chloride
- Alkalinity
- Acidity
- Volatile Residue
- Fixed Residue
- Conductivity
- Total Hardness
- Calcium as Ca
- Magnesium

9.3.8 Soil Analysis:

Soil analysis at 12 locations was done on following parameters:

- pH
- Carbonate
- Chloride
- Organic Material
- Specific Gravity
- Total Solubles
- Sulphates

9.3.9 Ecological Parks, Sanctuaries, Flora and Fauna Or any Eco Sensitive Zones

There are no Ecological Parks, Wild Life and Bird Sanctuaries or any Eco Sensitive Zones in existence within the project area.

Flora: The natural vegetation in the study area is sparse. Various kinds of trees and shrubs are found growing indigenously. On account of the pressure of population and extensive cultivation, very little land has been left under natural forest cover.

Strip forests along the roads and canals and block forests of Babool (Kikar) are on the forest record. Most of the area is occupied by agriculture fields. Wherever the forests are present, they are of open evergreen scrub or thorn type comprising mainly of:

ButeaMonosperma (Dhak)

Prosopis Cineraria (Jand)

Capparis Deciduas (Kaur)

Capparis Separia (Hins)

Fauna The majority domestic animals seen in the area are cow, buffalo, horse, donkey, goat, pig, and dog. The main birds found near project area, are pintail, coot, house sparrow, myna, cattle egret, little egret, pond heron, indian ring dove, blue rock pigeon, etc

9.3.10 Land-Acquisition Pattern

Approximately 30 % of the land for the proposed corridor requiring acquisition falls within Delhi and the remaining 70% in the state of Haryana. For details of land acquisition the SIA report may be referred to. The section passes through a variety of land use, viz. built up, barren and agricultural land.

9.3.11 Socio-economic characteristics of the project influence Districts

The SIA report may be referred to for details on socio economic characteristics.

9.3.12 Presence of Sensitive Receptors:

Sensitive receptors present at proposed corridor are as follows:

Type of Structure	Total
Temple	32
Mosque/ Mazar, Gurudwara	3+2
School	2
School boundary wall	6

9.3.13 Visual Resources

During the site survey along the project stretch, the elements of enhancements have been identified. The baseline elements such as cultural properties, water bodies (ponds), factories, borrow areas and other elements with their significance to the community have been identified based on their importance and relationship with the stretch.

9.4 ENVIRONMENTAL IMPACTS ASSESSMENT

This environmental impact assessment focuses on the major environmental issues identified for the pre-construction, construction and operational phases of the Project. Potential impacts that are likely to occur due to the proposed RRTS project have been quantified based on project particulars.

9.4.1 Positive Impacts

The positive environmental impacts may be listed as given below:

- traffic congestion reduction, reduction in road accidents
- reduced travel time, quick service with safety
- reduction in overall fuel consumption in the city
- reduction in urban air pollution and noise levels
- improvement in city road conditions
- benefits in the form of transfer of technology
- boost to industry, trade, commerce, communication,
- good employment opportunities, increased social, cultural and rural economy.
- economic opportunities for people who cannot drive due to physical, economic or social constraints.
- better environmental landscape and aesthetics.

9.4.2 Negative Environmental Impacts

Potential negative impacts likely to occur due to the proposed development may be quantified based on project particulars and baseline existing environmental conditions. Negative impacts may be listed under the following heads:

- Impacts due to construction works
- Impacts due to project operation

9.5 MITIGATION MEASURES

Based on environmental baseline conditions, planned project activities and its impacts assessed the set of measures to be taken during implementation and operations to avoid or offset adverse environmental impacts or to reduce them to acceptable levels, together with the action which needs to be taken to implement them, are enumerated in this section.

Based on project description, Environmental Baseline Data and Environmental Impacts, it is proposed to prepare the Environmental Management Plan for the following:

- Provision for relocation of communities and utility facilities,
- Safety & Traffic Congestion,

- Water Supply and Sanitation,
- Air Pollution Control,
- Noise Pollution & Vibration Control,
- Water Pollution Control,
- Mitigation measures for Spoil Generation from tunneling and excavation work,
- Soil Erosion Control, and
- Solid Waste Management.

9.6 ENVIRONMENTAL MANAGEMENT PLAN

9.6.1 Introduction

The proposed Delhi-Panipat RRTS project is similar to other infra-structure development projects. Its implementation needs a complete review of the ecosystem impact and socioeconomic aspects for addressing the same in an effective manner. It is imperative to develop appropriate environmental management plans to minimize negative impacts on the ecosystem and the community. The potential impacts have been identified and discussed in section 5. With the objective of minimizing the negative impacts and optimizing the positive benefits of the RRTS project, a comprehensive **Environmental Management System (EMS)** is drawn up. For details the detailed report on EIA may be referred to.

An environmental management system (EMS) should have various basic elements ascertaining the concern of the proponent namely,

- Commitment and Policy
- Planning,
- Implementation,
- Measurement and Evaluation,
- Review and Improvement.

Design Phase

- Land Acquisition
- Green Cover Management Plan
- Air Pollution
- Noise Management Plan
- Water Management Plan
- Avoidance of Nuisance
- Soil Management Plan
- Public Utility Management Plan
- Traffic Diversions
- Labour Management Plan

Operation Phase

- Water Quality
- Vibration Management Plan
- Safety Management
- Fire Management Plan
- On-Site Emergency Plan
- Off-Site Emergency Plan

9.7 ENVIRONMENTAL MONITORING PROGRAM

9.7.1 General

Monitoring of environmental factors and constraints will enable agencies to identify the changes in the environmental impacts at particular locations, application of mitigative measures and utilization of standard design guidelines for finalization of alignment design. Monitoring will also ensure that actions taken are in accordance with the construction contract and specifications. It provides a basis for evaluating the efficiency of mitigation and enhancement measures, and suggests further actions needed to be taken to achieve the desired effect.

To ensure the effective implementation of the EMP it is essential that an effective monitoring program be designed and carried out.

The monitoring includes:

- visual observations
- selection of environmental parameters at specific locations
- sampling and regular testing of these parameters

For details of EMP the detailed EIA study report submitted along the draft DPR may be referred to.

10 SOCIAL IMPACT ASSESSMENT AND R&R

10.1 Objective of the study

The main objective of RRTS is to “Promote and support the economic development of the region and relieve Delhi from excessive pressure on the infrastructure including traffic congestion. The RRTS will facilitate speedier and smoother transportation of public without any interruption between Delhi and the two NCR regions, Sonepat and Panipat -and their respective hinterlands at minimum cost and in the least time. It is anticipated that the construction of RRTS would induce economic development, generate employment and above all, improve economic integration of regions in the country with improved links among major economic and trade centers.

10.2 Methodology

100% Census Survey and 10 % Socio Economic exercise was carried out within the proposed ROW to identify the affected structures and land. The task included collection of details of the owner or occupant of the structure, its type and usage coming within COI on either side of the existing centerline. To collect this information a well-designed and pre-tested questionnaire was used. However, during the course of the survey, it was found out that a few of land lords were not available and in such cases the information was collected by revisiting their households till concrete data was gathered.

10.3 Type of Impact

The total extent of land to be acquired as per the approved alignment is 440.98 hectares. Due to land acquisition and clearing of existing ROW from encroachers, structures such as residential, commercial, community assets, religious structures, government buildings and kiosks will be impacted, affecting 1324 persons. A well designed Resettlement Action Plan has been formulated with adequate implementation strategy to ward off the negative impacts and simultaneously elevating the living standard of the PAPs at par or even better than the pre project standards.

10.4 Minimization of impact

The study was carried out with a participatory approach by involving the stakeholders, particularly the project beneficiaries and probable affected persons through a series of consultative process techniques. The population groups that were consulted include beneficiary group of people in the project influence area, particularly the shopkeepers, farmers, transport operators, schoolteachers, the local people and the Govt. officials who are involved in rural and women development programs and employment generation schemes. Care was taken to form participatory consultative groups as homogenous as possible.

Two-stage consultation was carried out in project corridor. In the first stage information about the project was disseminated to the local people and in the second stage their views/grievances/suggestions were solicited. Stakeholders suggestions have been incorporated in the design of alignment and shall be further implemented during construction and post construction Phases.

10.5 Socio Economic Profile

The composition of the population in project area was found to be slightly skewed in favor of male with 53.09% compared to 46.91% of female. This is reflected in the sex ratio, with 883 females out of 1000 males. The working population of the project-affected area is 65% respectively. The people of the project affected area are engaged in service and agriculture and farming. The average family size of 331 houses in the project affected area is 4 persons.

The literate population of the project affected area is around 80%.

The project affected people achieving primary level of education is 21%, middle level 19.8% and Secondary / Higher Secondary level education 23.7 %. The post 12th education claims a share of mere 16.5%. High degree of school enrollment among children between the age group of 6 to 14 years was noted.

Three pre-dominant types of structures are prevalent along the entire project area, the semi-pucca type of houses constitutes 24.47% of all dwelling units, pucca 68.58% while Kutcha houses account for 6.94%.

Almost 9.35% of households belong to vulnerable categories, while 3.32 % of the population lives below poverty line (BPL), the Scheduled Caste household are 1.51 % , the Schedule Tribe are 0.90% and there are no Women Headed Households (WHH) in the project affected area.

No major threat for either spread of HIV/AIDS or human trafficking is perceived by the people. No such cases have yet been reported to the local Govt. or to the people informally.

The distribution of PAPs as per the district is given in Table below.

Table 10-1: Social Vulnerability Household & General

	OBC	BPL	SC	ST	WHH	GENERAL
Delhi	6	4	1	0	-	21
Sonipat	2	5	1	2	-	140
Panipat	4	2	3	1	-	139
Total	12	11	5	3	Nil	300
Percentile	3.62	3.32	1.51	0.90	Nil	90.63
Source: Social Survey 2011						

Table below presents the estimates of land acquisition requirements for the project stretch along with the purpose of acquisition, area to be acquired as per classification of government and private land.

Table 10-2: Summary of Total Land Acquisition in RRTS

S. No.	Name of District	Name of Tehsil	Start and End Chainage	Land Acquisition Area in Ha		Total Land Acquisition including Depot Area in Ha.	Total Land Acquisition Depot Area in Ha.
				Private	Government		
1	Delhi	Delhi	Start km. 3.000 to End km. 29.360	23.6317	56.7596	80.3913	0
2	Sonipat	Sonipat	Start km. 29.360 & End km. 52.521	58.9226	17.9415	76.8641	0
3	Sonipat	Ganaur	Start km. 52.521 to End km. 66.177 Or Start Spur Line Area 4.532 to 8.905 And Depot Start km. 8.905 to End km. 10.640	67.3624	5.2112	72.5736	16.5514
4	Panipat	Samalkha	Start km. 66163 End Km.79299	37.5075	2.0558	39.5633	0
5	Panipat	Panipat	Start km. 79299 to End km. 98683 And Depot Start km. 98683 to End km. 101204	141.9055	29.6914	171.5969	113.3084
Total Area				**329.3297**	**111.6595**	**440.9892**	**129.8598**

The summary of impacts is given in table below

Table 10-3: Summary of Impacts

S No.	Impacts		No.
1	Land Acquisition Ha (including depot area)		**440.98**
2	Total Residential structure affected	249	
3	Total commercial structures affected	50	
4	Total Residential cum commercial structures affected	32	**331**
5	Total community (CPRs)		**106**
6	Total no. of DP		**1324**

10.6 Women's need and participation

In the process of R&R, women require special attention. Change caused by relocation does not have equal implications for members of both the sexes and may result in greater inconvenience to women. Due to disturbance in production system, reduction in assets like land and livestock, women may have to face the challenge of running a large household in limited income and resources. This in turn may force woman as well as children to participate in work for supplementing the household income. In contrast to this, due to changes that are likely to take places for any development project, especially changes in environment and land labour ratio, those women who at present are engaged in activities like agriculture labour, or collection and sale of forest produce may find themselves unemployed and dependent.

10.7 Disclosure of Information

The project preparation Support team while conducting structure survey has conducted information dissemination along the project route in following manner.

- Potential project affected families were consulted and canvassed them about proposed rail
- improvement program,
- Pictorial Methods to explain rail improvement proposals in the concerned settlement
- Information dissemination among the villagers explaining proposed RRTS improvement

10.8 Budget

Based on the Entitlement Matrix, the R&R budget for the Delhi to Panipat Section (RRTS) is as follows. The total R&R budget for the package is Rs. 3344.46 crores, out of which Rs. 3335.59 crores is towards compensation for land, structure and CPR cost and R&R cost is Rs 9.07 crores. Sufficient amount has been proposed relocation for community structures as well as its improvement. The Break-up of Cost of Land acquisition has been worked out as per the respective states policies and DLC rates.

Table 10-4: R&R and Land Acquisition Budget

S. No	Item	Amount (Crore)
1	Private Land Acquisition Cost	2144.31
2	Government Land Cost	1183.46
3	Structure Cost	5.14
4.	Community Structure Cost	2.48
5	R&R Assistance Cost	9.07
6	**Total (Rs in Crore)**	**3344.46**

11 CONSTRUCTION METHOD AND COMMISSIONING SCHEDULE

11.1 Assumptions and rates of production

11.1.1 Key dates

The programme assumes that the Award of Contract in is April 2014 with a Commercial Operating Date (COD) (Railway Opening) in October 2018.

It is anticipated that the land acquisition (with the rehabilitation and resettlement) shall be completed in the first year of the project.

11.1.2 Box portal diaphragm wall

Diaphragm walls are underground structural elements used as retention systems and permanent foundation walls. In this project, the diaphragm walls will locate in park section and in the road NH1. The diaphragm walls consist in panels of 3 m length.

We have assumed the construction of 4 panels per rig per week (full height rig). In addition, two diaphragm wall rigs (hydraulic grab) working at the same time. Therefore, the east wall and west wall can be built at the same time, in each section.

11.1.3 Ground treatment

Extensive ground treatment is required above the shallow tunnel crown for the improvement of the unsatisfactory conditions of the ground.

Estimated duration of treatment works is 20 days at each end of the tunnel.

11.1.4 Tunnelling

The drilling will be carried out with a TBM (tunnel boring machine). It is assumed that one TBM is launched from the Northern Portal , drives through to Kashmere Gate, and is then is taken back to be launched from Northern Portal for the other bore.

For this phase of the project, we have assumed the following advance rate of the TBM, subject to actual soil conditions:

The TBM (tunnel boring machine) advances daily, 3m initially for the first 3 weeks. Thereafter, when different ground conditions are encountered, the TBM can advance 10 m per day. The TBM works 24 hours per day, 7 days per week.

It is assumed that at the end of the tunnel the same conditions are found as at the beginning. The advance will therefore be 3 m for last 3 weeks of bore.

There are 63m of similar ground at the start and finish of each bore. These 63 m with an advance of 3m/day will give 21 days of tunnelling duration.

The total tunnel length is 1500m, this distance minus the 63m at the beginning and the 63m at the end of the tunnel; gives 1374m of central length. With a progress of 10 m per day, the TBM time taken for this central section 138 days.

11.1.5 Pier Construction

The construction duration for one pier (including piling, construction of the base, pier stem and bearing shelf) depends on the pier length. The length ranges and commensurate times are indicated below:

Standard	10 - 15m	9.1days/pier
High Standard	15 - 20m	13.1days/pier (+4days for addnl lift)
Goal Post	Pier x2 + PC Cross Beam Shell	21.2Allow 3 day for crossbeam

In addition, we have assumed 30m long deck spans per pier. The programme assumes that pier construction can take place at 22 main locations at the same time.

11.1.6 Precast Deck Production

Based on Bukit Panjang LRT, Singapore, 7.8 km of twin track elevated guideway was constructed with 254 spans comprising a total of 2,589 segments all cast over a 13 month period.

Delhi RRTS viaduct length is 103.5 km, and the time required, considering the time of one casting yard working, is 172.5 months.

With 8 available casting yards, the time is reduced to 21.56 months. The total in days is 432 (20 days per month).

11.1.7 Deck Erection

Using the example of the Dubai Metro project, 1 span (30m) is erected every 2 days.

Total number of spans is 5731.

Working 33 launchers at the same time will allow 11 spans to be erected per day. This gives a total of 521 days.

11.1.8 Station Construction

Station construction will be developed along with deck installation and deck unit delivery. Simple structures are erected with pre-cast elements wherever possible.

Based on Gautrain Midrand Station project, civil and building works lasted 297 days. We therefore estimate a duration of between 250 days and 300 days to build a station.

The completion of Kashmere Gate Station will be after the tunnelling and major civil engineering works are complete to construction the station box and reception chamber.

11.1.9 Depot Construction

From the Gautrain Midrand Train Depot project the construction duration of the following Civil and Building Works was: Earthworks 118 days, Excavation 38 days, Foundation Works 24 days and Civil Concrete Works 15 days.

Accordingly with the above data, we have assumed a conservative duration on each depot construction of 250 days.

11.1.10 Train Delivery

Total number of trains projected is 34; the delivery time is 8.5 days per train. However, this excludes the lead time to order and construct rolling stock in the factory.

The total delivery time for the 34 trains will be 300 days.

11.1.11 Track Laying

The railway track comprising track rails, fasteners, insulators, rail pads (formation, sleepers and ballast for ballasted track or resilient baseplates for slabtrack) forms the basis of this section.

In addition to track type the three different base conditions found along the route are considered.

11.1.12 Track in Tunnel

According to data from Gautrain, Sandton Gautrain Sandton Station to Portal, track laying rate was 27.76 m/day

Tunnel Length is 1500m

Total number of days is 55 days

11.1.13 Track in Viaduct

According to data from Gautrain, the track progress construction on viaduct is 132 m/day.

Total length viaduct is 100500m.

Total number of days is 762 days.

Assume the work proceeds on 2 indicative fronts of 381 days each.

At Grade

According to data from Gautrain, the track progress construction at grade is 132 m/day.

Total length of alignment at grade is 3000m.

Total number of days is 23 days.

11.1.14 OHLE

Installation time progress of Overhead line equipment (OHLE), along the entire railway line, according to data from Gautrain project, is 146 m/day.

The total length alignment is 105000m.

The total number of days is 720 (10500m / 146m/day = 720 days).

Working on two different fronts of the track at the same time the number of days is 360 days each.

11.1.15 Signalling

The progress installation of signalling along whole segments of track, according to data from Gautrain project, is 164 m/day.

The total track length is 105000 m.

The necessary installation time is 640 days. Working on 2 indicative fronts gives 320 days each.

11.2 Detailed construction schedule and commissioning programme

The detailed commission programme and construction schedule is provided as Annexure to this report

12 IDENTIFICATION OF UTILITIES TO BE DIVERTED

12.1 Identification and location of utilities and maps

Utilities that are falling on the alignment have been identified and mapped on the alignment. The following utilities have been identified and mapped:

- Crude Gas Pipeline
- Electric Lines
- Sewage Lines
- Telecommunications Network
- Water Pipelines & Tubewell/wells

The detailed drawings are submitted as separate volumes/ reports along with this draft DPR.

13 DISCUSSION WITH STAKEHOLDERS

13.1 Decision on stakeholder consultation

As per the Minutes of Meeting issued on 02.05.13 of Consultancy Review Committee (CRC)/ Sub-committee to Task Force meeting held on 17.04.13, it has been decided and conveyed to the consultants that the milestone for Stakeholder Workshop for the project has been shifted after the submission of Draft DPR. Thus the report on discussion with stakeholders would be delivered after the Stakeholder Consultation during the submission of Final DPR stage.

14 STATION YARD PLANS AND CHANGES IN EXISTING LAYOUT

14.1 Station yard plans and changes

The RRTS Delhi Panipat alignment has been designed as a separate alignment. The utilization of existing railway land/ tracks were found to be not feasible during the course of the study.

Since the RRTS is designed as a new system separate from the existing Indian Railway system, a detailed station plan study including Urban Design has been conducted and a separate report "Urban Design Study" has been submitted during the feasibility stage. This report may be referred to for any further information.

15 ANNEXURES

15.1 Annexure1 – Fleet Expansion Analysis

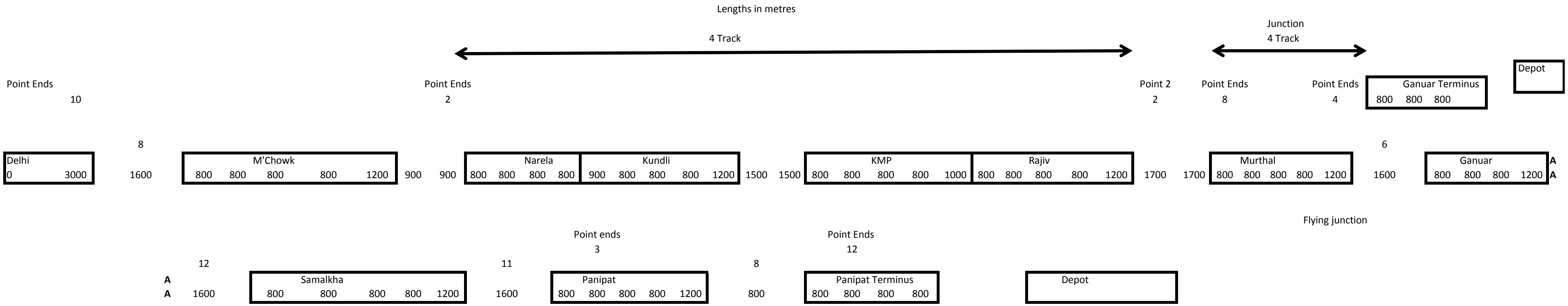
Analysis Using 3, 6, and 9 car sets (Fixed Formation)

		Purchasing Profile					Train Configuration									
Year	**Headway**	**3-car**	**6-car**	**9-car**	**Cars**	**Fleet**	**2x3**	**1x6**	**3x3**	**4x3**	**1x3 + 1x6**	**2x3 + 1x6**	**1x9**	**1x3 + 1x9**	**Trains**	**Note**
2021	4.5	34	17	0	204	204	17	17	0	0	0	0	0	0	34	6-car trains. Allows 3-car sets to be run off-peak to maintain frequency
Increment	4.5	1	0	11	102	306	0	0	6	0	17	0	11	0	34	9-car trains. Allows 6-car sets to be run off-peak @4.5 minutes.
2041	3.5	0	0	10	90	396	0	0	6	0	17	0	21	0	44	9-car trains. Provides 34No 6-car sets to run off-peak @4.5 minutes
2041+	3.5	44	0	0	132	528	0	0	0	6	0	17	0	21	44	12-car trains. Allows 9-car or 6-car off-peak service @3.5 minutes
		79	17	21												

Analysis Using 3, and 6 car sets (Fixed Formation)

		Purchasing Profile					Train Configuration									
Year	**Headway**	**3-car**	**6-car**	**9-car**	**Cars**	**Fleet**	**2x3**	**1x6**	**3x3**	**4x3**	**1x3 + 1x6**	**2x3 + 1x6**	**1x9**	**1x3 + 1x9**	**Trains**	**Note**
2021	4.5	34	17	0	204	204	17	17	0	0	0	0	0	0	34	6-car trains. Allows 3-car sets to be run off-peak to maintain frequency
Increment	4.5	12	11	0	102	306	0	0	6	0	28	0	0	0	34	9-car trains. Allows 6-car sets to be run off-peak @4.5 minutes.
2041	3.5	10	10	0	90	396	0	0	6	0	38	0	0	0	44	9-car trains. Allows 6-car sets to run off-peak @3.5 minutes
2041+	3.5	40	2	0	132	528	0	0	0	4	0	40	0	0	44	12-car trains. Allows 9-car or 6-car off-peak service at 3.5 minutes
		96	40													

15.2 Annexure 2 Sectioned Schematic



Equipment Numbers	Point Ends	Axle Counters
Delhi	8	30
M'Chowk	0	14
Narela	2	20
Kundli	0	20
KMP	0	20
Rajiv	2	22
Murthal	8	40
Ganuar	0	10
Ganuar Terminus	4	10
Samalkha	0	10
Panipat	4	20
Panipat Terminus	12	24
Depot 1	30	15
Depot 2	15	10
Plain Line	0	110
	85	**375**

Control centre **2**

Rolling stock to fit **30**

15.3 Annexure 3 – Timetabling Options

OPTION A (2021)
ALL STATIONS SERVICE

Kashmere Gate	dep	2400	0020	0040	then	0600	0605	0610	0615	0620	0625	0630	0635	0640	0645	0650	0655	then
Mukarba Chowk	dep	0012	0032	0052	at	0612	0617	0622	0627	0632	0637	0642	0647	0652	0657	0702	0707	at
Narela	arr	0017	0037	0057	the	0617	0622	0627	0632	0637	0642	0647	0652	0657	0702	0707	0712	the
	dep	0018	0038	0058	same	0618	0623	0628	0633	0638	0643	0648	0653	0658	0703	0708	0713	same
Kundi	dep	0022	0042	0102	minutes	0622	0627	0632	0637	0642	0647	0652	0657	0702	0707	0712	0717	minutes
KMP Interchange	dep	0028½	0048½	0108½	past	0628½	0633½	0638½	0643½	0648½	0653½	0658½	0703½	0708½	0713½	0718½	0723½	past
Rajiv Gandhi	arr	0032	0052	0112	each	0632	0637	0642	0647	0652	0657	0702	0707	0712	0717	0722	0727	each
	dep	0032½	0052½	0112½	hour	0632½	0637½	0642½	0647½	0652½	0657½	0702½	0707½	0712½	0717½	0722½	0727½	hour
		[1]	[1]	[1]	until	[1]	[1]	[1]	[1]	[1]	[1]	[1]	[1]	[1]	[1]	[1]	[1]	until
Murthal	arr	0039	0059	0119		0639	0644	0649	0654	0659	0704	0709	0714	0719	0724	0729	0734	midnight
	dep	0040	0100	0120		0640	0645	0650	0655	0700	0705	0710	0715	0720	0725	0730	0735	
Ganaur Terminus	arr						0648		0658		0708		0718		0728		0738	
Ganaur City	dep	0049	0109	0129		0649		0659		0709		0719		0729		0739		
Samalkha	dep	0055½	0115½	0135½		0655½		0705½		0715½		0725½		0735½		0745½		
Panipat	dep	0105½	0125½	0145½		0705½		0715½		0725½		0735½		0745½		0755½		
		[1½]	[1½]	[1½]		[1½]		[1½]		[1½]		[1½]		[1½]		[1½]		
IOCL Panipat	arr	0114	0134	0154		0714		0724		0734		0744		0754		0804		

IOCL Panipat	dep	2400	0020	0040	then		0600		0610		0620		0630		0640		0650	then
Panipat	dep	0007½	0027½	0047½	at		0607½		0617½		0627½		0637½		0647½		0657½	at
Samalkha	dep	0017	0037	0057	the		0617		0627		0637		0647		0657		0707	the
Ganaur City	dep	0024	0044	0104	same		0624		0634		0644		0654		0704		0714	same
		[1]	[1]	[1]	minutes		[1]		[1]		[1]		[1]		[1]		[1]	minutes
Ganaur Terminus	dep				past	0625		0635		0645		0655		0705		0715		past
Murthal	arr	0033	0053	0113	each	0628	0633	0638	0643	0648	0653	0658	0703	0708	0713	0718	0723	each
	dep	0034	0054	0114	hour	0629	0634	0639	0644	0649	0654	0659	0704	0709	0714	0719	0724	hour
Rajiv Gandhi	arr	0039½	0059½	0119½	until	0634½	0639½	0644½	0649½	0654½	0659½	0704½	0709½	0714½	0719½	0724½	0729½	until
	dep	0040	0100	0120		0635	0640	0645	0650	0655	0700	0705	0710	0715	0720	0725	0730	midnight
KMP Interchange	dep	0044½	0104½	0124½		0639½	0644½	0649½	0654½	0659½	0704½	0709½	0714½	0719½	0724½	0729½	0734½	
Kundi	dep	0050½	0110½	0130½		0645½	0650½	0655½	0700½	0705½	0710½	0715½	0720½	0725½	0730½	0735½	0740½	
Narela	arr	0054	0114	0134		0649	0654	0659	0704	0709	0714	0719	0724	0729	0734	0739	0744	
	dep	0055	0115	0135		0650	0655	0700	0705	0710	0715	0720	0725	0730	0735	0740	0745	
Mukarba Chowk	dep	0101	0121	0141		0656	0701	0706	0711	0716	0721	0726	0731	0736	0741	0746	0751	
		[1½]	[1½]	[1½]		[1½]	[1½]	[1½]	[1½]	[1½]	[1½]	[1½]	[1½]	[1½]	[1½]	[1½]	[1½]	
Kashmere Gate	arr	0114	0134	0154		0709	0714	0719	0724	0729	0734	0739	0744	0749	0754	0759	0804	

KEY: [1] Allowance for engineering work

15.4 Annexure 4 – Construction schedule and commissioning programme

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0 EXECUTIVE SUMMARY OF DRAFT DPR

0.1 Background

National Capital Region (NCR) is a unique example for inter-state regional development planning for a region with Nation Capital at its core. It is one of the largest National Capital Region of the World and constitutes about 1.60% of the country's land area. NCR is the home of 371 lakhs people living in 108 towns of which 17 are class I cities and more than 7500 rural settlements.

The four constituent Sub-Regions of NCR are given below:

1) Haryana - 40% 13,413 sq. kms. -9 districts- Faridabad, Gurgaon, Mewat, Rohtak, Sonepat, Rewari, Jhajjhar, Panipat and Palwal

2) Uttar Pradesh - 32% 10,853 sq. kms. – 5 districts - Meerut, Ghaziabad, Gautam Budha Nagar, Bulandshahr, and Baghpat

3) Rajasthan - 23% - 7,829 sq. kms. –1 district - Alwar district

4) Delhi - 5% - 1,483 sq. kms.

The population of NCR is projected to be 641.38 lakhs by 2021. Based on the projections & policies given in the Regional Plan-2021 for NCR, it is expected that the population of NCT-Delhi Sub-region would be 225 lakhs by 2021 and 163.50 lakhs, 49.38 lakhs & 203.50 lakhs for Haryana, Rajasthan Sub-region & Uttar Pradesh Sub-regions respectively.

NCR Planning Board prepared a Regional Plan with the perspective for year 2021 for the National Capital Region which was notified on 17.9.2005 for implementation. The Plan aims at promoting growth and balanced development of the National Capital Region. In this endeavor the effort is to harness the spread of the developmental impulse and agglomeration economies generated by Delhi. The above objective is sought to be achieved through:

i.) By providing suitable economic base for future growth and by identification and development of regional settlements capable of absorbing the economic development impulse of Delhi.

ii.) To provide efficient and economic rail and road based transportation networks (including mass transport systems) well integrated with the land use patterns.

iii.) To minimize the adverse environmental impact that may occur in the process of development of the National Capital Region.

iv.) To develop selected urban settlements with urban infrastructural facilities such as transport, power, communication, drinking water, sewerage, drainage etc. comparable with Delhi.

v.) To provide a rational land use pattern in order to protect and preserve good agricultural land and utilize unproductive land for urban uses.

vi.) To promote sustainable development in the Region to improve quality of life.

vii.) To improve the efficiency of existing methods and adopt innovative methods of resource mobilization, and facilitate, attract and guide private investment in desired direction.

The proposed Regional Rapid Transit System (RRTS) corridor between Delhi, Sonepat and Panipat is envisaged as part of the National Capital Region Planning Board's Transport Mobility Plan 2021 for a Mass Rapid Transit System that could provide an effective, high-speed and world class solution to benefit ridership between the cities of Panipat, Sonepat and towns of Kundli, Rajeev Gandhi Educational University, Murthal, Samalkha and Ganaur with Delhi. The RRTS corridor has been proposed to create a cost-effective yet world class transportation solution to provide a much needed relief to the NCR commuters and to discourage congestion within Delhi, a city bursting at its seams with inflow of population and strained resources and infrastructure.

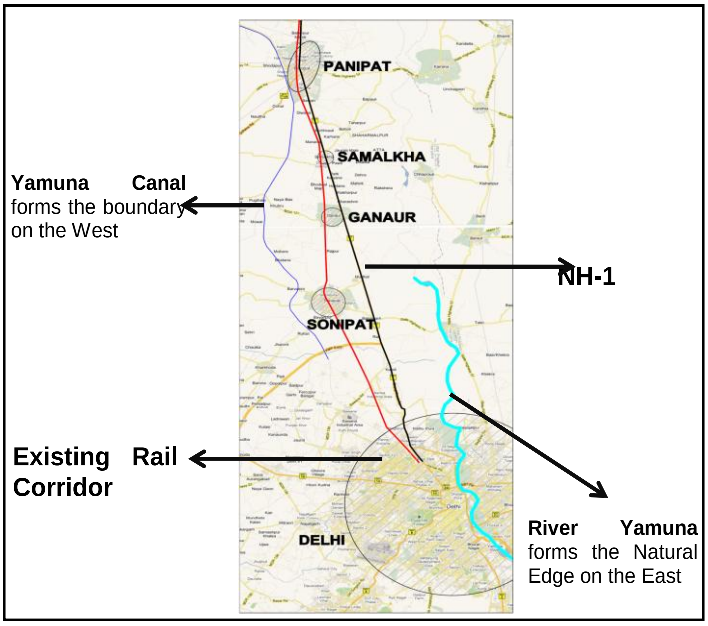
0.2 Agency

Delhi Integrated Multi Modal Transit Systems (DIMTS) has been awarded the work for development of Detailed Project Report for the proposed RRTS corridor by NCRPB. As a part of the ongoing assignment, this report "Draft Detailed Project Report" presents the financial and technical viability of the RRTS corridor.

0.3 Vision of RRTS

The Delhi-Sonepat-Panipat project corridor is in the states of Haryana and Delhi. The cities of Delhi and Panipat are connected through NH1 (6/8 lane highway) and Indian Railways trunk line. The cities and towns that lie in between Delhi and Panipat served by NH1 and the Indian Railway trunk line are Sonepat Ganaur, Samalkha, Kundli and Rai. It has been observed that most of the settlements/ development in these cities has taken place between the NH1 and Indian Railway corridor that provide connectivity between these cities as well as connectivity with Delhi and Panipat.

The project corridor is bound by the River Yamuna on the eastern fringe and the Western Yamuna Canal on the western side. It is generally observed that there is not much population to the east of NH-1, and almost all the city centres in Haryana state are located to the west of NH-1 upto Ambala. The YamunaRiver serves as the boundary between the states of Haryana and Uttar Pradesh. The western Yamuna Canal, NH-1 and the existing Indian Railway line are defined, continuous alignments between Delhi to Panipat and beyond.

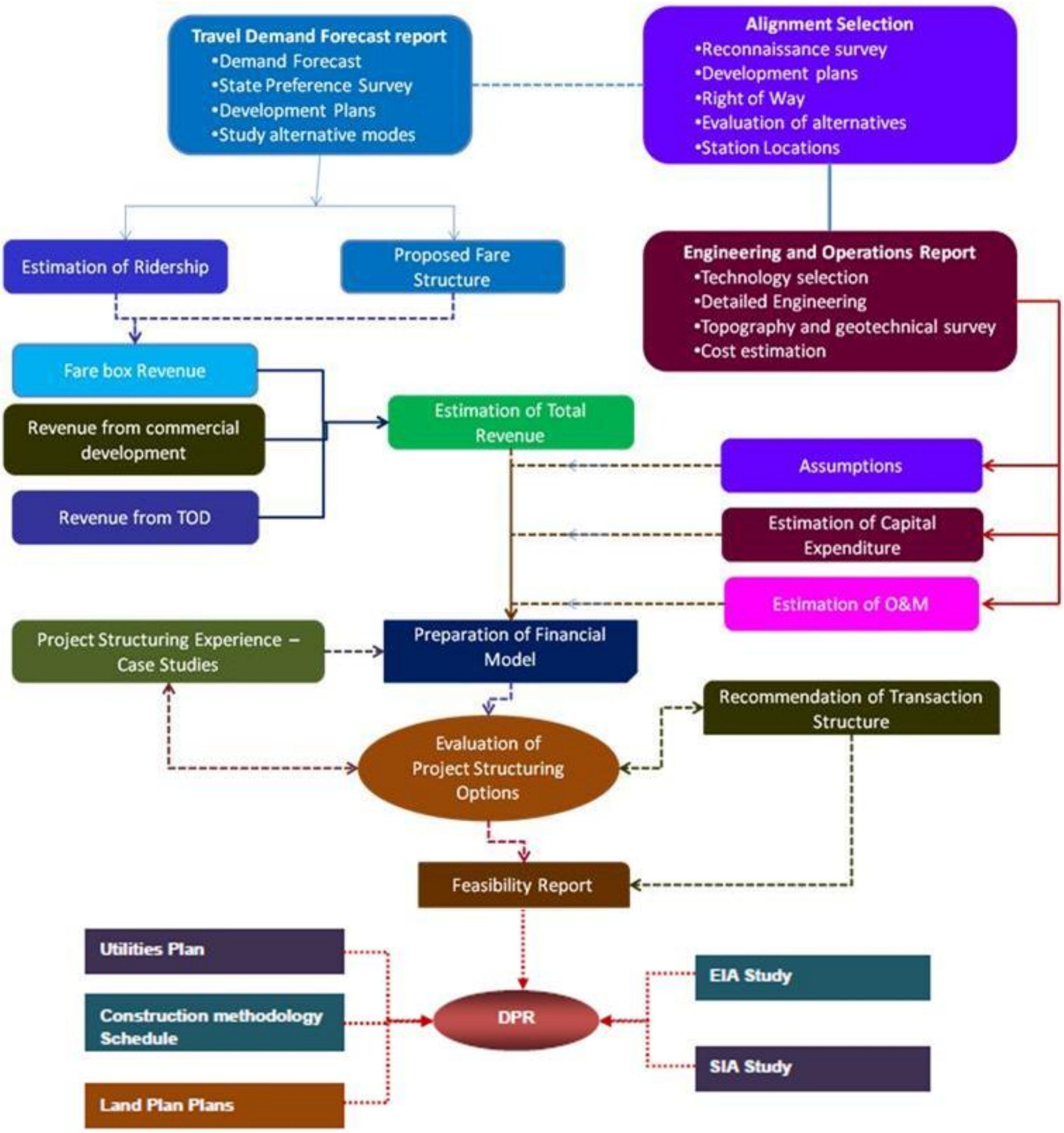


The vision of RRTS can be summarized in the following points:

- To create an an optimized hi-speed high quality transport system having predominantly seated accommodation and good comfort level for passengers
- The operating pattern may include both non-stop and stopping at all stations journeys. The non-stop journey between Delhi and Panipat to be in the order of 45-50 minutes for the RRTS corridor
- The Delhi terminus may be located for interchange with the existing Delhi Metro network or any other separate continuing link with other alignments in the RRTS
- Interchange with other MRTS corridors including the development of feeder systems to other MRTS corridors
- To use Broad gauge track and coaches must meet standard Indian structure profile
- Optimized locations of stations for ease of access to commuters and to serve maximum volume of ridership
- Optimize route, ridership and number of stops so as to achieve good operating speeds

0.4 Overall Approach for draft DPR

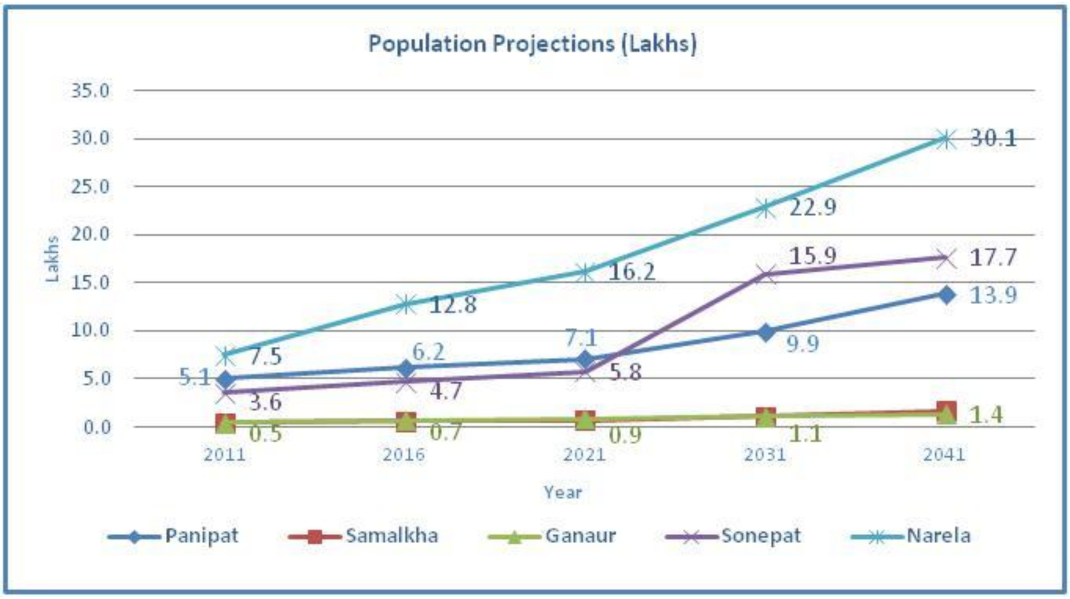
The figure below depicts the overall approach for preparation of the Viability Report for the RRTS Delhi Sonepat Panipat corridor.



0.5 Detailed Travel Demand Forecast Study

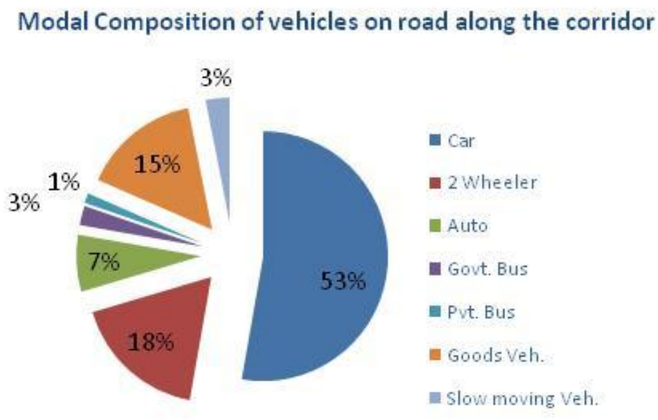
The development plans for main cities of Sonepat and Panipat along with Class-I and II towns of Ganaur and Samalkha have been studied. The development plans have projected the population for each of the towns for the year 2011 & 2021 in sync with the proposed development. Population is estimated for the horizon years 2031 and 2041 using Regression method. The demographics estimated are presented below.

Demographic profile along the corridor



0.6 Traffic Volume

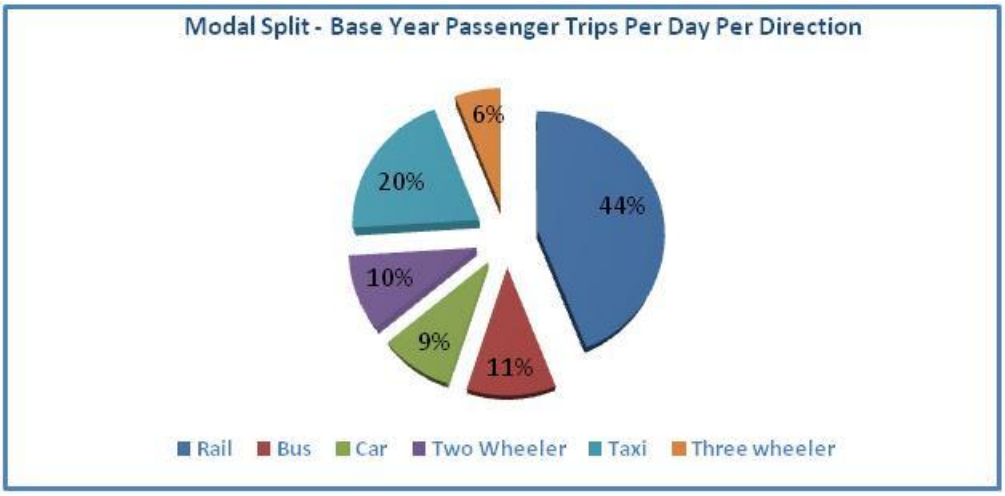
The average daily traffic and modal composition of vehicles on a typical week day in both the directions along the corridor is given below.



0.7 Travel characteristics of Base Year (2011) by Rail, Bus and Private Vehicles

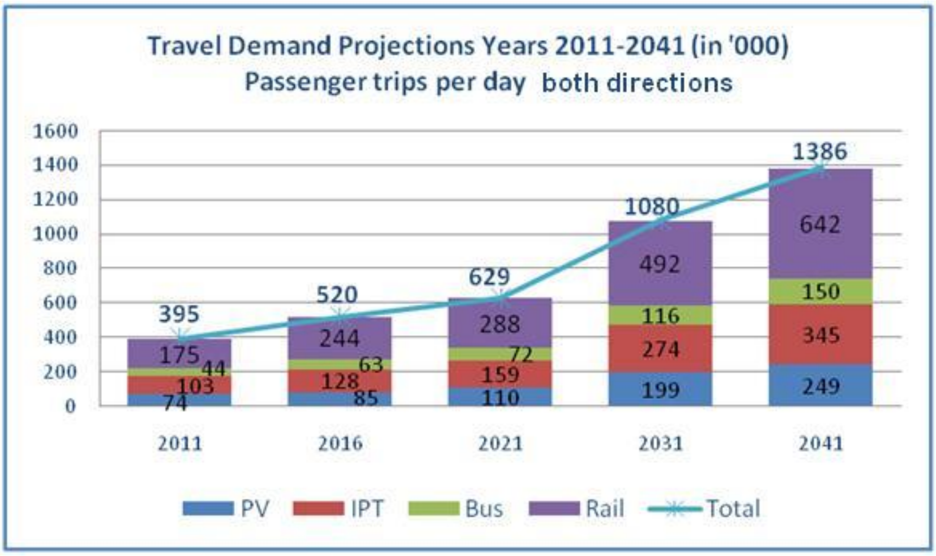
The total passenger movement from Delhi to Panipat along the study corridor is around 3.95 lakh passengers per day. The modal share shows that maximum (44%) share of passengers is carried by rail, 11% by buses and rest by private (19%) and IPT

(26%). The mode wise breakup of base year travel demand is presented in the following chart.



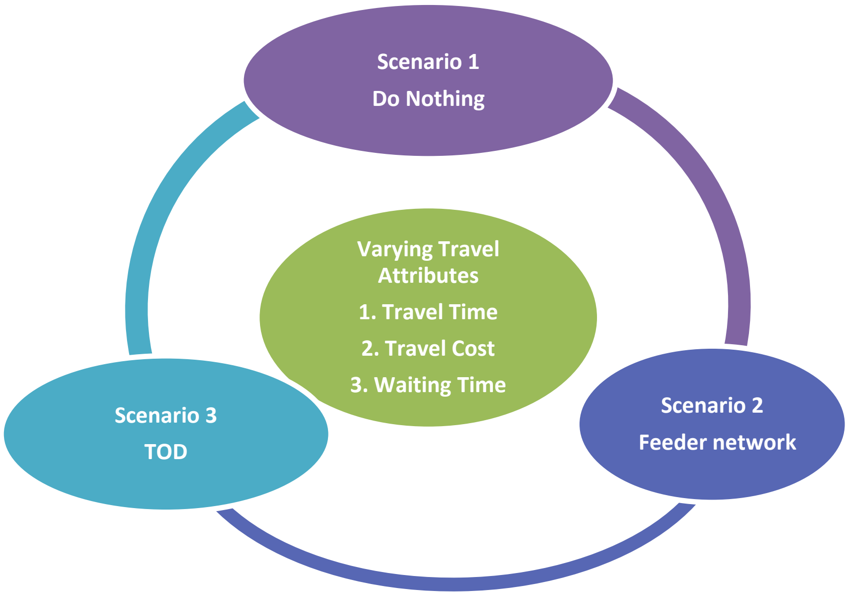
0.8 Travel Demand Forecast

Travel demand by various modes is forecasted for all the horizon years 2016, 2021, 2031, 2041.



0.9 Ridership Estimation for RRTS along the Delhi Sonepat Panipat Corridor

Stated preference surveys were conducted to arrive at binary logit mode choice model. The model is used to estimate shift from a given OD pair to RRTS based on the travel time, travel cost and waiting for that OD pair. This exercise of identifying the shift of travel from existing mode to RRTS is performed for each mode and the shift is calculated using the fares, travel time and waiting times of the existing mode to that of RRTS in the binary logit model obtained from analyzing stated preference data.



Demand has been estimated based on 74 minutes travel time between Delhi- Panipat, peak and off peak frequency as per operational plan and Rs1.1 per km fare as determined from Willingness To Pay. The fare between Delhi to Panipat City has been considered as Rs100 and the maximum fare from Delhi to IOCL Panipat has been extrapolated based on length to Rs 110. A concessional fare (monthly pass) has also been considered for the commuters. We have assumed that the concessional fare would be 25% less than the full fare for respective journeys for the consumers. It has been assumed that 75% of the passengers would be using the full fare and 25% would be using the concessional fare (monthly pass) for commuting between Delhi Panipat

In addition, a further analysis was conducted to delineate the TOD zones near to the various stations. The extra inducement of traffic from finalized TOD zones was accounted in revised forecasts.

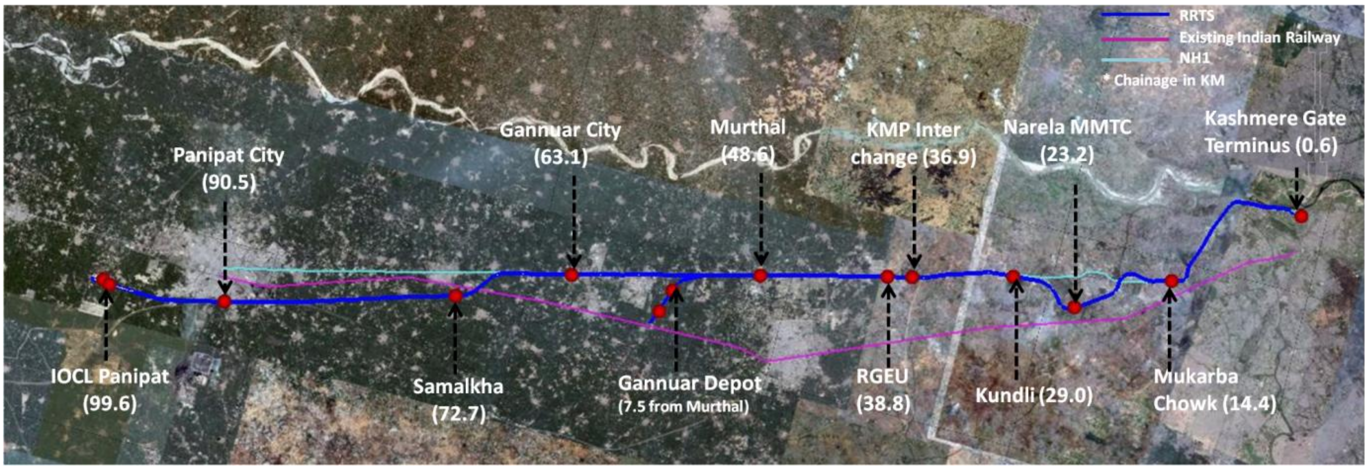
The ridership is presented in table below

Daily ridership

Year	Total ridership (in lakhs per day)
2016	3.77
2018	4.38
2021	5.47
2031	7.79
2041	9.83

0.10 Proposed Alignment

he Delhi Sonepat Panipat RRTS alignment is proposed to start at Maharana Pratap Inter State Bus Terminus (referred to as Kasmere Gate Terminal in this report) in Delhi and ends at IOCL Panipat terminal in Haryana covering a total distance of 111.2 kms that includes a spur length of 10.6 kms at Gannaur Depot. The alignment consists of a mix of elevated (100.7 kms), underground (2.7 kms), and segregated At Grade (7.8 kms), sections across the length of the corridor. There are 12 stations and 2 depots proposed on the corridor.



The Delhi terminal of the RRTS corridor is proposed to be located underground at Kashmere Gate parallel to, and at the same level as that of new proposed phase III underground Delhi Metro station thus providing the commuters integration with Delhi Metro and Inter State Bus Terminus at Kashmere Gate. Exiting the Kashmere Gate terminus, the alignment remains underground to cross a park, residential areas and ring road and emerges on the east side of the ring road. Thereafter the alignment goes elevated and follows ring road to reach Mukarba Chowk station in Delhi and follows NH1 thereafter towards Narela Multi Modal Transit Centre. As a multimodal transit station is proposed in Delhi Master Plan at Narela, the alignment moves westward from NH1 to integrate with Narela MMTC and then again joins back NH1 alignment to proceed northwards to Haryana. In Haryana the alignment utilizes the greenbelt along the west side of NH1 with stops at Kundli, KMP interchange (Kundli Manesar Palwal Interchange), Rajeev Gandhi Education University, Murthal and Gannuar. At Gannaur, a spur of 10.6 km length has been proposed towards the west of the main alignment for RRTS depot and Gannaur Depot station that will serve the Transit Oriented Development Zone to be developed at Gannaur. Moving northwards from Gannuar city station, the elevated main alignment moves westward to cross the Indian Railway alignment to reach Samalkha station parallel to the Indian Railway station at Samalkha. From Samalkha the alignment moves northwards to reach Panipat City station and further terminates at Panipat IOCL terminal station. Depots are proposed at Panipat IOCL terminal and Gannaur. Along the alignment three Transit Oriented Zones are proposed at (1) IOCL Panipat, (2) Samalkha, and (3) Gannaur Depot.

The following table summarizes the location of stations along with other details.

Sr. No	Stations	Station location	Distance from Previous station (KM)	Total KM
1	Kashmere Gate Terminus	Underground		
2	Mukarba Chowk	Elevated	13.8	13.80
3	Narela MMTC	Elevated	8.8	22.60
4	Kundli Border	Elevated	5.8	28.40
5	KMP Expressway interchange	Elevated	7.9	36.30
6	Rajeev Gandhi Education City (Rai)	Elevated	1.9	38.20
7	Murthal (Sonepat)	Elevated	9.8	48.00
9	Gannaur (at NH1)*	Elevated	14.5	62.50
10	Samalkha	Elevated	9.6	72.10
11	Panipat City	Elevated	17.8	89.90
12	IOCL Panipat	At Grade	9.1	99.00
8	Gannaur Depot (along the spur)*	At Grade	7.5	106.5
	Additional Length of alignment			4.70
	Total Length			**111.2**

* distance from Murthal

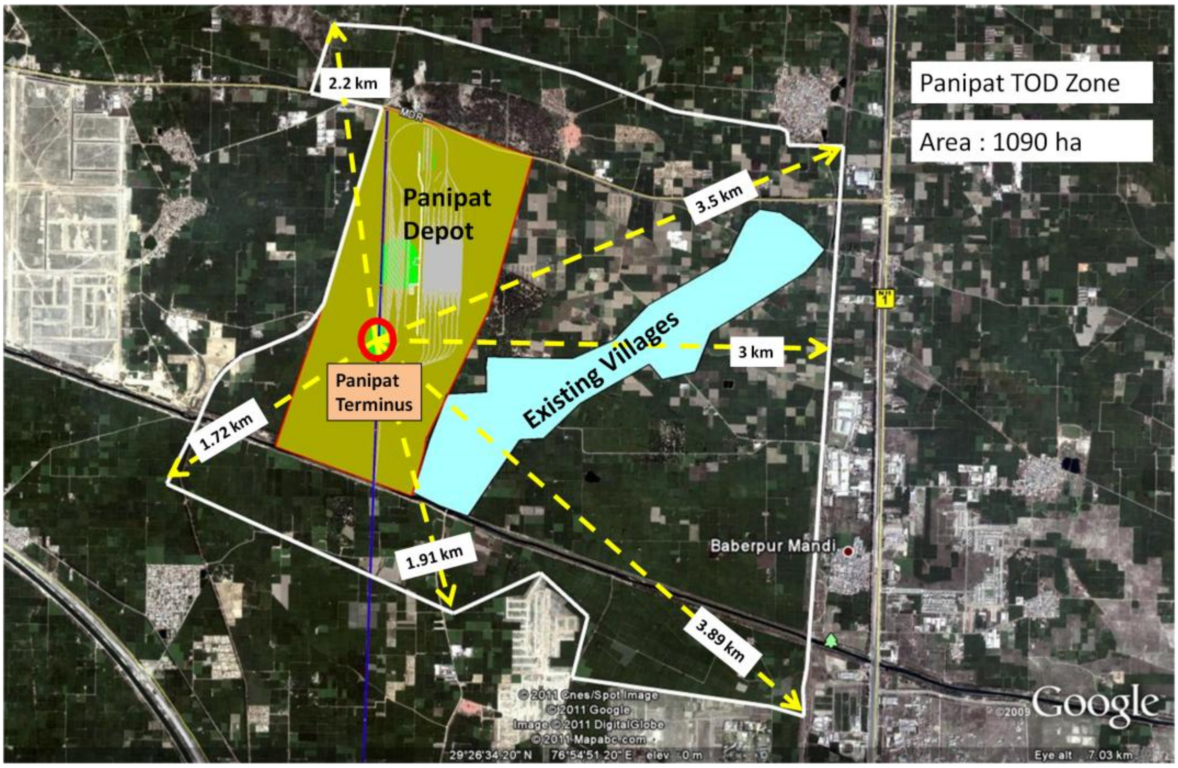
0.11 Transit Oriented Development Zones

A transit-oriented development (TOD) is a mixed-use residential or commercial area designed to maximize access to public transport, and often incorporates features to encourage transit ridership. A TOD neighborhood typically has a center with a transit station or stop (train station, metro station, or bus stop), surrounded by relatively high-density development with progressively lower-density development spreading outwards from the center.

Potential TOD sites

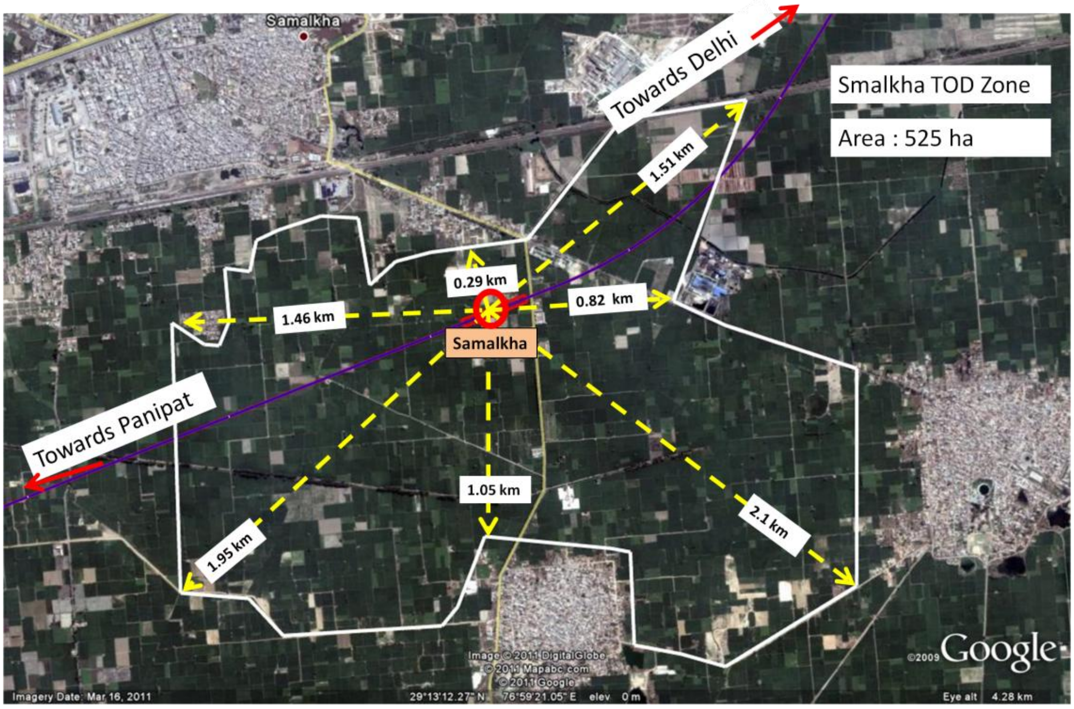
Three potential TOD sites have been in vicinity of IOCL Panipat, Samalkha and Gannaur Depot Stations.

Potential area for TOD at IOCL Panipat Depot

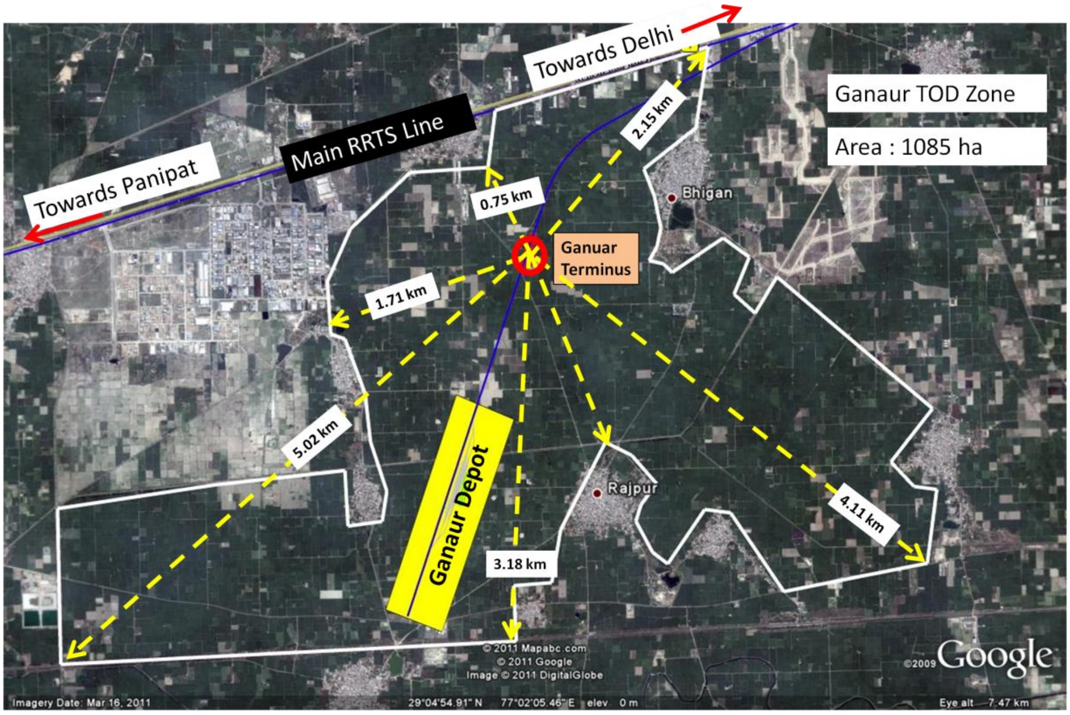


Towards Delhi

Potential area for TOD at Samalkha



Potential area for TOD at Gannuar Depot



0.12 Rolling Stock Selection

Physical attributes derived from the demand for rolling stock are summarized below :

- operating headway of 3.5 minutes at Ultimate System Capacity (2041);
- operating headway of 4.5 minutes at Opening System Capacity (2021);
- cars of 3.7 metres external width;
- three double doorways per bodyside of 1.5 metres nominal width;
- one luggage stack per driving car;
- two luggage stacks per middle car;
- one wheelchair position per driving train;
- seat pitch of 800 mm arranged airline-style. Alternatively, the seats could be arranged front/rear facing;
- preferred maximum standing passenger density of 3 per square metre;
- no tables;
- no toilets;
- no catering facilities;
- no equipment cabinets within the saloons;
- no bicycle accommodation;
- no train crew accommodation (other than the drivers).

The parameters shown in Table below are those selected to provide the optimum train and train services:

Parameter	At Opening System Capacity	At Ultimate System Capacity
Peak Hour System Capacity, PHPDT	16,281	27,683
Operational Headway, minutes	4.5	3.5
Required Train Passenger Capacity	1,252	1,628
Nominal Car Length, metres	24	24
Nominal Car Width, metres	3.7	3.7
Rail Gauge, mm	1,676	1,676
Seating Layout	2 + 3	2 + 3

Parameter	At Opening System Capacity	At Ultimate System Capacity
Style of Seat Layout	Airline	Airline
Seat Pitch, mm	800	800
Density of Standing Passengers in Normal Service, per square metre	3	3
Number of Cars per Train	6	9
Train Length, metres (formed from 3-car units)	152	228
Train Stopping Accuracy at Stations, metres	10	10
Number of Doorways per Bodyside	3	3
Nominal Width of the Bodyside Doors, metres	1.5	1.5
Number of Luggage Stacks per Driving Car	1	1
Number of Luggage Stacks per Middle Car	2	2
Number of Wheelchair Positions per Driving Car	1	1
Number of Wheelchair Positions per Middle Car	0	0
Toilets on the Trains	No	No
Tables on the Trains	No	No
Catering Facilities on the Trains	No	No
Bicycle accommodation on the Trains	No	No
Train Crew Accommodation on the Trains (other than the drivers)	No	No
Train Type	25 kV EMU	25 kV EMU
Train Configuration	Fixed formation of 3-car units and 6-car units	Fixed formation of 3-car units and 6-car units
Nominal Laden Car Weight (heaviest car), tonne	77	77
Extreme Car Weight, tonne	95	95

Parameter	At Opening System Capacity	At Ultimate System Capacity
Train Power with 160 km/hr maximum speed, MW	1.90	3.00
Energy Consumption for Single Journey with 160 km/hr maximum speed, kWh	2,235	3,350
Regenerative Braking Required	Yes	Yes
Cab-end gangways with close-off doors	Yes	Yes
Passenger Saloons and Driving Cabs to be Air Conditioned	Yes	Yes
CCTV in the Trains	Yes	Yes
Maximum Train Speed, km/hr	160	160
Maximum Initial Train Acceleration, m/s^2	1.0	1.0
Initial Train Acceleration to be Independent of Train Weight	Yes	Yes
Maximum Braking Rate, m/s^2	1.0	1.0
Average Service Braking Rate, m/s^2	0.5	0.5
Stop-all-stations Journey Time from Kashmere Gate to Panipat IOCL, minutes	74	74
Stop-all-stations Journey Time from Kashmere Gate to Ganaur Terminus, minutes	41	41
Number of Trains to be Provisioned	34	44
Number of Cars to be Provisioned	204	396
Track Gauge	1676mm Indian Broad Gauge	
Track Structure	ballastless track structure on main running lines	
Rails	60kg/m flat bottom	
Signalling	CATC	

The track cross section dimensions are built up as follows :

Element	Dimension	Comment
Emergency walkway	1000mm 700mm	Generally At OLE mast positions
OLE structure	300mm	
Structure clearance	2135mm	To track centreline
Track interval	4290mm	Straight track
Track interval on curves	4460mm	Minimum 400mR

0.13 Communications Systems

The Supervisory Control and Data Acquisition System (SCADA) will monitor and/or control equipment of the System including the fare collection equipment, CCTV, public and non-public Emergency Telephones (ET). It will display the alarms and will be able to control some functions of this equipment. The Remote Terminal Units (RTU) will be located in stations, substations and at the Depot

Other main components of the communications are :

- Fibre Optic Communication System
- Emergency Telephones
- Closed Circuit Television
- Passenger Information Display System
- Public Address System

0.14 Fare Collection System

For the fare collection system (FCS) a preventive maintenance schedule for each of the following system elements will be provided:

- automatic ticket vending machine (ATVM).
- automatic gate barriers (AGB).
- central and station computer system.

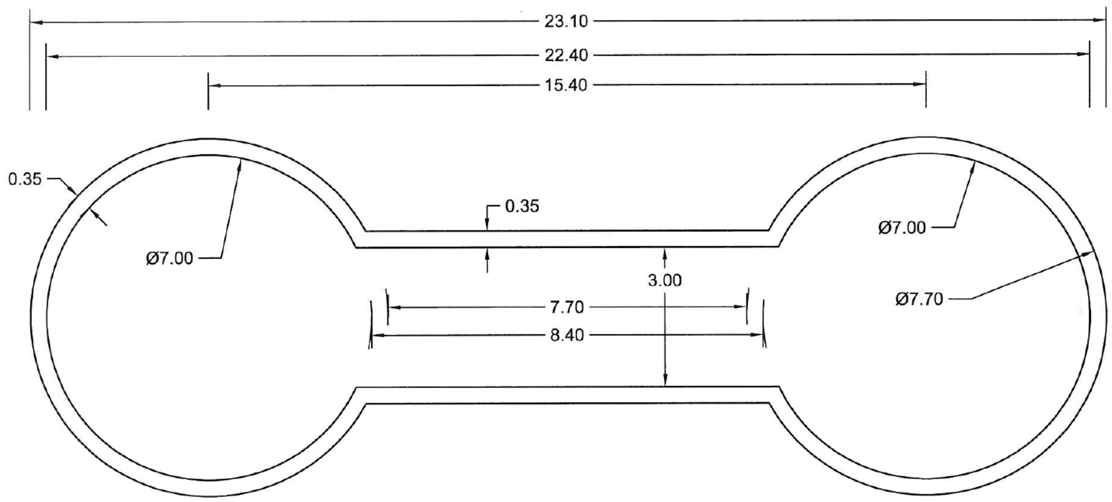
ATVMs, AGBs, station computers, central servers and computers will have self diagnostics. Preventive maintenance of the FCS consists mainly of visual inspection, cleaning and internal calibration.

0.15 Selection of Structural Form

The standard viaduct section will be formed from a precast post-tensioned concrete box girder, simply supported on single piers which are founded either on bedrock or a piled slab. The deck will carry the double track railway and will be completed by pre-cast parapets which will also form a continuous emergency walkway on both sides of the structure. Single track viaducts using similar features to the standard viaduct will be required on link lines and at stations with island platforms.

The Tunnel and Portals

For the first 2.5km length of the route out of Delhi is proposed to run underground, starting in a new station box near the existing DMRC Kashmere Gate station. Currently it is proposed that the RRTS tracks will run in twin bore tunnels with an external diameter of 7.70m.



Schematic of the Twin Bore Tunnel Section

0.16 Train operational Plan

In order to provide the required passenger capacity, the service headway could be 4.5 minutes and would be a nine minute interval service between IOCL Panipat and Kashmere Gate and a nine minute interval service between Ganaur Terminus and Kashmere Gate. Such a service will take 74 minutes between IOCL Panipat and Kashmere Gate, could be accommodated on a double track railway, and will require 29 train sets to operate. The total fleet will be 34 trains including standby trains and maintenance requirements.

0.17 Power

The RRTS: Delhi – Sonipat – Panipat railway will be a high power user. Supplies will be required for both traction and non traction systems supplied at high voltage.

Traction Power

The consumption of traction electrical power is closely related to the rolling stock characteristics, the service levels required and the permanent way geometry.

System Information	2021	2041
Estimated Energy Consumption per annum (MWh)	350,000	644,000

0.18 ASSUMPTIONS AND BOUNDARY CONDITIONS for Financial Analysis

Sr. No.	Particulars	Value
1	Base year for cost estimation	2013
2	Award of contract	October 2014
3	Years of construction	4
4	Commercial operation date (COD)	1st October 2018
5	Concession period/model period	30 years
6	End of concession period/model	30th September 2048

Sr. No.	Particulars	Rate (%)
1	Custom Duty	18.6%
2	Excise duty	8.2%
3	Value Added Tax	12.5%

Sr. No.	Particulars	Value
1	Inflation rate	5%
2	Discount rate	10%
3	Tax rate	32.45%
4	MAT	20.01%
5	80IA benefit taken from date	From COD
6	Tax holding in a block of 15 years	10 years
7(a)	Extent of Term Loan as a % of total project cost (Multilateral Funding) – In case the project is implemented by a Govt owned agency/ NCRTC	60%
7(b)	Extent of Term Loan as a % of total project cost	40%

	(Multilateral Funding) – in case the project is implemented under PPP route	
8	Interest rate on term Loan	2%
9	Term period	20 years
10	Moratorium	Nil
11	Interest rate on future capital expenditure	10%
12	Debt equity structure for future capital expenditure	80:20
13	Repayment period for future capital expenditure	10 years

Standard taxation workings at the prevailing rates have been assumed for the financial analysis. Provision under section 80 I (A) has been considered as the project qualifies for such benefits.

0.19 Revenue Estimation

Fare Box Revenue

Mode wise Comparison of Existing Fare Structure (Year 2010)

Sr. No.	Mode	Delhi – Panipat fare (in Rs.)	Journey Time	Remarks
1	EMU – Passenger	Rs 15	2-2.5hrs	
2	Kalka Shatabdi (AC Chair Car)	Rs 285 (actual) Rs151 (Prorated)	70-80 mins	Rs 151 fare is prorated based on distance on Delhi Chandigarh full fare
3	Jan Shatabdi (AC Chair Car)	210	85 mins	
4	State Transport bus (Non AC)	65 (approx)	1.5 – 2 hrs	
5	State Transport AC Volvo Bus	200 (approx)	1.5 hrs	
6	RRTS	100	74 mins.	

Fares between the stations is based on telescopic fare structure with a minimum fare 25% of Delhi Panipat City Fare (Rs 100 for Year 2010). A rebate of 25% on the journey fare is considered for the commuters opting for the monthly pass.

Other Revenue

The revenue from other sources is estimated from the following sources:

- Commercial area/ complexes developed at the station complex
- Advertisement panels

- Betterment charges in Transit Oriented Development zones – Charges on transaction of land/ built up area

Proposed Betterment charges in TOD zones

Sr. No.	Description	Unit	Rate
			Rupees
1	Land /Site/Plot	Per sq.m / transaction	1,000
2	Developed Area		
a	Residential	Per sq.m/ transaction	1,000
b	Commercial	Per sq.m/ transaction	2,000
c	Office	Per sq.m/ transaction	1,500

Following table provides summary of revenue streams and total estimated project revenues for key years.

Sr. No.	Revenue Stream	FY2020	FY2021	FY2031	FY2041	FY2046
		Rs. Million /Year				
1	Fare box	7579	9825	28872	59445	84883
2	Revenues from station commercial	1088	1486	3259	5309	6776
3	Revenue from advertisement	76	98	289	594	849
4	TOD betterment charges post construction	6075	6075	4455	2956	2287
5	**Total Project Revenue**	**14819**	**17484**	**36875**	**68304**	**94795**

0.20 Land Pooling concept for TOD zones

In order to achieve orderly development at identified TOD Zones and along the proposed RRTS corridor, Government may pool or assemble lands and to reconstitute them in accordance with the proposed detailed development plan/scheme. The reconstituted plots of land are allotted to the owners.

Urban Development Plans Formulation & Implementation Guidelines (UDPFI), Government of India has incorporated such schemes, based on pooled land development either by the government entity or by the private owners.

Land could be assembled, on the basis of a detailed development plan/scheme, through voluntary pooling by its owners, which could be consolidated thereby permitting the local agency to develop infrastructure according to a layout plan. A portion of the land may be reserved for the provision of services including RRTS infrastructure facilities, open spaces and roads while the rest may be developed into plots to be distributed among the owners as per their share in the pooled land. The higher value of the developed plots would compensate the lesser area and payment of betterment charges.

However, this process needs to be promoted and augmented by providing appropriate policy framework in order to promote planned development and to make available land for public purposes without involving any compulsory acquisition of land.

0.21 Capital Cost Estimation

Estimated capital cost for base year 2013

Item	Description	Units	Quantity	Rate (Rs. Crore/ per Unit)	Sub-Total (Rs. Crore)	Total (Rs. Crore)	Total (Rs Mil)
1.0	**Land**					**2163**	**21,626**
1.1	Private Land, R&R & EIA	Hectare	329.3	-	2162.6		
1.2	Government land	Hectare	111.6	-			
2.0	**Civil works, Alignment and formation**					**3435**	**34,349**
2.1	Tunneling Work	R Km	2.240	168.5	377.5		
2.2	Ramp - underground	R Km	0.325	52.2	17.0		
2.3	Ramp - Elevated	R Km	0.975	20.4	19.9		
2.4	Elevated Viaduct	R Km	93.990	30.7	2881.7		
2.5	At grade Alignment	R Km	7.180	1.7	12.0		
2.6	Single Track Viaduct	R Km	2.800	-	-		
2.61	Single Track Viaduct	Total Km	5.000	25.4	126.8		
3.0	**Station Building**		12.0			**1623**	**16,229**
3.1	Underground Terminal Station	Nos.	1.0	292.2	292.2		
3.2	Elevated Stations	Nos.	9.0	124.6	1121.2		
3.3	At grade Terminal Station	Nos.	2.0	104.7	209.5		
4.0	**E&M Works**		12.0			**374**	**3,735**
4.1	Electro mechanical works including Lifts, Escalators, DG sets, UPS,ECS						
4.11	Underground station	Nos.	1.0	74.2	74.2		
4.12	Elevated station	Nos.	9.0	29.4	264.7		
4.13	At grade station	Nos.	2.0	14.7	29.4		
4.2	Tunnel Ventilation	R Km	1.5	3.5	5.1		
5.0	**Depot-cum-Workshop**		2.0			**227**	**2,267**
5.1	IOCL Panipat Depot						

Item	Description	Units	Quantity	Rate (Rs. Crore/ per Unit)	Sub-Total (Rs. Crore)	Total (Rs. Crore)	Total (Rs Mil)
5.11	Civil works, Track work, OHE	Nos.	1.0	93.3	93.3		
5.12	Plant and Machinery	Nos.	1.0	84.9	84.9		
5.2	Gannaur Depot						
5.21	Civil works, Track work, OHE	Nos.	1.0	26.5	26.5		
5.22	Plant and Machinery	Nos.	1.0	22.0	22.0		
6.0	**Permanent Way**					**796**	**7,964**
6.1	Ballastless track for elevated & underground alignment	R KM	104.1	7.1	743.4		
6.2	Ballasted/Embedded track for at grade allignment	R KM	17.2	3.1	53.0		
7.0	**Traction & Power Supply incl. OHE, ASS etc.**					**931**	**9,307**
7.1	Under Ground Section	R KM	2.57	9.6	24.6		
7.2	Elevated & At Grade Section	R KM	120.9	7.5	906.1		
8.0	**Signalling and Telecom.**					**926**	**9,264**
8.1	Signalling	R KM	121.2	7.0	847.0		
8.2	Telecom.	No. of Stations	12.0	7	79.4		
9.0	**Automatic fare collection**					**62**	**622**
9.1	Ticketed Stations	No. of Stations	12.0	5.2	62.2		
10.0	**Misc. Works**					**195**	**1,954**
10.1	Utilities Relocation	R KM	111.2	0.6	61.3		
10.2	Misc. civil works such as median, road signages	R KM	111.2	0.6	61.3		
10.3	Barracks for Security Staff including security equipments	Nos.	12.0	0.6	6.6		
10.4	Staff Quarters for O&M	Nos.	12.0	5.5	66.2		
11.0	**Rolling Stock**					**2362**	**23,616**
11.1	EMU Coaches	Nos.	204.0	11.6	2361.6		
12.0	**Miscellaneous Items**					**152**	**1,518**
12.1	Training	Nos.	1.0	11.0	11.0		
12.2	Spares (%of 7,8,9 & 11)	%	2%	4280.9	85.6		

Item	Description	Units	Quantity	Rate (Rs. Crore/ per Unit)	Sub-Total (Rs. Crore)	Total (Rs. Crore)	Total (Rs Mil)
12.3	Testing and Commissioning Costs	Nos.	1.0	55.1	55.1		
13.0	**Total**						
13.1	Total (Including Land Cost)	Sum (1 to 12)			**13245**		**132,451**
13.2	Total (Excluding Land Cost)	Item 13.1 Less 1			11082.5		
13.3	General Charges incl. Project Management, Design charges etc.	% of 13.2		5%	554.1		
13.4	Contingency	% of 13.1+13.3		5%	690		
	Estimated Construction Cost on Year 2013 Basis (Excluding Land)					**12,327**	**123,266**
	Estimated Construction Cost on Year 2013 Basis					**14,489**	**144,892**

Base capital cost with taxes and duties

Sr. No.	Components	Amount in Rs. Million
1	Land	21626
2	Base Construction Cost (excl. land cost & General Charges and Contingency)	110825
3	**Total Base Project Cost**	**132451**
4	Total Central Taxes	**12006**
a	Customs Duty	7893
b	Excise Duty	4113
5	Cost including Central Taxes (3+4a+4b)	144457
6	State Tax (VAT)	**6759**
7	Cost including State Tax (5+6)	151216
8	Project Management, design and Procurement Charges @5% on (7 -1)	6479
9	Contingency @5% on (7+8)	7885
10	**Total Cost (incl. taxes excl. IDC)**	**165580**

0.22 Operation & Maintenance Cost Estimation

The operations and maintenance cost of RRTS Delhi Panipat would consist of the following:

- Staff costs
- Energy cost
- Maintenance cost

Staff Cost

Actual staff cost for key years is presented below

Number of Staff	
Main Depot	615
Second Depot	63
Train Crew	326
Station Staff	1,308
Total Staff Number	**2,312**
Salary Cost, Rs Mil per year	**Rs Mil/year**
FY 2020	1589
FY2021	1717
FY2031	4484
FY2041	11714
FY2046	17212

Energy cost

The energy cost has been estimated based on per unit charges calculated by using weighted average of variable and fixed energy charges (at 2013 price levels) levied by the states of Haryana and Delhi for DMRC

Base energy costs (at 2013 cost levels) have been calculated for 4 blocks of years namely 2018 -2021, 2021-2034 and 2035-2044 & 2044+ The estimation of the energy cost has been done based on the energy consumption in the following areas

- Energy consumption in traction
- Energy consumption in station
- Energy consumption in depot

The base energy cost is provided in table below

Timeline	Total Consumption, kWh	Energy Cost per year, (Rs Cr)	Total Demand, kVA	Demand cost per year, (Rs Cr)	Total cost per year, (Rs Cr)
2018 to 2020	373,109,280	185.79	64,685	10.57	196.35
2021 to 2034	547,837,741	272.79	94,977	15.52	288.31
2035 to 2044	670,150,208	333.70	116,182	18.98	352.68
2044+	884,576,324	440.47	153,357	25.06	465.52

Maintenance Expenditure

For repair and maintenance of the RRTS assets, apart from staff, some material will also be used. This includes spare parts and consumables. The cost of such material which is consumed annually depends on a lot of factors such as the design of the equipment, the intensity of usage, the maintenance philosophy, the manufacturer's recommendations, renewal plans etc. The Base maintenance costs (at 2013 price levels) per annum have been estimated at a rate of 0.8% of total base capital expenditure (excluding land). The total actual O&M cost is provided in table below:

Financial Year	Maintenance cost (Rs Million)	Manpower cost (Rs Million)	Energy cost (Rs Million)
FY 2019	718	761	1177
FY 2020	1459	1589	2345
2021	1572	1717	2415
2022	1778	1854	3652
2023	1867	2002	3762
2024	1960	2379	3875
2025	2058	2569	3991
2026	2161	2774	4111
2027	2269	2996	4234
2028	2383	3236	4361
2029	2502	3844	4492
2030	2627	4152	4627
2031	2923	4484	4765
2032	3587	4843	4908
2033	3766	5230	5056
2034	3955	6214	5207
2035	4152	6711	5363
2036	4360	7248	6758
2037	4578	7827	6960

2038	4807	8454	7169
2039	5047	10043	7384
2040	5300	10846	7606
2041	5565	11714	7834
2042	5843	12651	8069
2043	6135	13663	8311
2044	6442	14756	8560
2045	6764	15937	11638
2046	7102	17212	11988
2047	7457	18589	12347
2048	7830	20076	12718

0.23 Project Structuring and Viability

State governments have taken an aggressive stand in these projects and such stand has been very well supported by the Central Government in pushing through these projects either by way of necessary legislation, land acquisition, equity commitments.

NCRPB has been instrumental in signing of MoUs with various states government, besides Ministry of Urban Development, Govt. of India (MoUD) and Ministry of Railways for making equity contribution to the RRTS projects. Further, equity contributions are expected to be made in a company referred to as NCR Transport Company or say (“NCRTC”).

NCRTC is expected to be the holding company of all RRTS projects and to our understanding is proposed have an initial corpus of Rs. 100 crores shared in the following manner:

Name of the Entity	Share in NCRTC(%)
Govt of India (MOUD + MoR + NCRPB)	50
Govt. of National Territory of Delhi	12.5
State Govt. of Uttar Pradesh	12.5
State Govt. of Haryana	12.5
State Govt. of Rajasthan	12.5
Total	**100**

NCRTC Panipat Delhi Structure

Each of the RRTS project can be developed through NCRTC where respective investments amongst state governments could be split based on project specific details. Therefore potential investments contributions could be as set out below:

Equity Contribution Structure of Delhi – Sonepat - Panipat Project

Name of Entity	Percentage (%)
Govt of India (MOUD + MoR + NCRPB)	50
Govt. of National Territory of Delhi, State and **Govt. of Haryana**	50
Total	100

The contribution of GNCTD and Govt of Haryana could be split in terms of:

a) Route length
b) Investment
c) Shareholding in the holding company

Role of Lenders

Multi-lateral funding agencies such as JICA, World Bank and ADB have shown keen interest in funding these projects. These projects are typically backed by central government guarantees towards repayment. Typically the loan repayment could be done from the project company, however, the exchange rate risk is taken on by the central government in such debt financing deals.

The project of this size would require, ideally soft loan from a multi lateral institution on attractive terms such as a loan paid of 20 to 30 years with interest rate less than 2%. We believe that the project could obtain 40% - 60% of the construction cost as soft loan from suitable multi lateral funding agency e.g. World Bank, JICA and ADB with exchange rate risk typically borne by Government of India.

As discussed in the chapter on Assumptions and Boundary Conditions, a soft loan 60% of the total project cost at 2% interest rate has been considered for the project in case the project is done by NCRTC/ Govt agency where as a soft loan of 40% of the total project cost at 2% interest rate has been considered for the project if it is done under a PPP structure.

0.24 Viability and Structuring of Project under implementation by Government

Total Project cost and phasing under project implementation by government

As discussed in section of Assumptions and boundary conditions, a soft loan of 60% of the total project cost @ 2% interest rate with 20 year repayment period has been considered in case the complete project is implemented by NCRTC/ under a government agency.
The total project cost including all taxes, escalation of cost during construction and the component of interest during construction is estimated at Rs 19038 Crs.

The table below specifies the year wise breakup of funds required for the total capital expenditure.

Year wise actual capital expenditure required for project under implementation by Government (including IDC and margin money)

Component (Cost in Rs Mil)	FY15	FY16	FY17	FY18	FY19	Total
Land, R&R and Utility shifting	7209	14418	0	0	0	21626
Civil works, Alignment and formation	5625	16089	21886	11731	0	55331
Overhead Station buildings	1976	6224	8714	4575	0	21489
Underground Station buildings	455	1435	2008	1054	0	4953
Depot-cum-Workshop	0	953	1540	566	0	3058
Power supply and substations	0	0	5428	6705	1056	13189
S&T (excluding onboard) and AFC	0	0	5458	7163	1504	14126
Miscellaneous	525	1102	1157	1215	638	4636
Rolling Stock	4831	10146	10815	5762	0	31554
Total	20622	50366	57005	38772	3198	169963
Other charges(contingency and project management)	1830	4693	5577	3983	345	16428
total capital cost without IDC	22452	55059	62582	42755	3543	186391
IDC	0	3	596	1916	1116	3632
Total Capital cost without Margin money	22452	55063	63178	44671	4659	190023

Margin money	0	0	0	0	361	361
Total capital cost	22452	55063	63178	44671	5020	190384

Suggested project structure and roles under NCRTC/ government implementation

NCRTC shall be responsible for undertaking project activities including initial civil mechanical and electrical construction, procurement of rolling stock and operations of the project as well as undertaking future expansion expenditure for the project.

The contributors to the funding for the project could be as set out below:

Name of Entity
MoUD, Govt. of India + NCRPB
Ministry of Railways + Govt. of India
Govt. of National Territory of Delhi, State Govt. of Haryana

Further, the NCRTC could borrow money from multi-lateral financial institutions with suitable government guarantees, since multi-lateral financial institutions typically request for such guarantees as well as the fact that they would find it more convenient to fund a 100% government owned company as compared to a company with private sector majority holding.

The revenue of NCRTC would include revenue from operations of RRTS, advertisement, revenues from commercial areas at stations and betterment charges from ToD areas. In turn NCRTC shall spend on day to day operations of the project and debt servicing for the soft loan taken for development of the project.

Funding pattern

Following the project structure as suggested above, the total investment breakup for the funds to be supplied by each entity including multilateral agencies is presented in the table below:

Sl. No.	Name of Entity	Investment Based on Length		Contribution Based on Initial Investment	
		%	Rs. Million	%	Rs. Million
1.	Govt of India (MOUD + MoR + NCRPB)	20%	38,077	20%	38,077
2	Govt. of National Territory of Delhi	5.1%	9,757	4.4%	8,329
3	State Govt. of Haryana	14.9%	28,320	15.6%	29,746
4	**Total by Govt**	**40%**	**76,154**	**40%**	**76,154**
6	Soft Loan	60%	114,230	60%	114,230
7	**Total investment**	**100%**	**190,384**	**100%**	**190,384**

The aforesaid excludes the project funding required for additional investments in future as well replacement costs associated with the project.

Profit and loss account for the Project

The project profit and loss statement for the project is presented below:

P&L Statement (Rs Mil)	FY20	FY21	FY26	FY31	FY36	FY41	FY46
Revenue							
Fare box revenue	**7579**	**9825**	**19258**	**28872**	**41630**	**59445**	**84883**
Revenue from commercial development	1088	1486	2554	3259	4160	5309	6776
Revenues from Advertisment Rights	76	98	193	289	416	594	849
Other Revenue (from ToD Betterment Charges)	6075	6075	5265	4455	3820	2956	2287
Total Revenue	***14819***	***17484***	***27269***	***36875***	***50026***	***68304***	***94795***
Expenses							
Maintenance cost	1459	1572	2161	2923	4360	5565	7102
Manpower cost	1589	1717	2774	4484	7248	11714	17212
power cost	2345	2415	4111	4765	6758	7834	11988
Rehabilitation Grant	335	352	450	574	732	935	1193
Total operating expenses	***5728***	***6056***	***9496***	***12746***	***19098***	***26047***	***37494***
EBITDA	9090	11428	17773	24129	30929	42257	57300
Depreciation	5020	5128	5453	5731	5865	1517	1517
EBIT	4071	6300	12320	18398	25064	40740	55784
Interest on long term loan	*2170*	*2090*	*1485*	*1004*	*446*	*49*	*0*
Interest on short term loan	*137*	*182*	*300*	*409*	*545*	*738*	*1014*
PBT	**1764**	**4027**	**10535**	**16985**	**24073**	**39953**	**54770**
Tax	353	806	2,108	5,580	7,735	11,828	17,528
PAT	**1411**	**3222**	**8427**	**11405**	**16338**	**28125**	**37242**

Cash flow, IRR and DSCR for the project

The Weighted Average Cost of Capital (WACC) under implementation of NCRTC has been estimated to be 5.51%. The estimation of the internal rate of return for the project is based on cash flow projected for the 30 year period of operations i.e. from FY2018 to FY2048.

The IRR for the project are as follows:

- Project IRR (Post Tax) 6.97%
- Project IRR (Pre Tax) 8.43%
- Equity IRR (at 60% soft loan @2%) 8.11%
- Average DSCR 3.0

0.25 Viability and Structuring of Project under PPP framework

Role of Private Sector

Private sector as the concessionaire has been fairly active in the Indian market in being part of these projects on reasonable commercial terms. Some of the projects have been successfully bid out using land banks provided as part of the project, such as Hyderabad Metro project. Other projects have used the distinction of basic infrastructure costs and rolling stock required for the project in order to enable the private sector participation, besides use of some commercial development.

We have carried out analysis for structuring the project under the PPP frame work, wherein the project can be developed under a suitable PPP frame work.

As per our estimation done under the financial analysis, private sector would be in a position to contribute 25-40% of the initial cost of construction, besides undertaking several other project responsibilities

Role Division Between Private Sector and NCRTC

Based on technical analysis carried out, the project element which could be split between government and private sector are as follows:

Project Components – Government and Private Sector (at base cost of year 2013)

Item	Description	Total (Rs. Million)	Government Sector (NCRTC)	Private Sector
1.0	Government Contribution (land, R&R, Utility shifting)	23,580	23,580	-
2.0	Civil works, Alignment and formation	34,349	34,349	-
3.0	Station Building	16,229	2,922	13,307
4.0	E&M Works	3,735	794	2,941

5.0	Depot-cum-Workshop	2,267	1,198	1,069
6.0	Permanent Way	7,964	7,964	-
7.0	Traction & Power Supply incl. OHE, ASS etc.	9,307	9,307	-
8.0	Signalling and Telecom.	9,264	9,264	-
9.0	Automatic fare collection	622	-	622
10.0	Rolling Stock	23,616	-	23,616
11.0	Miscellaneous Items	1,518	-	1,518
12.0	General Charges incl. Design charge	5,541	3,388	2,154
13.0	Contingency	6,900	4,638	2,261
14.0	**Total Base Construction Cost**	**144,892**	**97,404**	**47,488**
	% of Initial Investment		**67%**	**33%**
	% of Total Lifecycle Investment		**50%**	**50%**

From the above analysis we suggest that about 67% of the initial construction cost would need to be contributed by the government or multilateral financial institutions. It would be prudent to, therefore split the project to deliver optimum project structuring wherein a government entity could raise fund from Financial Institutions and its own sources with about 33% of project cost from private sector investment.

Total Project Cost and phasing under PPP structure

As discussed in section of Assumptions and boundary conditions, a soft loan of 40% of the total project cost @ 2% interest rate with 20 year repayment period has been considered in case the project gets implemented under suggested PPP structure.
The total project cost including all taxes, escalation of cost during construction and the component of interest during construction is estimated at Rs 18,904 Crs.

The table below specifies the year wise breakup of funds required for the total capital expenditure.

Year wise actual capital expenditure required for project under PPP structure (including IDC and margin money)

Component (Cost in Rs Mil)	FY15	FY16	FY17	FY18	FY19	Total
Land, R&R and utility shifting	7209	14418	0	0	0	21626
Civil works, Alignment and formation	5625	16089	21886	11731	0	55331
Overhead Station buildings	1976	6224	8714	4575	0	21489

Underground Station buildings	455	1435	2008	1054	0	4953
Depot-cum-Workshop	0	953	1540	566	0	3058
Power supply and substations	0	0	5428	6705	1056	13189
S&T (excluding onboard) and AFC	0	0	5458	7163	1504	14126
Miscellaneous	525	1102	1157	1215	638	4636
Rolling Stock	4831	10146	10815	5762	0	31554
Total	20622	50366	57005	38772	3198	169963
Other charges(contingency and project management)	1830	4693	5577	3983	345	16428
total capital cost without IDC	22452	55059	62582	42755	3543	186391
IDC	0	0	305	1246	737	2288
Total Capital cost without Margin money	22452	55059	62887	44001	4280	188679
Margin money	0	0	0	0	361	361
Total capital cost	22452	55059	62887	44001	4641	189040

Funding Pattern

The table below presents the actual funding required upto project commissioning for the project considering the central and state govt taxes, escalation in capital cost during construction period, IDC and margin money

Total Investment breakup for project implementation under PPP structure (Capital cost including taxes, escalation, IDC and margin money)

Sl. No.	Name of Entity	Investment Based on Length		Contribution Based on Initial Investment	
		%	Rs. Million	%	Rs. Million
	Investments by DP Infraco				
1.	Govt of India (MOUD + MoR + NCRPB)	13.5%	25,536	13.5%	25,536
2	Govt. of National Territory of Delhi	3.5%	6,544	3.0%	5,586
3	State Govt. of Haryana	10.0%	18,992	10.5%	19,949

4	**Total by DP Infraco**	**27%**	**51,071**	**27%**	**51,071**
6	Soft Loan	40%	75,607	40%	75,607
	Investments by DP Rollco				
7	DP Rollco	33%	62,362	33%	62,362
8	**Total investment**	**100%**	**189,040**	**100%**	**189,040**

The aforesaid excludes the project funding required for additional investments in future as well replacement costs associated with the project. These costs shall be required to be incurred by the DP Rollco.

Profit and Loss Account for the Project under PPP structure

Profit and Loss Account for key years is presented below:

P&L Statement (Rs Mil)	FY20	FY21	FY26	FY31	FY36	FY41	FY46
Revenue							
Fare box revenue	**7579**	**9825**	**19258**	**28872**	**41630**	**59445**	**84883**
Revenue from commercial development	1088	1486	2554	3259	4160	5309	6776
Revenues from Advertisment Rights	76	98	193	289	416	594	849
Other Revenue (from ToD Betterment Charges)	6075	6075	5265	4455	3820	2956	2287
Total Revenue	***14819***	***17484***	***27269***	***36875***	***50026***	***68304***	***94795***
Expenses							
Maintenance cost	1459	1572	2161	2923	4360	5565	7102
Manpower cost	1589	1717	2774	4484	7248	11714	17212
power cost	2345	2415	4111	4765	6758	7834	11988
Rehabilitation Grant	335	352	450	574	732	935	1193
Total operating expenses	***5728***	***6056***	***9496***	***12746***	***19098***	***26047***	***37494***
EBITDA	9090	11428	17773	24129	30929	42257	57300
Depreciation	4976	5084	5409	5687	5832	1506	1506
EBIT	4115	6344	12364	18442	25096	40751	55795
Interest on long term loan	*1437*	*1395*	*983*	*695*	*330*	*49*	*0*
Interest on short term loan	*137*	*182*	*300*	*409*	*545*	*738*	*1014*

P&L Statement (Rs Mil)	FY20	FY21	FY26	FY31	FY36	FY41	FY46
PBT	2542	4767	11081	17338	24221	39964	54781
Tax	509	954	2217	5689	7776	11830	17529
PAT	**2033**	**3813**	**8864**	**11650**	**16444**	**28134**	**37252**

Cash flow project IRR & DSCR

The Weighted Average Cost of Capital (WACC) under PPP has been estimated to be 6.82%. The estimation of the internal rate of return for the project is based on cash flow projected for the 30 year period of operations i.e. from FY2018 to FY2048.

The project IRR for the project are as follows:

- Project IRR (Post Tax) 6.93%
- Project IRR (Pre Tax) 8.43%
- Average DSCR 3.72

Equity IRR for DP Rollco

As presented in the Table 5-15, the private partner DP Rollco, shall be investing 33% of the total project cost in the project.

NCRTC shall select the private partner DP Rollco based on the Capital grant (positive or negative) required by the private investor for investing the 33% of the funds.

For the suggested structure, the Equity IRR for the private investor DP Rollco has been estimated based on the following assumptions:

Parameter	Unit
Debt Equity structure of Private partner (after reduction of Capital Grant)	70:30
Interest Rate	10%
Moratorium Period/ Repayment Period	3Years/ 20Years
Capital Grant for Initial investment	20% (Rs 12663 mil)

The Equity IRR estimated for the private investor is 14.02%. In this scenario, the Government shall have to pitch in an additional grant of Rs 12663 million.

In case of a positive grant required by DP Rollco, the funding from the government for the project would increase to the extent of the amount of grant provided. The table below presents the various scenarios of grant and the respective total funds required from the government including the grant for DP Rollco

Scenarios for Grant (%)	Grant (Rs Mil)	Investment from DP Infraco (Rs Mil)*	Total from Government (Rs

			Mil)
0%	0	51071	51,071
5%	3166	51071	54,237
10%	6331	51071	57,402
15%	9497	51071	60,568
20%	12663	51071	63,734

*As presented in Table Table 5-15

0.26 Economic Internal Rate of Return (EIRR)

The benefits vehicle operating cost savings, time savings due to increased speed and environmental benefits with improved environment are added together to get the total savings.

For the proposed project, benefits from following were assessed:

- Savings in Fuel Consumption
- Savings in Vehicle Capital Costs
- Savings due to reduced Environmental Pollution
- Savings in Travel Time
- Savings in Road Construction costs
- Accident cost

The rate of return considered desirable for the transport infrastructure project in India is 12 percent. As EIRR of proposed RRTS facility is 26.92 %, which is above 12 percent cut-off rate, the project is economically viable.

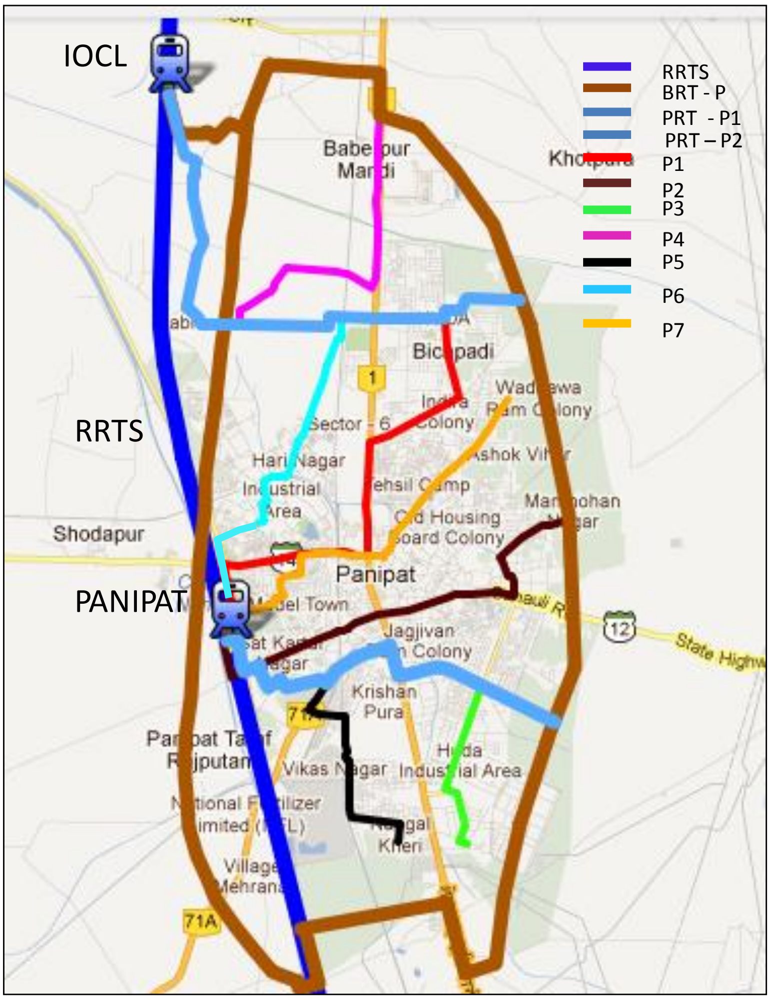
0.27 Feeder Network and Traffic Integration

This study identifies passenger's desire pattern's, distribution of residential and economic centre's in the influence area of each RRT station and define potential feeder services that could be provided to connect these nodes efficiently in conjunction with the RRT services. The Study has following components:

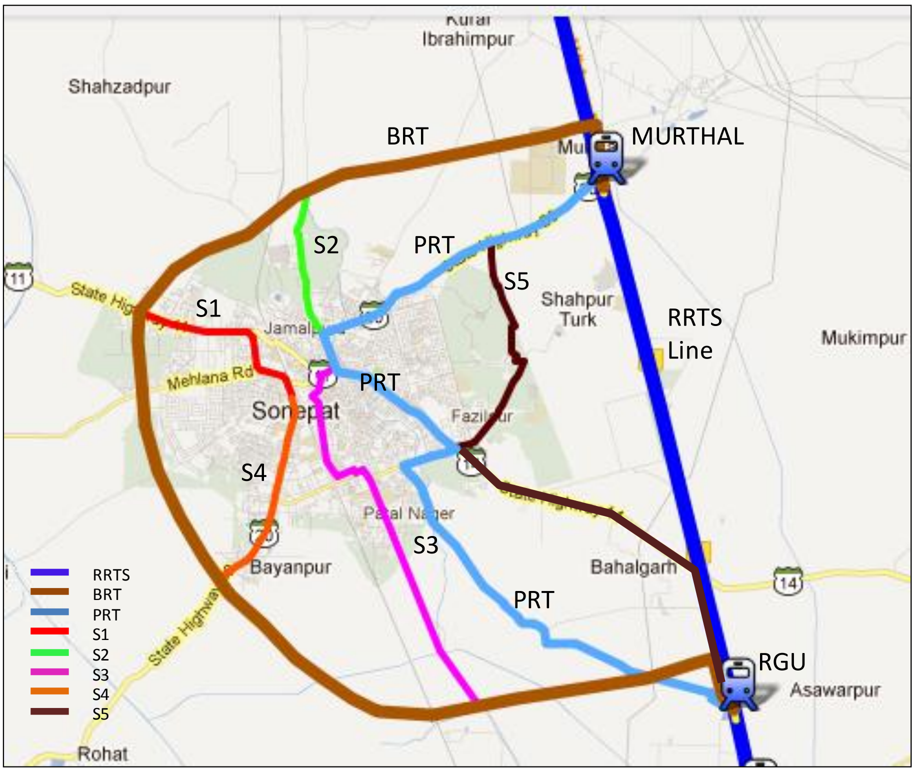
1. Review of RRT station connectivity's and identification of catchment area for major stations
2. Review and identifications of major traffic production/attraction centre's in catchment area
3. Review of Existing and proposed Bus Routes in catchment area
4. Suggest new Feeder Routes connecting major catchment area nodes not covered by existing system

5. Suggest any new system if required for integrating feeder services to the RRT station
6. Plan for complete Integrated Public Transport Network for Panipat and Sonepat region.

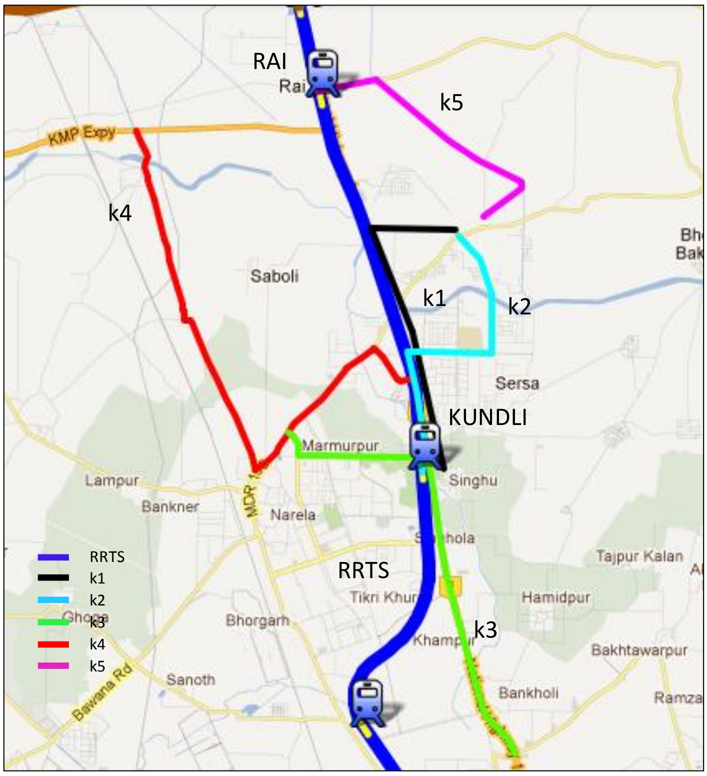
Proposed integrated network for Panipat is presented below



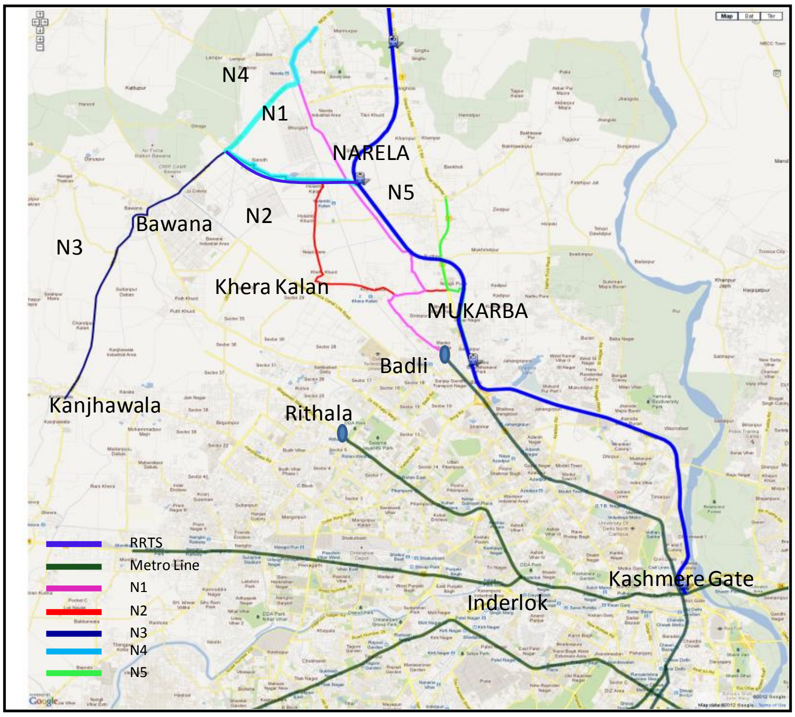
Proposed network for Sonepat is presented in figure below



Proposed network for Kundli region is presented below



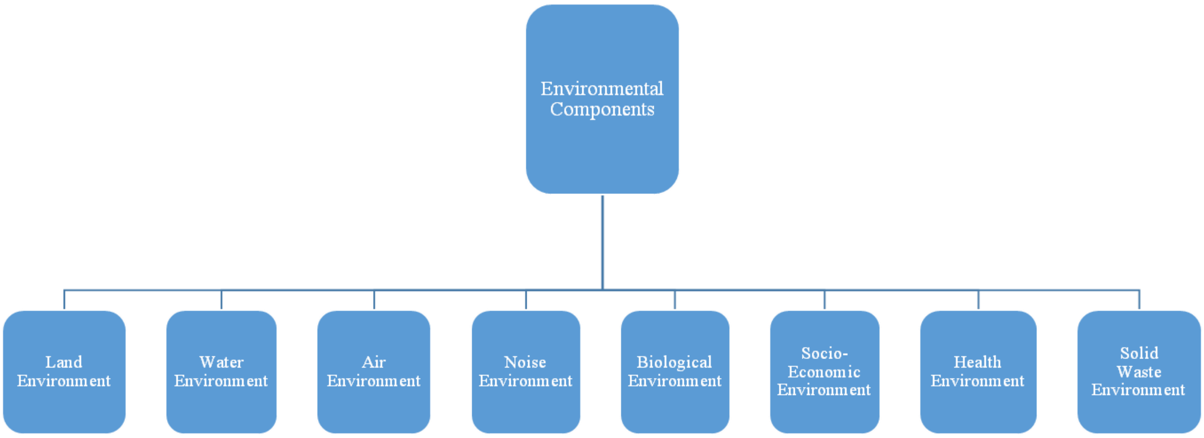
Proposed feeder network for Delhi region is presented below



The main thrust has been that providing feeder system to the main trunk line of RRT system cannot, by itself lead to a more efficient transit system. Integrating different types of modes, increases the seat-miles offered as a result of employing the most adapted and effective mode in each segment of the network. Transit modes should be made more attractive to choice-riders. Therefore, planning a feeder system to serve a RRTS can only be viewed as one component of a comprehensive transportation policy designed to shift the modal- split in favor of transit. The formulation and implementation of similar plans require the cooperation and coordination between various departments and agencies in each city/towns.

A good, easy access to the RRT system and an efficient dispersal system for the passengers at the station is crucial for choice of the commuter to ride the RRTS. The integrated multi modal transport feeder system proposed for Panipat includes at grade BRT System of 42km, elevated BRT/ PRT for 17.0km length and the rest with 40.5 km of feeder bus system. The total block cost for the infrastructure required is expected to be Rs 1730 crores. The block cost estimates for the infrastructure required for Sonepat is expected to be Rs 1413 crores. A total of Rs 3143 crores will be required to build the new infrastructure in the two regions of Panipat and Sonepat.

0.28 Environmental Impact Assessment



Environmental Management Plan

With the objective of minimizing the negative impacts and optimizing the positive benefits of the RRTS project, a comprehensive **Environmental Management System (EMS)**is drawn up. For details the detailed report on EIA may be referred to.

An environmental management system (EMS) should have various basic elements ascertaining the concern of the proponent namely,

- Commitment and Policy
- Planning,
- Implementation,
- Measurement and Evaluation,
- Review and Improvement.

Design Phase

- Land Acquisition
- Green Cover Management Plan
- Air Pollution
- Noise Management Plan
- Water Management Plan
- Avoidance of Nuisance
- Soil Management Plan
- Public Utility Management Plan
- Traffic Diversions
- Labour Management Plan

Operation Phase

- Water Quality
- Vibration Management Plan
- Safety Management
- Fire Management Plan
- On-Site Emergency Plan
- Off-Site Emergency Plan

Environmental Monitoring Programme

Monitoring of environmental factors and constraints will enable agencies to identify the changes in the environmental impacts at particular locations, application of mitigative measures and utilization of standard design guidelines for finalization of alignment design. Monitoring will also ensure that actions taken are in accordance with the construction contract and specifications. It provides a basis for evaluating the efficiency of mitigation and enhancement measures, and suggests further actions needed to be taken to achieve the desired effect.

To ensure the effective implementation of the EMP it is essential that an effective monitoring program be designed and carried out.

The monitoring includes:

- visual observations
- selection of environmental parameters at specific locations
- sampling and regular testing of these parameters

0.29 Social Impact Assessment and R&R

Land acquisition details

S No.	Impacts		No.
1	Land Acquisition Ha (including depot area)		**440.98**
2	Total Residential structure affected	249	
3	Total commercial structures affected	50	
4	Total Residential cum commercial structures affected	32	**331**
5	Total community (CPRs)		**106**
6	Total no. of DP		**1324**

Budget

S. No	Item	Amount (Crore)	Amount (Rs Mil)
1	Private Land Acquisition Cost	2144.31	21443
2	Government Land Cost	1183.46	11835
3	Structure Cost	5.14	51
4.	Community Structure Cost	2.48	24
5	R&R Assistance Cost	9.07	91
6	**Total**	**3344.46**	**33445**

0.30 Construction Method and Commissioning schedule

The programme assumes that the Award of Contract in is April 2014 with a Commercial Operating Date (COD) (Railway Opening) in October 2018.

The detailed commissioning schedule is presented along with draft DPR as an Annexure.

0.31 Identification of Utilities to be diverted

Utilities that are falling on the alignment have been identified and mapped on the alignment. The following utilities have been identified and mapped:

- Crude Gas Pipeline
- Electric Lines
- Sewage Lines
- Telecommunications Network
- Water Pipelines & Tubewell/wells

The detailed drawings are submitted as separate volumes/ reports along with this draft DPR.

0.32 Discussion with Stakeholders

As per the Minutes of Meeting issued on 02.05.13 of Consultancy Review Committee (CRC)/ Sub-committee to Task Force meeting held on 17.04.13, it has been decided and conveyed to the consultants that the milestone for Stakeholder Workshop for the project has been shifted after the submission of Draft DPR. Thus the report on discussion with stakeholders would be delivered after the Stakeholder Consultation during the submission of Final DPR stage.

0.33 Station yard Plan and changes

The RRTS Delhi Panipat alignment has been designed as a separate alignment. The utilization of existing railway land/ tracks were found to be not feasible during the course of the study.

Since the RRTS is designed as a new system separate from the existing Indian Railway system, a detailed station plan study including Urban Design has been conducted and a separate report "Urban Design Study" has been submitted during the feasibility stage. This report may be referred to for any further information.

0.34 Recommendations and Way Forward

The project is expected to be taken forward by NCRTC for implementation and operations. However, the role envisaged for NCRTC is not limited to Delhi-Panipat RRTS and is far wider in terms of development of transit infrastructure in NCR besides development of all RRTS projects.

Team for NCRTC would need to have following professionals:

- Finance professionals for implementation and operation phase
- Planning professionals for development of RRTS corridor
- Engineering professionals for implementation of RRTS projects
- Operations professionals from Engineering and other backgrounds

Apart from this there would be requirement of expertise and personnel related to areas such as transaction advisory, design and project management mainly during the project implementation phase.

Equity Contribution by Stakeholders

Based on structure of NCRTC, it is understood that the contribution between the Centre and State Governments shall be in the proportion of 50:50 to finance the government's equity contribution for the project cost.

To decide the basis of equity contribution from each state in a project, alternatives evaluated were based on (a) equal percentage (50% each), (b) route length passing through each state and (c) investment on RRTS project in each state.

Route length does not always reflect the extent of investment required, since the number of stations, alignment location (at grade, underground, elevated), land cost are also an important criteria. Typically a heavily built up area requires an underground system.

In case route length is used as the sole criteria, the states may decide to push in more length underground through their respective areas, which may reduce the overall viability of the project. Similarly, the states may demand additional number of stations since cost sharing is based on route length.

Based on aforesaid argument, we recommend that equity contribution could be made by states in the terms of estimated investment. The present report provides on the estimate of investment in each state and this could be further refined during the construction stage.

Options for Project Structure

Based on the scope of work envisaged, NCRTC could:

(A) Either deliver the entire scope of work on its own or

(B) Seek participation in delivery of the projects.

The former is not the most recommended option even though it has its advantages as described in the following paragraph.

The advantage of NCRTC taking up RRTS projects on its own would be a clear command and control wherein based on stakeholders decision and funds availability, the projects could be implemented swiftly. NCRPB / NCRTC could therefore explore the possibility of delivering the first project as a pilot project under the aforesaid model as adopted by DMRC.

However, as a long term option PPP structure would need to be explored, where part of the work responsibility financing and risks are shared with a suitable private developer.

Possible Options under PPP Structure

NCRTC could invite private investors either at the implementation stage or at the operations stage of the projects. Since it would be possible to invite the private operators at any point during the project operations phase, the advantages of involving private investors at project implementation stage are being discussed in this report.

For Rail based Urban Transit Project, the basic philosophy of separation of civil construction and other infrastructure development from Rolling Stock and Operation remains strong for PPP projects.

The options available with NCRTC for structuring the project under PPP mode are:

- Option 1 - NCRTC to undertake construction of civil structures under EPC contracts with rolling stock brought in by the Concessionaire (DP Rollco) or
- Option 2 - The Concessionaire (DP Rollco) undertakes the entire project on its own.

Option 2 can be implemented wherein DP Rollco is initially paid for civil construction based on predetermined milestones. Structuring the project under Option 2 would have advantages in terms of involvement of the private partner right through design and construction and thus reducing these risks that could cause irreparable damage to the project.

However for this project considering the amount of investment required, considering the risks related to construction, financing, land acquisition and administration issues, whether the market has sufficient depth to deliver such a project may be doubtful.

The Option 1 which would even though increase the requirement of coordination between NCRTC and DP Rollco would be better for comparatively less risk taking developers/ conservative developers.

Also in case of option 1, the bidding criteria would be far easier to define and understand since the cost of rolling stock and operations can be estimated and the construction cost and time related risks would be passed on to NCRTC.

Based on inputs from potential developers, NCTRC could take appropriate decision on the matter. In our opinion, Option 1 i.e. NCRTC undertaking civil and other infrastructure related implementation may be more feasible option as compared to the option 2 i.e. DP Rollco implementing the entire project on its own.

As a bidding tool, the 10% stake in DPRollco by NCRTC could be used by way of positive or negative valuation for nominal 10% of DPRollco.

Raising of Financial Resources

To raise financial resources three pronged strategy needs to be followed:

- Commencement of negotiations with financial institutions and Government of India for obtaining soft loan.
- Finalizing equity contribution plans with state governments
- Implementation of Transit Oriented Development Zones

Declaration of Transit Oriented Development zones and Land Availability

The actions which need to be taken related to ToD are:

a. Preparation of Development Plans based on ToD Areas within a timeframe say 3 months
    - Conduct Survey to mark land boundary, existing physical features - topography, slope, plot boundaries, existing structures.
    - Establish ownership of land by using revenue records.
    - Prepare detailed Development Plans including recommendations on FAR.
    - Superimpose Development Plan on Survey Maps.
    - Make provisions for RRTS infrastructure facilities, roads, dedicated bus corridors, subways, water, electricity, sewage, drainage, solid waste management, green areas, social areas and other special requirements.
    - Calculate total area required for infrastructure.
    - Reconstitute the remaining area.

b. Legislation for collection of TOD Betterment Charges/levies cess from ToD areas.

c. Land acquisition where required for the project infrastructure area.

d. Identification and marking of alignment on the green belt in Haryana.

e. Land pooling activities as defined below:
    - Respective State Government identifies area for Land Pooling
    - State Government nominate an Agency (A development authority, corporation, any other agency)
    - Agency appoints a Development Officer
    - Development Officer prepares detailed layout plan
    - Development Officer invites objections from land owners
    - Development Officer, based on review of objections, makes necessary revisions

- Authority, recommends to the state government for notification
- Develop major infrastructure

Financial compensation/ collection from land owners done by the Authority

1 FINANCIAL VIABILITY ASSESSMENT ASSUMPTIONS AND BOUNDARY CONDITIONS

1.1 Project timelines

1.1.1 Assumptions

Assumptions related to the timelines of the project considered for the assessment of the financial viability of RRTS project are presented in the table below:

Table 1-1 : Assumptions - Timelines

Sr. No.	Particulars	Value
1	Base year for cost estimation	2013
2	Award of contract	October 2014
3	Years of construction	4
4	Commercial operation date (COD)	1st October 2018
5	Operations Period for financial analysis/ Concession period	30 years
6	End of operations period for financial analysis/ end of concession period	30th September 2048

1.2 Phasing of Initial Capital Investment

It has been proposed that the Land acquisition and Rehabilitation & Resettlement (R&R) shall be completed in the first two financial years of construction (Oct 2014 to March 2016). Activities such as Civil works, alignment and formation, overhead station buildings, underground station buildings and procurement of rolling stock shall be undertaken during first three years of construction. Establishment of power supply & substation and control systems has been proposed between third and fourth year of construction. Miscellaneous works spread out over the four construction period.

The phasing of capital investment is as given below.

Table 1-2 : Implementation Phasing Plan

Sr. No.	Particulars	FY15 (Oct 14 – March 15)	FY16	FY17	FY18	FY19 (Apr 18-Oct 18)	Total
1	Land	33.33%	66.67%				100%
2	Civil works, Alignment and formation	12.5%	30%	37.5%	20%		100%
3	Overhead Station Buildings	10%	30%	40%	20%		100%
4	Underground Station Buildings	10%	30%	40%	20%		100%
5	Depot cum Workshop		32.5%	50%	17.5%		100%
6	Power Supply and Substations			42.5%	50%	7.5%	100%
7	Control Systems			40%	50%	10%	100%
8	R&R	33.33%	66.67%				100%
9	Miscellaneous	12.5%	25%	25%	25%	12.5%	100%
10	Rolling Stock	16.5%	33%	33.5%	17%		100%

1.3 Taxes and Duties

As the value of the central and state level taxes would depend on the actual amount of imports, indigenous products and services used for the project at the time of implementation, the level and rate of Custom duty, Excise duty and VAT have been assumed as per the standards followed in other similar projects in the country for example Delhi Metro project Phase III. The following table presents the rates taken for the central and state taxes:

Table 1-3 : Details of Applicable Rate of Taxes and Duties

Sr. No.	Particulars	Rate (%)
1	Custom Duty	18.6%
2	Excise duty	8.2%
3	Value Added Tax	12.5%

1.4 Financial & Taxation assumptions

Some of the key financial assumptions are given in the table below:

Table 1-4 : Key Financial Assumptions

Sr. No.	Particulars	Value
1	Inflation rate	5%
2	Discount rate	10%
3	Tax rate	32.45%
4	MAT	20.01%
5	80IA benefit taken from date	From COD
6	Tax holding in a block of 15 years	10 years
7(a)	Extent of Term Loan as a % of total project cost (Multilateral Funding) – In case the project is implemented by a Govt owned agency/ NCRTC	60%
7(b)	Extent of Term Loan as a % of total project cost (Multilateral Funding) – in case the project is implemented under PPP route	40%
8	Interest rate on term Loan	2%
9	Term period	20 years
10	Moratorium	Nil
11	Interest rate on future capital expenditure	10%
12	Debt equity structure for future capital expenditure	80:20
13	Repayment period for future capital expenditure	10 years

Standard taxation workings at the prevailing rates have been assumed for the financial analysis. Provision under section 80 I (A) has been considered as the project qualifies for such benefits.

1.5 Depreciation Rates

Standard depreciation workings at the prevailing rates have been assumed in the financial model. The pre-operative expenses and interest during construction are capitalized and amortized over the period of project period for depreciation purpose.

Table 1-5 : Applicable Depreciation Rates

Sr. No.	Depreciation rates	SLM for accounts (%)	WDV for taxation (%)
1	Land	0%	0%
2	Civil works & buildings	1.67%	10%
3	Rolling stock	3.17%	15%

4	Electrical works	7.07%	15%
5	Track work	1.63%	15%
6	E&M works	4.75%	15%
7	Lifts & Escalators	3.17%	15%
8	Signaling	4.75%	15%

1.6 Working Capital Assumptions

Assumption related working capital estimation is as set out below.

Table 1-6 : Working Capital Assumptions

Sr. No.	Depreciation rates	Value
1	Accounts Payable	30 Days
2	Minimum Cash Requirement	1%
3	Working Capital Margin	25%
4	Interest Cost on Bank Borrowing	10%

2 REVENUE ESTIMATION

2.1 Key Revenue Avenues

The project revenue has been estimated from two broad categories namely:

- Fare Box revenue
- Other sources – Revenue from rentals from commercial, transit oriented development, Advertisement, etc.

The section below describes the details of revenue estimated from the above identified sources for the lifecycle of the project.

2.2 Fare Box Revenue

The estimation of Fare Box revenue has been estimated under different scenarios by varying the following factors:

- Fare Structure – various scenarios under fare structure have been considered including Telescopic and Non-telescopic fares, consideration of monthly pass fare, along with year on year rate of increase in the fare to account for inflation.

- Ridership –Sensitivity of fare box revenue to the overall ridership has been explored under various scenarios.

2.2.1 Fare Structure

The fare structure has been proposed considering the following factors:

- The traffic survey for the study was conducted in 2010. The fare structure has been decided based on the outcome of traffic survey scenarios and comparison with fare structure of various modes of public transport between Delhi Panipat in 2010.
- The table below presents the 2010 fares of various modes of public transport that are currently operating in Delhi Panipat region along with approximate time taken to travel by these modes

Table 2-1 : Mode wise Comparison of Existing Fare Structure (Year 2010)

Sr. No.	Mode	Delhi – Panipat fare (in Rs.)	Journey Time	Remarks
1	EMU – Passenger	Rs 15	2-2.5hrs	
2	Kalka Shatabdi (AC Chair Car)	Rs 285 (actual) Rs151 (Prorated)	70-80 mins	Rs 151 fare is prorated based on distance on Delhi Chandigarh full fare

Sr. No.	Mode	Delhi – Panipat fare (in Rs.)	Journey Time	Remarks
3	Jan Shatabdi (AC Chair Car)	210	85 mins	
3	State Transport bus (Non AC)	65 (approx)	1.5 – 2 hrs	
4	State Transport AC Volvo Bus	200 (approx)	1.5 hrs	

- *Passengers' willingness to shift from their current mode of transport to RRTS* – As indicated in the travel demand forecast section of this report, the passenger willingness to shift has been conducted at three different price points of Rs 50, Rs. 100 and Rs. 150. As suggested by the Travel demand forecast survey conducted in year 2010, the commuters travelling by personal vehicle (primarily cars and taxis) have shown highest willingness to shift making them one of the prime target customers of RRTS. Also daily commuters travelling by state transport (Non AC) buses would also be willing to shift considering the saving in journey time achieved by shifting from bus to RRTS.

The table below provides the distance matrix used for deriving the fare between stations.

Table 2-2 : Distance between Stations

KM	Kashmere (	Mukharba	Narela	Kundli	KMP EH	RGEU	Murthal	Ganuar	samalkha	Panipat	IOCL
Kashmere Gate	0	14	23	28	36	38	48	63	72	90	99
Mukharba Chowk	14	0	9	15	23	24	34	49	58	76	85
Narela	23	9	0	6	14	16	25	40	50	67	76
Kundli	28	15	6	0	8	10	20	34	44	62	71
KMP EH	36	23	14	8	0	2	12	26	36	54	63
RGEU	38	24	16	10	2	0	10	24	34	52	61
Murthal	48	34	25	20	12	10	0	15	24	42	51
Ganuar	63	49	40	34	26	24	15	0	10	27	37
samalkha	72	58	50	44	36	34	24	10	0	18	27
Panipat	90	76	67	62	54	52	42	27	18	0	9
IOCL	99	85	76	71	63	61	51	37	27	9	0

Fare Structure for full one way fare Delhi – Panipat City

Considering the above factors a fare of Rs 100 (for FY 2011) is proposed between Kashmere Gate station and Panipat City station. The fare for Delhi to IOCL Panipat has been calculated on prorate basis, based on distance. This fare is calculated as Rs 110. The fare for subsequent years has been proposed to be increased at a nominal rate 5% per annum for the entire period of the project. Accordingly the actual full fare for FY2019 (i.e. the proposed first year of operations for the RRTS project) is projected at Rs 148/ ticket between Kashmere to Panipat City.

Fare structure for intermediate stops

It has been observed that in other similar projects like Delhi Metro or AC fare of Shatabadi trains of Indian Railways, Telescopic fare structure has been adopted. A similar structure is proposed for Delhi Panipat RRTS. It has been assumed that the minimum fare for a single journey would be kept at 25% of full fare between Kashmere

Gate and Panipat City station. Beyond this the fare would be prorated based on distance between the boarding and alighting stations.

The table below provides the fares between the stations based on telescopic fare structure (for FY2011), minimum fare 25% of Delhi Panipat City Fare (Rs 100)

Table 2-3 : Station wise Proposed Telescopic full fare for FY 2011

Rs/ticket	Kashmere G	Mukharba C	Narela	Kundli	KMP EH	RGEU	Murthal	Ganuar	samalkha	Panipat	IOCL
Kashmere Gat	0	25	25	32	40	42	53	70	80	100	110
Mukharba Ch	25	0	25	25	25	27	38	54	65	85	95
Narela	25	25	0	25	25	25	28	44	55	75	85
Kundli	32	25	25	0	25	25	25	38	49	68	79
KMP EH	40	25	25	25	0	25	25	29	40	60	70
RGEU	42	27	25	25	25	0	25	27	38	58	68
Murthal	53	38	28	25	25	25	0	25	27	47	57
Ganuar	70	54	44	38	29	27	25	0	25	30	41
samalkha	80	65	55	49	40	38	27	25	0	25	30
Panipat	100	85	75	68	60	58	47	30	25	0	25
IOCL	110	95	85	79	70	68	57	41	30	25	0

Fare structure for monthly pass passengers

It has been observed that there are many passengers commuting between Delhi Sonepat and Delhi Panipat on a daily basis. For the benefit of such commuters and for assisting their shift to the RRTS from their current modes of travel, a monthly pass fare is also suggested. A rebate of 25% on the journey fare is considered for the commuters opting for the monthly pass. Thus the Delhi – Panipat city one way fare considered for monthly pass passengers is Rs 75.

The table below provides the monthly pass fares between the stations based on telescopic fare structure (FY 2011 fare), minimum fare 25% of Delhi Panipat City Fare (Rs 75)

Table 2-4 : Station wise Proposed Telescopic Fare for monthly pass for FY2011

Rs/ticket	Kashmere Gate	Mukharba Chowk	Narela	Kundli	KMP EH	RGEU	Murthal	Ganuar	samalkha	Panipat	IOCL
Kashmere Gate	0	19	19	24	30	32	40	52	60	75	83
Mukharba Chowk	19	0	19	19	19	20	29	41	49	63	71
Narela	19	19	0	19	19	19	21	33	41	56	64
Kundli	24	19	19	0	19	19	19	28	36	51	59
KMP EH	30	19	19	19	0	19	19	22	30	45	52
RGEU	32	20	19	19	19	0	19	20	28	43	51
Murthal	40	29	21	19	19	19	0	19	20	35	43
Ganuar	52	41	33	28	22	20	19	0	19	23	30
samalkha	60	49	41	36	30	28	20	19	0	19	22
Panipat	75	63	56	51	45	43	35	23	19	0	19
IOCL	83	71	64	59	52	51	43	30	22	19	0

2.2.2 Ridership Estimation

The ridership of RRTS Delhi Panipat corridor has been estimated in detail under various scenarios of speed, waiting time and fare structure.

As per the detailed engineering study, the RRTS is proposed to have an operating average speed of 160km/h. By running a simulation on MTrail simulation Software it has been found out that for Delhi Panipat stretch with 160kmph average speed and train stopping at all intermediate stations, the one way journey from Kashmere Gate station to Panipat City station shall be completed in approximately 74 mins. Also the frequency of trains as per the detailed train schedule as given in Engineering and Operations report ranges from 4.5mins in 2018 to 2.5 mins in 2041 between Kashmere Gate and Gannuar. This would translate to an average waiting time of nearly 2.5 mins for the passengers.

Considering the above, the table below provides the daily ridership of RRTS between Delhi and Panipat for variables namely, (a) Full Fare for FY2011(Kashmere Gate – Panipat City) = Rs. 100; (b) Concessional fare/ monthly pass fare for FY2011 (Kashmere Gate – Panipat City) = Rs 75 (c) Travelling time from KG to Panipat city = 74mins and (c) waiting time of 2.5 mins

Table 2-5 : Estimated daily Ridership

Year	Total ridership (in lakhs per day)
2018	4.38
2021	5.47
2031	7.79
2041	9.83

The daily ridership for years in between 2018, 2021, 2031, 2041 and for the years beyond 2041 has been calculated by interpolation/ extrapolation of these ridership forecasts.

2.2.3 Revenue Estimation

The following key assumptions have been used to arrive at the yearly revenues for the project

- Two separate fares (no concession full fare and concessional monthly pass fare) have been used for revenue estimation.
- Ramp up Rates: In addition to above a ramp rate of 50%, 70%, 80% and 90% has been taken in the first four years of operations to account for any possibility of low ridership during the initial years of the operations.
- An escalation of 5% per annum has been assumed in the fare structure for the entire concession period.

Based on the fare and ridership estimate as discussed in the articles above, the table below summarizes the yearly revenue estimate from FY 2018-2019 till 20047-48.

Table 2-6 : Estimated Yearly Fare Box Revenue

Sr. No.	Financial Year	Yearly Fare Box Revenue (Rs. Millions)
1	FY-2019*	2468
2	FY-2020	7579
3	2021	9825
4	2022	12536
5	2023	15104
6	2024	16378
7	2025	17760
8	2026	19258
9	2027	20882
10	2028	22644
11	2029	24554
12	2030	26626
13	2031	28872
14	2032	31307
15	2033	33619
16	2034	36102
17	2035	38768
18	2036	41630
19	2037	44704
20	2038	48006
21	2039	51550
22	2040	55357
23	2041	59445
24	2042	63835
25	2043	68548
26	2044	73610
27	2045	79046
28	2046	84883
29	2047	91151
30	2048	97882

*considering 6 months operations in FY19

2.3 Other Revenue Sources

Besides farebox revenue, other potential sources of revenue have been identified. The identified sources are

a) Commercial Areas in station building complex
b) Advertisement Panels
c) TOD zones

2.3.1 Commercial Area in station building complex

For development of commercial area at each stations due care has been given to the factors such as

- location of station– commercial potential
- type of stations – elevated and underground
- area at concourse level
- land availability
- Current rental values in the city and rent escalation potential
- State/ district development plans

Suitable values for occupancy rate and increase in rental values per annum (assumed 5%) etc., have been taken to have a realistic estimate of the revenue potential of the commercial areas at the stations. It has been assumed that the occupancy would increase at a rate of 30% per annum after Commercial Operation Date (COD) of the project depends on the station location.

The table below gives the details of areas to be developed at each station for commercial exploitation along with assumed rental value and other parameters.

Table 2-7 : Station wise Property Development Proposed

Sr. No.	Stations	Commercial area in station building (Sqm)	Retail area in secondary building (sqm)	Rental value (Rs/ sqm) Year 2013	Starting occupancy (%)
1	Panipat IOCL	52486	0	220	40%
2	Panipat City	85285	0	330	50%
3	Samalkha	26696	0	165	40%
4	Gannaur city	27483	0	165	40%
5	Gannaur depot	52486	0	165	40%
6	Murthal	7932	17058	220	50%
7	RGEU	46591	13570	220	40%
8	KMP interchange	36205	13570	220	40%

9	Kundli	20251	6216	220	50%
10	Narela	84042	0	220	40%
11	Mukarba Chowk	3658	17025	330	50%
12	Kashmere Gate	382		330	60%

2.3.2 Advertisement Panels

The potential sources for revenue from advertisement on RRTS Delhi Panipat corridor shall be as follows:

- Advertisement panels inside the 12 proposed station locations
- Advertisement panels inside and outside the train
- Advertisement on viaduct at potential places wherever possible.
- Digital displays inside the stations and trains.

As most of the Delhi Panipat line passes through virgin areas the advertisement revenue potential does not have a benchmark for estimation. Considering this we have taken a conservative view on the revenue estimates from advertisement. The revenue from advertisement has been kept at 1% of the farebox revenue for each respective year.

The table below provides the details of revenue from rentals on commercial areas inside the station buildings and secondary buildings and the revenue from advertisement.

2.3.3 Revenue Estimates from Commercial and Advertisement

Table 2-8 : Commercial and Advertisement Revenue

Sr. No.	Financial Year	Commercial and Advertisement Revenue (Rs. Millions)		
		Revenue from station commercial and other commercial areas around stations	Advertisement Revenue	Total
1	FY-2019*	797	25	822
2	FY-2020	1088	76	1164
3	2021	1486	98	1584
4	2022	1946	125	2072
5	2023	2206	151	2357
6	2024	2316	164	2480
7	2025	2432	178	2610

Sr. No.	Financial Year	Commercial and Advertisement Revenue (Rs. Millions)		
8	2026	2554	193	2746
9	2027	2682	209	2890
10	2028	2816	226	3042
11	2029	2956	246	3202
12	2030	3104	266	3370
13	2031	3259	289	3548
14	2032	3422	313	3735
15	2033	3594	336	3930
16	2034	3773	361	4134
17	2035	3962	388	4350
18	2036	4160	416	4576
19	2037	4368	447	4815
20	2038	4586	480	5066
21	2039	4816	516	5331
22	2040	5056	554	5610
23	2041	5309	594	5904
24	2042	5575	638	6213
25	2043	5853	685	6539
26	2044	6146	736	6882
27	2045	6453	790	7244
28	2046	6776	849	7625
29	2047	7115	912	8026
30	2048	7471	979	8449

2.4 Transit Oriented Development Zones

A transit-oriented development (TOD) is a mixed-use residential or commercial area designed to maximize access to public transport, and often incorporates features to encourage transit ridership. A TOD neighborhood typically has a center with a transit station or stop (train station, metro station, or bus stop), surrounded by relatively high-density development with progressively lower-density development spreading outwards from the center.

2.4.1 Potential TOD area statement

The table below summarizes the TOD area and provides the details of the TOD zones and area considered for further analysis in the business plan report.

Table 2-9 : Potential TOD area statement

Sr. No.	TOD Zones	Potential Area marked on Map (Ha)- *(subject to change after discussions with state Govt.)*	Area taken for analysis in Business Plan (Ha)	Proposed Land use
1	IOCL Panipat Depot	1090	600	Mixed
2	Samalkha	525	300	Mixed
3	Gannaur Depot	1085	600	Mixed
	Total	**2700**	**1500**	

We have taken a conservative view on collection of revenues in form of TOD betterment charges from the potential TOD area and have only taken 1500 hectares for revenue calculations in the business plan out of 2700 hectares identified. This gives enough room for adjustment or any downside in revenues arising out of TOD.

According to latest guidelines from UTTIPEC regarding Transit Oriented Development, the density of a TOD zone can range between 600-800 dwelling units with an FAR of 3-4. Hence it is assumed that the TOD zone will be a high population density. Out of the total 1500 hectares land area, 60% of the area proposed for development in terms of the table given below.

Table 2-10 : Proposed Built-up area in TOD zones

Sr. No.	Description	%	Developed Area	FAR	Built-up Area
1	Total Area	1500 ha			
2	Developed Area	60%			
a	Residential	30%	450 Ha	3	1350 Ha
b	Commercial	10%	150Ha	3	450 Ha

c	Office	20%	300 Ha	4	1200 ha
d	Green Area / Roads/Common area /others	40%	600 Ha	-	-

2.5 TOD Betterment Charges

Development strategy

Due to the RRTS project the value of land and value of the built-up area would increase in these proposed TOD zones and adjacent influence areas. Further velocity of transaction would be very high due to the speculation in this zone. To raise funds required for development of the project, it is proposed that the state government should levy TOD betterment charges on each property transaction both on land and built up area in the aforesaid TOD zones. Following rates have been used in this draft DPR that could be charged at the time of registration of property from the buyers/sellers.

Table 2-11 : Proposed TOD Betterment Charges Rate

Sr. No.	Description	Unit	Rate
			Rupees
1	Land /Site/Plot	Per sq.m / transaction	1,000
2	Developed Area		
a	Residential	Per sq.m/ transaction	1,000
b	Commercial	Per sq.m/ transaction	2,000
c	Office	Per sq.m/ transaction	1,500

It is assumed that towards completion of construction of RRTS the velocity of transaction would increase from 5% to 20%. To estimate the total betterment charges generated from TOD area following formula adopted;

Total TOD betterment charges for the year = Rs. 1,000 per sqm per transaction X Total TOD area X velocity of transaction for the corresponding year.
The TOD betterment charges could be applied within 3 months of the release of this Report to capture the initial burst of Capital inflow into the TOD zone. This amount during construction of the project could be utilized towards state government's equity contribution for the project. Further it is assumed that the state government would come out with development plan for TOD area within next six months itself.
Following table provides year wise estimated TOD betterment charges during the construction period.

Table 2-12 : Estimated TOD betterment charges during Construction

Sr. No.	Year	Velocity of Transaction	Built up Area	Total Cess
		%		Rs. Million
1	2014	5%	3000 ha	750
2	2015	10%	3000 ha	1500
3	2016	20%	3000 ha	3000
4	2017	20%	3000 ha	3000
5	2018	20%	3000 ha	8100
	Total			**16350**

Similarly, total TOD betterment charges estimated during the operations period of the project till 2048 based on the assumed velocity of transaction for the corresponding year and type of use (built-up area) and applicable rate of betterment charges for each type of usage (residential/commercial/office) as provided in the proposed table above has been calculated. The velocity of transactions has been assumed such that immediately after commissioning of the project higher number of transactions are expected (20%) and after a period of time this could reduce gradually towards the end of the project period (5%).

The table below gives the detailed year wise estimated revenue from TOD betterment charges and the total amount of fund generated upto FY 2048. The funds collected would be used to repay the soft loan including interest and principal.

Table 2-13 : Estimated TOD betterment charges during Operations

Sr. No.	Year	Velocity of Transaction	Residential	Commercial	Office	Total TOD betterment charges
		%	Rs. Million			
			@Rs.1000	@Rs.2000	@Rs.1500	
1	2019	15%	2025	1350	2700	6075
2	2020	15%	2025	1350	2700	6075
3	2021	15%	2025	1350	2700	6075
4	2022	14%	1890	1260	2520	5670
5	2023	14%	1890	1260	2520	5670
6	2024	14%	1890	1260	2520	5670
7	2025	13%	1755	1170	2340	5265
8	2026	13%	1755	1170	2340	5265
9	2027	13%	1755	1170	2340	5265
10	2028	12%	1620	1080	2160	4860
11	2029	12%	1620	1080	2160	4860

Sr. No.	Year	Velocity of Transaction	Residential	Commercial	Office	Total TOD betterment charges
		%	Rs. Million			
12	2030	12%	1620	1080	2160	4860
13	2031	11%	1485	990	1980	4455
14	2032	11%	1485	990	1980	4455
15	2033	11%	1485	990	1980	4455
16	2034	10%	1411	941	1881	4232
17	2035	10%	1340	893	1787	4021
18	2036	9%	1273	849	1698	3820
19	2037	9%	1210	806	1613	3629
20	2038	9%	1149	766	1532	3447
21	2039	8%	1092	728	1455	3275
22	2040	8%	1037	691	1383	3111
23	2041	7%	985	657	1314	2956
24	2042	7%	936	624	1248	2808
25	2043	5%	889	593	1185	2667
26	2044	6%	845	563	1126	2534
27	2045	6%	802	535	1070	2407
28	2046	6%	762	508	1016	2287
29	2047	5%	724	483	966	2173
30	2048	5%	688	459	917	2064

Following table provides summary of revenue streams and total estimated project revenues for FY2020 (first full stable year of operations), FY2021, FY2031, FY2041 and FY2046.

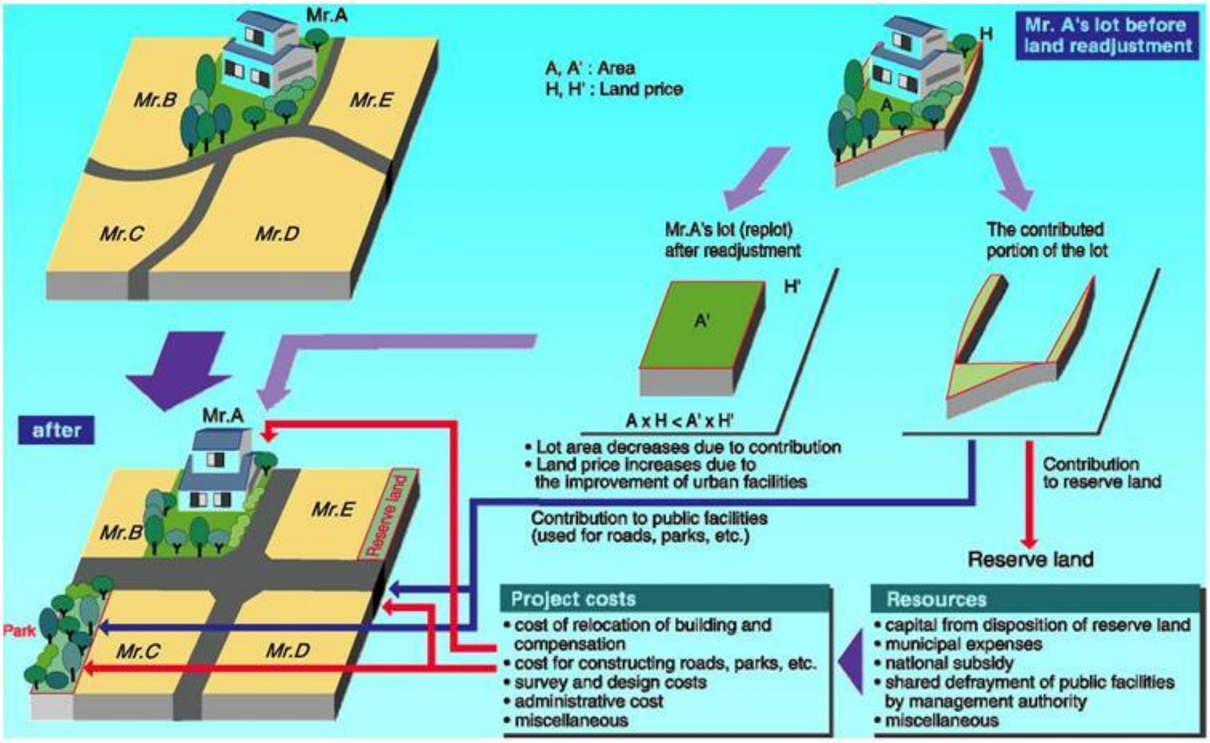
Table 2-14 : Summary of Project Revenue

Sr. No.	Revenue Stream	FY2020	FY2021	FY2031	FY2041	FY2046
		Rs. Million /Year				
1	Fare box	7579	9825	28872	59445	84883
2	Revenues from station commercial	1088	1486	3259	5309	6776
3	Revenue from advertisement	76	98	289	594	849
4	TOD betterment charges post construction	6075	6075	4455	2956	2287
5	**Total Project Revenue**	**14819**	**17484**	**36875**	**68304**	**94795**

2.6 Land pooling concept for TOD zones

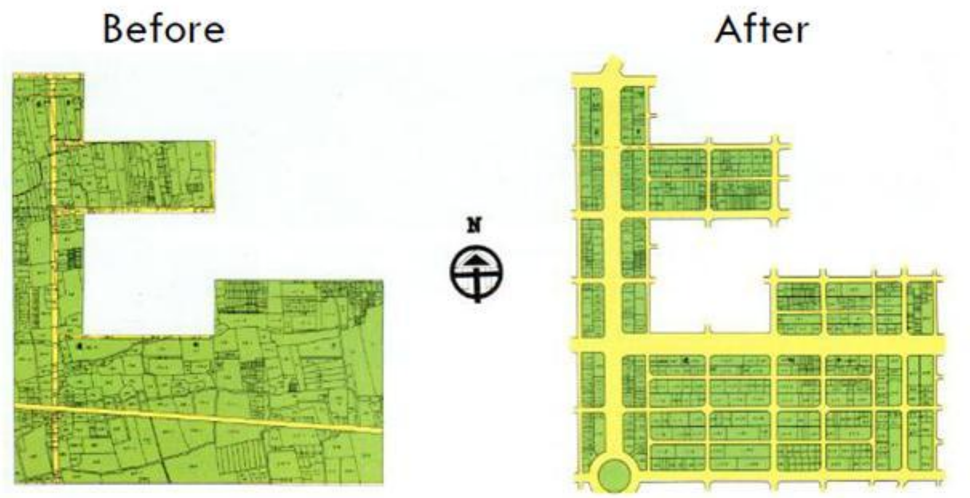
2.6.1 The concept

In order to achieve orderly development at identified TOD Zones and along the proposed RRTS corridor, Government may pool or assemble lands and to reconstitute them in accordance with the proposed detailed development plan/scheme. The reconstituted plots of land are allotted to the owners.



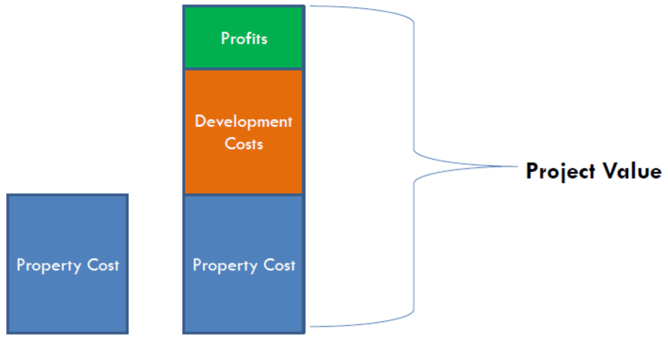
Urban Development Plans Formulation & Implementation Guidelines (UDPFI), Government of India has incorporated such schemes, based on pooled land development either by the government entity or by the private owners.

Land could be assembled, on the basis of a detailed development plan/scheme, through voluntary pooling by its owners, which could be consolidated thereby permitting the local agency to develop infrastructure according to a layout plan. A portion of the land may be reserved for the provision of services including RRTS infrastructure facilities, open spaces and roads while the rest may be developed into plots to be distributed among the owners as per their share in the pooled land. The higher value of the developed plots would compensate the lesser area and payment of betterment charges.



(Source: Kaohsiung Municipal Government, 1979)

However, this process needs to be promoted and augmented by providing appropriate policy framework in order to promote planned development and to make available land for public purposes without involving any compulsory acquisition of land.



2.6.2 Salient features of land pooling

- Through Proper planning, land is re-distributed in a properly reconstituted plots after deducting the land required for Infrastructure
- During the process, a number of private parcels is temporarily put into common ownership and later reallocated to a new highest and best use
- Specific land identified for infrastructure area is shared by all owners
- Enables development of commonly pooled land without compulsorily acquiring the same
- Final plots, are reduced in size but better in shape, buildability and accessibility
- Owners voluntarily agree to pool their land, redistribute the reconstituted plots of land among themselves and share the development cost.
- Government agency puts up the infrastructure
- Cost of infrastructure development met through Land owners/ buyers and sale of common commercial space

2.6.3 Role of Government and other relevant agency

- State Government identifies area for Land Pooling
- State Government nominates an Agency (A development authority, corporation, any other agency)
- Agency appoints a Development Officer
- Development Officer prepares detailed layout plan
- Development Officer invites objections from land owners
- Development Officer, based on review of objections, makes necessary revisions
- Authority, recommends to the state government for notification

- Infrastructure is developed by the Agency
- Financial compensation/ collection from land owners done by Authority

2.6.4 Broad Process

Broad process is indicated below:

- Identification of TOD Zones, areas along the corridor for Land Pooling Scheme
- Conduct Survey to mark land boundary, existing physical features - topography, slope, plot boundaries, existing structure
- Revenue record to establish ownership of land
- Superimpose Development Plan on Survey Maps
- Make provisions for RRTS Infrastructure facilities, Roads, Dedicated bus corridor, Subways,Water, Electricity, Sewage, Drainage, Solid Waste Management, Green Areas, Social Areas, Special Requirements
- Calculate total area required for infrastructure
- Reconstitute remaining area
- Reduce area required for infrastructure
- Give proper shape to each plot and
- Locate the final plot nearer to the original plot

Indicative distribution of land is provided in table below

Sl. No.	Item	Percentage of land
1.	Roads	19.83
2.	Water Bodies	1.24
3.	Institutional Area	5.54
4.	Parks and gardens	4.66
5.	Housing for weaker section	7.89
6.	Reconstituted plots for original owner	48.43
7.	Residential land Bank (for Authority)	7.77
8.	Commercial land Bank (for Authority)	4.64
	Total	100.00

2.6.5 Benefits of land pooling scheme

To owners

- Ownership is retained by the original owners
- Owners are free to retain the land, form co-operative, sell to a buyer at a market determined price
- Allow existing landowners to share the wealth generated from urban development
- Adjusted outmoded property boundaries

To Government:

- Objective of Planned Development with less stress to owners
- It will avoid the heavy up-front capital requirement for property acquisitions by the government
- Capture land value increments to cover urban development costs
- Cost of infrastructure gets shared between government and owners/ buyers
- Land pooling may allow urban redevelopment to be self-financing.
- Does not have to acquire land even for infrastructure area
- Cash flows may remain positive, except in initial phase (small investment in planning activity required)

3 CAPITAL COST ESTIMATION

3.1 Introduction

Capital Cost estimate for the proposed RRTS Delhi Sonepat Panipat corridor has been prepared covering the cost heads for the following areas at 2013 price levels:

- Civil works, Alignment and formation,
- Station buildings,
- E&M works,
- Depot and workshop,
- Permanent way,
- Traction,
- Signalling and telecom,
- AFCS,
- Land acquisition and R&R,
- Rolling stock and
- Miscellaneous works (spares, trainings, testing and commissioning, Utility diversions etc.)

Capital cost estimates have been prepared for the civil and systems works of the Delhi - Panipat RRTS corridor. The cost has been calculated as per route km for items spread over the alignment and per unit for items not related to route length.

All items related with alignment, whether in underground or elevated construction, like permanent way OHE, signalling and telecommunication, have been estimated on cost per km basis. Cost of underground alignment construction per route km excludes station lengths The cost of stations and depots are estimated separately as per the initial design plans prepared.

The cost for underground stations includes cost of civil structures and architectural finishes. Similarly, cost of elevated portion includes civil work for station structures, architectural finishes, platform roofing etc.

Cost of E&M works, permanent way, power supply, signaling and telecommunication, automatic fare collection, rolling stock, have been assessed separately.

Land cost has been assessed on the basis of each segment of the land that is required. The cost of acquiring private land is only considered in the estimates for arriving final costs.

3.2 Capital Cost Estimation Basis

The capital cost of various items have been assessed on the basis of the following:

- For each system and works like Viaduct, Tunnels, Rolling Stock, Power Supply, Signals, Communications, AFC, Depots, M&P etc a list of items and quantities has been prepared based on the consultant's experience, traffic studies, operations simulation and alignment survey.
- For major civil works including the alignment, elevated via-duct, the cost has been estimated based on Rate Analysis based on latest Schedule of Rates provided by Ministry of Road Transport and Highways.
- The rates of other items have been assessed from market prices or rates from similar works in Indian Railways and Metro projects in India.
- For station costs, a separate study for conceptual design and costs has been conducted.
- Cost of M&P has been taken from Indian Railways COFMOW purchase rates and where these are not available, from rates in other Indian Railways or Metro projects.
- Taxes & Duties such as Customs Duty, sales Tax, Works Tax, VAT, etc., wherever applicable, have been worked out on the basis of prevailing rates and included in the cost estimates separately.

3.3 Civil Engineering Works

3.3.1 Land

The land required for the project has been kept at the barest minimum level and worked out on area required basis. It has been tried to keep the private land acquisition at a minimum level. In Haryana portion of the alignment, after Samalkha station, it has been tried to utilize the 50m green belt alongside of NH1 to keep the land acquisition at a minimum level. A total of 441 hectares of land would need to be acquired out which 329 hectares would be private land. The details of land acquisition and R&R cost has been provided in the Social Impact Assessment and R&R report submitted along with draft DPR

Annual Rehabilitation grant: Apart from the on time payment for land acquisition, we propose an annual payment equivalent to 1% of land cost to be escalated at 5% per annum to the individual land owners for the entire concession period of the project (till FY2048).

The table below provides the details of the total cost of acquisition for the project

Table 3-1 : Estimated land requirement and cost

S. No	Item	Amount (Rs Crore)	Amount (Rs Mil)
1	Private Land Acquisition Cost	2144.31	21443.1
2	Government Land Cost**	-	-
3	Structure Cost	5.14	51.4
4.	Community Structure Cost	2.48	24.8
5	R&R Assistance Cost	9.07	90.7
6	**Total (Rs in Crore)**	**2161**	**21610**

** The cost of land acquisition for govt land is Rs 1183.46 Crs. However for financial analysis it has been assumed that the cost of land acquisition for government land would be zero.

3.3.2 Alignment

3.3.2.1 Underground Section

The length of underground and elevated sections of the RRTS has been calculated after a detailed survey. In the underground section the construction work will be generally done by tunnel boring machines due to the densely populated area of the alignment. Where feasible, cut and cover method will be used.

The rates adopted for cut and cover section, as well as for work to be done by Tunnel Boring Machine are based on consultations with tunneling experts and cost of similar works. Suitable allowance has been made for the larger diameter tunnels for the RRTS.

3.3.2.2 Elevated Section

Most of the alignment will be on elevated via duct. Actual broad BOQ for the elevated alignment has been worked out. Latest Schedule of Rates provided by Ministry of Road Transport and Highways (year 2012) have been used to estimate the cost.

3.3.3 Stations

3.3.3.1 Underground Stations

Underground stations have to be constructed by cut and cover method. The rate proposed for stations (length 400m) includes cost of station structures, platforms, architectural finishes, etc. Provisions for electrical and mechanical works, lifts and escalators etc., have been made separately in the station cost.

The cost for OHE, Permanent Way, Signaling and Telecommunication, Automatic Fare Collection at stations have been taken separately in the costs of these items and have not been included in the station costs. The station conceptual designs as well as the costs have been prepared by professional architects appointed for this purpose.

3.3.3.2 Elevated Stations

Rates used for elevated stations include the works of station structures, platforms, architectural finishes, covering, etc. Provisions for electrical and mechanical works, lifts and escalators etc., have been made separately in the station cost.
The cost for OHE, Permanent Way, Signaling and Telecommunication, Automatic Fare Collection at stations have been taken separately in the costs of these items and have not been included in the station costs. The station conceptual designs as well as the costs have been prepared by professional architects appointed for this purpose.

3.4 Depots

The RRTS corridor will have a depot cum workshop at IOCL Panipat and a sub depot at Gannaur. For each depot a layout and size of trackwork, repair sheds, stabling lines, maintenance buildings, Stores building, Administrative office, Canteen, Water supply, etc has been estimated in detail. The cost of these items is based on the schedule of rates, the rates adopted by Indian Railway Workshops and new Metro Rails in India.

The M&P required for the depots has been assessed based on the workload. Cost of the M&P has been from Indian Railways Centre for Modernization of Workshops or where not available from COFMOW, from market costs or cost incurred in Railway and metro projects.

The cost of OHE, trackside S&T equipment has been accounted for under the heads of these items and not included in the depot cost. Some S&T equipment exclusive to the depots like internal telephone exchange, intercom, computerized attendance system and clocks etc have been taken in the depot costs. Similarly cost of depot auxiliary substation, electrical connections to M&P etc have been taken in depot costs.

3.5 Rolling Stocks

The cost of Rolling Stock has been estimated through consultations with manufacturers as well as through comparison with Metro rail coaches currently being procured in Delhi Metro. Consideration has been given to the non standard and larger size of the RRTS coaches.

3.6 Traction and Power Supply

For working out the power supply cost, the number and capacity of traction sub stations has been worked out, based on the number of trains to be run and the auxiliary load. The number and capacity of auxiliary sub stations has been based on the experience of metro stations.

The length of OHE and ring main is known from the alignment study and depot layouts. Provision has been made to cover the cost of service connection charges from Grid Sub Station to Receiving Sub Station. Cost of SCADA has also been added.

The costs have been calculated on route km basis separately for underground alignment, and elevated section as the requirement and costs are different.

3.7 Permanent Way

For underground and elevated alignment ballastless track and for At grade alignment and depots ballasted track has been proposed. The length of the track including portions in loop lines and ramps has been calculated from the alignment study done. The length of ballasted track in depots has been calculated from the depot layout.

The rates adopted for ballastless track, are based on Delhi Metro and experience on other similar projects. For ballasted and embedded track in depots, the rates have been taken from estimates of Indian Railways workshops.

3.8 Automatic Fare Collection

The number of gates required at each station has been worked out based on the peak hour passengers at the station. The number of other equipment like Baggage Screening Machines, Ticket Office Machines, End Cabinets, Portable Ticket Readers, Central Computer and Router at OCC, Station Computer, Networking Equipment etc has been calculated for each station. The rates for these items are based on the cost of similar works currently being undertaken in India.

3.9 Signalling and Telecommunication Works

The S&T costs include train on board equipment, trackside equipment, software development, installation and integration. The rates adopted are based on the Delhi Metro rates, with appropriate adjustments to account for stations spacing, signal blocks, communication linkages required, other equipments etc on the RRTS compared to the Metro.

3.10 General Charges and Contingencies

Considering nature of project, provision @ 5% has been made towards general charges including design charges on all items, except cost of land. Provision for contingencies @ 5% has been made on all items including general charges and land cost.

3.11 Capital Cost estimate

3.11.1 Base Capital Cost

The following table estimates the basic cost at 2013 levels for various heads as stated above along with the basis of estimation as well as inclusions/ exclusions.

Table 3-2 : Estimated Capital Cost for base year 2013

Item	Description	Units	Quantity	Rate (Rs. Crore/ per Unit)	Sub-Total (Rs. Crore)	Total (Rs. Crore)	Total (Rs Mil)
1.0	**Land**					**2163**	**21,626**
1.1	Private Land, R&R & EIA	Hectare	329.3	-	2162.6		
1.2	Government land	Hectare	111.6	-			
2.0	**Civil works, Alignment and formation**					**3435**	**34,349**
2.1	Tunneling Work	R Km	2.240	168.5	377.5		
2.2	Ramp - underground	R Km	0.325	52.2	17.0		
2.3	Ramp - Elevated	R Km	0.975	20.4	19.9		
2.4	Elevated Viaduct	R Km	93.990	30.7	2881.7		
2.5	At grade Alignment	R Km	7.180	1.7	12.0		
2.6	Single Track Viaduct	R Km	2.800	-	-		
2.61	Single Track Viaduct	Total Km	5.000	25.4	126.8		
3.0	**Station Building**		12.0			**1623**	**16,229**
3.1	Underground Terminal Station	Nos.	1.0	292.2	292.2		
3.2	Elevated Stations	Nos.	9.0	124.6	1121.2		
3.3	At grade Terminal Station	Nos.	2.0	104.7	209.5		
4.0	**E&M Works**		12.0			**374**	**3,735**
4.1	Electro mechanical works including Lifts, Escalators, DG sets, UPS,ECS						
4.11	Underground station	Nos.	1.0	74.2	74.2		
4.12	Elevated station	Nos.	9.0	29.4	264.7		
4.13	At grade station	Nos.	2.0	14.7	29.4		
4.2	Tunnel Ventilation	R Km	1.5	3.5	5.1		
5.0	**Depot-cum-Workshop**		2.0			**227**	**2,267**
5.1	IOCL Panipat Depot						
5.11	Civil works, Track work, OHE	Nos.	1.0	93.3	93.3		
5.12	Plant and Machinery	Nos.	1.0	84.9	84.9		
5.2	Gannaur Depot						
5.21	Civil works, Track work, OHE	Nos.	1.0	26.5	26.5		
5.22	Plant and Machinery	Nos.	1.0	22.0	22.0		
6.0	**Permanent Way**					**796**	**7,964**

Item	Description	Units	Quantity	Rate (Rs. Crore/ per Unit)	Sub-Total (Rs. Crore)	Total (Rs. Crore)	Total (Rs Mil)
6.1	Ballastless track for elevated & underground alignment	R KM	104.1	7.1	743.4		
6.2	Ballasted/Embedded track for at grade allignment	R KM	17.2	3.1	53.0		
7.0	**Traction & Power Supply incl. OHE, ASS etc.**					**931**	**9,307**
7.1	Under Ground Section	R KM	2.57	9.6	24.6		
7.2	Elevated & At Grade Section	R KM	120.9	7.5	906.1		
8.0	**Signalling and Telecom.**					**926**	**9,264**
8.1	Signalling	R KM	121.2	7.0	847.0		
8.2	Telecom.	No. of Stations	12.0	7	79.4		
9.0	**Automatic fare collection**					**62**	**622**
9.1	Ticketed Stations	No. of Stations	12.0	5.2	62.2		
10.0	**Misc. Works**					**195**	**1,954**
10.1	Utilities Relocation	R KM	111.2	0.6	61.3		
10.2	Misc. civil works such as median, road signages	R KM	111.2	0.6	61.3		
10.3	Barracks for Security Staff including security equipments	Nos.	12.0	0.6	6.6		
10.4	Staff Quarters for O&M	Nos.	12.0	5.5	66.2		
11.0	**Rolling Stock**					**2362**	**23,616**
11.1	EMU Coaches	Nos.	204.0	11.6	2361.6		
12.0	**Miscellaneous Items**					**152**	**1,518**
12.1	Training	Nos.	1.0	11.0	11.0		
12.2	Spares (%of 7,8,9 & 11)	%	2%	4280.9	85.6		
12.3	Testing and Commissioning Costs	Nos.	1.0	55.1	55.1		
13.0	**Total**						
13.1	Total (Including Land Cost)	Sum (1 to 12)			**13245**		**132,451**
13.2	Total (Excluding Land Cost)	Item 13.1 Less 1			11082.5		

Item	Description	Units	Quantity	Rate (Rs. Crore/ per Unit)	Sub-Total (Rs. Crore)	Total (Rs. Crore)	Total (Rs Mil)
13.3	General Charges incl. Project Management, Design charges etc.	% of 13.2		5%	554.1		
13.4	Contingency	% of 13.1+13.3		5%	690		
	Estimated Construction Cost on Year 2013 Basis (Excluding Land)					**12,327**	**123,266**
	Estimated Construction Cost on Year 2013 Basis					**14,489**	**144,892**

3.11.2 Base Capital Cost with taxes and duties

The table below provides the details of Capital cost including central taxes (customs duty and excise duty) and state taxes (VAT).

Table 3-3 : Base capital cost with taxes and duties (at 2013 price level)

Sr. No.	Components	Amount in Rs. Million
1	Land	21626
2	Base Construction Cost (excl. land cost & General Charges and Contingency)	110825
3	**Total Base Project Cost**	**132451**
4	Total Central Taxes	**12006**
a	Customs Duty	7893
b	Excise Duty	4113
5	Cost including Central Taxes (3+4a+4b)	144457
6	State Tax (VAT)	**6759**
7	Cost including State Tax (5+6)	151216
8	General Charges including Project Management, design etc. @5% on (7 -1)	6479
9	Contingency @5% on (7+8)	7885
10	**Total Cost (incl. taxes excl. IDC)**	**165580**

3.11.3 Capital expenditure for future expansion and replacements

The following table gives the capex requirement for future expansion and replacement of equipment such as rolling stock, E&M, track work etc.

Table 3-4 : Expansion and Replacement CAPEX Investment Phasing Plan (on 2013 prices)

Particulars/ Year Capex in Rs Crs on 2013 prices	2021 (FY 22)	2031 (FY-32)	2036 (FY37)
Rolling stock	928.4	1582.1	
E&M cost			1571.0
Track work		87.0	

These costs are exclusive of taxes and duties.

4 OPERATIONS & MAINTENANCE COST ESTIMATION

4.1 Introduction

The operations and maintenance cost of RRTS Delhi Panipat would consist of the following:

- Staff costs
- Energy cost
- Maintenance cost

4.2 Staff cost

4.2.1 Staff Cost

The total number of staff in different categories namely train operation, maintenance staff at depots and station staff at each location has been assessed for the RRTS. This assessment is based on contemporary staffing pattern on Metro Rail systems, suitably modified to account for the lesser number of stations on the RRTS. The number of train drivers has been calculated based on the duty hours and the number of trains to be run. The staff requirement is estimated at 2,312 personnel for the initial phase (2018) and subsequently for every 5 year from COD till the system achieves its ultimate design capacity, an incremental increase in manpower is considered at 10%. Accordingly, the number of staff per km is estimated about 23 persons (for the year 2018) and the total estimated manpower cost is at Rs. 927 Million per year based on the constant price (i.e. 2013 base year price).

Further an adjustment in terms of increase in staff cost has been made year on year basis at the rate of 8% from the base year. For the first full year (i.e. FY2020) of operation the annual estimated cost is about Rs. 1,589 Million. Year wise estimated annual manpower cost is as given below.

Table 4-1 : Staff cost

Number of Staff	
Main Depot	615
Second Depot	63
Train Crew	326
Station Staff	1,308
Total Staff Number	2,312
Salary Cost, Rs Mil per year	Rs Mil/year

FY 2020	1589
FY2021	1717
FY2031	4484
FY2041	11714
FY2046	17212

4.3 Energy cost

4.3.1 Energy Consumption

Energy consumption have been calculated for 4 blocks of years namely 2018 -2021, 2021-2034 and 2035-2044 & 2044+ The estimation of the energy cost has been done based on the energy consumption in the following areas

- Energy consumption in traction
- Energy consumption in station
- Energy consumption in depot

4.3.1.1 Energy consumption in traction

The energy consumption in traction is based on the train operations schedule and total energy consumed by the train in one trip from Kashmere gate to IOCL Panipat station and Kashmere Gate station to Gannaur Depot station. The table below summarizes the assumptions and energy consumption calculations for traction:

Table 4-2 : Energy consumed in traction power

Timeline	Route	No of Cars per train	Single trip journey time, mins	Terminus dwell time, mins	Round trip time, mins	Single trip energy consumed, kWh	Energy consumed per round trip, kWh	Energy consumed per train per hour, kWh	No. Of trains on the route	Energy consumed by all the trains per hour, kWh	Energy consumed by all the trains per hour, with 15% losses, kWh	Energy consumed by all the trains per hour, with 10% contingency, kWh	Energy consumed by all the trains per hour, with regeneration, kWh	Traction Energy per route per year, kWh
2018 to 2020	KG to IOCL	6	73	4.5	155	2,235	4,470	1,730	18	31,146	36,642	40,713	32,571	221,025,299
	KG to Ganaur	6	41	4.5	91	1,255	2,511	1,655	11	18,208	21,422	23,802	19,041	129,215,160
	Total Traction Energy per year, kWH													**350,240,460**
	Total Traction Demand kVA 2018to 2020 with 0.85 power factor													**60,720**
2021 to 2034	KG to IOCL	9	73	4.5	155	3,350	6,700	2,594	18	46,684	54,922	61,025	48,820	331,290,717
	KG to Ganaur	9	41	4.5	91	1,882	3,763	2,481	11	27,292	32,108	35,676	28,541	193,678,204
	Total Traction Energy per year, kWh													**524,968,921**
	Total Traction Demand kVA 2021 to 2034 with 0.85 power factor													**91,012**
2035 to 2044	KG to IOCL	9	73	3.5	153	3,350	6,700	2,627	22	57,804	68,005	75,561	60,449	410,203,829
	KG to Ganaur	9	41	3.5	89	1,882	3,763	2,537	13	32,979	38,799	43,110	34,488	234,036,073
	Total Traction Energy per year, kWh													**644,239,902**
	Total Traction Demand kVA 2034 to 2044 with 0.85 power factor													**111,690**

2044+	KG to IOCL	12	73	3.5	153	4,465	8,930	3,502	22	77,043	90,639	100,710	80,568	546,734,358
	KG to Ganaur	12	41	3.5	89	2,508	5,015	3,381	13	43,956	51,713	57,459	45,967	311,931,662
	Total Traction Energy per year, kWh													**858,666,019**
	Total Traction Demand kVA 2044+ with 0.85 power factor													**148,865**

Other inputs and assumptions for calculations

Hours per day	20
Days per week	6.5
Weeks per year	52.2
Regeneration	20%

4.3.1.2 Energy consumption in Stations

The energy consumption in stations has been estimated based on the installed capacity at stations and by applying suitable diversity factor. The table below provides the detailed estimates of the energy consumed inside the station areas.

Table 4-3 : Energy consumed in stations

KG station power	725	kW
Other stations power	490	kW
Power for all 12 stations	6,115	kW
Diversity factor	0.4	
Power for all 12 stations with diversity factor	2,446	kW
Station consumption per year	**16,598,556**	**kWh**
Station Demand kVA with 0.85 power factor	**2,878**	**kVA**

4.3.1.3 Energy consumption in Depots

The energy consumption in depots has been estimated based on the installed capacity at depots and by applying suitable diversity factor. The table below provides the detailed estimates of the energy consumed inside the depots areas.

Table 4-4 : Energy consumed in depots

Panipat Depot power when headway is 4.5 mins	973	kW
Panipat Depot power when headway is 3.5 mins	1,720	kW
Ganaur Depot throughout	567	kW
Power for both depots 2018 to 2034	1,540	kW
Power for both depots 2034 to 2041+	2,287	kW
Diversity factor	0.6	
Power for both depots 2018 to 2034 with diversity factor	924	kW
Power for both depots 2034 to 2041+ with diversity factor	1,372	kW
Total Depot consumption per year 2018 to 2034	**6,270,264**	**kWh**
Total Depot consumption per year 2034 to 2041+	**9,311,749**	**kWh**
Depot Demand kVA 2018 to 2034 with 0.85 power factor	**1,087**	**kVA**
Depot Demand kVA 2034 to 2041+ with 0.85 power factor	**1,614**	**kVA**

4.3.1.4 Per unit energy charges

The energy cost has been estimated based on per unit charges calculated by using weighted average of variable and fixed energy charges (at 2013 price levels) levied by the states of Haryana and Delhi for DMRC as mentioned in the tables below

Table 4-5: Per unit energy charges for 2013

Per unit energy charge for year 2013	Haryana (Rates for DMRC in 2013)	Delhi (Rates for DMRC in 2013)	Weighted Average per unit energy charge
Energy Cost (Rs/kwh)	4.8	5.5	4.98
Demand Cost (Rs./kVA)	140	125	136
Length of Corridor in State (KM)	82.7	28.5	

4.3.2 Base Energy Cost

The table below provides the base energy cost in Rs Crs (at 2013 prices) calculated for all the years of operation

Table 4-6 : Base energy cost (at 2013 price level)

Timeline	Total Consumption, kWh	Energy Cost per year, (Rs Cr)	Total Demand, kVA	Demand cost per year, (Rs Cr)	Total cost per year, (Rs Cr)
2018 to 2020	373,109,280	185.79	64,685	10.57	196.35
2021 to 2034	547,837,741	272.79	94,977	15.52	288.31
2035 to 2044	670,150,208	333.70	116,182	18.98	352.68
2044+	884,576,324	440.47	153,357	25.06	465.52

4.4 Maintenance Expenditure

4.4.1 Base maintenance Cost

For repair and maintenance of the RRTS assets, apart from staff, spare parts and consumables will also be used. The cost of such material which is consumed annually depends on a lot of factors such as the design of the equipment, the intensity of usage, the maintenance philosophy, the manufacturer’s recommendations, renewal plans etc. The Base maintenance costs (at 2013 price levels) per annum have been estimated at a rate of 0.8% of total base capital expenditure (excluding land). Also additional maintenance costs have been considered as and when the additional asset is added to the system. This additional maintenance cost has also been assumed to be 0.8% of the additional capital expenditure incurred for the asset addition in the respective years

4.5 Total Operations and Maintenance cost

Total Operations and Maintenance cost has been calculated based on the following escalation rates:

Table 4-7 : Escalation rates for O&M cost

O&M cost component	Year on Year escalation rate
Manpower cost	8%
Energy cost	3%
Maintenance cost	5%

The total O&M cost considered for all the years of the project operations (FY19-FY48) is given in the table below:

Table 4-8 : Total O&M cost

Financial Year	Maintenance cost (Rs Million)	Manpower cost (Rs Million)	Energy cost (Rs Million)
FY 2019	718	761	1177
FY 2020	1459	1589	2345
2021	1572	1717	2415
2022	1778	1854	3652
2023	1867	2002	3762
2024	1960	2379	3875
2025	2058	2569	3991
2026	2161	2774	4111
2027	2269	2996	4234
2028	2383	3236	4361
2029	2502	3844	4492
2030	2627	4152	4627
2031	2923	4484	4765
2032	3587	4843	4908
2033	3766	5230	5056
2034	3955	6214	5207
2035	4152	6711	5363
2036	4360	7248	6758
2037	4578	7827	6960

Financial Year	Maintenance cost (Rs Million)	Manpower cost (Rs Million)	Energy cost (Rs Million)
2038	4807	8454	7169
2039	5047	10043	7384
2040	5300	10846	7606
2041	5565	11714	7834
2042	5843	12651	8069
2043	6135	13663	8311
2044	6442	14756	8560
2045	6764	15937	11638
2046	7102	17212	11988
2047	7457	18589	12347
2048	7830	20076	12718

5 PROJECT STRUCTURING AND VIABILTY

5.1 Recent Project Cases

Recent projects already commissioned and under construction have been used as a template to understand the typical project structures prevalent in the industry in India and are presented in the table below.

Table 5-1 : Recent Project Deals in India

Projects	Length (km)	Project Cost	Cost /km	GOI + GOS (%)	Soft Loan (%)	Pvt. Sector
	km	Rs. Crore	Rs. Cr./ km	(%)	(%)	(%)
DMRC Phase I	65	10,571	163	40	60	Nil
Phase 2	124.3	18,894	152	40	46	Nil
Phase 3	103.5	35,242	341	60	40	Nil
Delhi Airpt Lnk	22.7	3,869	170	54	Nil	46
Bangalore	42.3	11,609	274	55	45	Nil
Chennai	45	14,600	324	40.8	59.2	Nil
Kolkata	14.7	4,874	332	55	45	Nil
Mumbai L1	11	2,356	214	28.1	Nil	71.9
Mumbai L2	32	8,250	258	19.8	Nil	80.9
Hyderabad	71.6	12,132	170	12	Nil	88

5.2 Role of State Government

State governments have taken an aggressive stand in these projects and such stand has been very well supported by the Central Government in pushing through these projects either by way of necessary legislation, land acquisition, equity commitments.

5.3 Role of NCRPB

NCRPB has been instrumental in signing of MoUs with various states government, besides Ministry of Urban Development, Govt. of India (MoUD) and Ministry of Railways for making equity contribution to the RRTS projects. Further, equity contributions are expected to be made in a company referred to as NCR Transport Company or say ("NCRTC").

NCRTC is expected to be the holding company of all RRTS projects and to our understanding is proposed have an initial corpus of Rs. 100 crores shared in the following manner:

Table 5-2 : NCRTC Shareholding Pattern

Name of the Entity	Share in NCRTC(%)
Govt of India (MOUD + MoR + NCRPB)	50
Govt. of National Territory of Delhi	12.5
State Govt. of Uttar Pradesh	12.5
State Govt. of Haryana	12.5
State Govt. of Rajasthan	12.5
Total	**100**

5.4 NCRTC Panipat Delhi Structure

Each of the RRTS project can be developed through NCRTC where respective investments amongst state governments could be split based on project specific details. Therefore potential investments contributions could be as set out below:

Table 5-3 : Equity Contribution Structure of Delhi – Sonepat - Panipat Project

Name of Entity	Percentage (%)
Govt of India (MOUD + MoR + NCRPB)	50
Govt. of National Territory of Delhi and State Govt. of Haryana	50
Total	**100**

The contribution of GNCTD and Govt of Haryana could be split in terms of following options:

a. In terms of route length

Sr. No	States	Route Length	% Share in total project	% Share in 50%
		Km	%	%
1	Delhi	28.5	25.6%	12.8%
2	Haryana	82.7	74.4%	37.2%
	Total	**111.2**	**100%**	**50%**

b. In terms of investment in respective states

Sr. No	States	% Share of investment in respective state	% Share in 50%
		%	%
1	Delhi	21.9%	10.95%
2	Haryana	78.1%	39.05%
	Total	**100%**	**50%**

Note: The share in investment has been calculated based on base cost for the project including land cost however excluding taxes and duties.

Share of base project cost between states have been prepared based on prorate basis using route length as given in table above. In case of share of project cost based on investment, common facilities such as depot, land for depot, singaling & telecom, permanent way, R&R, rolling stock and Miscellaneous works have been taken on route length basis whereas station buildings, E&M works, civil, alignment and formation have been taken on actual basis based on investment in each state.

c. In terms of shareholding in the holding company

Sr. No	States	Share in NCRTC
		%
1	Delhi	12.5%
2	Haryana	12.5%
	Total	**25%**

This leaves 25% balance to be picked up by these state governments or any other entity.

5.5 Role of Lenders

Multi-lateral funding agencies such as JICA, World Bank and ADB have shown keen interest in funding these projects. These projects are typically backed by central government guarantees towards repayment. Typically the loan repayment could be done from the project company, however, the exchange rate risk is taken on by the central government in such debt financing deals.

The project of this size would require, ideally soft loan from a multi lateral institution on attractive terms such as a loan paid of 20 to 30 years with interest rate less than 2%. We believe that the project could obtain 40% - 60% of the construction cost as soft loan from suitable multi lateral funding agency e.g. World Bank, JICA and ADB with exchange rate risk typically borne by Government of India.

As discussed in the chapter on Assumptions and Boundary Conditions, a soft loan 60% of the total project cost at 2% interest rate has been considered for the project in case the project is done by NCRTC/ Govt agency where as a soft loan of 40% of the total project cost at 2% interest rate has been considered for the project if it is done under a PPP structure.

5.6 Viability and Structuring of Project under implementation by Government

5.6.1 Total project cost and Phasing

As discussed in section of Assumptions and boundary conditions, a soft loan of 60% of the total project cost @ 2% interest rate with 20 year repayment period has been considered in case the complete project is implemented by NCRTC/ under a government agency.
The total project cost including all taxes, escalation of cost during construction and the component of interest during construction is estimated at Rs 19038 Crs.

The table below specifies the year wise breakup of funds required for the total capital expenditure.

Table 5-4 : Year wise actual capital expenditure required (including IDC and margin money)

Component (Cost in Rs Mil)	FY15	FY16	FY17	FY18	FY19	Total
Land, R&R and Utility shifting	7209	14418	0	0	0	21626
Civil works, Alignment and formation	5625	16089	21886	11731	0	55331
Overhead Station buildings	1976	6224	8714	4575	0	21489
Underground Station buildings	455	1435	2008	1054	0	4953
Depot-cum-	0	953	1540	566	0	3058

Workshop						
Power supply and substations	0	0	5428	6705	1056	13189
S&T (excluding onboard) and AFC	0	0	5458	7163	1504	14126
Miscellaneous	525	1102	1157	1215	638	4636
Rolling Stock	4831	10146	10815	5762	0	31554
Total	20622	50366	57005	38772	3198	169963
Other charges(contingency and project management)	1830	4693	5577	3983	345	16428
total capital cost without IDC	22452	55059	62582	42755	3543	186391
IDC	0	3	596	1916	1116	3632
Total Capital cost without Margin money	22452	55063	63178	44671	4659	190023
Margin money	0	0	0	0	361	361
Total capital cost	22452	55063	63178	44671	5020	190384

5.6.2 Suggested project structure and roles under NCRTC/ government implementation

NCRTC shall be responsible for undertaking project activities including initial civil mechanical and electrical construction, procurement of rolling stock and operations of the project as well as undertaking future expansion expenditure for the project.

The contributors to the funding for the project could be as set out below:

Table 5-5 : Contributions to the project

Name of Entity
MoUD, Govt. of India + NCRPB
Ministry of Railways + Govt. of India
Govt. of National Territory of Delhi, State Govt. of Haryana

Further, the NCRTC could borrow money from multi-lateral financial institutions with suitable government guarantees, since multi-lateral financial institutions typically request for such guarantees as well as the fact that they would find it more convenient to fund a 100% government owned company as compared to a company with private sector majority holding.

The revenue of NCRTC would include revenue from operations of RRTS, advertisement, revenues from commercial areas at stations and betterment charges from ToD areas. In turn NCRTC shall spend on day to day operations of the project and debt servicing for the soft loan taken for development of the project.

5.6.3 Funding pattern

Following the project structure as suggested above, the total investment breakup for the funds to be supplied by each entity including multilateral agencies is presented in the table below:

Table 5-6 : Total Investment breakup under implementation by Government (Capital cost including taxes, escalation, IDC and margin money)

Sl. No.	Name of Entity	Investment Based on Length		Contribution Based on Initial Investment	
		%	Rs. Million	%	Rs. Million
1.	Govt of India (MOUD + MoR + NCRPB)	20%	38,077	20%	38,077
2	Govt. of National Territory of Delhi	5.1%	9,757	4.4%	8,329
3	State Govt. of Haryana	14.9%	28,320	15.6%	29,746
4	**Total by Govt**	**40%**	**76,154**	**40%**	**76,154**
6	Soft Loan	60%	114,230	60%	114,230
7	**Total investment**	**100%**	**190,384**	**100%**	**190,384**

The aforesaid excludes the project funding required for additional investments in future as well replacement costs associated with the project.

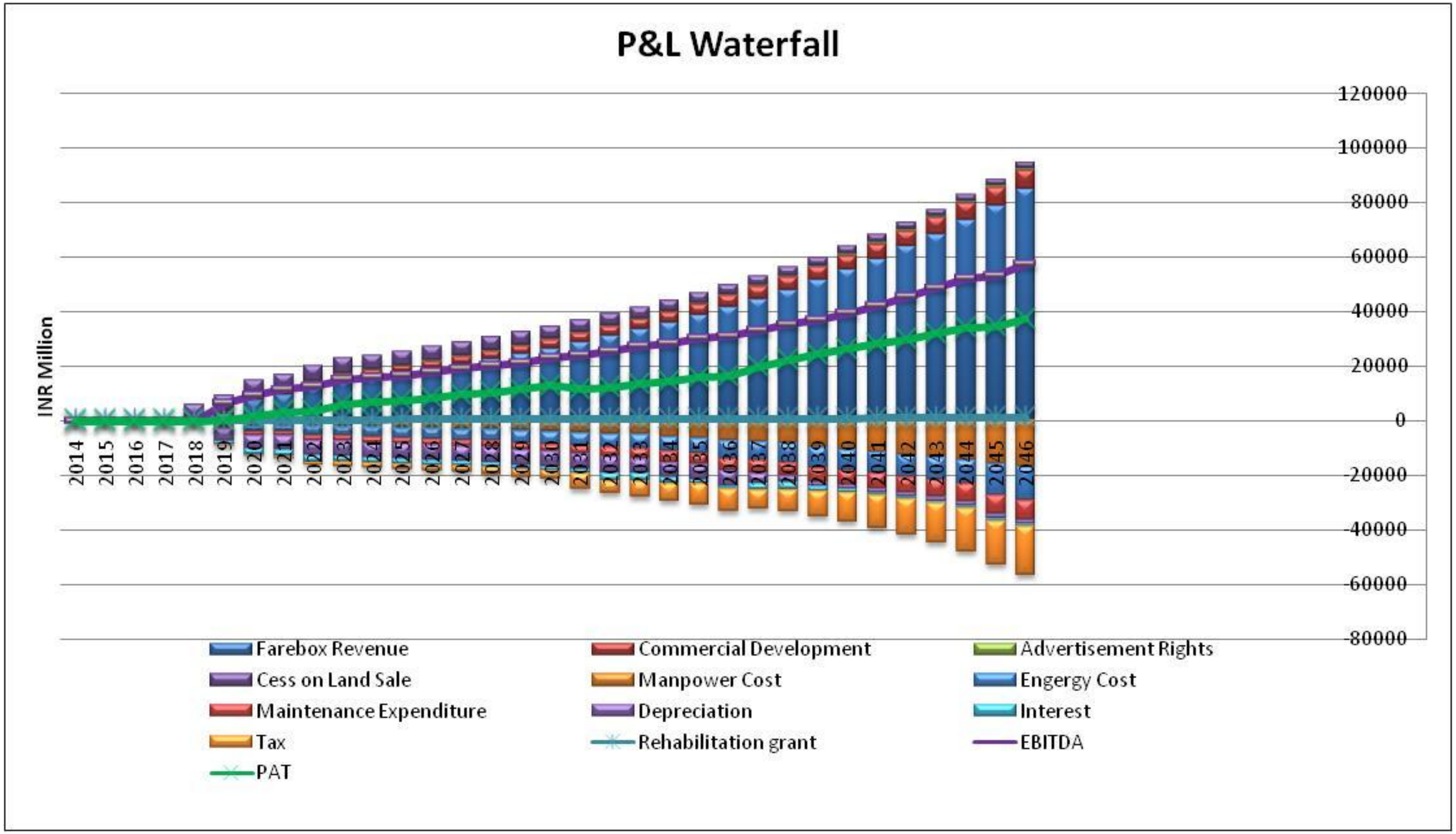
5.6.4 Profit and loss account for the Project

The project profit and loss statement for the project is presented below:

Table 5-7 : Profit and Loss statement synopsis for key years

P&L Statement (Rs Mil)	FY20	FY21	FY26	FY31	FY36	FY41	FY46
Revenue							
Fare box revenue	**7579**	**9825**	**19258**	**28872**	**41630**	**59445**	**84883**
Revenue from commercial development	1088	1486	2554	3259	4160	5309	6776
Revenues from	76	98	193	289	416	594	849

P&L Statement (Rs Mil)	FY20	FY21	FY26	FY31	FY36	FY41	FY46
Advertisment Rights							
Other Revenue (from ToD Betterment Charges)	6075	6075	5265	4455	3820	2956	2287
Total Revenue	***14819***	***17484***	***27269***	***36875***	***50026***	***68304***	***94795***
Expenses							
Maintenance cost	1459	1572	2161	2923	4360	5565	7102
Manpower cost	1589	1717	2774	4484	7248	11714	17212
power cost	2345	2415	4111	4765	6758	7834	11988
Rehabilitation Grant	335	352	450	574	732	935	1193
Total operating expenses	***5728***	***6056***	***9496***	***12746***	***19098***	***26047***	***37494***
EBITDA	9090	11428	17773	24129	30929	42257	57300
Depreciation	5020	5128	5453	5731	5865	1517	1517
EBIT	4071	6300	12320	18398	25064	40740	55784
Interest on long term loan	*2170*	*2090*	*1485*	*1004*	*446*	*49*	*0*
Interest on short term loan	*137*	*182*	*300*	*409*	*545*	*738*	*1014*
PBT	**1764**	**4027**	**10535**	**16985**	**24073**	**39953**	**54770**
Tax	353	806	2,108	5,580	7,735	11,828	17,528
PAT	**1411**	**3222**	**8427**	**11405**	**16338**	**28125**	**37242**


P&L Waterfall
INR Million
120000
100000
80000
60000
40000
20000
0
-20000
-40000
-60000
-80000
2014 2015 2016 2017 2018 2019 2020 2021 2022 2023 2024 2025 2026 2027 2028 2029 2030 2031 2032 2033 2034 2035 2036 2037 2038 2039 2040 2041 2042 2043 2044 2045 2046
Farebox Revenue
Commercial Development
Advertisement Rights
Cess on Land Sale
Manpower Cost
Engergy Cost
Maintenance Expenditure
Depreciation
Interest
Tax
Rehabilitation grant
EBITDA
PAT

5.6.5 Cash flow and IRR for the project

The estimation of the internal rate of return for the project is based on cash flow projected for the 30 year period of operations i.e. from FY2018 to FY2048.

The IRR for the project are as follows:

- Project IRR (Post Tax) 6.97%
- Project IRR (Pre Tax) 8.43%
- Equity IRR (at 60% soft loan @2%) 8.11%

Assessment of Weighted Average Cost of Capital

The above IRRs can be compared with the weighted average cost of capital (WACC) for the project as assessed below:

- Cost of equity for government: 10 year Indian Government security rate + 3% = 11.8% (source: Bloomberg, GIND10YR dated 17th Feb 2014 – 8.8%)
- Cost of debt: 2% (multilateral funding)
- Debt equity ratio: 60%/40%
- WACC = 11.8%x40% + 2%x(1-34%)x60% = 5.51%

The table below presents for the key years the cash inflow and outflow for the project and the project IRRs

Table 5-8 : Project Cash flow for estimation of Project IRR (Post Tax)

Particulars (All figures in Rs Mil)	FY14	FY15	FY16	FY17	FY18	FY19	FY20	FY21	FY26	FY31	FY36	FY41	FY46	FY48*
Inflow														
PAT	-250	-263	-276	-290	-304	150	1411	3222	8427	11405	16338	28125	37242	43129
Interest	0	0	0	0	0	1182	2307	2272	1785	1412	991	787	1014	1165
Depreciation	0	0	0	0	0	5020	5020	5128	5453	5731	5865	1517	1517	1513
Total Inflow	**-250**	**-263**	**-276**	**-290**	**-304**	**6352**	**8737**	**10622**	**15666**	**18549**	**23194**	**30429**	**39772**	**45807**
Outflow														
Capital Investment	0	-22452	-55063	-63178	-44671	-5020	0	-3420	0	-8973	-9556	0	0	105826
IDC	0	0	3	596	1916	1116	0	0	0	0	0	0	0	0
Total Outflow	0	-22452	-55059	-62582	-42755	-3904	0	-3420	0	-8973	-9556	0	0	105826
Netflow	**-250**	**-22715**	**-55335**	**-62872**	**-43059**	**2448**	**8737**	**7202**	**15666**	**9576**	**13638**	**30429**	**39772**	**151633**
Project IRR (Post Tax)	**6.97%**													

* It may be noted that the project IRR has been calculated for 30 years of operations for the project. At the end of 30 years, the residual value of civil works escalated at 5% has been added.

Table 5-9 : Project Cash flow for estimation of Project IRR (Pre Tax)

Particulars (All figures in Rs Mil)	FY14	FY15	FY16	FY17	FY18	FY19	FY20	FY21	FY26	FY31	FY36	FY41	FY46	FY48*
Inflow														
PAT	-250	-263	-276	-290	-304	613	2542	4767	11081	17338	24221	39964	54781	63789
Interest	0	0	0	0	0	801	1573	1577	1283	1103	875	787	1014	1165
Depreciation	0	0	0	0	0	4976	4976	5084	5409	5687	5832	1506	1506	1503
Total Inflow	**-250**	**-263**	**-276**	**-290**	**-304**	**6389**	**9090**	**11428**	**17773**	**24129**	**30929**	**42257**	**57300**	**66457**
Outflow														
Capital Investment	0	-22452	-55059	-62887	-44001	-4641	0	-3420	0	-8973	-9556	0	0	105826
IDC	0	0	0	305	1246	737	0	0	0	0	0	0	0	0
Total Outflow	**0**	**-22452**	**-55059**	**-62582**	**-42755**	**-3904**	**0**	**-3420**	**0**	**-8973**	**-9556**	**0**	**0**	**105826**
Netflow	**-250**	**-22715**	**-55335**	**-62872**	**-43059**	**2485**	**9090**	**8008**	**17773**	**15156**	**21373**	**42257**	**57300**	**172283**
Project IRR (Pre Tax)	**8.43%**													

* It may be noted that the project IRR has been calculated for 30 years of operations for the project. At the end of 30 years, the residual value of civil works escalated at 5% has been added.

5.6.6 Debt Service Coverage Ratio

The table below provides details of Debt service coverage ratio for the project

Table 5-10 : DSCR for key years

All figs in Rs Mil	FY19	FY20	FY21	FY26	FY31	FY36	FY41	FY46
PAT	150	1411	3222	8427	11405	16338	28125	37242
Depreciation	5020	5020	5128	5453	5731	5865	1517	1517
Interest	1182	2307	2272	1785	1412	991	787	1014
Total Cash Available During Loan Tenor	**6352**	**8737**	**10622**	**15666**	**18549**	**23194**	**30429**	**39772**
Total Debt	**4038**	**8018**	**7984**	**7497**	**7124**	**7322**	**3272**	**1014**
Cash Available Post Debt Service	**2314**	**719**	**2638**	**8169**	**11425**	**15872**	**27157**	**38758**
DSCR	1.57	1.09	1.33	2.09	2.60	3.17	9.30	39.23
Min DSCR	**0.76**							
No. of years when DSCR<1.25	**3**							
Average DSCR	**3.0**							
Years of distress	FY20, FY22, FY23							

5.6.7 Scenario Analysis

A comprehensive scenario analysis has been conducted to understand the impact of variation in various revenue and cost elements on the viability of the project. Project IRR, Equity IRR and DSCR have been calculated to understand the project viability under various scenarios

5.6.7.1 Defining Scenarios

Following scenarios have been generated in the financial model and IRR's and DSCR have been calculated for each of the scenario. It may be noted that each scenario is independent in its own and all scenarios are mutually exclusive. This analysis is for comparison of the base case with individual scenarios

- Scenario 1 - Waiver in central and State taxes on Capital cost
- Scenario 2 – Variation in capital cost by +10% or -10%
- Scenario 3 – Variation in farebox revenue by +10% or -10%

- Scenario 4 – Variation in Other revenue by +10% or -10%
- Scenario 5 – Variation in O&M cost by +10% or -10%
- Scenario 6 – Soft loan rate of interest at 5% instead of 2% (In case of exchange rate risk borne by the Project)

5.6.7.2 Scenario Results

The table below presents the results of running the above scenarios in the financial model

Table 5-11 : Scenario Analysis

No.	Scenario	Variation	Project IRR (Post Tax)	Project IRR (Pre - Tax)	Equity IRR (Post Tax)	Average DCSR	Minimum DSCR	No. of Distress Years
	BASE CASE		**6.97%**	**8.43%**	**8.11%**	**3.00**	**0.76**	**3**
1	Waiver of Central taxes		7.66%	9.23%	9.14%	3.36	0.88	3
	Waiver of Central and State taxes		8.01%	9.63%	9.67%	3.51	0.91	2
2	Capital cost	+10%	6.37%	7.73%	7.23%	2.81	0.72	4
		-10%	7.66%	9.22%	9.09%	3.31	0.82	3
3	Fare box revenue	+10%	7.67%	9.25%	9.18%	3.34	0.83	2
		-10%	6.21%	7.53%	6.88%	2.66	0.70	6
4	Other revenues	+10%	7.17%%	8.69%	8.44%	3.06	0.80	3
		-10%	6.76%	8.17%	7.75%	2.93	0.72	3
5	O&M cost	+10%	6.62%	8.01%	7.54%	2.85	0.72	3
		-10%	7.31%	8.84%	8.64%	3.15	0.80	3
6	Long term loan Interest rate 5%		7.15%	8.43%	7.04%	2.62	0.67	5

5.6.7.3 Project viability under base cost model (without escalation and soft loan)

Apart from the scenarios generated above, for understanding the project cost and revenues and it viability under base cost (2013 price levels) a base cost model has been constructed considering the following:

- Project Revenues at 2013 price levels with no escalation in fare, commercial tariffs etc.
- Project cost at 2013 price levels with no escalation in electricity charges, maintenance charges and salaries.
- Without considering the impact of financing (soft funding)

The IRR results for base cost model are as follows:

Post Tax Project IRR: 4.31%

Pre Tax Project IRR: 5.33%

5.7 Viability and structure of project under PPP structure

5.7.1 Role of Private Sector

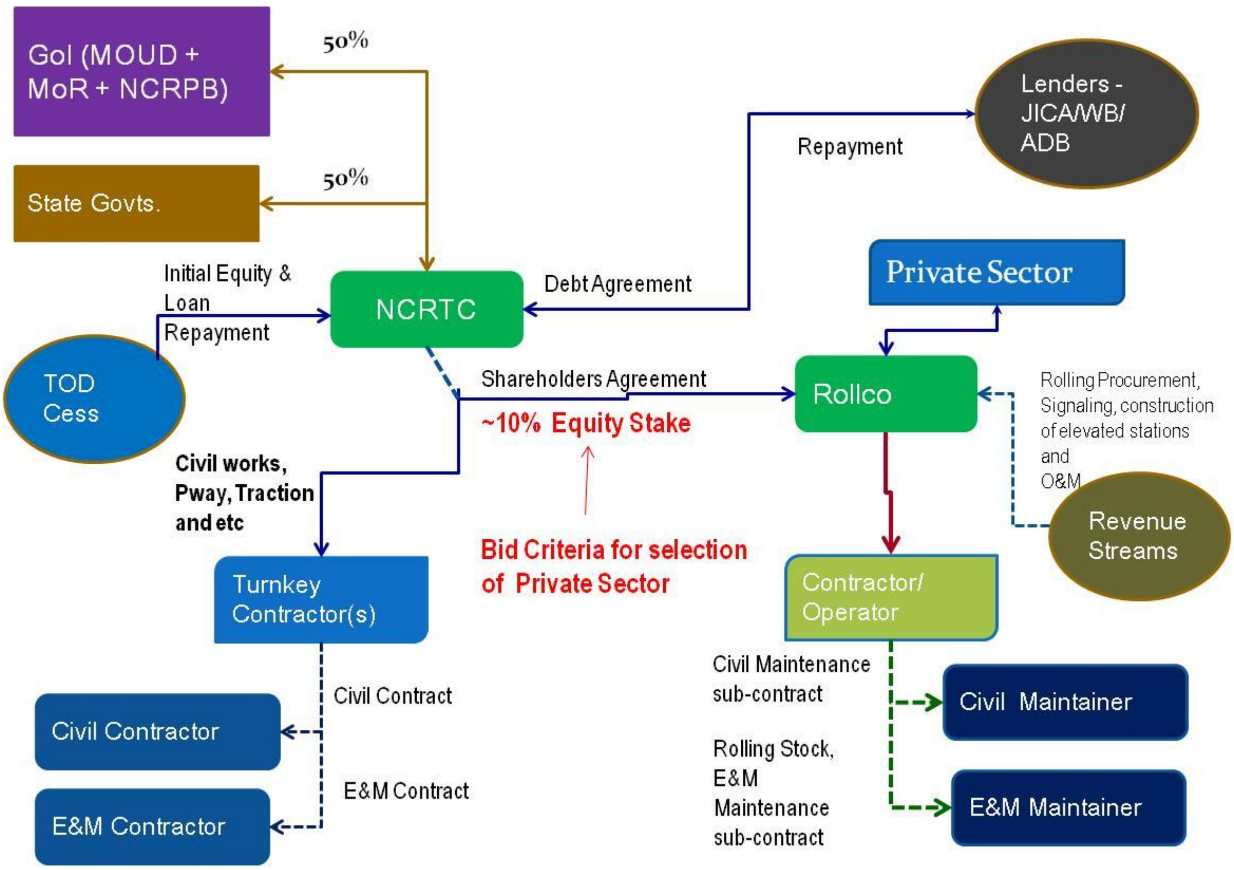
Private sector as the concessionaire has been fairly active in the Indian market in being part of these projects on reasonable commercial terms. Some of the projects have been successfully bid out using land banks provided as part of the project, such as Hyderabad Metro project. Other projects have used the distinction of basic infrastructure costs and rolling stock required for the project in order to enable the private sector participation, besides use of some commercial development.

We have carried out analysis for structuring the project under the PPP frame work, wherein the project can be developed under a suitable PPP frame work.

As per our estimation done under the financial analysis, private sector would be in a position to contribute 25-40% of the initial cost of construction, besides undertaking several other project responsibilities.

5.7.2 Typical Project Structure

Figure 5-1: Typical Project Structure



5.7.3 Role Division between Private Sector and NCRTC

Based on technical analysis carried out, the project elements that could be split between government and private sector are as follows below:

Table 5-12 : Project Components – Government and Private Sector (based on year 2013 base cost)

Item	Description	Total (Rs. Million)	Government Sector (NCRTC)	Private Sector
1.0	Government Contribution (land, R&R, Utility shifting)	23,580	23,580	-
2.0	Civil works, Alignment and formation	34,349	34,349	-
3.0	Station Building	16,229	2,922	13,307
4.0	E&M Works	3,735	794	2,941
5.0	Depot-cum-Workshop	2,267	1,198	1,069
6.0	Permanent Way	7,964	7,964	-
7.0	Traction & Power Supply incl. OHE, ASS etc.	9,307	9,307	-
8.0	Signalling and Telecom.	9,264	9,264	-
9.0	Automatic fare collection	622	-	622
10.0	Rolling Stock	23,616	-	23,616
11.0	Miscellaneous Items	1,518	-	1,518
12.0	General Charges incl. Design charge	5,541	3,388	2,154
13.0	Contingency	6,900	4,638	2,261
14.0	**Total Base Construction Cost**	**144,892**	**97,404**	**47,488**
	% of Initial Investment		**67%**	**33%**
	% of Total Lifecycle Investment		**50%**	**50%**

From the above analysis we suggest that about 67% of the initial construction cost would need to be contributed by the government or multilateral financial institutions. It would be prudent to, therefore split the project to deliver optimum project structuring wherein a government entity could raise fund from Financial Institutions and its own sources with about 33% of project cost from private sector investment.

5.7.4 Suggested Project Structure

The specific role of fund which could be launched by NCRTC and the role of private sector based on analysis provided in the previous section is being setout in the following paragraphs.

It is proposed that the project implementation in taken by way of splitting the project in the following:

a) NCRTC DP Infraco Fund (“DPInfraco Fund”) managed by NCRTC
b) RRTS Delhi-Panipat Rolling stock Limited (“DPRollco”) or the PPP Partner

5.7.5 Role of NCRTCDP Infraco Fund

NCRTC DPInfraco Fund can be responsible for undertaking project activities marked as Government Sector as set out in the previous table.

The contributors to DP Infraco fund could be as set out below:

Table 5-13 : Contributions to DP Infraco Fund

Name of Entity
MoUD, Govt. of India + NCRPB
Ministry of Railways + Govt. of India
Govt. of National Territory of Delhi, State Govt. of Haryana

NCRTC could take up implementation of earmarked project activities from capitalization provided by the various government entities such as the central government and the state governments. Further, the NCRTC could borrow money from multi-lateral financial institutions with suitable government guarantees, since multi-lateral financial institutions typically request for such guarantees as well as the fact that they would find it more convenient to fund a 100% government owned company as compared to a company with private sector majority holding.

As discussed in the chapter of Assumptions and Boundary conditions, for estimation of project viability under PPP structure, it has been assumed that 40% of initial project cost shall be supported through multilateral funding in form of soft loan.

The revenue of NCRTC would be primarily from betterment charges from ToD areas. In order to ensure high level of transparency in the transaction of these projects in long term of nature, it is suggested that revenue from ToD do not directly accrue to DPRollco and should accrue to NCRTC. NCRTC in turn could decide the disbursements based on commitments made to multilateral institutions, DPRollco and state governments, in this order.

The funds borrowed from multi lateral financial institutions could be paid through revenues collected as betterment charges/levies from ToD areas. Dividends and surplus retained by NCRTC can be used for development of additional projects in the future.

5.7.6 Role of DP Rollco/ PPP Partner

DPRollco can be responsible for undertaking project activities as set out in table above marked as Private Sector in the Table in previous section.

Revenue from DPRollco shall be primarily be fare box revenue, revenue from rentals at stations and commercial development at the stations and adjacent area and advertisement etc. DPRollco will be required to undertake initial capital investment on rolling stock, signaling and elevated stations above ground.

Besides the initial investment DPRollco shall required taking up of all operation and maintenance cost as well as making additional investments and replacements of equipment required from time to time.

In order to obtain a reasonable level of control, it is suggested that 10% of DPRollco is held by NCRTC DP Infraco Fund with atleast with 2-3 Directors from equity holder from NCRTC DP Infraco Fund.

5.7.7 Total project cost and Phasing

As discussed in section of Assumptions and boundary conditions, a soft loan of 40% of the total project cost @ 2% interest rate with 20 year repayment period has been considered in case the project gets implemented under suggested PPP structure.
The total project cost including all taxes, escalation of cost during construction and the component of interest during construction is estimated at Rs 18,904 Crs.

The table below specifies the year wise breakup of funds required for the total capital expenditure.

Table 5-14 : Year wise actual capital expenditure required for project under PPP structure (including IDC and margin money)

Component (Cost in Rs Mil)	FY15	FY16	FY17	FY18	FY19	Total
Land, R&R and utility shifting	7209	14418	0	0	0	21626
Civil works, Alignment and formation	5625	16089	21886	11731	0	55331
Overhead Station buildings	1976	6224	8714	4575	0	21489
Underground Station buildings	455	1435	2008	1054	0	4953
Depot-cum-Workshop	0	953	1540	566	0	3058
Power supply and substations	0	0	5428	6705	1056	13189
S&T (excluding onboard) and AFC	0	0	5458	7163	1504	14126
Miscellaneous	525	1102	1157	1215	638	4636
Rolling Stock	4831	10146	10815	5762	0	31554
Total	20622	50366	57005	38772	3198	169963
Other charges(contingency and project management)	1830	4693	5577	3983	345	16428

total capital cost without IDC	22452	55059	62582	42755	3543	186391
IDC	0	0	305	1246	737	2288
Total Capital cost without Margin money	22452	55059	62887	44001	4280	188679
Margin money	0	0	0	0	361	361
Total capital cost	22452	55059	62887	44001	4641	189040

5.7.8 Funding pattern

Following the project structure as suggested above, the actual funding required upto project commissioning for the project considering the central and state govt taxes, escalation in capital cost during construction period, IDC and margin money is presented in table below:

Table 5-15 : Total Investment breakup for project implementation under PPP structure (Capital cost including taxes, escalation, IDC and margin money)

Sl. No.	Name of Entity	Investment Based on Length		Contribution Based on Initial Investment	
		%	Rs. Million	%	Rs. Million
	Investments by DP Infraco				
1.	Govt of India (MOUD + MoR + NCRPB)	13.5%	25,536	13.5%	25,536
2	Govt. of National Territory of Delhi	3.5%	6,544	3.0%	5,586
3	State Govt. of Haryana	10.0%	18,992	10.5%	19,949
4	**Total by DP Infraco**	**27%**	**51,071**	**27%**	**51,071**
6	Soft Loan	40%	75,607	40%	75,607
	Investments by DP Rollco				
7	DP Rollco	33%	62,362	33%	62,362
8	**Total investment**	**100%**	**189,040**	**100%**	**189,040**

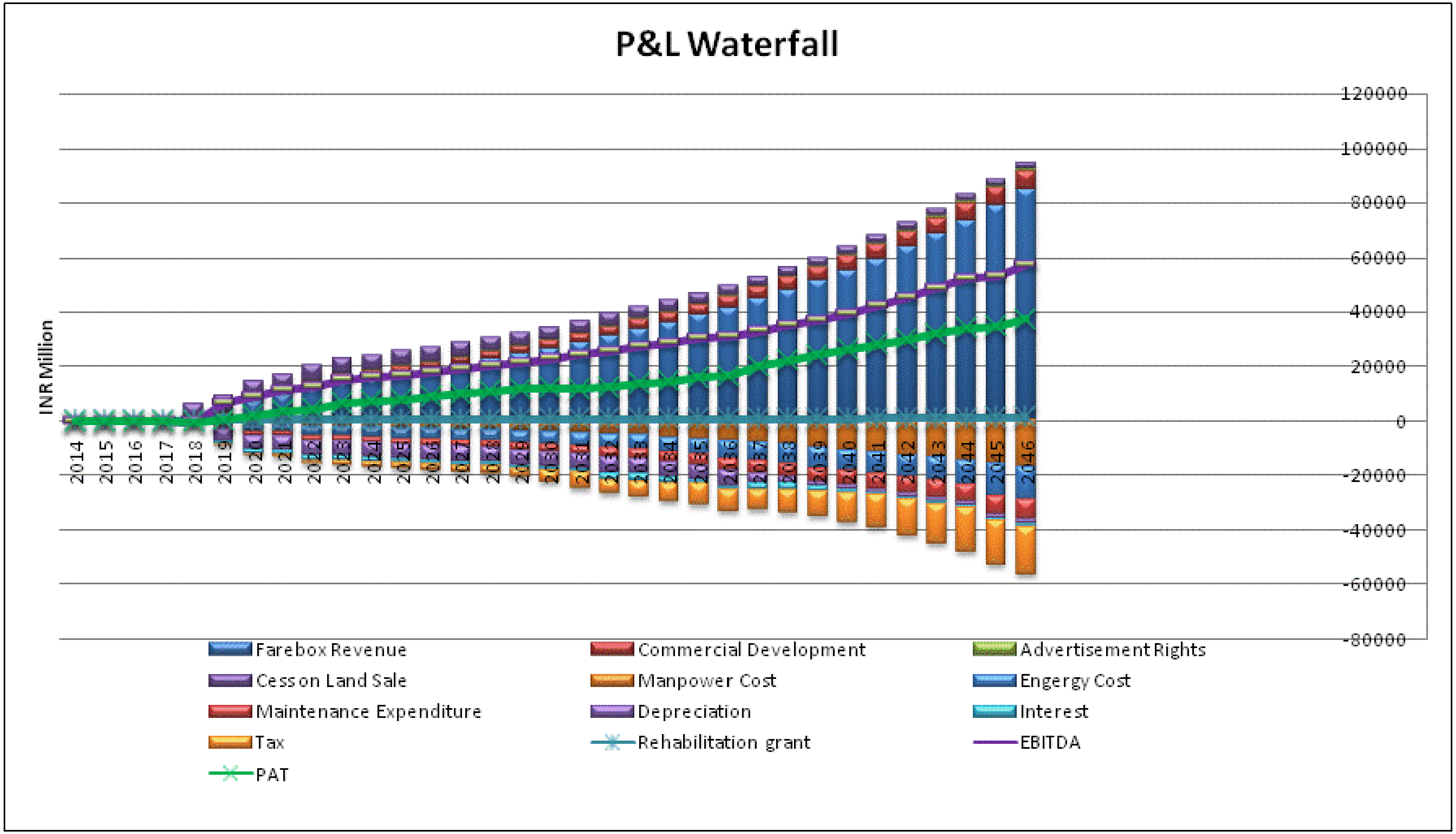
The aforesaid excludes the project funding required for additional investments in future as well replacement costs associated with the project. These costs shall be required to be incurred by the DP Rollco.

5.7.9 Profit and loss account for the Project under PPP structure

The project profit and loss statement for the project is presented below:

Table 5-16 : Profit and Loss statement synopsis for key years

P&L Statement (Rs Mil)	FY20	FY21	FY26	FY31	FY36	FY41	FY46
Revenue							
Fare box revenue	**7579**	**9825**	**19258**	**28872**	**41630**	**59445**	**84883**
Revenue from commercial development	1088	1486	2554	3259	4160	5309	6776
Revenues from Advertisment Rights	76	98	193	289	416	594	849
Other Revenue (from ToD Betterment Charges)	6075	6075	5265	4455	3820	2956	2287
Total Revenue	***14819***	***17484***	***27269***	***36875***	***50026***	***68304***	***94795***
Expenses							
Maintenance cost	1459	1572	2161	2923	4360	5565	7102
Manpower cost	1589	1717	2774	4484	7248	11714	17212
power cost	2345	2415	4111	4765	6758	7834	11988
Rehabilitation Grant	335	352	450	574	732	935	1193
Total operating expenses	***5728***	***6056***	***9496***	***12746***	***19098***	***26047***	***37494***
EBITDA	9090	11428	17773	24129	30929	42257	57300
Depreciation	4976	5084	5409	5687	5832	1506	1506
EBIT	4115	6344	12364	18442	25096	40751	55795
Interest on long term loan	*1437*	*1395*	*983*	*695*	*330*	*49*	*0*
Interest on short term loan	*137*	*182*	*300*	*409*	*545*	*738*	*1014*
PBT	2542	4767	11081	17338	24221	39964	54781
Tax	509	954	2217	5689	7776	11830	17529
PAT	**2033**	**3813**	**8864**	**11650**	**16444**	**28134**	**37252**


P&L Waterfall
INR Million
120000
100000
80000
60000
40000
20000
0
-20000
-40000
-60000
-80000
2014
2015
2016
2017
2018
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2044
2045
2046
Farebox Revenue
Commercial Development
Advertisement Rights
Cess on Land Sale
Manpower Cost
Engergy Cost
Maintenance Expenditure
Depreciation
Interest
Tax
Rehabilitation grant
EBITDA
PAT

5.8 Cash flow and Project IRR for the project

5.8.1 Project IRR

The estimation of the internal rate of return for the project is based on cash flow projected for the 30 year period of operations i.e. from FY2018 to FY2048.

The project IRR for the project are as follows:

- Project IRR (Post Tax) 6.93%
- Project IRR (Pre Tax) 8.43%

Assessment of Weighted Average Cost of Capital

The above IRRs can be compared with the weighted average cost of capital (WACC) for the project under the scenario of PPP funding as assessed below:

- Cost of equity for government: 10 year Indian Government security rate + 3% = 11.8% (source: Bloomberg, GIND10YR dated 17th Feb 2014 – 8.8%)
- Cost of capital for PPP partner: 9.42% (based on 70:30 debt equity to be funded at 10% for debt and 16% for equity)
- Cost of debt: 2% (multilateral funding)
- Debt equity ratio: 40%/60%
- WACC = 11.8%x27% + 2%x(1-34%)x40% + 9.42%x33% = 6.82%

The table below presents for the key years the cash inflow and outflow for the project and the project IRRs

Table 5-17 : Project Cash flow for estimation of Project IRR under PPP structure (Post Tax)

Particulars (All figures in Rs Mil)	FY14	FY15	FY16	FY17	FY18	FY19	FY20	FY21	FY26	FY31	FY36	FY41	FY46	FY48*
Inflow														
PAT	-250	-263	-276	-290	-304	490	2033	3813	8864	11650	16444	28134	37252	43139
Interest	0	0	0	0	0	801	1573	1577	1283	1103	875	787	1014	1165
Depreciation	0	0	0	0	0	4976	4976	5084	5409	5687	5832	1506	1506	1503
Total Inflow	**-250**	**-263**	**-276**	**-290**	**-304**	**6267**	**8582**	**10474**	**15556**	**18440**	**23152**	**30427**	**39771**	**45807**
Outflow														
Capital Investment	0	-22452	-55059	-62887	-44001	-4641	0	-3420	0	-8973	-9556	0	0	105826
IDC	0	0	0	305	1246	737	0	0	0	0	0	0	0	0
Total Outflow	0	-22452	-55059	-62582	-42755	-3904	0	-3420	0	-8973	-9556	0	0	105826
Netflow	**-250**	**-22715**	**-55335**	**-62872**	**-43059**	**2363**	**8582**	**7054**	**15556**	**9467**	**13596**	**30427**	**39771**	**151633**
Project IRR (Post Tax)	**6.93%**													

* It may be noted that the project IRR has been calculated for 30 years of operations for the project. At the end of 30 years, the residual value of civil works escalated at 5% has been added.

Table 5-18 : Project Cash flow for estimation of Project IRR under PPP structure (Pre Tax)

Particulars (All figures in Rs Mil)	FY14	FY15	FY16	FY17	FY18	FY19	FY20	FY21	FY26	FY31	FY36	FY41	FY46	FY48*
Inflow														
PAT	-250	-263	-276	-290	-304	613	2542	4767	11081	17338	24221	39964	54781	63789
Interest	0	0	0	0	0	801	1573	1577	1283	1103	875	787	1014	1165
Depreciation	0	0	0	0	0	4976	4976	5084	5409	5687	5832	1506	1506	1503
Total Inflow	**-250**	**-263**	**-276**	**-290**	**-304**	**6389**	**9090**	**11428**	**17773**	**24129**	**30929**	**42257**	**57300**	**66457**
Outflow														
Capital Investment	0	-22452	-55059	-62887	-44001	-4641	0	-3420	0	-8973	-9556	0	0	105826
IDC	0	0	0	305	1246	737	0	0	0	0	0	0	0	0
Total Outflow	**0**	**-22452**	**-55059**	**-62582**	**-42755**	**-3904**	**0**	**-3420**	**0**	**-8973**	**-9556**	**0**	**0**	**105826**
Netflow	**-250**	**-22715**	**-55335**	**-62872**	**-43059**	**2485**	**9090**	**8008**	**17773**	**15156**	**21373**	**42257**	**57300**	**172283**
Project IRR (Pre Tax)	**8.43%**													

* It may be noted that the project IRR has been calculated for 30 years of operations for the project. At the end of 30 years, the residual value of civil works escalated at 5% has been added.

5.8.2 DSCR for project under PPP implementation structure

The table below provides details of Debt service coverage ratio for the project

Table 5-19 : DSCR for key years under PPP implementation structure

All figs in Rs Mil	FY19	FY20	FY21	FY26	FY31	FY36	FY41	FY46
PAT	490	2033	3813	8864	11650	16444	28134	37252
Depreciation	4976	4976	5084	5409	5687	5832	1506	1506
Interest	801	1573	1577	1283	1103	875	787	1014
Total Cash Available During Loan Tenor	**6267**	**8582**	**10474**	**15556**	**18440**	**23152**	**30427**	**39771**
Total Debt	**2691**	**5353**	**5357**	**5064**	**4884**	**5275**	**3272**	**1014**
Cash Available Post Debt Service	**3576**	**3228**	**5117**	**10493**	**13556**	**17877**	**27155**	**38758**
DSCR	2.33	1.60	1.96	3.07	3.78	4.39	9.30	39.23
Min DSCR	**0.91**							
No. of years when DSCR<1.25	**1**							
Average DSCR	**3.72**							
Year of distress	FY22							

5.8.3 Scenario Analysis

A comprehensive scenario analysis has been conducted to understand the impact of variation in various revenue and cost elements on the viability of the project. Project IRR, Equity IRR and DSCR have been calculated to understand the project viability under various scenarios

5.8.3.1 Defining Scenarios

Following scenarios have been generated in the financial model and IRR's and DSCR have been calculated for each of the scenario. It may be noted that each scenario is independent in its own and all scenarios are mutually exclusive. This analysis is for comparison of the base case with individual scenarios

- Scenario 1 - Waiver in central and State taxes on Capital cost
- Scenario 2 – Variation in capital cost by +10% or -10%
- Scenario 3 – Variation in farebox revenue by +10% or -10%
- Scenario 4 – Variation in Other revenue by +10% or -10%
- Scenario 5 – Variation in O&M cost by +10% or -10%

- Scenario 6 – Soft loan rate of interest at 5% instead of 2% (In case of exchange rate risk borne by the Project)

5.8.3.2 Scenario Results

The table below presents the results of running the above scenarios in the financial model

Table 5-20 : Scenario Analysis

Scenario No.	Scenario	Variation	Project IRR (Post Tax)	Project IRR (Pre - Tax)	Average DCSR	Minimum DSCR	No. of Distress Years
	BASE CASE		**6.93%**	**8.43%**	**3.72**	**0.91**	**1**
1	Waiver of Central taxes		7.63%	9.23%	4.22	1.05	1
	Waiver of Central and State taxes		7.98%	9.63%	4.38	1.09	1
2	Capital cost	+10%	6.33%	7.73%	3.50	0.85	1
		-10%	7.62%	9.22%	3.97	0.97	1
3	Fare box revenue	+10%	7.63%	9.25%	4.14	0.99	1
		-10%	6.17%	7.53%	3.31	0.83	1
4	Other revenues	+10%	7.13%%	8.69%	3.80	0.96	1
		-10%	6.72%	8.17%	3.64	0.86	1
5	O&M cost	+10%	6.57%	8.01%	3.53	0.86	1
		-10%	7.26%	8.84%	3.91	0.96	1
6	Long term loan Interest rate 5%		7.06%	8.43%	3.33	0.81	3

5.8.4 Debt Servicing under PPP structure

The debt servicing of the soft loan can be under taken from the TOD betterment charges levied on sale of built up area as described in the Revenue estimation chapter.
The table below provides the Net Present Value (@10% discount factor) of the revenues generated from ToD Betterment Charges and principal and interest repayment of the soft loan from the multilateral agencies

Table 5-21 : Debt servicing under PPP implementation structure

Cess on TOD	Rs Millions NPV@10%	Remarks
Debt Servicing		
Principal Repayment	19,075	
Interest Repayment	4,961	
Total Debt servicing	**24,037**	
Rehabilitation grant during operations	4,488	
TOD betterment charges collected during operations	29651	
Surplus after debt servicing and rehabilitation grant during operations	1,126	Surplus funds after debt servicing may be distributed among the shareholders

5.8.5 Equity IRR for DP Rollco

As presented in the Table 5-15, the private partner DP Rollco, shall be investing 33% of the total project cost in the project.

NCRTC shall select the private partner DP Rollco based on the Capital grant (positive or negative) required by the private investor for investing the 33% of the funds.

For the suggested structure, the Equity IRR for the private investor DP Rollco has been estimated based on the following assumptions:

Table 5-22: Assumptions for Equity IRR of DP Rollco

Parameter	Unit
Debt Equity structure of Private partner (after reduction of Capital Grant)	70:30
Interest Rate[1]	10%
Moratorium Period/ Repayment Period	3Years/ 20Years
Capital Grant for Initial investment	20% (Rs 12663mil)

The Equity IRR estimated for the private investor is 14.04%. In this scenario, the Government shall have to pitch in an additional grant of Rs 12663 million.

[1] Funding through ECB route with LIBOR Rate: 0.5% to 1%; Premium over LIBOR: 2% - 5% and Hedging cost: 4%-6%

5.8.6 Equity IRR for DP Rollco under various scenarios of Grant

The table below presents the various scenarios of Grant and the respective Equity IRR for DPRollco.

Table 5-23: Scenarios for Capital Grant and Equity IRR of DP Rollco

Grant (%)	Grant (Rs Million)	Equity IRR
Base Case		
20% (Base Case)	12663	14.02%
Scenarios		
0%	0	11.54%
5%	3166	12.08%
10%	6331	12.62%
15%	9497	13.33%

In case of a positive grant required by DP Rollco, the funding from the government for the project would increase to the extent of the amount of grant provided. The table below presents the various scenarios of grant and the respective total funds required from the government including the grant for DP Rollco.

Table 5-24: Total funds from Govt. (including grant) under various scenarios of grant

Scenarios for Grant (%)	Grant (Rs Mil)	Investment from DP Infraco (Rs Mil)*	Total from Government (Rs Mil)
0%	0	51071	51,071
5%	3166	51071	54,237
10%	6331	51071	57,402
15%	9497	51071	60,568
20%	12663	51071	63,734

* As presented in Table 5-15

5.8.7 Equity IRR for DP Rollco under various scenarios of Interest rate for DPRollco

The table below presents the various scenarios of interest rates the respective Equity IRR for DPRollco.

Table 5-25: Scenarios Equity IRR for DPRollco under different interest rates

Long Term Interest Rate (%)	Equity IRR
Base Case	
10% (Base Case)	14.04%
Scenarios	
8%	15.13%
12%	12.99%

6 ECONOMIC VIABILITY ASSESSMENT

6.1 Approach

Economic viability of the proposed RRTS project has been assessed within the broad framework of "Cost-Benefit Analysis", generally used for appraisal of public investment projects. In economic evaluation, benefits are computed for the economy as a whole rather than for an individual entity that has made the investment. In case of financial analysis the profits become the major factor for evaluation whereas in economic analysis the benefits to the economy are the main criteria for evaluation.

The economic analysis involves comparison of project costs and benefits in economic terms under the "with" and "without" project conditions and determining the Economic Internal Rate of Return (EIRR) of the project using discounted cash flow technique. This shows the return which the society could expect from the proposed investment during the project life, i.e. analysis period. The EIRR is then compared with the accounting rate of return considered as the cut-off point for undertaking the investment by the Government of India and international funding agencies like the World Bank and the Asian Development Bank (ADB).

The main steps followed are:

i) Estimation of capital and maintenance costs at economic prices, along with the capital cost phasing

ii) Estimation of economic benefits

iii) Comparison of annual streams of costs with benefits and estimation of EIRR

The project is further subjected to sensitivity analysis by assessing the effects of adverse changes in the key variables on the base EIRR. This helps to gauge the economic strength of the project to withstand future risks and uncertainties..

6.2 The Improvement

Description of economic benefits and costs of the Delhi –Sonepat PanipatRRTS requires the identification of the changes brought out by it in the transport sector of the economy. Most importantly, RRTS contributes to the diversion of a high proportion of current private traffic from road to RRT and serves part of the growing passenger traffic demand in NCR. As a result, there will be a reduction in the number of buses, passenger cars and other vehicles carrying passengers on NCR roads. There will be savings in travel time for passengers traveling by RRT due to higher speed and residual traffic left on road will also be benefited due to reduced congestion. The RRTS will also bring about a reduction in air pollution because of the substitution of electricity for petrol and diesel and enhances safety on the roads. There will also be a reduction in the number of accidents on the roads.

Investment in the RRT could result in the reduction of government investments on road developments and buses as also in the private sector investment on buses, cars and other vehicles carrying passengers. There will be reductions in motor vehicles operation and maintenance charges to both the government and the private sector.

In addition, there will be health and other environmental benefits to the public due to reduced pollution from the transport sector of NCR. Land and house property owners gain from the increased valuation of house property prices due to the RRT. While some of the above benefits are quantifiable, others are difficult to measure. For the proposed project, benefits from following were assessed:

- Savings in Fuel Consumption
- Savings in Vehicle Capital Costs
- Savings due to reduced Environmental Pollution
- Savings in Travel Time
- Savings in Road Construction costs
- Accident cost
- Comfort cost

In addition the items quantified above, the community will be benefited by following items which are difficult to quantify. These are listed below;

- Health Benefits.
- Savings in vehicular operating costs due to the decongestion effect on residual traffic
- Land price increase

6.3 Project Cost and Scheduling

The cost of the proposed RRTS infrastructure project consists of two main components:

- Capital cost of construction of RRTS
- Operation and Maintenance cost

Economic analysis requires the conversion of financial costs into economic costs to take care of distortions in prices due to market imperfections. Taxes and duties are removed from financial prices, as these are not real costs to the economy, but are only transfer payments.

All financial costs have been converted into economic costs, which are net of taxes and duties, by applying the standard conversion factor of 0.9.

All financial costs have been taken at base value of 2013 price levels.

6.4 Capital Cost and it's Phasing

The base capital cost of the project without central and state taxes is estimated at Rs14,489 Crs (2013 prices) . The project cost is to be incurred over five financial years, with as discussed in the financial viability section of the DPR. The facilities will be operational from October 2018. Also as discussed in the financial viability section capital expenditure for future has also been considered. The cost of land acquisition is Rs 2163 Crs. As discussed and suggested during review with ADB consultants, the land cost has been removed from the total cost to estimate the economic cost of the project. Since the base capital cost does not contain any central and state taxes, the base capital cost less land acquisition cost has been taken as the economic cost of the project The calculated economic capital cost and its phasing along with future expenditure is provided in the table below:

Table 6-1: Capital cost - Economic cost of project (Rs Crs)

Year	Economic cost of project (Rs Crs)
2014	1458
2015	3589
2016	4112
2017	2865
2018	302
2021	842
2031	1644
2036	1510

6.5 Operations and maintenance cost

The operation and maintenance (O&M) cost involves energy cost, staff cost and other operation and maintenance of running RRTS and related facilities. The cost of operation and maintenance is estimated and described in the chapter of Estimation of Operations and Maintenance cost of the financial viability section of the report.

The operation and maintenance cost is converted into economic costs by applying a factor of 0.85 to financial costs. (The conversion factor has been taken from economic studies followed by DMRC in their DPRs (reference DPR for Jaipur Metro phase II).The project duration for operations is assumed to be from year 2018 to 2048. The operation and maintenance cost in financial terms is vary from year to year depending upon the level of operations and maintenance required in each year. However for economic viability, the operations and maintenance cost for each year has been taken at base year 2013 price levels.

6.6 Project benefits

The commissioning of the proposed RRTS project is expected to result in both direct and indirect benefits to the users. The present analysis covers quantification of direct benefits in terms of savings in time, VOC/fuel, capital cost of cars, highway construction. Benefits due to improved environmental conditions are also quantified using rapid techniques.

6.6.1 Time Savings

In order to work out time savings, the speeds for different vehicles have been calculated from surveys. The RRTS speeds were determined from simulation done as part of operation plan. The time savings have been worked out as the difference of travel time under “with and “without” project situations. The savings of travel time of passengers traveling by the RRTS instead of by road are calculated as the product of the number of passengers traveled daily and the time saved on the average passenger trip lead on the corridor.

The average Value of Time per person is arrived based on traffic surveys conducted for project. The average VOT rates adopted are Rs. 81.4 per hour. Passenger time saving per annum for RRTS is then calculated as the product of daily passengers carried, time saved on average lead on an annual basis and the value of time of RRTS passengers. Benefits to residual vehicles are not considered in present analysis. The total time savings per year are presented in table below

Table 6-2 : Economic benefits – Time savings

Year	Time Saving (Rs Cr/Year)
2018	492
2021	795
2031	1133
2041	1884
2046	2135

6.6.2 Fuel Cost Savings

There are savings in fuel consumption due to the diversion of a part of the road traffic to RRTS and reduced congestion to vehicles still operating on the roads. Fuel saved due to traffic diverted to the RRTS is estimated given the estimates of diverted traffic and the distance travelled and fuel consumption norms of different vehicles. The total fuel savings based on 2013 price levels is presented below. An economic price of Rs 45/liter for petrol and diesel (excluding taxes ~40% and subsidy on diesel) has been considered for estimation of fuel cost savings.

Table 6-3 : Economic benefits – Fuel cost savings

Items	Units	2018	2021	2031	2041	2046
Fuel saved per year	lts ('000)	104888	131247	186912	235860	273426
Cost of fuel saved per year	Rs Crs	472	591	1402	841	1230

6.6.3 Saving in road construction cost

Due to the lesser number of vehicles on road due to RRTS, lesser road capacity will be required. This will results in savings of highway construction cost. To estimate savings, total additional express highway lanes required in “without RRTS situation” were calculated and multiplied with average construction cost of Rs 33 crore/km for 2+2 lane express highway for 100 km length. The land acquisition cost was estimated by assuming 60 m ROW requirement for 100 km stretch of land acquisition. It has been estimated that by 2018 an additional 2+2 lanes would be required in case RRTS is not constructed. This requirement increases to 3+3 lanes by 2021, 4+4 lanes by 2031 and 6+6 lanes by 2041.

6.6.4 Environmental benefits

Fewer vehicles and the decongestion for the residual traffic on influence area roads due to RRTS could lead to reduced air pollution. An estimate of the pollution reduction by a vehicle in this context could be obtained by multiplying the distance saved by the relevant emission coefficient for different pollutants for each category of vehicle. The emission coefficients for different vehicles are given in table below. Estimates of reduction in distance traveled every day due to the lesser vehicles on the road is estimated by assuming average vehicle travel of 55 km for cars, 25 kms for 2 wheelers and 200 km for buses . The monetary value of these pollution loads are estimated using the estimates of prices of pollutants made in some recent studies in India which are reported in the same table

Table 6-4 : Pollutant by vehicle type (kg/km)

Pollutant	car	2wheel	Bus	Cost (Rs)
PM	0.03	0.075	0.05	4777
NOX	0.2	0.3	0.87	6724
HC	0.25	0.7	2.75	502
CO	1.98	2.2	0.66	448

(*Source: Social Cost-Benefit Analysis of Delhi Metro, M N Murty, Kishore Kumar Dhavala, Meenakshi Ghosh and Rashmi Singh, 2006)*

Table 6-5 : Economic benefits: Savings due to reduction in pollutants

Year	Cost Savings (Rs. Cr)
2018	351
2021	437
2031	622
2041	784
2046	889

6.6.5 Vehicle capital cost savings

The number of vehicles going off the road due to the introduction of RRTS was estimated by determining the shift of private vehicle passengers and bus passengers. Based on average occupancy of various vehicle types, passenger data was converted into vehicles for analysis purpose. This data was projected as per the transport demand forecasts conducted for the project. The total capital cost saving due to fewer vehicles on the road is estimated and presented in Table below:

Table 6-6 : Economic benefits: Vehicle capital cost saving

Year	Cost Saving (Cr)
2018	3467
2021	1398
2031	1918
2041	1686

6.6.6 Accident cost

The savings due to reduction in accident cost has been estimated based on the reduction in total vehicles. As per MORTH data on Road accident statistics of India: year2004, the number of accidents/ 10000vehicle has been taken as 59.12 and number of persons killed/ 10000 vehicles has been taken as 12.74. The unit vehicle cost has been assumed as Rs 5 lakhs and unit person cost Rs 1 crore.

6.7 Economic Internal Rate of Return (EIRR)

. The net cash flow statement for economic benefits are presented in table below**.** The rate of return considered desirable for the transport infrastructure project in India is 12 percent. As EIRR of proposed RRTS facility is 26.92%, which is above 12 percent cut-off rate, the project is economically viable.

Table 6-7 : Economic benefits: EIRR and cashflow (Rs Crs)

Year	Costs		Benefits (Rs Crs)							
	Capital Costs	O&M Cost	Fuel Cost Saving	Time Saving	Vehicle Capital Cost Saving	Environmental Benefits	Highway cost Savings	Accident cost	Total	Net Benefits (Rs Crs)
2014	1458									-1458
2015	3589									-3589
2016	4112									-4112
2017	2865									-2865
2018	302	167	472	492	3467	351	7875	137	12794	12325
2019		323	509	530	0	378	17	148	1581	1259
2020		325	548	571	0	407	17	160	1702	1377
2021	842	410	591	795	1398	437	5044	172	8436	7184
2022		410	612	824	0	452	33	177	2098	1688
2023		417	634	854	0	469	33	182	2171	1755
2024		417	657	884	0	485	33	188	2247	1830

Year	Costs		Benefits (Rs Crs)							
	Capital Costs	O&M Cost	Fuel Cost Saving	Time Saving	Vehicle Capital Cost Saving	Environmental Benefits	Highway cost Savings	Accident cost	Total	Net Benefits (Rs Crs)
2025		417	680	916	0	503	33	193	2326	1909
2026		417	705	949	0	521	198	199	2572	2156
2027		417	730	983	0	540	33	205	2491	2074
2028		424	756	1019	0	559	33	211	2578	2154
2029		424	784	1055	0	579	33	217	2669	2244
2030		430	812	1093	0	600	33	224	2762	2332
2031	1644	447	841	1133	1918	622	1852	230	6596	4504
2032		447	861	1159	0	636	50	237	2944	2496
2033		456	881	1187	0	651	50	244	3013	2557
2034		456	902	1215	0	667	50	252	3084	2629
2035		510	923	1243	0	682	50	259	3157	2647
2036	1510	510	945	1273	0	698	198	267	3381	1361
2037		510	967	1302	0	715	50	275	3309	2798
2038		519	990	1333	0	732	50	283	3387	2868
2039		519	1013	1364	0	749	50	291	3467	2948
2040		519	1037	1397	0	766	50	300	3550	3030
2041		519	1061	1884	1686	784	3506	309	9230	8711
2042		519	1087	1928	0	803	51	318	4187	3667
2043		519	1112	1974	0	822	52	327	4288	3768
2044		615	1139	2021	0	842	53	337	4392	3776
2045		615	1166	2069	0	862	54	347	4498	3882
2046		615	1193	2118	0	882	56	358	4606	3991
2047		615	1222	2168	0	903	57	368	4718	4103

6.8 Sensitivity Analysis

The robustness of the project's viability is further demonstrated by the sensitivity analysis. Because of the uncertainties pertaining to traffic forecasts and critical parameters relating to cost and benefits, a sensitivity analysis was carried out to test the economic strength of the project. The variations in the following parameters have been examined, considering them to be on the conservative side:

- Increase in cost by 15 percent
- Decrease in benefits by 15 percent
- Increase in cost by 15 percent and decrease in benefits by 15 percent
- EIRR excluding benefits due to highway cost savings

The results of the sensitivity analysis are presented in the table below

Table 6-8 : Economic benefits: EIRR sensitivity analysis

Case	Economic Internal Rate of Return
Base Case	26.92%
15% increase in costs	22.85%
15% Decrease in benefits	22.22%
15% increase in costs and 15% decrease in benefits	18.62%
Excluding benefits due to highway cost savings	15.23%

7 RECOMMENDATIONS AND WAY FORWARD

7.1 Project Implementation by NCRTC and NCRPB

NCRPB has been spearheading the RRTS projects and has been able to bring the projects on the agenda of Central Government and State Governments. NCRPB has further been instrumental in formation of NCRTC with equity holding from the participating states.

The project is expected to be taken forward by NCRTC for implementation and operations. However, the role envisaged for NCRTC is not limited to Delhi-Panipat RRTS and is far wider in terms of development of transit infrastructure in NCR besides development of all RRTS projects.

In Phase 1 itself 3 RRTS projects are envisaged and the investment in these three projects itself would be in the range of Rs. 90,000 crores. For project implementation and operations a man power of around 10,000 would be required in case all the three RRTS projects are taken by NCRTC itself.

This would still leave to be addressed by NCRTC all other soft issues related to development of transit infrastructure, coordination between states, implementation and management of ToD betterment charges, other commercial issues, tariff fixation and land acquisition and development of all the remaining RRTS other than envisaged in phase 1 RRTS.

7.2 Team for NCRTC

Team for NCRTC would need to have following professionals:

- Finance professionals for implementation and operation phase
- Planning professionals for development of RRTS corridor
- Engineering professionals for implementation of RRTS projects
- Operations professionals from Engineering and other backgrounds

Apart from this there would be requirement of expertise and personnel related to areas such as transaction advisory, design and project management mainly during the project implementation phase.

7.3 Equity Contribution by Stakeholders

One of the important issues is what should be the basis for equity contribution by the stakeholders. Each of the stakeholders of NCRTC shall contribute a defined amount for project implementation.

Based on structure of NCRTC, it is understood that the contribution between the Centre and State Governments shall be in the proportion of 50:50 to finance the government's equity contribution for the project cost.

The State Governments that would contribute to each RRTS project would typically be the states from where RRTS alignment passes through. Therefore the states of UP and Rajasthan may not like to contribute towards Panipat-Delhi RRTS project. The two states of Delhi and Haryana could contribute to the project.

To decide the basis of equity contribution from each state in a project, alternatives evaluated were based on (a) equal percentage (50% each), (b) route length passing through each state and (c) investment on RRTS project in each state.

Route length does not always reflect the extent of investment required, since the number of stations, alignment location (at grade, underground, elevated), land cost are also an important criteria. Typically a heavily built up area requires an underground system.

In case route length is used as the sole criteria, the states may decide to push in more length underground through their respective areas, which may reduce the overall viability of the project. Similarly, the states may demand additional number of stations since cost sharing is based on route length.

Based on aforesaid argument, we recommend that equity contribution could be made by states in the terms of estimated investment. The present report provides on the estimate of investment in each state and this could be further refined during the construction stage.

7.4 Options for Project Structure

Based on the scope of work envisaged in para 1 of this Chapter, NCRTC could:

(A) Either deliver the entire scope of work on its own or

(B) Seek participation in delivery of the projects.

The former is not the most recommended option even though it has its advantages as described in the following paragraph.

The advantage of NCRTC taking up RRTS projects on its own would be a clear command and control wherein based on stakeholders decision and funds availability, the projects could be implemented swiftly. There have been success stories in this model. DMRC is the classic success story wherein due to large and low cost funds availability from the Central Government, State Government and Multi-lateral Institutions, have helped to deliver the project. Also, availability of support at policy level, administrative support, support in land availability, timely availability of clearances such as archeological and heritage clearances, traffic and security clearances have helped the project. The high level of technical competence and skill set available from the multi-lateral institution has also been one of the important criteria for the success of DMRC model.

NCRPB / NCRTC could therefore explore the possibility of delivering the first project as a pilot project under the aforesaid model as adopted by DMRC.

However, as a long term option PPP structure would need to be explored, where part of the work responsibility financing and risks are shared with a suitable private developer.

7.5 PPP Structure

NCRTC could invite private investors either at the implementation stage at the operations stage of the projects. Since it would be possible to invite the private operators at any point during the project operations phase, the advantages of involving private investors at project implementation stage are being discussed in this report.

For Rail based Urban Transit Project, the basic philosophy of separation of civil construction and other infrastructure development from Rolling Stock and Operation remains strong for PPP projects.

Lessons need to be learnt from the New Delhi Airport Express Line project wherein the Concessioning Authority has taken over the operations from the Concessionaire. Issues related to coordination and control, construction quality, design issues, aggressive bidding based on real estate outlook, operational and inter-connection could have led to aforesaid situation.

It would be possible to insulate the RRTS project from potential problems through suitable contractual structures. It may be noted that equity cross holding may not lead to better co-ordination and control in absence of appropriate contractual structures. However minor equity stake could assist in more active decision making process.

Financial Analysis of NCRTC and DPRollco have been made in order to understand the project finances. The suggested project structure will require a high level of refinement and appropriate contractual agreement between parties with clear roles and responsibilities.

Irrespective of the project structure NCRTC would need to a play and active role in selection of suitable private developer, implementation and operations.

7.6 Possible Options under PPP Structure

The options available with NCRTC for structuring the project under PPP mode are:

- Option 1: NCRTC to undertake construction of civil structures under EPC contracts with rolling stock brought in by the Concessionaire (DP Rollco) or
- Option 2: The Concessionaire (DP Rollco) undertakes the entire project on its own.

Option 2 can be implemented wherein DP Rollco is initially paid for civil construction based on predetermined milestones. Structuring the project under Option 2 would have advantages in terms of involvement of the private partner right through design and construction and thus reducing these risks that could cause irreparable damage to the project.

However for this project considering the amount of investment required, considering the risks related to construction, financing, land acquisition and administration issues, whether the market has sufficient depth to deliver such a project may be doubtful.

The Option 1 which would even though increase the requirement of coordination between NCRTC and DP Rollco would be better for comparatively less risk taking developers/ conservative developers.

Also in case of option 1, the bidding criteria would be far easier to define and understand since the cost of rolling stock and operations can be estimated and the construction cost and time related risks would be passed on to NCRTC.

Based on inputs from potential developers, NCTRC could take appropriate decision on the matter. In our opinion, Option 1 i.e. NCRTC undertaking civil and other infrastructure related implementation may be more feasible option as compared to the option 2 i.e. DP Rollco implementing the entire project on its own.

As a bidding tool, the 10% stake in DPRollco by NCRTC could be used by way of positive or negative valuation for nominal 10% of DPRollco.

7.7 Raising of Financial Resources

To raise financial resources three pronged strategy needs to be followed:

- Commencement of negotiations with financial institutions and Government of India for obtaining soft loan.
- Finalizing equity contribution plans with state governments
- Implementation of Transit Oriented Development Zones

7.8 Declaration of Transit Oriented Development zones and Land Availability

The actions which need to be taken related to ToD are:

a. Preparation of Development Plans based on ToD Areas within a timeframe say 3 months
   - Conduct Survey to mark land boundary, existing physical features - topography, slope, plot boundaries, existing structures.
   - Establish ownership of land by using revenue records.
   - Prepare detailed Development Plans including recommendations on FAR.
   - Superimpose Development Plan on Survey Maps.
   - Make provisions for RRTS infrastructure facilities, roads, dedicated bus corridors, subways, water, electricity, sewage, drainage, solid waste management, green areas, social areas and other special requirements.
   - Calculate total area required for infrastructure.
   - Reconstitute the remaining area.

b. Legislation for collection of TOD Betterment Charges/levies cess from ToD areas.

c. Land acquisition where required for the project infrastructure area.

d. Identification and marking of alignment on the green belt in Haryana.

e. Land pooling activities as defined below:
   - Respective State Government identifies area for Land Pooling
   - State Government nominate an Agency (A development authority, corporation, any other agency)
   - Agency appoints a Development Officer
   - Development Officer prepares detailed layout plan

- Development Officer invites objections from land owners
- Development Officer, based on review of objections, makes necessary revisions
- Authority, recommends to the state government for notification
- Develop major infrastructure

Financial compensation/ collection from land owners done by the Authority

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EXECUTIVE SUMMARY

1.0 INTRODUCTION

National Capital Region Planing Board (NCRPB) has appointed M/s Delhi Integrated Multimodal Transit System (DIMTS) in association with M/s Consulting Engineers Group Ltd (CEG) to produce detailed project report (DPR) for a High speed rail link Regional Rapid Transit System from Delhi to Panipat. A high speed rail corridor of about 111 km length comprising of Delhi (Mukarba, Chowk, Narela), Sonepat (Kundli, Rai, Murthal Gannaur) and Panipat (Samhalkha, Panipat city) is proposed. The new system will facilitate integration with other modes of transport such as Delhi Metro and bus networks. RRTS is a clean, environment friendly alternative. The proposed high speed rail system will be on the elevated tracks (except the first 3 km of underground portion), and will facilitate integration with other modes of transport networks.

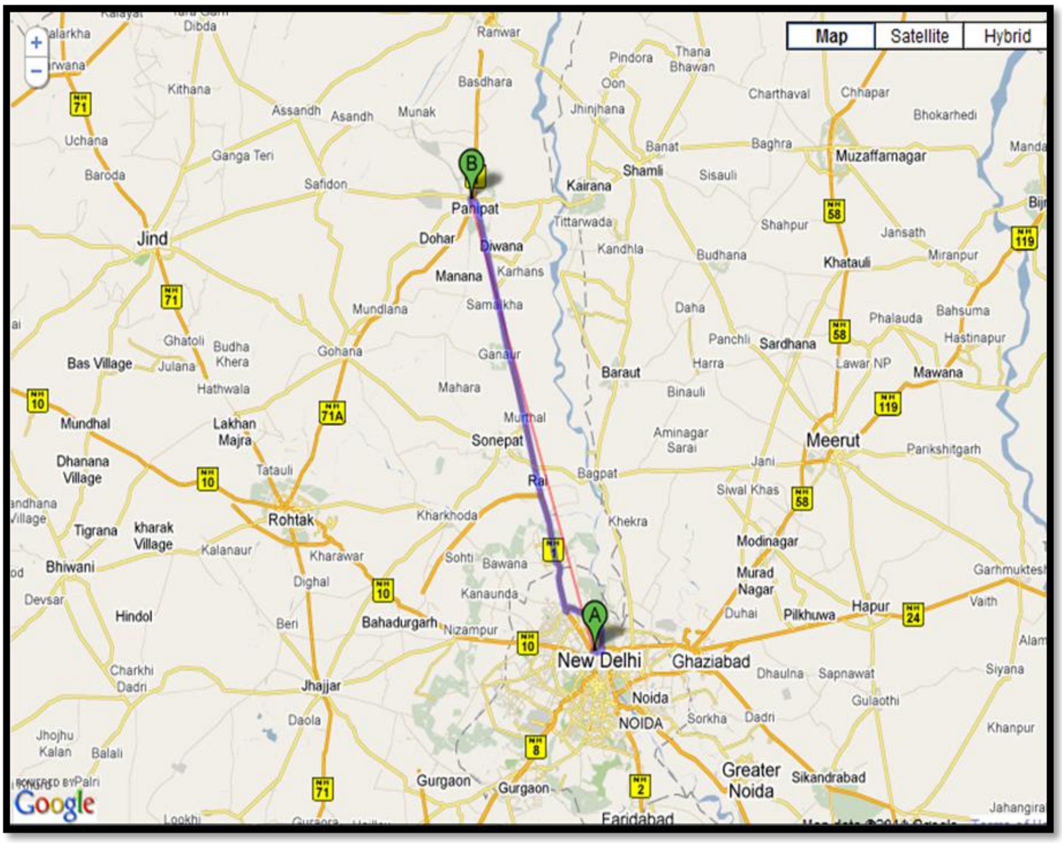


Figure ES-01 Map showing the study area

DIMTS

The construction period for the completion of the High speed Regional Rapid Rail Transit System freight will be six years.

2.0 OBJECTIVES AND OF SCOPE THE ASSIGNMENT

NCRPB has opted to conduct Environmental Impact Assessment study and formulate Environmental Management Plan (EMP) with an objective to mitigate potential negative impacts, if any, arising due to implementation of the proposed project.

The scope of the study in general is as follows:

- To conduct a literature review for both, the project activities and the study area.
- To collect data on baseline environmental status of the study area.
- To compile data on statutory environmental standards applicable to project activity
- Impact assessment of the proposed activities on the base line environment in the project area and to advise appropriate pollution abatement measures.
- To prepare an Environmental Management Plan (EMP) detailing the measures for improving the environmental quality.
- Budgetary cost estimation for implementation of the EMP.
- To identify critical environmental attributes, which are to be monitored and managed during the implementation and operation of the proposed project.

3.0 BASE LINE ENVIRONMENT

Data was collected from secondary sources for the macro-environmental setting like geological, climatic, physiographic, biological and socio-economic environment within project influence area. Information has been collected to record the micro-environmental features within the Corridor of Impact.

First hand (Primary) information collected includes environmental monitoring covering ambient air, water, soil, noise and tree enumeration, location and measurement and preparation of base maps, extrapolating environmental and socio economic features along the project alignment.

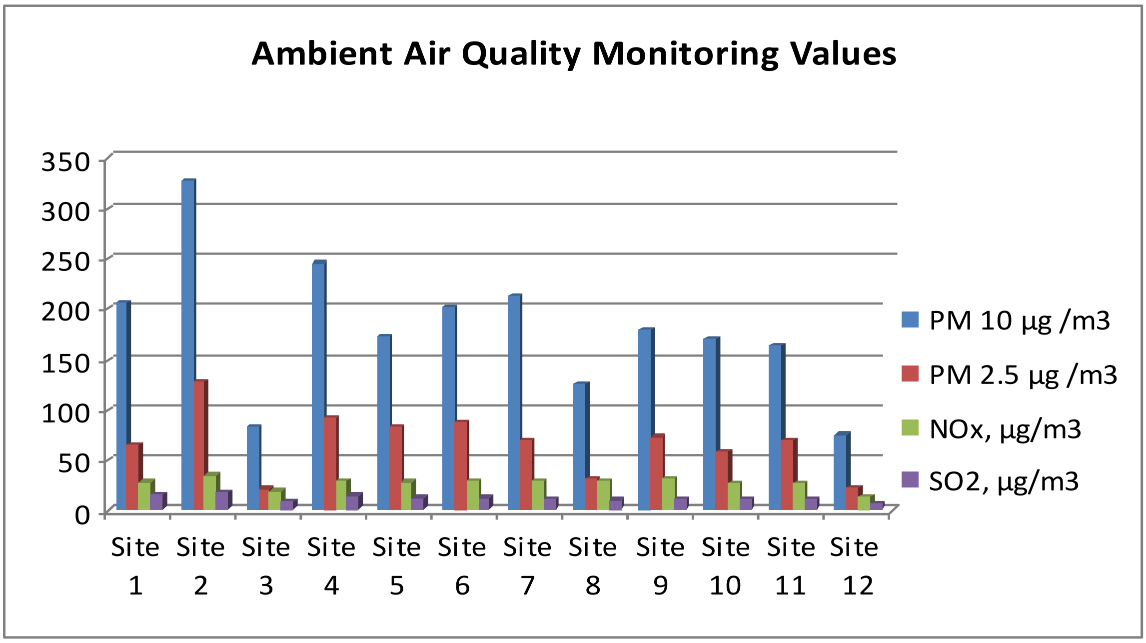


Figure ES-2 Graph showing variation in ambient air quality at selected locations

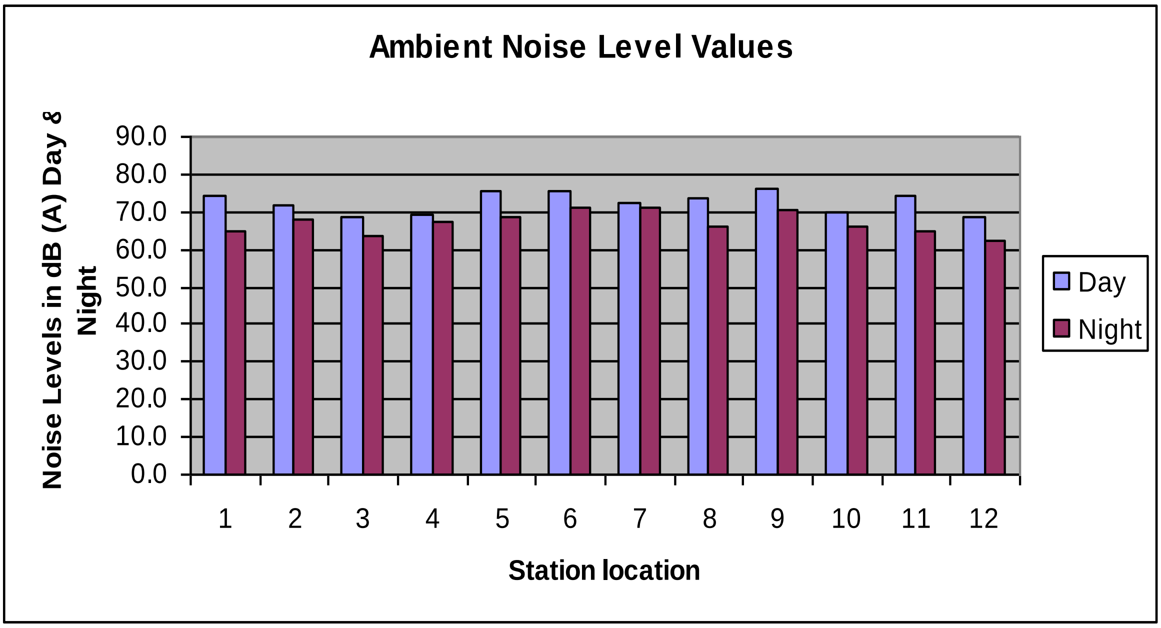


Figure ES-3 Graph of Leq values at selected locations in the project corridor

4.0 POTENTIAL IMPACT ANALYSIS

Based on the baseline environmental status described and the proposed project activities, potential impacts have been assessed and predicted, and appropriate mitigation measures are suggested to avoid / reduce / compensate for the potential adverse impacts of the project and enhance its positive impacts. The impacts due to the development of the proposed RRTS corridor have been assessed for the planning phase, construction phase and implementation phase.

5.0 MITIGATION OF ENVIRONMENTAL IMPACTS

Prevention or avoidance of impact is better than mitigation of impact. Hence avoidance and reduction of adverse impacts approaches were adopted during the design stage. In-depth site investigations have been carried out so that sensitive environmental resources are effectively avoided, leading to the environmentally best-fit option. The appropriate mitigation measures have been suggested during various phases of the project.

(i) Impacts on land environment

S.No.	Environmental Parameter	Severity of Impact	Cause of Impact	Mitigation Proposed
1.	Topography change	Local impacts	Construction of pile foundations for elevated corridor	Controlled light charge may be used to dislodge the rock if, any. No heavy blasting is proposed. Median between pillars will be width protected and planted.
2.	Change in Land use (a) Loss of land	Low impact Most of the corridor is elevated. 1062.721 hectares of land will be acquired for stations and depot.	Change in land use pattern in acquired land	Land acquisition to be minimized
	(b) Generation of excavated soil and rock	3,55,000 cubic meters of excavated soil and rock will be generated. Adverse impact	Most of the generated soil and rock will be back filled. Contamination of air, water and land is not expected	The generated soil and rock will be disposed properly at pre-designated sites to o avoid contamination
	(c) Soil erosion	Moderate, direct, long term negative impact	Some borrow areas for requirement of earth will be developed. Sand and Grit will be obtained from quarries approved by mining departments.	Residual spoils will be disposed properly • It is recommended that provision of silt fencing is made by contractor. • Quarries will be reclaimed.

S.No.	Environmental Parameter	Severity of Impact	Cause of Impact	Mitigation Proposed
3.	Contamination of soil	Direct, long term negative impact	•Oil & diesel spills •Emulsion sprayer •Production of hot mix and rejected materials •Residential facilities for the labour and officers •Routine and periodical maintenance	Hazardous Waste (Management and Handling Rules, 1989) to be enforced. •Oil interceptor will be provided for accidental spill of oil and diesel •Septic tank will be constructed for waste disposal.

(ii) Impacts on water environment

Sl No.	Item	Severity of Impact	Cause of Impact	Mitigation/Enhancement
1.	Alternation of cross drainage	Very low impact	Construction of median plantation, closets, protector walls and elevated viaduct will necessitate construction of new cross drains	Construction of new drains, wherever required will improve the drainage characteristics of the project area
2.	Water requirement for project	Direct impact	• Water requirement for Construction activity. • Water requirement of labour	Contractor needs to obtain approvals for taking adequate quantities of water from surface water sources. This is required to avoid depletion of water resources.

Sl No.	Item	Severity of Impact	Cause of Impact	Mitigation/Enhancement
3.	Contamination of water	Direct adverse impact	• Oil & diesel spills • Emulsion sprayer and laying of hot mix. • Residential facilities for the labor. • Routine and periodical maintenance	Hazardous Wastes (Management &Handling) Rules, 1989 to be enforced • Oil interceptor will be provided for accidental spill of oil and diesel at the depot. Replacing cars with trains will reduce the ground water contamination from oil spills. • Septic tank will be constructed for waste disposal

(iii) Impacts on noise environnent

Sl No.	Item	Severity of Impact	Cause of Impact	Mitigation/Enhancement
1	Sensitive receptors	Direct impact	Increase in noise pollution	Noise barriers to be considered
2	Noise Pollution (Construction Stage)	Direct impact, short duration	Man, material and machinery movements • Establishment of labor camps onsite offices, stock yards and construction plants Stone crushing, and batching plants, diesel generators etc • Community residing near to the work zones	Area specific and for short duration •Machinery to be checked & complied with noise pollution regulations. Appropriate locations will be finalized depending at site conditions away from habitat as far as possible. • Noise pollution regulation to be monitored and enforced. •Temporary as the work zones will be changing with completion of construction.

Sl No.	Item	Severity of Impact	Cause of Impact	Mitigation/Enhancement
3	Noise Pollution (Operation Stage)	Marginal impact	Due to increase in traffic near stations (due to improved facility). However trains will replace many road vehicles. RRTS trains are quieter and therefore RRTS will have overall positive impact.	Will be compensated with the uninterrupted movement of heavy and light vehicles

6.0 ENVIRONMENTAL MANAGEMENT PLAN

Environmental Management Plan is an implementation plan to mitigate and offset the potential adverse environmental impacts of the project and enhance its positive impacts.

The environment management plan has been prepared to achieve applicable environmental standards to comply with applicable MoEF and State environmental laws/regulations. The EMP will provide guidance to its own staff in conducting subsequent monitoring & reporting for effective supervision by NCRPB during various stages of the project.

7.0 COST ESTIMATES AND ENVIRONMENTAL BUDGET

Construction cost of the project is estimated at Rs.15,000 Crores excluding the cost of land acquisition, contingencies and other charges, which shall be Rs 3344.46 Crores. Environment cost of the project is Rs 1.64 Crores.

8.0 SUMMARY OF THE ENVIRONMENTAL FEATURES

The entire environmental profile covering both side of the proposed alignment has been studied, Based on this analysis, the following conclusions can be drawn:-

1. There is no Reserve/ Protected forest/Wild life sanctuary located along the proposed corridor.

2. There is no Archeological Site / monument located along the proposed corridor.

3. There is no wetland identified along the proposed corridor.

4. There are 437 structures including schools, and colleges located along the proposed alignment.

5. The major tree species present along the alignment are Eucalyptus, Cocus nucifera, Delonix regia and Peltophorum etc. 621 trees are proposed to be uprooted along proposed alignment. Additional 1800 trees are proposed for compensatory afforestation in available avenue areas.

CHAPTER – 1

INTRODUCTION

1.1 GENERAL

The present transport system is characterized by road traffic congestion with declining ambient air quality accompanied by a rising trend in road accidents. The focus of all efforts need to be on reducing congestion, improving air quality by lowering levels of vehicular pollution and enhancing road safety while improving amenities for commuters. To provide safe, eco-friendly, cost-effective and efficient modes of transportation through a well-integrated multi-modal transport system, the development activity should be carried out in harmony with the environment, within the carrying capacity of the ecosystem through judicious planning. The development of the proposed Delhi-Sonepat-Panipat Regional Rapid Transit System (RRTS) corridor connecting the Delhi/National capital region (NCR) with Haryana is planned, and offers one such alternative.

The NCR consists of following three sub – regions:

(i) The Haryana Sub-Region (13,413 sq km) comprising of nine districts:- Faridabad, Gurgaon, Mewat, Palwal, Rohtak, Sonepat, Rewari, Jhajjhar and Panipat

(ii) Rajasthan Sub-Region (7,829 sq km) comprising of District Alwar

(iii) Uttar Pradesh Sub-Region (10,853 sq km) comprising of five districts namely, Meerut, Ghaziabad, Gautam Buddha Nagar, Bulandsahar and Baghpat

NCR covers an area of 33,578 Sq Kms spreading over four constituent states of Delhi, Haryana, Rajasthan and Uttar Pradesh. The NCR spreads over 22 cities, which are turning into one seamless urban zone. The Regional Transport System is a critical element enabling growth and contributing to regional prosperity and social development. The existing regional transport system has inadequate capacity, internal competition and poor management. It is not in line with unabated growth in travel demand. To act as a growth facilitator there is an urgency to take early concerted and effective measures to plan, develop, operate and manage an integrated multi-modal transport system to service the region and promote its productivity and competitiveness in the national and international sphere. The National Capital Region Planning Board (NCRPB) initiated preparation of a Regional Rapid Transit System for NCR to be within the policy framework of the NCR Regional Plan - 2021.

1.2 NEED OF THE PROJECT

The proposed RRTS corridor **Delhi-Sonepat-Panipat** falls in the Delhi and Haryana state. Haryana is one of the industrially developed states of the country and has the largest number of large and medium industrial units among the states in the northern region. The rapid growth in the Panipat and Sonepat area shows that the trips are expected to grow. The originating passengers from Panipat and Sonepat are about 45,000 per day.

The goal of the proposed RRTS is to reduce the dependence of commuters on road based transportation alone to a combination of road-cum rail transportation system. This shall effectively reduce traffic congestion and pollution on roads to achieve balanced and harmonious growth of NCR.

The objective is to:

- promote and support the economic development of the region and relieve the National Capital of excessive pressure on the infrastructure including traffic congestion,
- to develop an adequate and efficient cost effective regional rapid transit system to provide comfortable and fast transit to settlements in NCR and meet the high growth in transport demand,
- to provide accessibility to all parts of the region.

The preliminary environmental examination for the proposed project has been undertaken as a parallel exercise with the engineering analysis, so as to bring out the environmental concerns at the planning and the design stage. This is to ensure that the environmental considerations are given due weightage in the design of the proposed RRTS corridor. The objective is to avoid / minimize adverse environmental and social impacts with possible economical engineering solutions. Alignment plan for the proposed RRTS on Satellite imagery is shown in figure 1.1and after ground truthing figure 1.2.

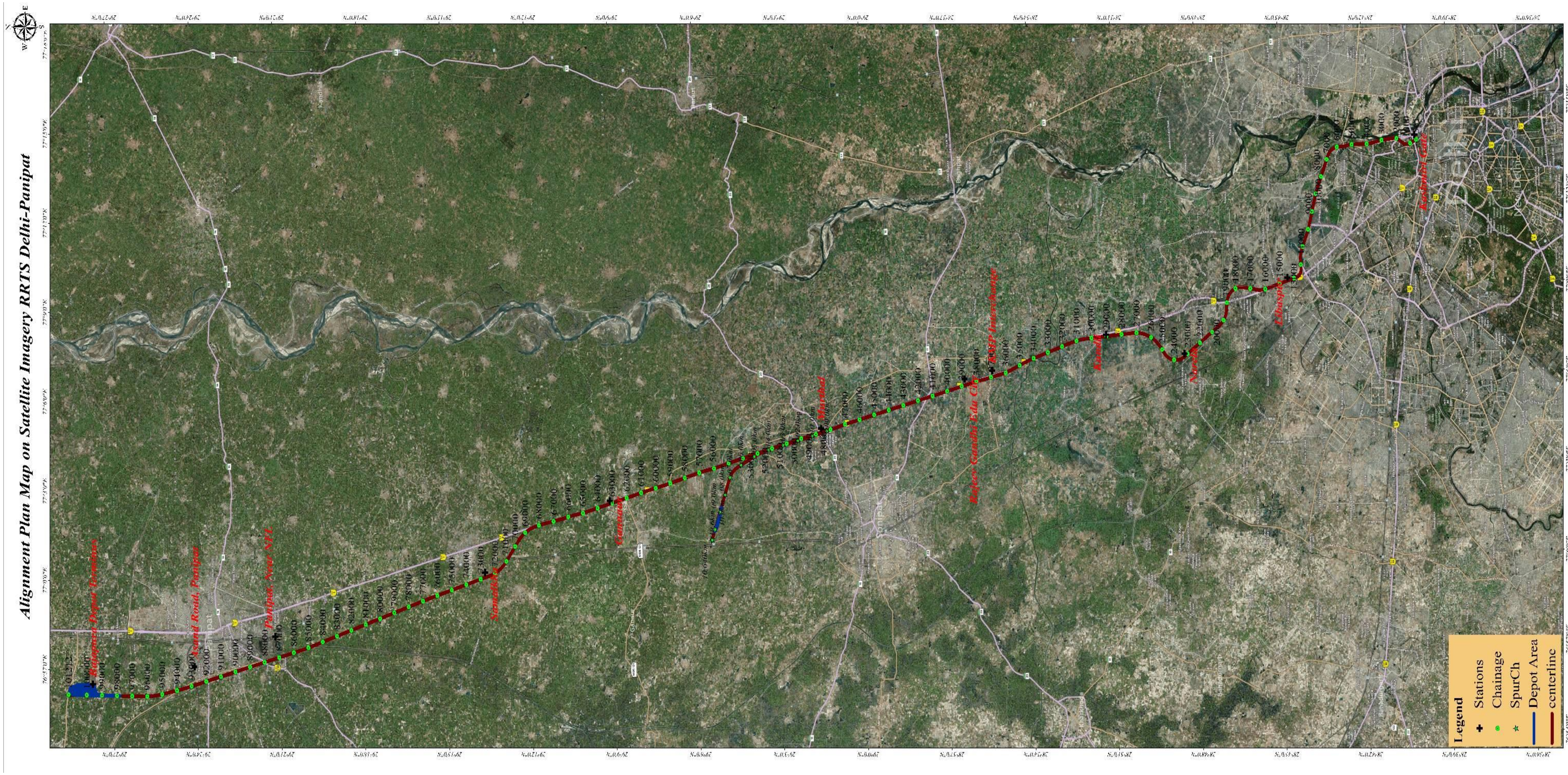
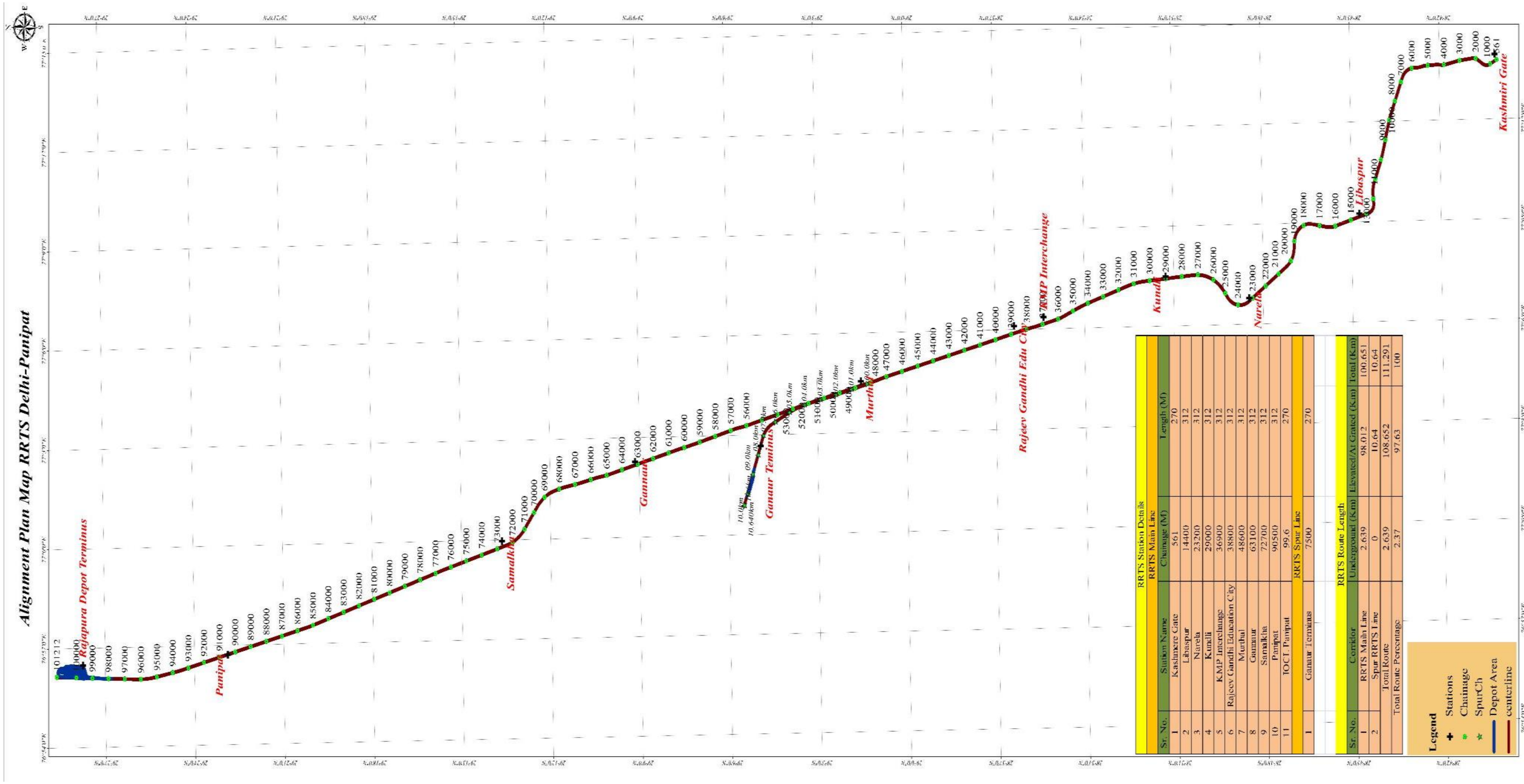


Figure 1.1: Alignment plan for the proposed RRTS on Satellite imagery



RRTS Station Details			
RRTS Main Line			
Sr. No.	Station Name	Chainage (M)	Length (M)
1	Kashmere Gate	561	270
2	Libaspur	14400	312
3	Narela	23200	312
4	Kundli	29000	312
5	KMP Interchange	36900	312
6	Rajeev Gandhi Education City	38800	312
7	Murthal	48600	312
8	Gannaur	63100	312
9	Samalkha	72700	312
10	Panipat	90500	312
11	IOCT. Panipat	99.6	270
RRTS Spur Line			
1	Ganaur Terminus	7500	270

RRTS Route Length				
Sr. No.	Corridor	Underground (Km)	Elevated/At Graded (Km)	Total (Km)
1	RRTS Main Line	2.639	98.012	100.651
2	Spur RRTS Line	0	10.64	10.64
	Total Route	2.639	108.652	111.291
	Total Route Percentage	2.37	97.63	100

Figure 1.2 Alignment Plan for RRTS Delhi-Sonepat-Panipat

1.3 SALIENT FEATURES OF THE PROJECT

The salient features of the project proposed have been broadly firmed up as below:

1. Total length of project is 111.8 Km,
2. a dedicated corridor exclusively for running RRTS trains at an average speed of 160 Kmph,
3. investigation and recommendations for the safety of the high-speed trains operating in open country, which may include fencing of the route and CCTV surveillance,
4. investigation of the fire safety of the trains and stations taking into account national and international standards,
5. advanced signaling system facilitating better and efficient operation of trains,
6. Modern stations designed to provide pleasant ambience and high quality facilities. Each station will be provided with the following:
   a) ticket machines (appropriate to the ticketing system chosen),
   b) passenger information systems,
   c) emergency help points,
   d) automatic revenue protection,
   e) CCTV,
   f) public address system,
   g) fire and emergency evacuation systems,

1.4 BASELINE ENVIRONMENTAL SURVEYS

In any major developmental initiative aimed at promoting the benefits to the community or the state/country, the associated environmental impacts leading to short term or long term changes in the environment should be seriously examined, before embarking on the proposed project.

The baseline environmental survey in the case of RRTS Delhi-Panipat Project basically includes establishing the status of the physical, chemical, ecological and socio-economic aspects of the city and its environs in general; and those areas/parts of the city, where the corridor is proposed to be built and put into operation.

1.5 LEGAL POLICIES AND INSTITUTIONAL FRAMEWORK

The Ministry of Environment and Forests (MoEF), Government of India, as the nodal agency, formulates environmental policies and delineates mechanism to ensure compliance of the same. A number of legislations enacted by the Government of India and a few legislations enacted by the Government of Delhi & Haryana having a bearing on the Regional Rapid Transit Project.

The brief summary of legislations having a bearing on the proposed RRTS Project is given below:

(i) The Forest Conservation Act (1981):

The Forest Conservation Act was promulgated with the objective of preventing further depletion of India's forest wealth. This act restricts the use of forest lands for non-forest purposes. Specific permission of the Government of India will have to be obtained, if any state government requires use of forest lands for non-forest purposes.

(ii) Water (Prevention and Control of Pollution) Act, (1974):

Water Act was promulgated to preserve water quality by prevention of water pollution. This Act empowers Pollution Control Boards to fix wastewater discharge standards. The sewage and industrial effluent standards have been defined by the Central & State Pollution Control Boards, who enforce the legislation through consent management process and continuous monitoring. The wastewater discharge standards shall also be applicable to the project. (The wastewater discharge standards are provided in (Annexure 1.0)

(iii) Air (Prevention and Control of Pollution) Act, (1981):

Air Act was promulgated to enhance air quality by prevention and control of air pollution. Air pollution is controlled through regulation of emission of pollutants into the ambient air / atmosphere. The Act empowers the Central/ State Pollution Control Boards to fix ambient air quality standards. The air emission standards have been defined by the CPCB, who enforces the legislation.

(iv) The Environment Protection (EP) Act (1986):

Environment Protection Act is umbrella legislation. Ministry of Environment and forest is the nodal agency, which formulates environmental policies. The National Ambient Air Quality Standards and Ambient Noise Standards have been defined under EP Act. The standards are to be adhered during and after in any project activities.

(The National Ambient Air Quality Standards & Ambient Noise Standards are provided in Annexure 1.0)

(v) The Tree Act (1984):

This Act has been promulgated to protect the tree wealth in non-forest areas. While the Forest Conservation Act applies to forest areas, the Tree Act applies to all the non-forest areas, belonging to both public and private. Under this Act, permission of the "Tree Officer" has to be obtained before cutting down a tree.

(vi) State Level Environmental Legislation

The consent under Air and Water Act are under the preview of Delhi Pollution Control Committee (DPCC) & Haryana State Pollution Control Board. Moreover, clearances for setting up hot-mix plants, batching plants, etc., under the Air and the Water Acts, establishing new quarries and establishment of new tube-wells / bore-holes is vested with State Agencies like, SPCB, State Department of Mining and Sate Ground Water Boards / Authorities respectively.

(vii) Other Legislations Applicable to Construction Projects

It is to be ensured that other legislations like Child Labor (Prohibition and Regulation) Act; 1986, Minimum Wages Act; 1948, The Factories Act; 1948, The Building and Other Construction Workers (Regulation of Employment and Conditions of Service) Act, 1996, Building Bye Laws, etc. are also properly followed.

1.6 INSTITUTIONAL MECHANISM

The legislative provisions are mandatory and need to be fully adhered to. Apart from the above acts, there are certain institutional mechanisms that will have to be reviewed, while implementing the Regional Rapid Rail Transit project Delhi-Sonepat-Panipat

The Ministry of Environment and Forests (MoEF), Government of India:

The MoEF regulates issues notifications / circulars relating to implementation of the Environmental Acts. The MoEF in its notification dated 14th September 2006 has stipulated that any creation, expansion or modernization of project or activity listed in schedule-I shall not be undertaken without the prior environmental clearance. The procedures to be followed for according such clearance have been notified.

However, Railway development projects have been excluded from this list. RRTS being a High speed rail transit system is also not included in the MoEF notification dated 14th September 2006.

Central and State Pollution Control Boards: These are the enforcement agencies contemplated under the Air Act, Water Act and EP Act. They are the agencies, which would be enforcing the environmental standards at Central and State levels.

Environment Management Plans: Certain accepted standards need to be adhered to while preparing Environmental Impact Assessment reports. The Environment Management System (EMS) proposed should be as per IS/ISO 14001/1996. Life cycle and life cycle assessment should be as per IS/ISO 14040.

Guidelines for Rail/ Road/Highway Projects (1981):

MoEF has issued guidelines for rail/ road/highway projects in 1981, which are to be followed, in the background, while preparing the project reports.

Clearance Requirements for the Project

National Capital Planning Board (NCRPB) has formulated various policy guidelines; acts and regulations aimed at protection and enhancement of environmental resources. The clearances/ permissions/ approvals under various acts, rules and guidelines are required for proposed project during pre-construction and construction phases are given in below **Table 1.1. and Table 1.2** respectively.

Table 1.1: Summary of Clearances & NOCs Required during pre-construction phases

Sl. No	Type of clearance	Statutory	Applicability	Project stage	Time	Responsibility
1	Prior Environmental	SEIAA	Not applicable	Pre construction	-	
2	Permission for activities near archeologically protected area	Archaeological Survey of India/ the state department of Archeology	Not applicable, as project corridors are beyond 300 m distance from identified archeological sites / heritage sites		-	Project Authorities / Contractor
3	Forest clearance	State Department of Environment & Forest MoEF	Not applicable as there is no diversion of forest land. However Tree cutting permission will have to be taken from the Competent Authority		-	
4	NOC and consents under Air, Water, EP Acts and Noise rules	State Pollution Control Board	For establishing project		2-3 months	
5	NOC and consents under Air, Water, EP Acts and Noise rules	State Pollution Control Board	For operating Hot mix plants , crushers and batching plants	Construction (prior to work initiation)	1-2 months	Project Authorities
6	Permission to	State	Storage and		2-3	

Sl. No	Type of clearance	Statutory	Applicability	Project stage	Time	Responsibility
	store Hazardous materials	Pollution Control Board	transportation of hazardous materials and explosives		months	
7	PUC certificate for use of vehicles for construction	Department of Transport	For all construction Vehicles		1-2 months	
8	Quarry lease deeds and license	Dept. of Geology and mines	Quarrying and borrowing operations	Construction (prior to work initiation)	2-3 months	Quarry Licenses shall be obtained by Contractor
9	NOC for water extraction for construction and allied works	Central Ground water authority (CGWA)	Ground water extraction	Construction (prior to work initiation)	2-3 months	

Table 1.2: Permissions/ Approvals Required for Project during Construction Phase

S. No	Construction activity	Statutory authority	Statute under which Clearance is Required	Responsibility	
				Implementation	Supervision
1.	Tree Cutting	Department of Environment, and Forest District Collector	Forest (Conservation) Act, 1980	PIU	PIU (Project Implementation Unit)
2	Crushers and Batching plants	Concerned State Pollution Control Board	Consent to establish and consent to operate under Air (Prevention and Control of Pollution) Act, 1981	Contractor	PIU (Project Implementation Unit)
3	Discharges from construction activities	Concerned State Pollution Control Board	Consent to establish and consent to operate under Water (Prevention and Control of Pollution) Act, 1974	Contractor	PIU (Project Implementation Unit)
4	Storage, handling and transport of hazardous materials	Concerned State Pollution Control Board	Hazardous Wastes (Management, Handling and Trans-boundary Movement) Rules, 2008	Contractor	PIU (Project Implementation Unit)
5	Sand mining, quarries and borrow areas	Department of Mines and Geology, Govt. of Haryana and Govt. of Delhi	Environmental (Protection) Act, 1986	Contractor	PIU (Project Implementation Unit)

S. No	Construction activity	Statutory authority	Statute under which Clearance is Required	Responsibility	
				Implementation	Supervision
6	Groundwater extraction	Ground Water Authority of Haryana and Delhi		Contractor	PIU (Project Implementation Unit)
9	Location and Layout of workers Camp, Equipment, storage yards, Quarries	Concerned State Pollution Control Board	Environment (Protection) Act, 1986	Contractor	PIU (Project Implementation Unit)

1.7 ORGANIZATION OF THE REPORT

The Environmental impact assessment Study of the project has been presented in the following chapters.

Chapter-1 Introduction:

- Brief background of the project,
- scope of the EIA study,
- EIA methodology and organization of the report,
- Legal and administrative framework / policy relevant to the present project.

Chapter-2 Project Description:

- Describes type of the project,
- Salient features of the project
- Design details on of the project.

Chapter-3 Methodology and Baseline Environmental Scenario:

- Methodology adopted for the study
- Baseline environmental profile of the study area

  (10 km on either side of the proposed alignment),
- Environmental features within 500 m of the proposed alignment.

Chapter 4 Environmental Impact Assessment:

- Prediction of potential environmental impacts by the development of the project on the surrounding area.
- The impacts due to development of the proposed LRT System are assessed for construction phase and operation phase.

Chapter 5 Mitigation Measures:

- The mitigation measures to avoid/mitigate the negative impacts,
- Enhancement measures to due to the development of proposed LRT on various parameters of the environment during various phases.

Chapter 6 Environmental Monitoring Program:

The environmental monitoring plan contains:

- Identification of the Performance indicators
- Environmental monitoring program
- Reporting system
- Monitoring plan

Chapter 7 Environmental Management Plan:

- Environmental management plans for various environmental parameters,
- Implementation details,
- Budgetary Provisions

Chapter-8 Project Benefits

- Direct Benefits Monitoring plan
- Indirect Benefits
- Environmental Benefits

Chapter 9 Conclusions:

- Conclusions and Recommendations

CHAPTER-2

PROJECT DESCRIPTION

2.0 INTRODUCTION

National Capital Region (NCR) has an acute traffic problem with congested gridlocked roads, causing high levels of air and noise pollution. Highly congested areas of NCR need a guided transport system to reduce road traffic. There is no space available at ground level to build new railways. The underground railways are very expensive. It is therefore proposed to build an elevated high speed Regional Rapid Transit System (RRTS) system running on viaduct, generally following existing road alignments, with piers at some 35m centers supporting a concrete deck. The viaduct deck will generally be constructed from precast sections constructed off-site, and then pre-stressed together, which will have less noise and dust impact than in-situ concrete construction.

The proposed RRTS system will facilitate integration with other modes of transport such as metro rail and bus networks. The LRT scheme will be one of a major transport projects serving the rapidly growing NCR Region. This will be less disruptive than a railway constructed at grade. The new trains will be electrically powered. Road traffic will reduce as a consequence of the new rail system, so air and noise pollution would reduce. The scheme will allow passenger interchange with the Delhi Metro, which is having direct connectivity to New Delhi airport. The proposed routes covered are as follows:

2.1 THE EXISTING CORRIDOR

Delhi and Panipat are connected by a six - lane divided carriageway, National Highway No.1 (NH -1). Right of way of NH -1 is 60 m. The stretch traverses through a dense mix of semi built up areas catering to the towns of Kundli, Rai, Murthal, Ganaur, Samalkha and Panipat. The traffic entering and exiting Sonepat is about 20,625 vehicles daily, 72% of which are passenger vehicles, 20% are goods and the remaining 8% are non motorized vehicles.

The traffic entering and exiting Panipat is about 86,604 vehicles daily of which 61%are passenger vehicles 36% are Goods vehicles and the remaining 3% are non motorized vehicles. The NCR limit on this proposed rail corridor extends up to Panipat terminus at a distance of approximately 111km from Delhi.

2.2 PROPOSED CORRIDOR

The proposed Project corridor has been divided into two sections

Underground Tunneled section: It is the starting section of the proposed project corridor. It starts from chainage 0.6 km. The ending point of the tunnel section is at chainage 3.0 km. A significant amount of excavation will be required for tunnel construction. The length of tunnel section will be 2.5 km approximately and the diameters of the proposed tunnels are expected to be 8 m each. After chainage 3.0 km the elevated section will be started and the rest of the alignment will be elevated except at depots.

Elevated Section: After the end of the tunnel at the chainage of 3.0 km, the alignment will become elevated until the end point of project that is at chainage 101.2 km. (Rajapur village near Panipat Refinery). The section is an electrified double line Elevated rail corridor.

2) Depots: Two Depots or Maintenance Yards are proposed which are expected to be at grade.

1. Ganaur depot: This intermediate depot is proposed on the spur line (length 10.6 Km) having the area of 35,95,052 sq m between Murthal and Ganaur and west of NH-1.

2. Panipat Depot: Will be situated at end point (chainage 100.8 km) of the proposed corridor. The area of the depot is 39,87,908 sq m.

2.3 PROPOSED STATIONS

The proposed RRTS corridor starts from Kashmere gate (Mori Gate), croses Mukarba Chowk and enters at Narela (last station in Delhi region). Alignment enters Haryana region through Kundli station and traverses through habitations of Rai, Murthal Samhalkha and then terminates at Panipat. Proposed alignment will be traversing through two States Delhi and Haryana, including three districts of Delhi, Sonepat and Panipat with 1 underground, 9 elevated and 1 at grade stations are being proposed along the proposed alignment. (Table 2.1)

Table 2.1 Station Details of the Proposed Project

RRTS Station Details			
RRTS Main Line			
Sr. No.	Station Name	Chainage (M)	Length (M)
1	Kashmere Gate	561	270
2	Libaspur	14400	312
3	Narela	23200	312
4	Kundli	29000	312
5	KMP Interchange	36900	312
6	Rajeev Gandhi Education City	38800	312
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8	Gannaur	63100	312
9	Samalkha	72700	312
10	Panipat	90500	312
11	IOCL Panipat	99.6	270
RRTS Spur Line			
1	Ganaur Terminus	7500	270

RRTS Route Length				
Sr. No.	Corridor	Underground (Km)	Elevated/At Grated (Km)	Total (Km)
1	RRTS Mailn Line	2.639	98.012	100.651
2	Spur RRTS Line	0	10.64	10.64
Total Route		2.639	108.652	111.291
Total Route Percentage		2.37	97.63	100

Kashmiri Gate (0.6 Km)

RRTS starting terminus will be located at Kashmiri Gate. (Figure 2.1) This is the only underground station within the proposed corridor. The starting terminus has been considered at chainage 0.6 Km. the Area of this station will be 20,460.8 sq m.

Figure 2.1 View of Kashmiri gate

Figure 2.2 View near Wazirabad

Mukarba- Chowk

This is the next station of RRTS at 14.4 kms. The Badli Industrial Area is situated at distance of 600 m east of the proposed alignment while moving towards Narela Station. (Some HT lines exist at a distance of 10-15 m from the proposed alignment. The electricity board has agreed to move these HT lines from the path of the proposed alignment.)

The alignment will pass within the center of an existing supplementary drain. An MCD compost plant & landfill are located close to this station having a height of approx 25 m to 30 m. Wazirabad drain transverses in parallel with the proposed alignment (Figure 2.2)

MMTC Station Nerela (23.2 km)

This is the last station that comes within Delhi State. The Region surrounded by Narela Station is mostly agricultural fields. All India Radio station towers are in the close proximity to the proposed alignment north of this station location.

Kundli Station (29.0 Km)

Kundli is the first station within the Haryana State and is located at chainage 29.0 km. (Figure 2.3). Some plywood industries and cold storage exist along the project corridor. The Proposed project alignment enters into Sonepat district of Haryana State at the chainage of 29.0km.

Figure 2.3 View near Kundli

KMP Interchange Station (36.9 Km)

This is the second station within Haryana State. The elevated expressway (Figure 2.4) (Kundli – Manesar- Palwal expressway) KMP intersects the proposed station. The height of piers at or near KMP station may be varied according to existing pillars of KMP express way. Some high tension electricity lines are also present along the station which may have to be moved/cause problems during construction.

Figure 2.4 Views at KMP Station to the west of NH -1.

Rajiv Gandhi Education City (38.8 Km)

This station comes under Rai village of Sonepat district. This is an important industrial station in the village "Rai". Various industries of food products, blankets, springs and breweries etc. are present in "Rai". Besides serving Rai, this station is also expected to serve the upcoming university traffic.

Murthal Station (48.6 Km)

North of Rajiv Gandhi Education City station is Murthal. The area is surrounded by some electronics and blanket industries.

Ganaur City Station (63.1 Km)

This is the last station that comes within Sonepat District. After leaving the NH-1 at chainage 69.0 Km at village Bhodwal Majri, the proposed alignment traverses in the agricultural field. It crosses Indian railway line at an approximate chainage of 71.0 Km.

Samalkha (72.7 Km)

This is the first station within Panipat District. The area along the proposed alignment and station comes within agricultural land. No sensitive area / populated area /industrial area are lined in the way of the proposed RRTS alignment.

Panipat City Station (90.5 Km)

This is penultimate station of the RRTS project. The station is proposed between the two distributaries of Western Yamuna Canal, west of Panipat City.

Panipat Depot Station and Terminus (99.6Km)

The Panipat Terminus station is located at an approximate chainage of 99.6 km near Rajapur Village close to Panipat Refinery. This area is currently owned by HSIDC as shown in figure 2.5 below.

Figure 2.5 View near Panipat Depot Station and Terminus

2.4 CONSTRUCTION PERIOD

The construction period for the completion of the Regional Rapid Transit System Light Rail Transit System freight corridor is likely to be approximately Six years.

2.5 WATER REQUIREMENT

The total water requirement during construction period will be about 1630 KLD spread over the construction period of about 6 years. The daily requirement for per kilometer length during construction period will be about 14,700 liter and will be met through local water resources.

2.6 CONSTRUCTION MATERIAL

Construction material will be required in sufficiently large quantities. Aggregates, sand, cement and steel will be obtained through the local manufacturers/ dealer. The project involves removal of soil from piling excavations.

2.7 COST ESTIMATES

Construction cost of the project is estimated at Rs.15,000 Crores excluding the cost of land acquisition, contingencies and other charges, which shall be Rs 3344.46 Crores.

CHAPTER -3

METHODOLOGY & BASELINE ENVIRONMENTAL SCENARIO

3.0 PURPOSE/OBJECTIVES

The environmental feasibility study determined the environmental sensitivity of the project route. That in turn helps the level of planning in terms of time, budget and effort required to take up the particular project for development.

Environmental feasibility of the study area has the following major objectives:

- preparation of Baseline
- identification and assessment of Impacts, Policy, legal and institutional issues for planning for Implementation of EMP during Design, Construction and Operational phases
- identification of environmental sensitive receptors.
- scoping and future course of work for Environmental Assessment process.

Environmental Screening process requires a thorough understanding of various environmental parameters and its effect on the project planning and implementation.

The screening process involved the following steps.

- Preparation for various surveys
- Reconnaissance site visit
- Preparation of all background data relating to the proposed rail line that are to be screened
- Preparation of base maps to plot the proposed rail line accurately as far as possible
- Identification of the valued ecosystem components (VEC) that are important for the project
- Devising or Preparation of formats for recording these parameters
- Identification of an environmental screening survey team
- Training of the survey team to record the data in the survey formats
- Actual ground surveys to collect or record the data in the relevant sheets
- Analysis of the data collected by qualitative and quantitative techniques

3.1 ENVIRONMENTAL IMPACT ASSESSMENT METHODOLOGY

The EIA procedure proceeded simultaneously with design of the project road and methodology is shown in Figure 3-1. The important findings of the assessment helped in modification of the designs at locations where people and properties are impacted. Hence impacts can be avoided and wherever the impacts were unavoidable mitigation measures were incorporated. The methodology involved in the preparation of EIA is as follows:

- Change in environmental parameter values / data due to proposed activities are crucial for impact assessment.
- Primary data have been collected from field sources.
- Extensive field surveys were carried out along the proposed corridor to obtain primary baseline data relating to the following attributes:

(a) Environmental Studies

- Ambient Air Quality
- Ambient Noise level
- Water quality
- Soil sample analysis
- Green cover studies

(b) Others

- Property to be Acquired

Pre-existing utilities like electric poles, telephone cables, water and sewerage lines etc. were recorded for relocation at a later date

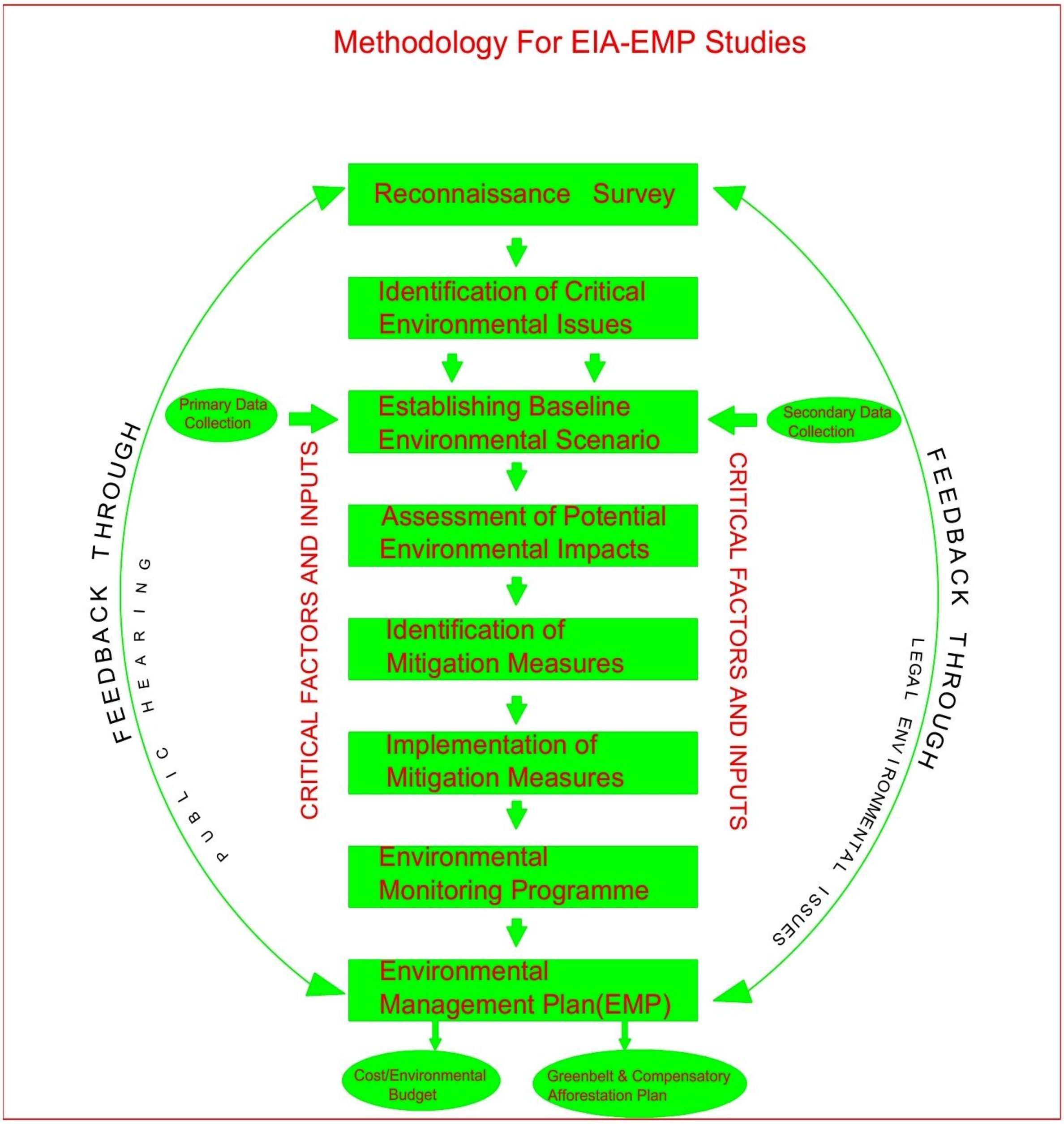


Figure 3.1: Methodology of Environmental Impact Assessment

The Valued Environmental Components (VEC) are defined as social or bio physical component of an environment which is of value (for any reason) within a project influence area. In the case of rail projects, it is a zone covering 50 m on both sides from the centre line of the project route. This could be water pollution or air pollution that can be carried out to far distances. In some other cases, this is even more as in the case of wildlife, debris disposal and for material sources.

Based on the environmental studies, primary data on following Valued Environmental Components (VECs) shall be collected as follows:

Physical environment

- Disposal of debris/materials resources
- Water resources (Surface and Ground water)
- Soil erosion
- Air/Water/Noise pollution

Bio-Environment

- Number of trees within the ROW
- Wildlife/nesting places/mud holes and other habitats
- Forests
- Reserved Forests (RFs)
- National parks and sanctuaries
- Wetlands

Socio-Economic Environment

- Drinking water sources
- Schools/hospitals/college (declared silence zones)
- Cultural properties such as temples/shrines and other religious and archaeological monuments and properties
- Residential properties
- Commercial properties
- Tourism locations
-

3.2 PROJECT INFLUENCE AREA

The areas of direct influence will be confined in a linear fashion along the corridor, where the construction activities take place. In case of the alignment adjacent to NH-1, the area of direct influence is 10 m towards the east side of the central line of the proposed RRTS corridor and 20 m towards the west side of the proposed centre- line, for other areas, 15 m on either side of the centre line will be influenced by the project.

Adjacent to 60m RoW of NH-1 30m width of land is available for RRTS including green belt developed by HUDA (20m wide). Hence the centre line of RRTS is eccentrically placed with 10m width towards NH-1 and 20m width towards HUDA green belt. This has been done to minimize the acquisition of private land.

3.3 TYPES AND SOURCES OF DATA COLLECTION

Environmental experts have undertaken a reconnaissance survey of the project corridor. During survey, the existing baseline environmental conditions along the corridor have been assessed and significant environmental issues have been identified. The reconnaissance survey has been supplemented by detailed field investigations.

3.3.1 Secondary Data Collection

Secondary data pertaining to the significant environmental issues are collected from various governmental, quasi-governmental, research institutions,& non-governmental organizations. Some of the likely sources of the secondary data are:

- India Meteorological Department (IMD)
- Directorate of Agriculture
- District Statistical Office (s)
- Forest Department
- Department of Town and Country Planning
- State Pollution Control Board
- Irrigation Department
- Soil and Land use Planning Boards
- Department of Geology and Mines
- Department of Archeology

Apart from these published data, additional relevant environment data was collected from individual research works; either published or unpublished. The source of the data has been documented in the report as reference. The data collected has been broadly subjected to the ground truth verification during detailed field investigations and modifications necessary to the database have been carried out.

3.3.2 Primary Data Generation

After the completion of the secondary data collation, primary data has been generated for the relevant attributes. Some of the attributes are ambient air quality, ambient noise, water quality, ecological studies, soil investigations, etc. The test procedures for generating the primary data conform to the guidelines stipulated by the Central/ State Pollution Control Board, Ministry of Environment & Forests and relevant Indian Standards. The samples were analyzed at laboratories recognized by State/ Central Pollution Board and/ or Ministry of Environmental and Forest, Government of India.

3.4 BASELINE ENVIRONMENTAL CONDITION

3.4.1 Physical Environment

Delhi: The average temperature of New Delhi during summer ranges from 25º C to 46º C. Summer in Delhi stays until October before winter starts to sets in. The arrival of monsoon in the end of June brings some relief to Delhi. The city does not witness much of rainy season. The monsoon lasts from July to September. October sees the end of the monsoon, but it is reasonably pleasant. Winter Season starts from the end of November and continues till February-March. Winters are short in comparison to summer. Temperatures fall substantially to as low as 3 to 4º C at the peak of winter. Dense fog envelopes the city in January, reducing visibility on the streets.

Sonipat: The climate is characterized by an intensely hot summer and a cold winter. November to March is winter; summer season prevails during May and June. Temperature during **January** reaches 7.3^{o}C, while in May and June, temperature reaches 47^{o}C. Southwest monsoon fetches about 75% of rainfall between July to September during which the weather is mild. Annual average rainfall in the district is 511.4 mm. During the monsoon period the district experiences high humidity; while in April and May it goes below 20%. Similarly, in the monsoon periods, the winds are strong, and in post-monsoon and winter months it is light. Thunderstorm and dust storms, often accompanied with squalls are experienced during the period from April to June.

Panipat: Panipat is located in the northwest part of the country, where the climate is mostly sub tropical and semi arid. There are three distinct seasons. Monsoon - hot and **humid** season from mid-June to September. Second season, winter, is the cool and dry season from October to March. The third season, summer, is characterized by hot and dry weather which prevails from April to mid-June. May and June experiences high temperatures and the lowest is recorded in the months of December and January. Panipat experiences unreliable rainfalls which are mainly concentrated in monsoon seasons. The region receives rainfall mainly under the influence of the southwest monsoon from July to September. Around 70 percent of rainfall is received during this season and the remaining rainfall is received during

December to February. The annual average rainfall is about 621 mm; the district is mainly drained by the River Yamuna and its tributaries.

3.4.2 Seismic Profile of the Area

The project corridor falls in Zone IV of the seismic Zonation Map (Hazard Map) Seismicity as shown in figure 4.1. The seismic risk in Zone IV indicates high vulnerability to earthquakes according to the Seismic Zoning Map of India (BIS 2000, zones).Seismic zones are rated from I to Zone V, in which Zone V has the highest risk seismic zone. Most earthquakes in this region are shallow, though a few earthquakes of intermediate depth have been recorded in Haryana. The alluvial cover of the Indo-Gangetic plain makes even distant earthquake felt here quite strongly.

Figure 3.2 Map of Seismic Zones of India

3.4.3 Topography & Geology of the Study Area

(i) Delhi Region

The quartzites of Delhi system exposed in the area belong to Pre- Cambrian age. The quartizites are pinkish to grey in colour, hard, compact, highly jointed, fractured and weathered. These occur with inter beds of mica- schists and are intruded locally by pegmatite's and quart veins. The strike of these rocks varies north east - south - west to north northeast – south southeast with steep dips towards south east and east except for some local variations due to folding. The prominent joint sets are strike joints, bedding joints and dip joints. Quartzites are ferruginous and gritty types on weathering and subsequent disintegration give rise to coarse sand (Badarpur sands). Chemical weathering of deer horizons is also common.

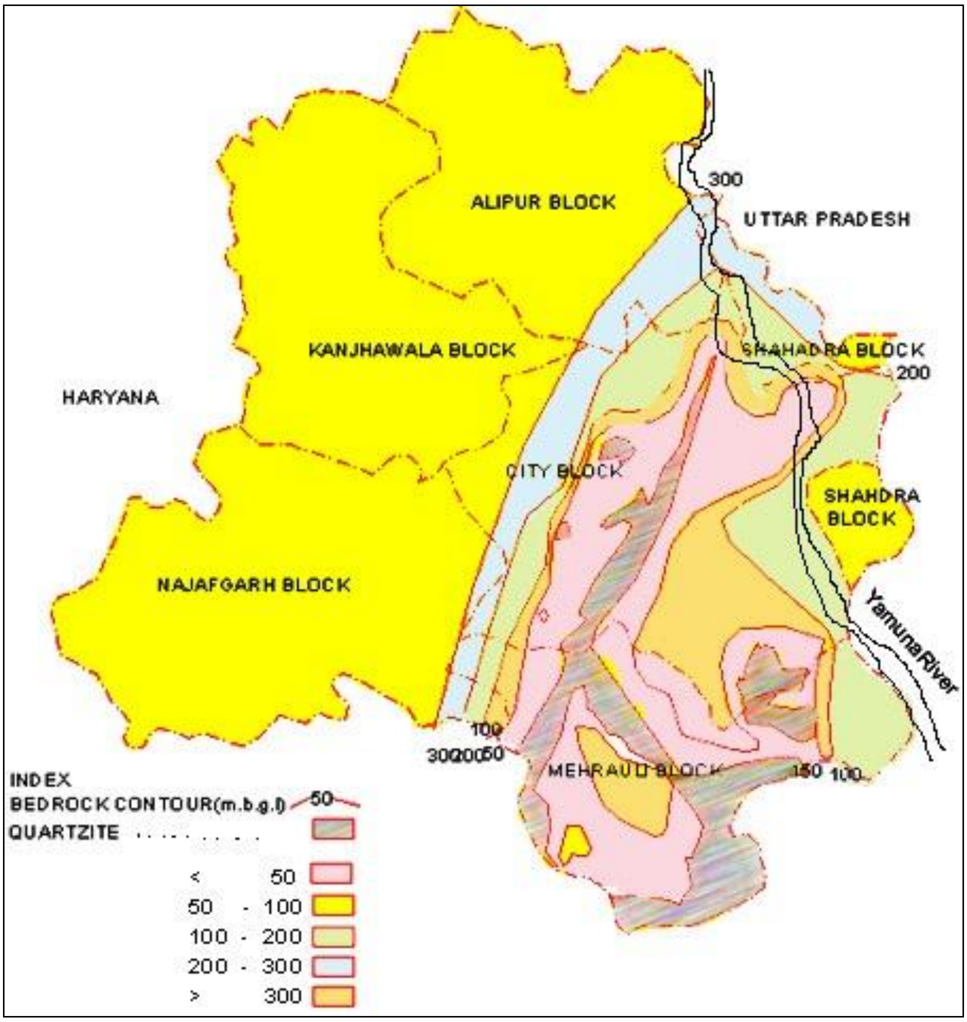


Figure 3.3 Bedrock Profile of Delhi

The exploratory drilling undertaken has brought out the subsurface configuration of rock formation and depth to bedrock is different parts of NCT of Delhi. The nature of bedrock topography is rendered uneven due to existence of sub surface ridges. Thickness of alluvium overlying the quartzites increases away from the outcrops. The thickness of alluvium is 300m or more in most parts of Najafgarh, Kanjhawala and Alipur blocks while in the south eastern parts of Alipur block, it varies from 100m to 300m. In the eastern parts of Najafgarh Block, the thickness range is from 50m to 300m. In the city block, west of the ridge, the alluvium thickness increases away from the ridge to 300m or more. East of the ridge, in the area upto river Yamuna, the alluvium thickness is comparatively less to about 165 m. East of river Yamuna covering parts of city and Shahdara blocks, the thickness ranges from 48 to 240 m. In the Chattarpur basin of Mehrauli block, the alluvial thickness varies from a few metres near the periphery to 115m around Satbari bund. (Figure 3.3)

(ii) Panipat Region

Panipat district forms part of Indo gangetic plain and lies in Yamuna Sub basin of the Ganges basin. Physio-graphically, the district is characterized by two distinct features vast upland plains and Yamuna flood plains. The district is mainly drained by River Yamuna and its tributaries. Topography of Panipat Town is almost flat with gentle slope in the northwest to southeast direction towards Yamuna River. Panipat Main Drain originating in the northwestern side passes through the town towards Yamuna in southeast direction. (Figure 3.4)

Figure 3.4: Geological Map of India

3.4.4 Landuse / Landcover status of the Project Area

Landuse / Landcover study for the proposed railway alignment was conducted with the help of IRIS P VI-LIS IV, Survey of India GT sheets. The proposed RRTS alignment predominantly passes through the agricultural land followed by settlements in Delhi and Panipat region (Fig. 3.5 Land use / Land Cover Map RRTS Delhi-Panipat).

There are 8 Major canal crossings in the proposed route and Wazhirabad drain intersects the alignment near Libaspur at Ch. 13.00.

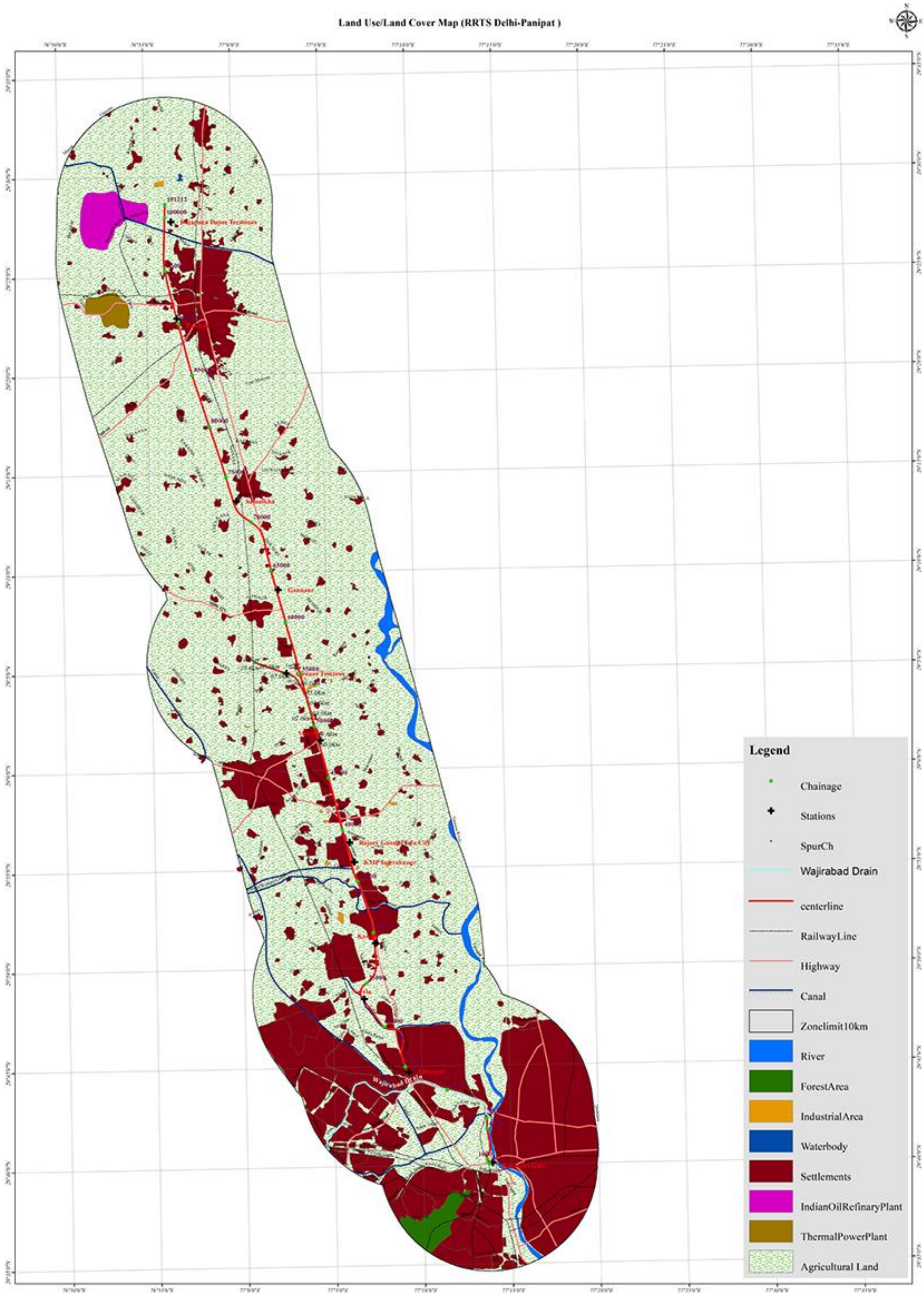


Fig. 3.5 Land use / Land Cover Map RRTS Delhi-Panipat

3.5 AIR QUALITY

Evaluation of the resultant air quality due to the proposed project requires the determination of the existing air quality in terms of Suspended Particulate Matter (SPM), Respirable Particulate Matter (RPM), Sulphur dioxide (SO_2), Oxides of Nitrogen (NO_2), and Carbon Monoxide (CO). No secondary data of the ambient air quality in the proposed project area was available. Consequently air quality monitoring has been done.

Sampling and analytical procedure

RDS APM-460 BL Respirable dust samplers (RDS) with provision for gaseous sampling APM-411 (Envirotech, New Delhi) was used for measuring the concentrations of TSPM, PM10, NO2 and SO2 in the ambient air. The sampling inlet was placed 1-3 metres above the ground level and 15-30 metres away from the earthen shoulder of the existing route, depending upon the site available for the RDS. The RDS APM-460 BL Respirable Dust Sampler has been provided with a cyclone. The cyclone has been designed to provide separation of PM10 particles. Atmospheric air was drawn for ~24 hours in three shifts through the cyclone and 20 X 25 cm glass fiber filter (GF/A) sheet at a flow rate of 0.8 to 1.4 m3/min and finally the average flow rate was calculated.

As the air with suspended particulate enters the cyclone, coarse non-respirable dust is separated from the air stream by centrifugal forces. The suspended particulate matter falls through the cyclone's conical hopper and gets collected in the cyclonic-cup. The fine dust comprising the respirable fraction of TSPM passes through the cyclone and gets collected on GFF. The amount of non-respirable suspended particulate matter (NRSPM) and respirable particulate per unit volume of air passed was calculated on the basis of the difference between initial and final weights of the cyclone cup and that of the filter paper, and the total volume of the air drawn during sampling. Mass concentration of TSPM was calculated by adding the concentration of PM10 and NRSPM. For gaseous (SO2 and NO2) sampling the impingers was exposed for ~24 hour in four hours slot at an impingement rate of 1 litre/min to get representative sample in a day. SO2 was analyzed by the modified West-Gaeke method on Spectronic-21 spectrophotometer at wavelength of 560 nm. NO2 was analyzed employing the Jacob-Hochheiser modified method on a spectrophotometer at wavelength of 540 nm (Lodge, 1989). During the monitoring period, 24 hourly samples were collected for two days a week for SPM, RPM, SO2 and NO2. And CO was estimated by taking one hour samples. The methods and standards used for the sampling and analysis are given in Annexure-1.

The results of ambient air quality are presented in table 3.3. The ambient air concentration of TSPM was observed higher. The probable reason for the high levels of atmospheric TSPM and PM_{10} could be due to industrial, agriculture activities and traffic congestion. Gaseous pollutants (SO_2 and NO_2) were found below the permissible limits at all the locations. Ambient Air quality monitoring photographs are shown from Fig 3.6 to Fig 3.11

Fig 3.6: Ambient Air Quality Monitoring at Mori Gate

Figure 3.7 : Air Quality Monitoring at Libaspur

Fig 3.8 : Air Quality Monitoring at Samhalkha

Fig 3.9 : Air Quality Monitoring at Rai

Fig 3.10 Ambient Air Quality Monitoring at Gannaur

Figure 3.11 : Air Quality Monitoring at Panipat Road

3.5.1 Wind Parameters

An weather monitoring station was installed during summer season April to June 2010 to record various meteorological parameters on hourly basis to understand the wind pattern, Temperature variation, solar isolation and relative humidity variation etc. The meteorological data recorded during the monitoring period is very useful for proper interpretation of the baseline information as well as an input for prediction models.

Wind speed and wind direction play a major role in the dispersion of air pollutants. The stronger the winds the greater will be the dilution and dissipation of pollutants.

The predominant wind directions observed were West (W) to East (E). In project influence area the calm conditions are comparatively less. Gaseous concentration build- up in any location is directly proportional to the calm conditions. This helps the pollutants to disperse rapidly, away from pollution-prone areas.

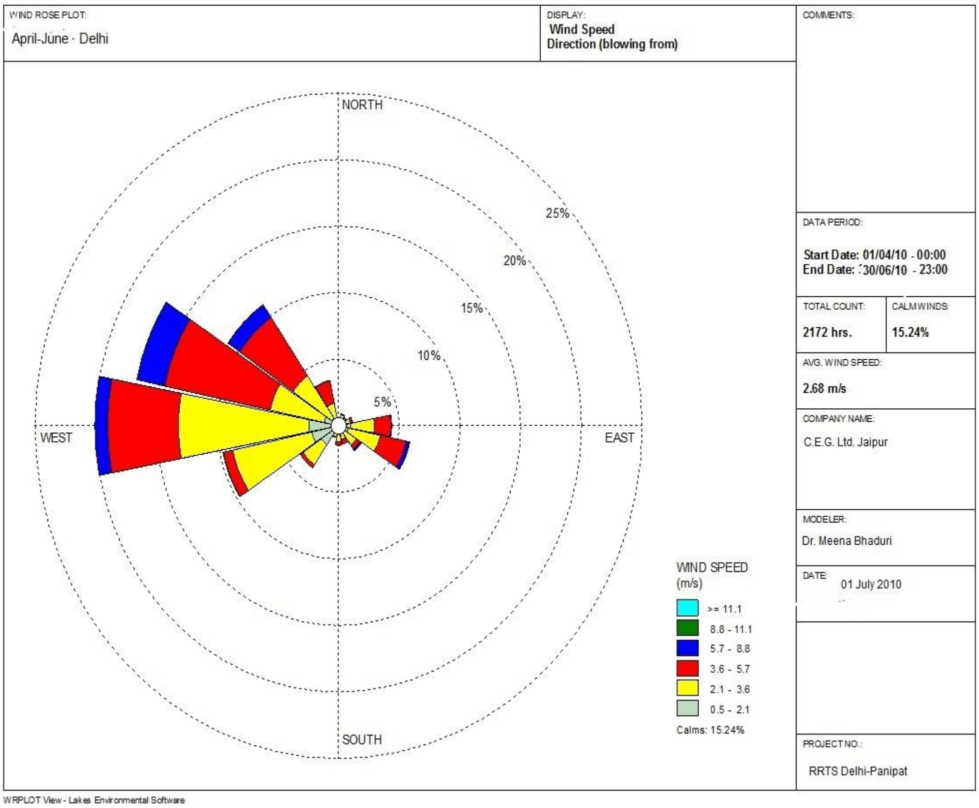


Fig 3.12: Wind Rose Diagram For Delhi, April to June 2010

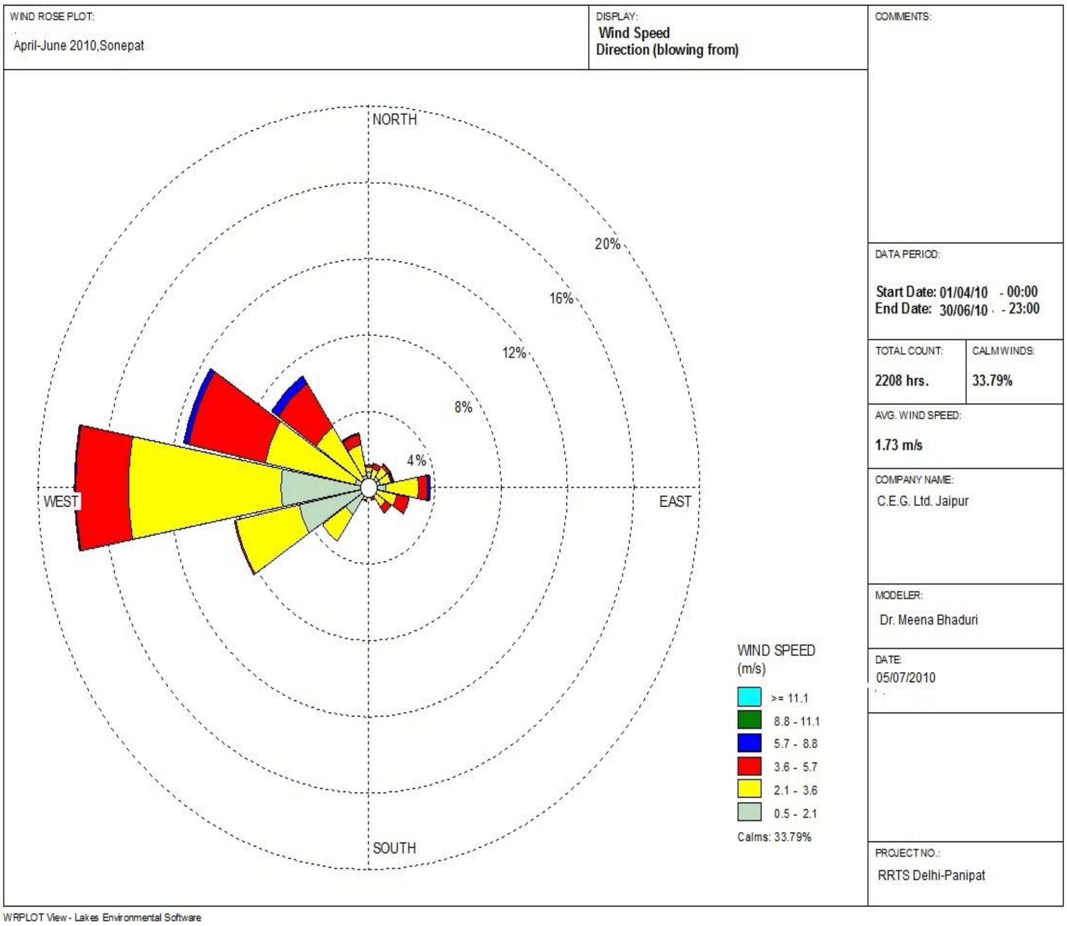


Fig 3.13: Wind Rose Diagram For Sonepat, April to June 2010

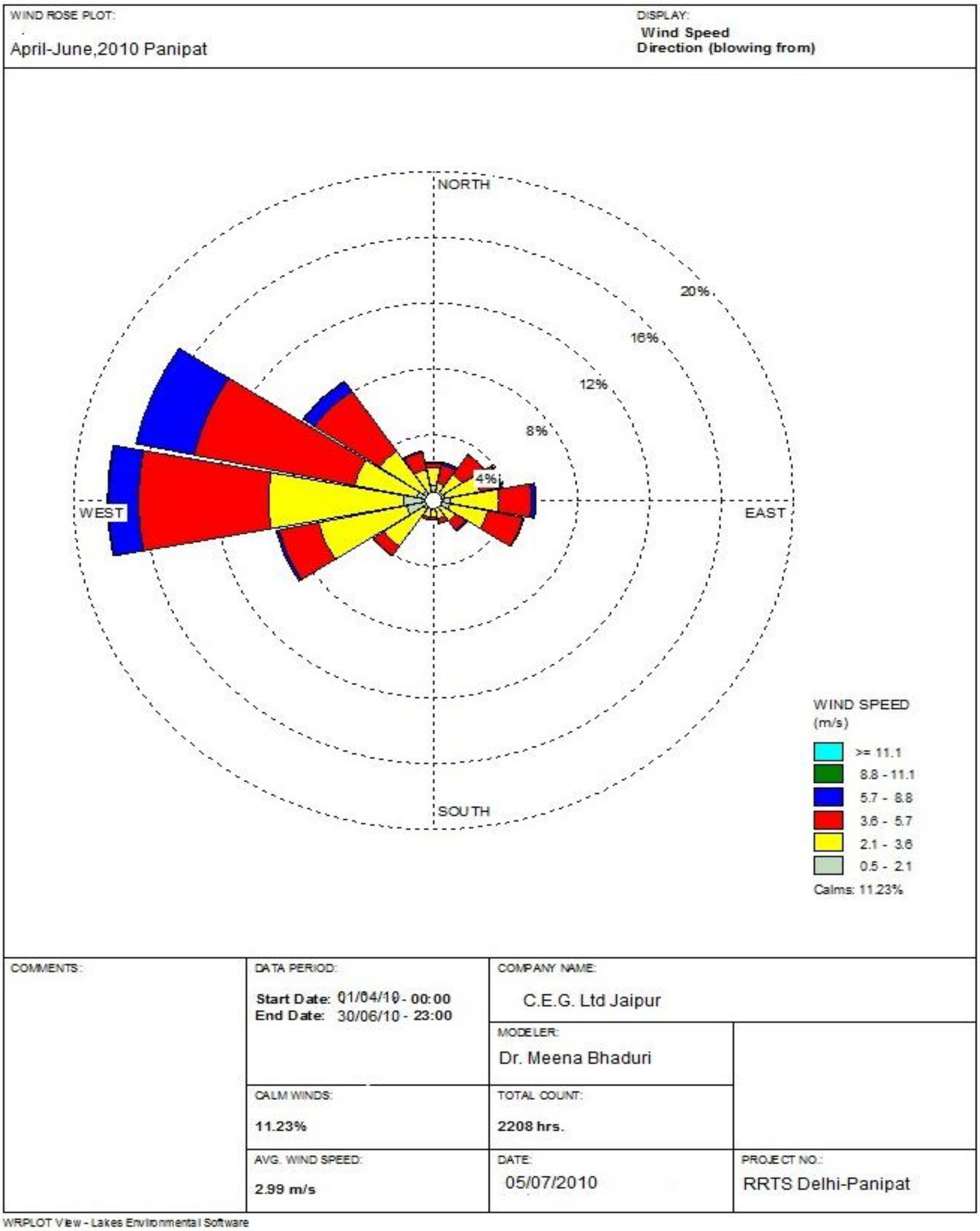


Fig 3.14: Wind Rose Diagram For Panipat, April to June 2010

3.5.2 SELECTION OF MONITORING LOCATIONS

Monitoring stations were identified based on site conditions such as

- Sources of pollutants (Industrial/Commercial/Residential), environmental features and existence of sensitive / critical areas i.e. educational institutions, hospitals, archaeological / cultural sites.
- Nature of construction, diversions, congestion, parking places, bus / taxi stands, number and frequency of vehicles.
- Natural Water bodies in the study areas, Natural vegetation in the study areas or other major affected areas. However, the survey has also been conducted for the entire area in the vicinity of proposed RRTS Project.
- SPCB / CPCB and MoEF's guidelines were followed for sampling, monitoring and analysis,

Figure and give the locations for monitoring of air, noise, sampling for water and soil on RRTS Delhi-Panipat Corridor

Table 3.1: Summary of Ambient Air & Noise Quality monitoring locations

Station	Location
Site 1	Kashmiri Gate,
Site 2	Libaspur,Landfill at Mukarba Chowk
Site 3	Bhogarh, Narela
Site 4	Kundli
Site 5	KMP Interchange
Site 6	Rajeev Gandhi Education City
Site 7	Murthal
Site8	Gannaur
Site 9	Samalkha
Site 10	Panipat, near NFL
Site 11	Asand Road,Panipat
Site 12	Rajapura Panipat, Depot Terminus

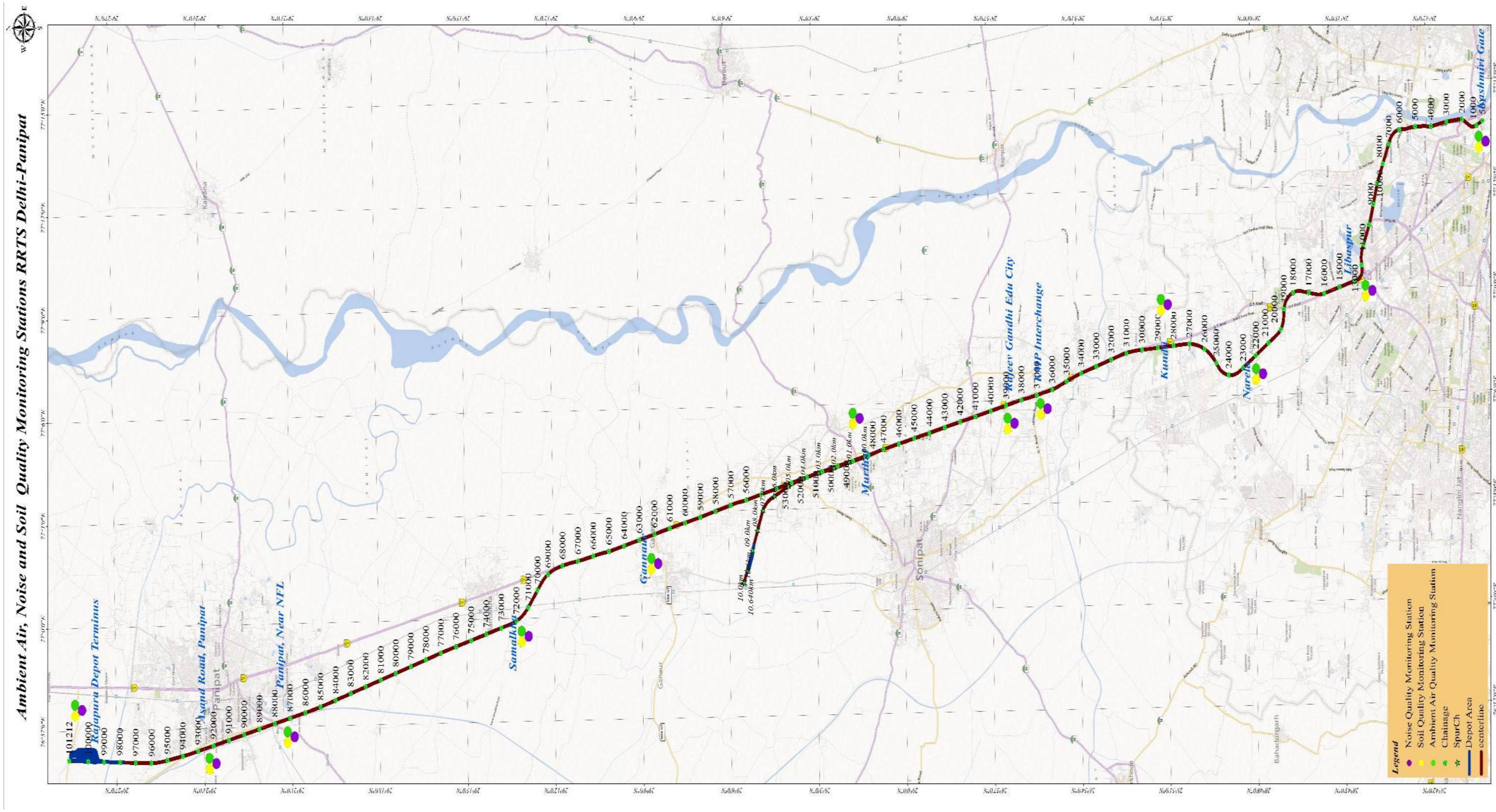


Fig 3.15. Ambient Air, Noise and Soil quality monitoring locations for Delhi-Sonepat –Panipat RRTS

Table 3.2 Ambient Air Monitoring

Parameters	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Site 7	Site 8	Site 9	Site 10	Site 11	Site 12	National Ambient Air Quality Standards, Maximum limit			
													Industrial, Residential, Rural and Other area		Ecologically Sensitive Area	
													Annual	24 Hrs.	Annual	24 Hrs.
Particulate matter size less than 10µg, µg /m³	206	326.2	81.5	244.5	172.2	201.2	212.4	124.3	179.0	168.9	162.6	73.7	60	100	60	100
Particulate matter size less than 2.5 µg, µg /m³	64.1	126.4	20.2	91.5	81.3	86.4	68.3	30.8	71.9	57.7	68.2	21.0	40	60	40	60
Nitrogen Dioxide, µg/m³	26.6	33.4	17.9	27.2	26.6	27.6	27.9	27.5	29.5	25.6	26.1	12.6	40	80	30	80
Sulphur Dioxide, µg /m³	14.5	16.4	7.6	13.0	11.1	10.9	10.2	9.0	10.2	9.4	9.8	4.8	50	80	20	80
Carbon monoxide, mg/m³	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	02*	04#	02*	04#

Where: *= Maximum limits for 8 hourly monitoring, #= Maximum limits for 1 hourly monitoring

The 24-hourly values of $PM_{2.5}$ (max 126.4 $\mu g/m^3$ at site 2) at all the locations were observed to be very high, in comparison with the limit of 60 $\mu g/m^3$ for residential, rural & other areas, as stipulated in the National Ambient Air Quality Standards. The high level of SPM is only because of vehicular pollution. There are no other interferences.

- The 24-hourly values of PM_{10} $\mu g/m^3$ at all locations were also observed on the higher side in comparison with limit of 100 $\mu g/m^3$ for residential, rural & other areas as per the National Ambient Air Quality Standards. Maximum PM10 level was observed at site 2 (326.25 $\mu g/m^3$) and the high level of RPM is due to vehicular pollution. There are no other interferences.
- The 24-hourly values of SO_2 (max 16.4 $\mu g/m^3$ at site 2) at all the locations were below the permissible limit of 80 $\mu g/m^3$ as stipulated in the National Ambient Air Quality Standards for residential, rural & other areas.
- The 24-hourly values of NOx (max 33.4 $\mu g/m^3$ at site 2) at all the locations were within the prescribed limit of 80 $\mu g/m^3$ stipulated in the National Ambient Air Quality Standards for residential, rural & other areas.
- The 1-hourly values of CO were below 1.15 mg/m^3at all the locations were within the prescribed limit of 4 mg/m^3 stipulated in the National Ambient Air Quality Standards for residential, rural & other areas.

3.6 NOISE

Noise level has been measured at different locations along project corridor. The noise data results are shown in Table 3.3**.** At various places, 24 hours noise recorded data shows that the values were higher than the prescribed permissible limits of 65 dBA (day) and 55 dBA (night) in commercial area and higher than permissible limits of 55 dBA (day) and 45 dBA (night) in residential areas.

Fig 3.16. Ambient Noise Quality Monitoring at Panipat

Fig: 3.17: Ambient Noise Quality Monitoring at Mukarba Chowk

Table 3.3 Noise Monitoring

Parameter			Site 1	Site 2	Site 3	Site 4	Site 5	Site6	Site 7	Site 8	Site 9	Site 10	Site 11	Site12	**Ambient Air Quality Standards in respect of Noise,** Limits in dB(A) Leq,[THE NOISE POLLUTION (REGULATION AND CONTROL) RULES, 2000]			
															Industrial	Commercial	Residential	Silence
Noise Data		Day	82.5	84.3	77.9	79.3	87.4	84.0	80.3	83.5	89.5	77.1	84.8	76.8	-	-	-	-
		Night	73.5	76.7	73.9	72.2	79.0	79.2	79.6	70.7	80.0	70.5	72.8	65.1				
	L_{min}	Day	67.6	62.2	61.5	61.0	64.3	66.2	67.9	67.1	67.9	66.0	63.4	64.5	-	-	-	-
		Night	61.1	63.6	57.3	65.0	59.1	61.8	67.1	63.3	67.0	62.9	59.6	59.6				
	dB(A) Leq	Day	74.2	71.8	68.8	69.2	75.5	75.8	72.3	73.7	76.3	69.8	74.1	68.5	75	65	55	50
		Night	65.1	68.0	63.7	67.6	68.3	70.9	70.9	66.0	70.6	65.9	64.6	62.6	70	55	45	40

3.7 SOIL QUALITY ANALYSIS:

The results have been summarizing in Table 3.5

Table 3.5 (Soil Test Results)

S.NO	LOCATION Place	Soil Texture	pH	CARBONATE %	Chloride %	Organic Content %	Specific Gravity	Total Soluble Solids (%)	Sulphate (as SO4) %
1	Kundali	sandy silt	7.8	0.042	0.0019	4.3	2.61	0.072	0.071
2	Ganour	sandy silt	7.5	0.030	0.001	4.4	2.65	0.076	Less than 0.005
3	Panipat (Asand road)	Silty sand	6.9	0.036	0.001	3.7	2.59	0.064	Less than 0.005
4	Kasmiri Gate	sandy silt	7.5	0.054	0.002	7.8	2.59	0.080	0.139
5	Bhorgarh	Silty sand	8.3	0.024	0.002	3.4	2.72	0.068	0.166
6	Rajapura	Silty sand	8.7	0.030	0.003	4.1	2.69	0.088	Less than 0.005
7	Chulkhana(Samalkha)	Silty sand	7.3	0.072	0.010	7.5	2.54	0.056	0.071
8	Rajeev Gandhi Education City	Silty sand	9.4	0.012	0.018	3.3	2.69	0.124	0.062
9	KMP intercity	Silty sand	8.5	0.018	0.005	3.8	2.66	0.040	0.071
10	Panipat(near (NFL)	sandy silt	7.9	0.024	0.001	3.3	2.64	0.068	Less than 0.005
11	Libaspur	sandy silt	9.0	0.048	0.001	4.2	2.64	0.052	Less than 0.005
12	Murthal	sandy silt	7.8	0.030	0.003	3.4	2.64	0.036	Less than 0.005

3.8 WATER QUALITY ENVIRONMENT

Water Resources

The project traverses along Yamuna River and the Supplementary Drain of Irrigation & flood control dept, govt. of Delhi. The names of the channels with their respective Chainages are given in Table 3.5.

Table-3.5: Water body along the project route

Sl. No.	Name of river or water body	Chainage
1	Yamuna river	1.9 km to 4.00 km
2	Supplementary drain ,dept. of Irrigation &Flood Control Dept	6. 4km to 23.7 km

Water pollution impacts and possible sedimentation during construction of rail would be carefully controlled and monitored. In spite of the irrigation facilities in the districts, especially along the project area canals are the major source of water supply.

Water Quality

Water quality can be expressed in terms of physical, chemical and biological characterization of water. Environmental survey was conducted and four sampling locations for ground water were selected along the project corridor. In order to find out the primary data of existing water quality scenario, details of the sampling locations and their results are given in Table 3.6 Parameters being analyzed for water pollution are given in Table 3.6

Fig 3.18: Surface and Ground Water quality monitoring locations for Delhi-Sonepat –Panipat RRTS

Table 3.6: Water Monitoring Results

Sample ID / Location	Source	pH	Sulphate (as SO4) mg/L	Total Dissolved Solids mg/L	Chloride mg/L	Alkalinity mg/L	Acidity mg/L	Volatile Residue mg/L	Fixed Residue mg/L	Condu-ctivity uS/cm	Total Hardness mg/L	Calcium as Ca mg/L	Magnesium as Mg mg/L
Carnal KMP Interchange	GW	8.0	102.9	181.0	29.2	85.9	14.4	105.0	76.0	259.0	257.4	37.7	39.8
Budhpur	Nala water	7.6	120.2	1388.0	228.7	272.7	19.2	493.0	895.0	2360.0	470.3	123.0	39.8
Kasmiri gate	GW	8.0	378.2	435.0	111.8	454.5	14.4	138.0	297.0	550.0	198.0	57.5	13.3
Rajapura	GW	7.7	77.4	563.0	43.0	126.3	4.8	183.0	380.0	720.0	158.4	25.8	22.9
KMP Interchange	Nala water	8.2	393.8	1116.0	180.5	343.4	9.6	288.0	828.0	1600.0	673.2	45.6	136.2
Libaspur	GW	7.2	169.5	1008.0	177.1	353.5	43.2	253.0	755.0	1452.0	371.3	91.3	35.0
Bhorgarh	Nala water	7.0	206.6	787.0	163.3	151.5	24.0	282.0	505.0	1053.0	287.1	11.9	62.7
Murthal	GW	7.3	341.1	1273.0	178.8	454.5	57.6	239.0	1034.0	1826.0	806.9	121.0	122.9
Canal 3 KM from Samalkha	Canal	8.0	62.1	118.0	17.2	75.8	9.6	41.0	77.0	215.0	123.8	33.7	9.6
Rajeev Gandhi Education City	GW	7.6	439.9	1300.0	211.5	404.0	43.2	264.0	1036.0	1960.0	643.5	77.4	109.7
Kundli	GW	7.7	664.6	1578.0	240.7	343.4	28.8	303.0	1275.0	1950.0	544.	83.3	82.0
Chulkhana,	GW	7.4	192.2	743.0	134.1	272.7	19.2	194.0	549.0	1002.0	435.6	69.4	63.9

Samalkha													
Panipat	Canal	8.8	157.6	255.0	25.8	75.8	9.6	53.0	202.0	308.0	173.3	43.6	15.7
Ganour	GW	8.1	395.9	1100.0	60.2	479.8	48.0	258.0	842.0	1528.0	450.5	37.7	86.8
Panipat	GW	7.9	74.9	460.0	24.1	257.6	14.4	185.0	275.0	480.0	262.4	43.6	37.4
Panipat near NFL	Canal	7.9	89.3	185.0	22.4	85.9	19.2	78.0	107.0	160.0	138.6	27.8	16.9
Panipat near NFL	GW	8.0	95.1	179.0	55.0	106.1	9.6	80.0	99.0	210.0	158.4	29.8	20.5
QudisiaBagh		7.7	2120	1395	168.2	380.6	313.6	10.15	835	431	964	202.4	80.3
Gurudwara, Majnu ka Tila		7.7	580	380	38.3	111.9	130.2	10.15	180	117	263	46	15.8
Yamuna River		8	610	390	34.9	97.9	154.4	10.15	190	102	288	42	20.7

3.9 ECOLOGICAL PARKS, SANCTUARIES, FLORA AND FAUNA OR ANY ECO SENSITIVE ZONES

There are no Ecological Parks, Wild Life and Bird Sanctuaries or any Eco Sensitive Zones in existence within the project area.

Flora: The natural vegetation in the study area is sparse. Various kinds of trees and shrubs are found growing indigenously. On account of the pressure of population and extensive cultivation, very little land has been left under natural forest cover.

Strip forests along the roads and canals and block forests of Babool (Kikar) are on the forest record. Most of the area is occupied by agriculture fields. Wherever the forests are present, they are of open evergreen scrub or thorn type comprising mainly of:

- ButeaMonosperma (Dhak)
- Prosopis Cineraria (Jand)
- Capparis Deciduas (Kaur)
- Capparis Separia (Hins)

According to the revised survey of forest types in India, the natural vegetation is of the study area falls under "Tropical Dry Deciduous Forests" with sub-type: Northern Dry Mixed Deciduous type.

Common Trees found in the area are;

- Acacia Nilotica (Babul)
- Albizzia Lebbek (Siris)
- Azadirachta Indica (Neem)
- Bauhinia Variegate (Kachnar)
- Butea Monsperma (Dhak)
- Cassia Fistula (Amaltash)
- Crataeva Nurvala (Barna)
- Dalbergia Sissoo (Shisham)
- Moringa Oleifera (Sohanjna)
- Morus Alba (Sahtoot)
- Saraca Indica (Ashok)

Among the fruit trees the important are Mangifera Indica (Mango) and Syzygium Cumini (Jamun). Some of the important medicinal plants in the study area are Achyranthes Aspera, Argemone Mexicana, Croton Sparcifours, Euphorbia Hirta, Solanum Xanthocarpum, Tribulus Terristris, Vitex Negundo, Abrus Precatorius, Abutilon Indicum and Adhatoda Vasica.

Fauna

The majority domestic animals seen in the area are cow, buffalo, horse, donkey, goat, pig, and dog.

The main birds found near project area, are pintail, coot, house sparrow, myna, cattle egret, little egret, pond heron, indian ring dove, blue rock pigeon, etc

3.10 LAND-ACQUISITION PATTERN

Approximately 30 % of the land for the proposed corridor requiring acquisition falls within Delhi and the remaining 70% in the state of Haryana.

Total land acquisition	1062.721 Ha
Govt Land	598.7621 Ha (Approx 56%)
Private Land	463.9592 Ha (Approx 44%)

The section passes through a variety of land use, viz. built up, barren and agricultural land.

3.11 SOCIO-ECONOMIC CHARACTERISTICS OF THE PROJECT INFLUENCE DISTRICTS

Table 3.7 Demographic profile of Delhi and Haryana State

Description	Delhi		Haryana	
	2011	2001	2011	2001
Approximate Population	**16,753,235**	**13,850,507**	**2.53 Crore**	**2.11 Crore**
Actual Population	**16,753,235**	**13,850,507**	**25,353,081**	**21,144,564**
Male	8,976,410	7,607,234	13,505,130	11,363,953
Female	7,776,825	6,243,273	11,847,951	9,780,611
Population Growth	**20.96%**	**46.31%**	**19.90%**	**28.06%**
Percentage of total Population	1.38%	1.35%	2.09%	2.06%
Sex Ratio	**866**	**821**	**877**	**861**
Density/km2	**11,297**	**9,340**	830	964

Description	Delhi		Haryana	
	2011	**2001**	**2011**	**2001**
Density/mi2	29,238	24,172	**573**	**478**
Area km2	**1,483**	**1,483**	**44,212**	**44,212**
Area mi2	573	573	17,070	17,070
Total Child Population (0-6 Age)	**1,970,510**	**2,016,849**	**3,297,724**	**3,335,537**
Male Population (0-6 Age)	1,055,735	1,079,618	1,802,047	1,833,655
Female Population (0-6 Age)	914,775	937,231	1,495,677	1,501,882
Literacy	**86.34%**	**81.67%**	**76.64%**	**67.91%**
Male Literacy	91.03%	87.33%	85.38%	76.10%
Female Literacy	80.93%	75.24%	66.77%	59.61%
Total Literate	12,763,352	9,664,764	16,904,324	12,093,677
Male Literate	7,210,050	5,700,847	9,991,838	7,480,209
Female Literate	5,553,302	3,963,917	6,912,486	4,613,468

Table: 3.8 Demographic Profiles of, Sonipat and Panipat Districts

Description	Panipat		Sonepat	
	2011	**2001**	**2011**	**2001**
Actual Population	**1,202,811**	**967,449**	**1,480,080**	**1,279,175**
Male	646,324	528,860	798,948	695,723
Female	556,487	438,589	681,132	583,452
Population Growth	**24.33%**	**38.58%**	**15.71%**	**22.39%**
Area Sq. Km	1,268	1,268	2,122	2,122
Density/km2	**949**	**763**	**697**	**603**
Proportion to Haryana Population	4.74%	4.58%	5.84%	6.05%
Sex Ratio (Per 1000)	**861**	**829**	**853**	**839**
Child Sex Ratio (0-6 Age)	833	808	790	787
Average Literacy	**77.5**	**69.2**	**80.8**	**72.8**
Male Literacy	85.4	78.5	89.4	83.1
Female Literacy	68.2	58	70.9	60.7

Description	Panipat		Sonepat	
	2011	**2001**	**2011**	**2001**
Total Child Population (0-6 Age)	**164,747**	**143,262**	**187,926**	**181,877**
Male Population (0-6 Age)	89,873	79,250	104,981	101,792
Female Population (0-6 Age)	74,874	64,012	82,945	80,085
Literates	**803,663**	**352,512**	**1,044,513**	**492,953**
Male Literates	475,230	216,972	620,434	305,146
Female Literates	328,433	569,484	424,079	798,099
Child Proportion (0-6 Age)	**13.70%**	**14.81%**	**12.70%**	**14.22%**
Boys Proportion (0-6 Age)	13.91%	14.99%	13.14%	14.63%
Girls Proportion (0-6 Age)	13.45%	14.59%	12.18%	13.73%

3.12 PRESENCE OF SENSITIVE RECEPTORS:

Sensitive receptors present at proposed corridor are as follows:

Type of Structure	Total
Temple	32
Mosque/ Mazar, Gurudwara	3+2
School	2
School boundary wall	6
Total Residential structure affected	239
Commercial	50
Residence-Commercial	32
Religious	37
Common Property/ Govt. Structures	69

3.13 VISUAL RESOURCES

During the site survey along the project stretch, the elements of enhancements have been identified. The baseline elements such as cultural properties, water bodies (ponds), factories, borrow areas and other elements with their significance to the community have been identified based on their importance and relationship with the stretch.

CHAPTER – 4

ENVIRONMENTAL IMPACTS ASSESSMENT

4.0 INTRODUCTION

The present transport system is characterized by road traffic congestion with declining ambient air quality accompanied by a rising trend in road accidents. The focus of all efforts need to be on reducing congestion, improving air quality by lower levels of vehicular pollution and enhancing road safety while improving amenities for commuters. The proposed RRTS scheme will be one of several major transport projects serving the rapidly growing regions of Delhi & Haryana. RRTS scheme will allow passenger to interchange with the Delhi Metro, which will provide convenient rail link to Delhi airport. To provide safe, eco-friendly, cost-effective and efficient modes of transportation through a well-integrated multi-modal transport system, the development activity should be carried out in harmony with the environment, within the carrying capacity of the ecosystem through judicious planning. Prediction of potential impacts due to proposed developments of RRTS scheme is carried out through well designed environmental impact assessment process.

The potential impacts have been assessed and predicted based on the present environmental status already identified qualitatively and quantitatively. The impacts due to the development of the proposed RRTS project have been assessed for the planning phase, construction phase and implementation phase. The proposed project activities are to be implemented with appropriate mitigation measures that are suggested to avoid / reduce / compensate for the potential adverse impacts of the project and enhance its positive impacts.

The possible impacts due the proposed RRTS project could be visualized as follows **(Figure 4.1).**

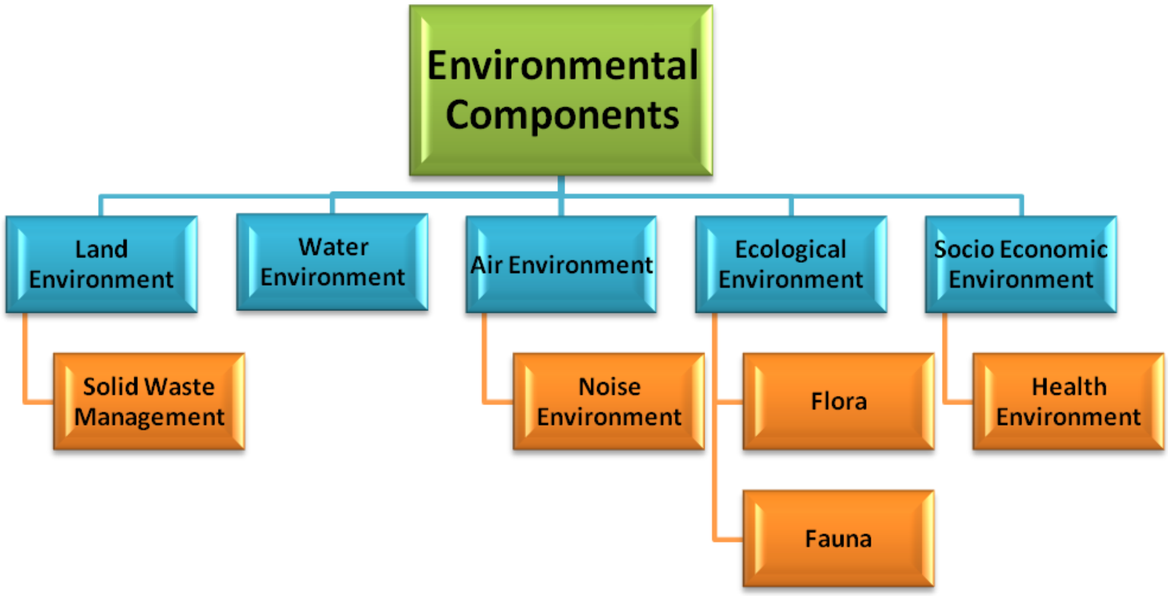


Figure 4.1: Components for Environmental Impact Evaluation

1. Impacts due to project design
2. Impacts during project construction phase
3. Impacts during operation phase

These impacts involving various environmental and socio-economic attributes during the different phases of the project are discussed.

4.1 IMPACTS DUE TO PROJECT DESIGN

The project RRTS is planned with an High speed rail corridor, Delhi-Sonepat-Panipat (111.0 km Stretch). Considering the operational and land acquisition problems in an already crowded city, the above corridor will be constructed in an elevated track sections (Except the first 03 km. which is underground) with facilities for inter-transfer at the crossing stations.

Due to the elevated rail construction and associated infrastructure facilities like RRTS stations, depots, ticketing counters and peripherals, certain environmental and socioeconomic impacts are anticipated.

4.1.1 Impact on Land

The alignment for the proposed project has been chosen to keep the land requirement, especially of private property, to a bare minimum. Based on this concept the alignment has been designed from main roads, busy areas or within the Govt. Land. The total land acquisition is 1062.721 hectares These impacts need a careful review, assessment and mitigation measures.

4.2. CONSTRUCTION AND OPERATION PHASE IMPACTS OF RRTS

The RRTS project may exhibit certain short and long-term impacts on the environment. The magnitude and domain of these impacts may however, vary with respect to each component of the ecosystem. Environmental impacts during the construction phase are of a temporary and transitory nature. The impacts during the operational stages of RRTS may be long-lasting and permanent in nature. It is therefore essential to assess the nature and magnitude of the impacts, which will help in formulation of appropriate environmental management plans to avoid or minimize the adversity.

4.2.1 Land Clearing

Most of the proposed project components would be in well-developed areas of the city with distinct land usage patterns ranging from the residential ,commercial to already well-established industrial activities. As construction activities are primarily land based, many impacts can be identified in the soil component in the proposed area making the soil susceptible to erosion by wind and rain subsequently.

For the construction of an elevated track, the existing structures and trees in the area will have to be cleared and removal of the existing structures would result in the generation of the rubble, which has to be disposed off appropriately. In addition, during the process of demolishing these structures, and clearing the sites for construction purposes, it will result in the release of huge quantities of air borne dust. Heavy earth moving equipment used for clearing existing structures, the tippers to be used for the removal of the earth and rubble will also increase air pollution and noise levels in the area.

A tunnel of 2.35 km length and 14 m diameter will generate spoil of 3,55,000 m^3 (muck) will also require clearing and proper disposal by concessionaire.

4.2.2 Socio-economic impact of the project

1324 persons will be impacted, due to land acquisition and clearing of ROW (Right Of Way) from encroachers using occupied land areas for say residential, commercial, and religious and community purpose structures constructed. A resettlement action plan will be formulated which will include an acceptable implementation strategy to ward off resistance from local public and simultaneously elevating the living standard of the Project Affected Persons (PAPs).

The people of the project affected area are engaged in services, business, manufacturing and trading. There are 331 households in the project affected area. The average family size living in 331 houses (residential and residential cum commercial) in the project affected area is 5 persons per family. The people of the study area are well aware of the development of the infrastructure, because of high literacy standards. There are a few study area corridors, which are part of the well planned urban development and have well constructed houses. 95 % of the houses fall under the permanent category. It reflects the higher living standards of the project affected persons.

No significant cases for either spread of HIV/AIDS have been reported to the local Govt. or to the people informally.

The summary of impacts is given in **Table 4.1**

Table- 4.1 Summary of Impacts

S No.	Impacts	No.
1	**Land Acquisition including depot area (in m^2)**	**1062.721**
2	**Total Number of structures affected,** **Category Wise:**	**437**
	Total Residential structure affected	**249**
	Total commercial structures affected	**50**
	Total Residential cum commercial structures affected	**32**
	Total Common Property resources (CPRs)	**69**
3	**Total no. of DP**	**1324**

Source: *Social Survey 2012*

4.2.3 Impact on Air Quality

Planning Phase

The RRTS operations evaluated on environmental grounds will become favorable as its single positive impact on the environment by way of large reduction of fuel burning in densely populated urban areas, causing reduction in gaseous emissions, unlike other modes of urban road transport, since in the metro rail system, the motive power is electrical energy and eliminates gaseous emissions. It is further projected that full scale operations of the RRTS would have a cascading effect on reducing the traffic volumes and density of the automobiles operating within city roads, and with their anticipated reduction in number and density over a period of time an improvement in the existing air quality picture is a certainty. The carbon foot print of the city will significantly improve, and therefore, the project may also qualify for Carbon Credit.

Construction Phase

During the construction phase, the air quality is likely to be affected due to generation of dust from construction activities and gaseous emissions from construction vehicles. However, the impact will be localized, short-termed and reversible.

Two possible major sources of emissions from the construction activities are:

(i) Dust emissions from non-combustion sources and

(ii) Exhaust emissions from construction vehicles and stationary combustion sources.

Localized air quality impacts will be temporary but significant. Dust and vehicle emissions will be generated by construction activities like earthworks and construction of piers. Dust emissions generally consist of large particles that settle out relatively close to the source, whereas exhaust emissions generally consist of fine particles that can drift further away from the source. There will be potential for dust emissions, wherever any of these activities are taking place. The most likely points of impact include:

1. At proposed station sites where major excavation will occur, for the work of piling.
2. Fugitive dust from dump trucks; and
3. Locations where excavation spoils are transferred from dump trucks to spoil receiving site.

Combustion emission sources typically associated with such type of projects include:

(i) Diesel exhausts emissions from mobile sources, including earth-moving equipment, and dump trucks;

(ii) Exhaust from stationary combustion sources, including generators, heaters, and possibly off-site construction and fabrication (including concrete-casting facilities)

It is estimated that nearly 3,55,000 M^3 excavated soil has to be handled and shifted from place of generation to disposal sites. The air pollutants will be released by the vehicles and may be spread over distances if, not moved in the trucks covered with tarpaulin sheets. Best management practices shall be adopted during construction to minimize dust and exhaust emissions.

Operation Phase

Air pollutants such as NOx, SO_2, PM_{10}, PM $_{2.5}$ and CO, are expected to register a decline following LRT in operations, mainly due to anticipated reduction in the existing mode of road traffic. This is a very significant positive impact of the RRTS project.

- ❖ RRTS will reduce plying of diesel buses currently used along the route and is expected to reduce private passenger vehicles (motor bikes and cars). The overall reduction in vehicle emissions that occurs as a result of LRT in operation will decrease the dependency on roads.
- ❖ The movement of trucks during peak hours may have some impact near stations, however, these impacts are localized and concentrated in a specified area only.
- ❖ Plantation along the RRTS corridor is likely to further improve the air quality of the area.

There will be a diesel powered maintenance vehicle used occasionally. There may be a requirement to provide diesel generator in the depot to provide back up of electricity supply. It is expected that electrical back up will be by a UPS system. Powered maintenance the selection and installation of DG sets will be in accordance with the norms set forth by MoE&F. The operation of these DG sets in confined locations can create some air pollution problems, which should be managed by proper chimneys, smoke barriers baffles, mufflers etc.

4.2.4 Impact on Noise Quality

Quiet trains replace many cars. Most of the passengers are are pedestrians come to the station by public transport. Car parking requirements are generally not much.

Construction Phase

Noise levels will tend to register a rise on account of the following: the first source is the construction activity, which generates considerable noise levels from Material Handling, DG sets, Compressors etc. The second source of noise is the increase in automobile activities in the work area and third one is the background noise of the usual traffic which may increase due to frequent honking

Haulage roads: There will be no separate haulage roads, and mostly all material transport and construction equipment / vehicle will ply on the existing municipal roads only. Large numbers of truck movements would be required to remove spoils, ballast, rail tracks and water and construction equipment to and from the construction site.

Track laying machinery: In the depot the machine/s used to lay the track would emit considerable noise; such noise will be raised over the elevated corridor and hence this impact will be faced by the operators / workmen close to erection site only. Noise impacts would, however, be localized and temporary in nature.

Construction of elevated stations: Station construction area/s would witness longer hours of noise-generating activities in one location. Noise levels generated by construction activities are likely to vary depending on the combination of equipment being operated at any one time. Normal noise levels due to equipments generally used in construction phase are given in table 4.3.

Table- 4.3 Noise levels due to equipment in construction phase

Equipment Category	Lmax Level dB (A)
Bar Bender	75
Chain Saw	81
Compactor	80
Compressor	80
Concrete Mixer	85
Concrete Pump	82
Crane	85
Dozer	85
Front End Loader	80
Generator	82
Gradall	85
Grader	85
Paver	85
Pneumatic Tools	85
Scraper	85
Tractor	84

Source: EPA, 1971: “Noise from construction equipment and operations, building equipment and home appliances”. NTID 300.1

However efforts shall be made to keep the levels under control by appropriate noise attenuation and employee safety measures. By putting up proper barricades and by the use of proper doping (sound absorbing) materials in barricades at construction sites the ambient noise levels can be contained. In view of the size and need for early completion of the project, it is quite natural that the construction works will be carried out in the night times as well. It will be ensured that the noise levels on account of the operation of various machines do not exceed the values given in the **figure 4.2**

Source: Stuart Eaton Feb.,2006 ARCS Reference No:0135-20. Workers' compensation board of BC engineering section report.

Figure 4.2 Noise Generation due to construction equipments

Operational Phase

During operational phase of RRTS noise would be intermittent, and will be on elevated corridors and thus much away from moving traffic on the ground. And, due to reduction of vehicular traffic, the road traffic noise levels will come down.

4.2.5 Vibrations during construction phase

Induced vibration in built up structures result form both ground borne and airborne excitations (figure 4.3).The major causes of the vibrations are road traffic, construction activities – attributable to man made reasons; as also seismic activities, etc. – that are natural reasons. This cause excitation of structure through its foundation and these induced vibrations get enhanced due to resonance effects in the various structural elements like beams, doors, windows, floors and ceiling, etc. These vibrations may propagate to the adjacent structures. If, the strains associated with these vibrations exceed the natural elastic limit of these elements at any point, irreversible damage is likely to occur. The machines like Bull Dozers, etc., during their operation may cause vibrations in the area of operations, which will travel the vicinity.

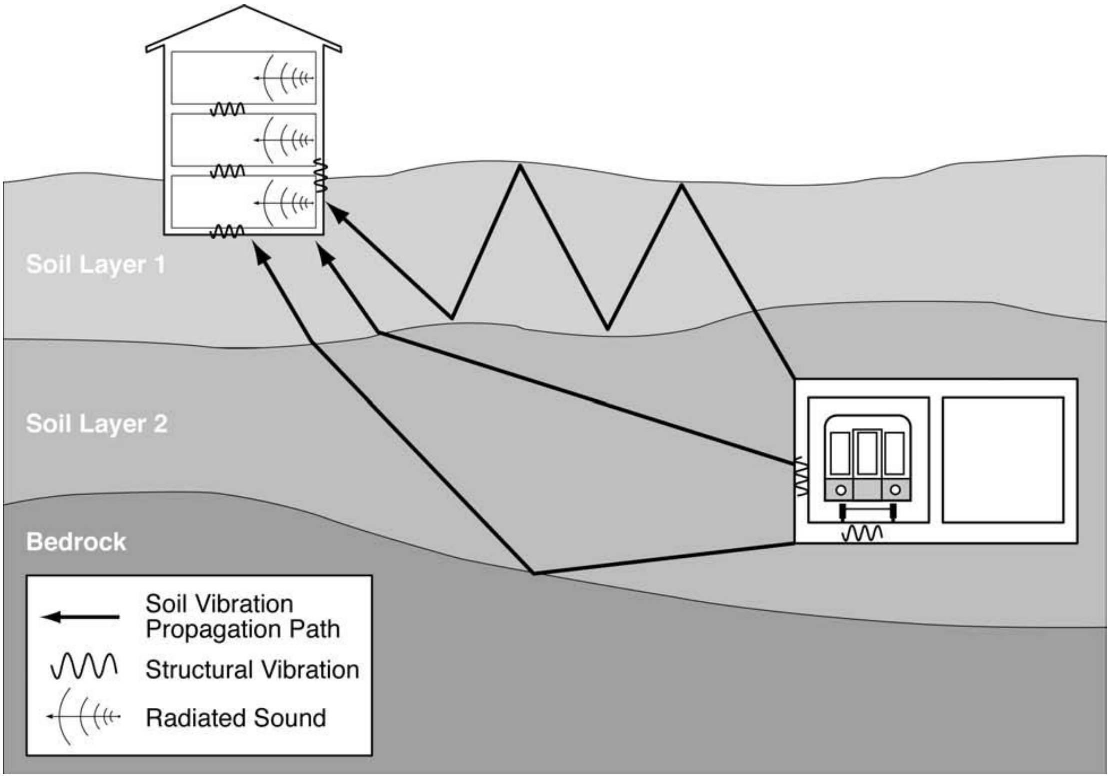


Figure 4.3 Ground Level Vibrations Propagation

Operation phase

No significant vibration impacts are expected to travel to adjoining structures once the RRTS system is in operation. Vibration from the operation of the trains shall not be significant due to the resilient fasteners, elastomeric pads under the rail and the continuous welded rail. However, there may be a "rumble" noise from the trains heard from the ventilation systems.

Review of literature * concludes that High speed trains generate ground vibrations of less than 0.5mm/s magnitude . It is probable that some isolated areas may be impacted during the operational phase by low frequency noise caused by the ground-borne vibration. The extent of this impact will be limited and it may be possible to mitigate the effect by adopting suitable mitigation steps.

*1.American National Standards Institute, Guide to the Evaluation of Human Exposure to Vibration in Buildings. ANSI S3.29-1983
2. International Organization for Standardization, "Evaluation of Human exposure to whole body vibration: Part 2 – Continuous and shock-induced vibration in buildings (1 – 80 Hz), ISO 2361-2- 1989
3. International Organization for Standardization, "Mechanical Vibration and Shock : Evaluation of human exposure to whole body vibration: Part 2 – Vibration in buildings (1 to 80 Hz), ISO 2631- 2-2003.
4. J. T. Nelson, H. J. Saurenman, "State-of-the-Art Review: Prediction and Control of Ground borne Noise and Vibration from Rail Transit Trains," U.S. Department of Transportation, Urban Mass Transportation Administration, Report Number UMTA-MA-06-0049-83-4, DOT-TSC-UMTA- 83-3, December 1983.
5. Y. Tokita, "Vibration Pollution Problems in Japan," In Inter-Noise 75, Sendai, Japan, pp. 465- 472, 1975.

4.2.6 Impact on Water Quality

Baseline studies have already indicated that the study area traverses along a Nallah and intersects supplementary drain of irrigation department at Panipat station at the end point of corridor.

Since the proposed alignment is elevated section therefore water sources like bore wells and open wells are likely to be unaffected.

Water Requirement for the construction of proposed Project

The water demand during the construction phase of the project is quite significant as water is required for various activities at batching plant for mixing, curing etc. Details of the water requirement (Approx.) for during the construction phase are given in the **Table 4.4**

Table 4.4: Expected requirement of water (KLD)

Activity	Water requirement (KLD)
For mixing the concrete	300

Curing and wetting	545
Washing and dust suppression	690
Labor camps @ 80 lpd for 600 persons	50
Other	45
Total	**1630**

1630KL per day water will be required for the proposed project during its peak construction period. Use of ground water should be avoided as much as possible to meet the requirements during the construction phase. Surface water shall be preferred to be used for construction, wherever available.

On the basis of baseline studies and field visits some of the likely potential impacts have been identified, which are discussed here.

Impact on Surface Water

The design of the elevated track requires the construction of the pillars on which the beam will be placed and track is laid and the construction of the pillars as such will not have any impact on the surface water as they are not likely to cause any disturbance. Further, these pillars would not hamper the ground water movements or affect recharge of the ground water as their base is about 1.5 m radius only.

Impact on Ground Water

Water demand aspects need to be evaluated. The construction activities for the proposed project require about 1630 KLD water. Appropriate plans shall be made in collaboration with Govt. agencies.

4.2.7 Water Demand during Operational Phase

During the operational phase of the there will be a continuous requirement of water for various purposes:

a) Maintenance of carriages and station facilities, Depot maintenance

b) For meeting commuting public needs, and

c) For fire-fighting purposes.

Provision of drinking water will be made for passengers at the railway stations in accordance with Indian Rail Standards. The water demand at each station may vary depending on passenger turn outs from 50 m^3 per day to about 100m^3 per day. According to Central Public Health and Environmental Engineering Organization (CPHEEO), water requirements at stations have various components, viz.

(i) Personal use by staff and passengers,

(ii) Fire fighting water requirement will be taken as per norms.

(iii) Make-up water for air conditioning and ventilation etc.

(iv) Platform washing requirement has been worked out at the rate of 2-lit per sq m as per CPHEEO.

4.2.8 Impact on soil quality

Project construction activity may induce erosion, physical and chemical desegregations of soil. Erosion of soil may occur due to removal of vegetation and excavation activity. Site selected for the project has sparse vegetation; hence impact owing to removal of vegetation would be minimal, however construction and associated activities would enhance erosion if not managed properly.

Construction Phase

Factors contributing to soil erosion during construction phase are

- Increased runoff and decrease in permeability of the soil.
- Use of heavy machinery and storage of materials results in compaction of the soil.
- Compaction of the soil as well as mixing of construction material with soil would also lead to reduced infiltration of water, decrease in permeability and increased runoff.
- Physical desegregations would occur due to excavation of different layers of soil and subsequent mixing of different layers and would lead to disruption of soil structure.

Several management measures will be implemented to minimize the soil erosion and other impacts such as removal and use of topsoil from construction site to areas earmarked for plantation, etc.

Operational Phase

During the operational phase, there shall not be any activity impacting soil quality and characteristics. No significant adverse impact is expected on the soils and areas around the site.

4.2.9 Impact on Green Cover

Construction phase

About 621 trees will be affected. Some of the trees will be partially pruned. About 1,800 trees shall have to be uprooted.

4.2.10 Waste Management

Excavation Activities

Excavation activities will be required at different locations for elevated track and station areas. The estimated quantum of the excavated soil and rocks will be about 3,55,000 cubic meters. Out of this about some amount of soil will be backfilled in excavated areas after piling work is over and rest have to be disposed at appropriate locations. (at pre designated municipal sites).

Operational phase

The RRTS projects do not witness large volumes of generation of liquid, or solid or gaseous wastes both, due to the operations and arising due to the daily commuters. The RRTS being introduced in National Capital Region (NCR) has been conceptualized with minimum waste generation. The problem of waste handling and control during the operational phase assumes less significance compared to other modes of urban transport. The RRTS projects do not witness large volumes of generation of liquid, or solid or gaseous wastes both, due to the operations and arising due to the daily commuters. However, secondary activities like commercial projects, eating joints, parking areas will generate Municipal Solid Waste as also Domestic sewage wastewater on a regular basis.

Liquid wastes (oil spillage) during change of lubricants, cleaning and repair processes, in the Depot for maintenance of rolling stock shall be trapped in a grit chamber for settling of suspended matter. The collected oil shall either be auctioned or incinerated, so as to avoid any underground water contamination.

The liquid waste generation from the daily commuters will be minimal. The RRTS stations will be equipped with toilet facilities for the general public. Due to short travel time significant solid waste generation is not anticipated. Solid waste littering will be prohibited within RRTS coaches or station premises.

However small amounts of solid wastes like paper, wrappers, covers, other types of rubbish/refuse and food waste generated during transit etc., will be managed and collected in refuse bins at various locations on the platforms and around station premises.

The daily commuters will be trained through sign boards, CCTVs and strict vigilance not to litter/split or generate liquid or solid waste in RRTS premises. The concerned agencies responsible for Collection / transportation and treatment of Municipal Solid Waste viz., Nagar Nigam and its contractors; as also Water Supply and Sewerage Board and its contractors will have to be made aware about the secondary and cascading developments likely around the station premises. Adequate commitments for management of such wastes may be prudent decision.

4.3 HEALTH RISKS

Construction Site

Proper sanitation facilities (water supply and human waste disposal) will be provided for construction workers in absence of same insect / viral disease vector induces health risk to local workers and nearby population. Mitigation measures shall include proper water supply, sanitation, drainage, health care and human waste disposal facilities. These risks could be reduced by providing adequate facilities in worker's camps and providing employment to local labor.

4.4 TRAFFIC CONGESTIONS

The proposed project is an elevated section throughout (except the first 3 km tunnel section) and is mainly on the median of existing road network in Delhi region and thus will be requiring barricading of the construction sites. It will reduce the area for traffic movement resulting in short term problems like traffic jams, road congestion etc,

It is expected that pressure on the other inter connecting roads will increase as particularly two and three wheelers will tend to avoid the roads with barricades and travel on minor roads. This would create considerable problems for the smooth flow of existing traffic. Therefore, a site-specific traffic diversion plans will be developed and implemented for identified duration of construction activities in the region in consultation with the city traffic police officials.

4.5 VISUAL IMPACTS

In both the corridors, the proposed RRTS project will bring about some permanent visual changes altering the existing landscape. The elevated alignment may interfere with the visual aspects of natural scenery in some portions of the city. At the same time, the elevated structure may also help to improve visual aesthetics within the urban landscape.

The RRTS stations shall be designed for entraining and alighting purposes for commuters. The areas in close proximity to the stations will witness substantial changes as thousands of commuters will pass through the area every day resulting in increased demand for related facilities.

EIA studies have reviewed these concerns for the RRTS project and have concluded that:

(i) the underground tunnel section would not be an obstacle to the groundwater flow because it is far too small a structure to form a significant barrier to cause any substantial changes to the groundwater regime;

(ii) the underground structures, both tunnel and station are basically “watertight”. Only a small amount of seepage may be anticipated in the tunnel which could be controlled through proper engineering solutions such as directional drainage, and the use of high powered sumps Tunneling is expected to be done using Tunnel Boring Machines (TBM’s) which allow for rapid and safe tunneling which modern tunneling techniques can provide for proper watertight shielding in the areas where water table is above the tunnel level.

(iii) where the alignment runs within the drain, and piling work would be required within the drain, steps could be taken to provide adequate steps during pre-construction, construction and post construction phases to ensure that the untreated drain water does not find a passage for seepage into the unconfined or the deeper confined aquifers.

(iii) in the Yamuna Floodplain area, the effect of piling activities during the construction phase is not expected to cause any changes to the existing groundwater regime in any manner, nor cause any deterioration in groundwater quality.

4.6 ENVIRONMENTAL MATRIX

The screening of Impacts has been carried out using activities pertinent to the development of the project in pre-construction (planning), construction and operational phases. Based on the observations on various environmental and social parameters of the project, a checklist has been prepared. Weightage has been assigned for various environmental attributes. Environmental components, like ambient air, noise, surface and ground water, land (including land use, soil), resource requirement / depletion / consumption, occupational health & safety of people - including that of the construction and operational workers, have been considered in the screening process.

Each impact is qualitatively evaluated to be either adverse or beneficial. Each adverse or beneficial impact is further classified into either short term (ST) or long term (LT) impacts. The color coding has been used to report the degree of adverse and beneficial impacts.

	HIGHLY ADVERSE
	MODERATELY ADVERSE
	HIGHLY BENIFCIAL

LT	LONG TERM
ST	SHORT TERM
NA	NOT APPLICABLE

Sl. No	Activity	Air	Noise	Solid Waste	Ground water (Water Pollution)	Ecology	Land use	Social	Resource Use	Health Safety	Aesth-etics
					Planning Phase						
1	Land Acquisition							LT			
2	Change in Land use						LT				

Sl. No	Activity	Air	Noise	Solid Waste	Ground water (Water Pollution)	Ecology	Land use	Social	Resource Use	Health Safety	Aesth-etics
3	Tree felling					ST					
	Construction Phase										
1	Excavation	ST	ST	ST	NA		ST				ST
2	Blasting	ST	ST	ST						ST	
3	Dumping of excavated material						LT and favorable				
4	Traffic diversion	ST	ST					ST	NA		
5	Generation of muck			ST	NA						ST
6	Use of batching plant	ST	ST		NA				ST		
7	Use of DG sets	ST	ST						ST		ST
8	Impact on structures						ST				ST
9	Construction of labor camp(s)		ST	ST		NA	ST	ST	ST	ST	
	Operation Phase										
1	Operation of RRTS trains	LT	LT					LT	LT	LT	LT
2	Maintenance of racks in stabling yard			LT	LT / Negative						
3	Use of DG sets	ST	ST						ST		ST
4	Development of feeder routes							LT		LT / Negative	LT
5	Generation of employment							LT			

It is observed from the checklist that the

- Maximum numbers of negative impacts are taking place during the construction phase, which are temporary (Short Term) in nature.
- It is forecasted that sectors affected are occupational Health & Safety, Land, and Noise.
- Components like Ecology, Surface water and Resource consumption remain largely unaffected

  Beneficial impacts shall become pronounced and may be harvested during the Operational phase.

CHAPTER-5

MITIGATION MEASURES

5.1 LAND ENVIRONMENT

Land acquisition, soil contamination and soil erosion are the major impacts on land environment especially in urban areas. Though aimed at enhancing the efficiency of public transport system, the proposed project involves land acquisition of 1062.721 hectares. Major land environment impacts and proposed mitigation measures are summarized in Table 5.1.

Table 5.1: Mitigation Measures for Land Environment

S.No.	Environmental Parameter	Severity of Impact	Cause of Impact	Mitigation Proposed
1.	Topography change	Local impacts	Construction of pile foundations for elevated corridor	Controlled light charge may be used to dislodge the rock if, any. No heavy blasting is proposed. Median between pillars will be width protected and planted.
2.	Change in Land use (a) Loss of land	Low impact Most of the corridor is elevated. About 1062.721 hectares of land will be acquired for stations and depot.	Change in land use pattern in acquired land	Land acquisition to be minimized
	(b)Generation of excavated soil and rock	3,55000 cubic meters of excavated soil and rock will be generated. Adverse impact	Most of the generated soil and rock will be back filled. Contamination of air, water and land is not	The generated soil and rock will be disposed properly at pre-designated sites to o avoid contamination

S.No.	Environmental Parameter	Severity of Impact	Cause of Impact	Mitigation Proposed
	(c)Soil erosion		expected	
		Moderate, direct, long term negative impact	Quarries	Residual spoils will be disposed properly • Provision of stilt fencing will be made. • Quarries will be reclaimed.
3.	Contamination of soil	Direct, long term negative impact	•Oil & diesel spills •Emulsion sprayer •Production of hot mix (for approach roads development in station area) and rejected materials •Residential facilities for the labor and officers •Routine and periodical maintenance	Hazardous Waste (Management and Handling Rules, 1989) to be enforced. •Oil interceptor will be provided for accidental spill of oil and diesel •Septic tank will be constructed for waste disposal.
4.	Seismology	No impact	Natural process	Adequate Designs inputs commensurate with the seismological settings of the region will be adopted for foundations and other structures.

5.2 MITIGATION MEASURES FOR SOIL ENVIRONMENT

Construction Phase

- ❖ Suitable protection measures consisting of bio-engineering techniques, such as plantation of grass and shrubs shall be provided to control erosion.
- ❖ Sources of sand and grit shall be decided in consultation with mining department and keeping in view the ecological sensitivity of the area.
- ❖ Top soil removed from agricultural land may be stored separately in bonded areas and utilized during plantation or refilling of excavated area.
- ❖ Selection of borrow areas (Some borrow areas for requirements of earth will be developed. It will be ensured that sand and grit is obtained only from approved quarries by mining department) will be done considering the waste land available in the district. A separate borrow area management plan will be made providing location, ownership details, timing of borrowing and rehabilitation measures.

Mitigation measures for Spoil Generation from tunneling and excavation work:

- ❖ excavated muck shall be disposed off at approved sites only.
- ❖ undertake random sampling of spoils from underground station excavations and tunnelling to determine presence of contaminants. Disposal of contaminated spoils shall only be to disposal sites equipped and licensed to handle such wastes.
- ❖ determine water content of spoils to ascertain if spoils dewatering is necessary. Undertake necessary spoils dewatering and provide adequate treatment facilities to ensure that resulting wastewater meets CPCB standards.
- ❖ stockpiling of spoils shall not be undertaken due to the limited footprint of the construction site. Spoils shall be trucked away immediately to disposal sites. If any small stockpiles be developed, these shall be covered by plastic sheeting
- ❖ trucks transporting spoils shall be tightly covered with tarpaulin or other suitable materials to minimize dust emission and spills.
- ❖ wheel washing shall be undertaken to remove mud so as to ensure that access roads are kept clean. Road surfaces shall be regularly cleaned of spilled spoils.

- the spoils disposal site shall be located at least 50 m from surface water courses and shall be protected from erosion by avoiding formation of steep slopes and grassing.
- spoil disposal shall not cause sedimentation and obstruction of flow of watercourses, damage to agricultural land and densely vegetated areas.
- specific Muck disposal site will be added. If any recycling is to be done that will be added.

Operational Phase

No impact is envisaged during the operational phase

5.3 AMBIENT AIR QUALITY

Construction Phase

During the construction stage, there are two major sources: the first one is construction activities at working zones, which cause primarily dust emission and second are from operation of the construction plant, equipments and machinery, which causes gaseous pollutants.

The specific measures include:

- Locating the plant at a significant distance from nearest human settlement in the predominant down wind direction.
- Vehicles delivering fine materials like soil and fine aggregates shall be covered to reduce spills on existing roads.
- Water will be sprayed on earthworks, temporary haulage and diversions on a regular basis.
- Batch type hot mix plants fitted with the bag filter / cyclone and scrubber will be installed for the reduction of the air pollution.
- Pollution control systems like water sprinkling and dust extractors and cover on conveyors will be installed for the crushers.
- All vehicles, equipment and machinery used for construction will be regularly maintained to ensure that the emission levels conform to the SPCB/CPCB norms.
- Air pollution monitoring plan has been delineated for construction phase separately for checking the effectiveness of the mitigation measures adopted during the construction phase of the Contract

- Air quality monitoring shall be conducted during construction period as per CPCB norms. The location and frequency of air monitoring is covered in EMP.
- Impact on air quality is likely to be temporary and reversible.

Operation Phase

- Air quality of the area is likely to be improved as reduction in emissions due to shifting of passengers from road transportation to RRTS .
- Plantation along the RRTS corridor is likely to improve the air quality of the area.

5.4 MITIGATION MEASURES ON WATER QUALITY

Due to the proposed project there will be some direct and indirect long term impacts on the water quality of the study area, mitigation measures for water quality during the construction phase includes the following:

- Oil interceptor will be provided at RRTS workshops and depot stations
- Construction work close to the streams or water bodies will be avoided during monsoon.
- Construction laborers camps will be located at least 1000 m away from the nearest habitation.
- Water quality shall be monitored regularly near the construction site.

Table 5.2 summarizes the major impacts on water environment and their proposed mitigation measures

Table 5.2: Mitigation Measures for Water Quality

Sl No.	Item	Severity of Impact	Cause of Impact	Mitigation/Enhancement
1.	Loss of water bodies	Not significant as no major water bodies are fully affected	Part or acquisition of source of water	Relocation of ground / surface water sources.

2.	Alteration of cross drainage	Very low impact	Construction of viaduct	Construction of new viaduct will improve the drainage characteristics of the project area
3.	Water requirement for project	Direct impact	• Water requirement for Construction activity. • Water requirement of labor	Contractor needs to obtain approvals for taking adequate quantities of water from surface water sources. This is required to avoid depletion of water resources.
4.	Contamination of water	Direct adverse impact	• Oil & diesel spills • Emulsion sprayer and laying of hot mix (for approach roads development in station area). • Residential facilities for the labor. • Routine and periodical maintenance	Hazardous Wastes (Management & Handling) Rules, 1989 to be enforced • Oil interceptor will be provided for accidental spill of oil and diesel • Septic tank will be constructed for waste disposal
5.	Water quality monitoring		• Effectiveness / shortfall (if any) • Any unforeseen impact	Measures will be received & improved to mitigate / enhance environment due to any unforeseen impact

Treatment of Oil & Wastewater

The different types of contamination of wastewater require a variety of strategies to remove the contamination. A typical oil-water separator as shown in fig 6.1 is proposed at depot locations.

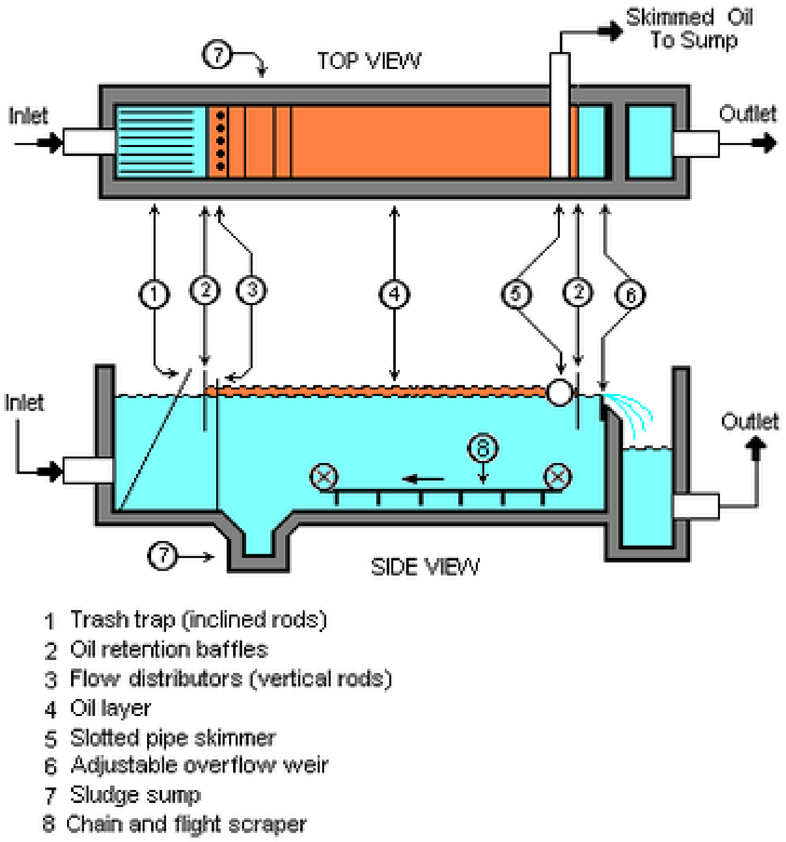
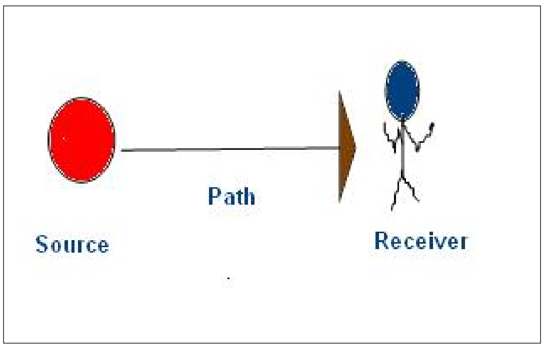


Figure: 5.1 A typical oil-water separator to be used at depot

5.5 NOISE ENVIRONMENT

Environmental noise particularly railway noise, is a complex phenomenon because its intensity and characteristics vary with time depending upon the frequency and speed of the RRTS trains. A noise problem generally consists of three inter-related elements- the source, the receiver and the transmission path. This transmission path is usually the atmosphere through which the sound is propagated, but can include the structural materials of any building containing the receiver (Fig 6.2)



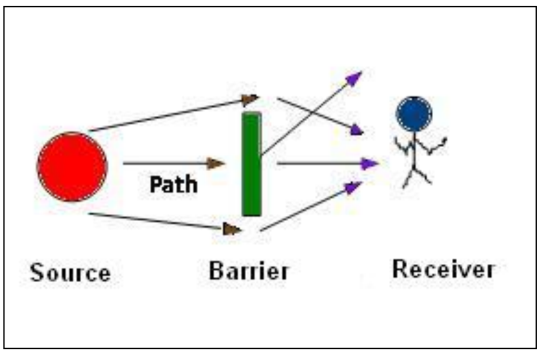


Fig.5.2: Inter-relationship between the elements of noise

Construction Phases

- Construction noise level has to be kept at minimum by putting up proper barricades and by the use of proper doping (sound absorbing) materials in barricades at construction sites, the ambient noise levels can be reduced. Special physical barriers of noise shall be used wherever the track is in proximity to sensitive areas like hospitals, Temples etc.
- Noise standards will be strictly enforced for all vehicles, plants, equipment, and construction machinery. All construction equipment used for an 8-hour shift will conform to a standard of less than 75 dB(A). If required, high noise producing generators such as concrete mixers, generators, graders, etc. must be provided with noise shields.
- Machinery and vehicles will be maintained regularly, with particular attention to silencers and mufflers, to keep construction noise levels to minimum.
- Workers in the vicinity of high noise levels will be provided earplugs/ earmuff, helmets and will be engaged in diversified activities to prevent prolonged exposure to noise levels of more than 75 dB(A) per 8 hours shift.
- All elevated and intermediate floors shall be provided with sound absorbent and resilient floors to arrest structural and air borne noises at the source itself.
- Proposed tree and shrub plantations planned for avenue plantation especially close to settlements, may form an effective sound buffer during the operation stage. Some examples include Neem, Mango, Tamarind, Gulmohar, Peepal, Ashoka etc
- People will be convinced / educated to prevent sensitive land uses from developing up adjacent to the project corridor.

Operation Phase

- All schools, hospitals and cultural properties which have been identified and those that are close to the project alignment i.e with in 100 m distance will require noise control measures, however the noise barriers shall be provided at these locations to reduce the noise level which is very much critical. The noise level may be reduced upto 10-15 dB(A) by providing noise barriers to accommodate the long term impact.

- However, due to reduction of vehicular traffic, the road traffic noise will come down when RRTS trains are in operation

Fig 5.3 shows the working of a noise barrier and **Fig 5.4** shows the artistic view of a metal noise barrier and **Table 5.3** summarizes the major impacts on noise environment and their proposed mitigation measures

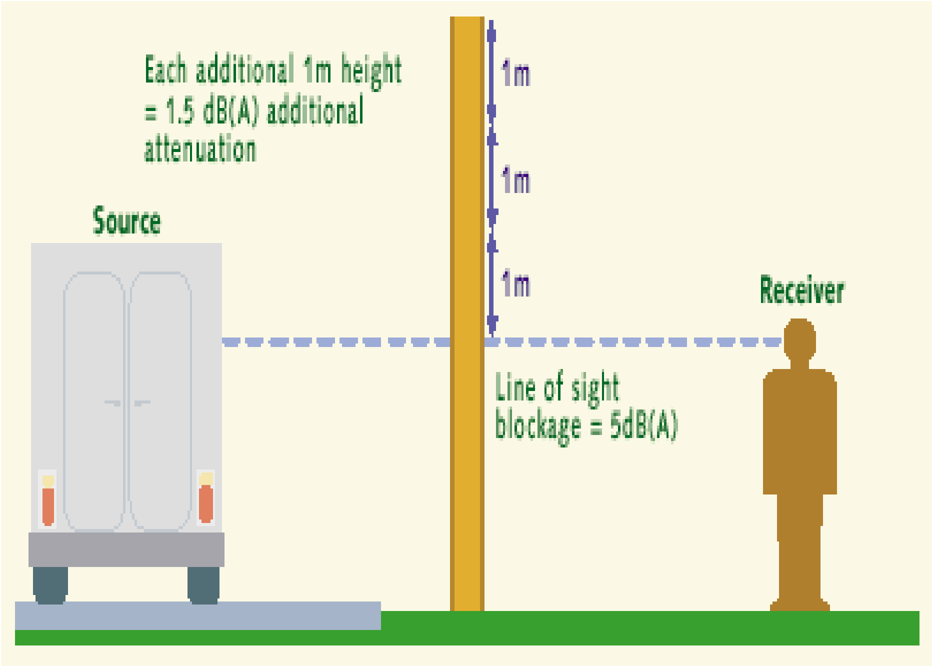


Fig 5.3 Working of a noise barrier

Fig 5.4: Artistic view of a metal noise barrier

Table 5.3: Mitigation Measures for Noise Quality

Sl No.	Item	Severity of Impact	Cause of Impact	Mitigation/Enhancement
1	Sensitive receptors	Direct impact	Increase in noise pollution	Noise barriers to be provided
2	Noise Pollution (Construction Stage)	Direct impact, short duration	Man, material and machinery movements • Establishment of labor camps onsite offices, stock yards and construction Plants stone crushing, asphalt production plant and batching plants, diesel generators etc • Community residing near to the work zones	Area specific and for short duration •Machinery to be checked & complied with noise pollution regulations. Camps to be setup away from the settlements, in the down wind direction. • Noise pollution regulation to be monitored and enforced. • Temporary as the work zones will be changing with completion of construction
3	Noise Pollution (Operation Stage)	Marginal impact	due to increase in traffic (due to improved facility)	will be compensated with the uninterrupted movement of heavy and light vehicles
4	Noise Pollution Monitoring		Effectiveness / shortfall (if any) Any unforeseen impact	Measures will be revised & improved to mitigate/ enhance environment due to any Unforeseen impact.

Efficient Track and wheel maintenance:- Effective maintenance of track and wheel can reduce upto 10 dB(A) noise and vibration levels. The Condition of the rails and wheels- If not maintained in good condition. Some maintenance procedures that are particularly effective to avoid increases in ground-borne vibration are:

- ❖ Wheel truing to re-contour the wheel, provides a smooth running surface, and removes wheel flats. The most dramatic vibration reduction results from removing wheel flats and out of roundness.
- ❖ Implement vehicle reconditioning programs, particularly when components such as suspension system, brakes, wheels, and slip-slide detectors will be involved.
- ❖ Install wheel-flat detector systems to identify vehicles which are most in need of wheel truing.
- ❖ Install wheel geometry measurement devices (e.g. laser based systems installed at entrance of depot) with possibility of detecting out of roundness, difference of wheel diameter of wheels on the same axle, wheel wear. (Vibration reduces more than 10 dB)
- ❖ Resilient Fasteners: Resilient fasteners are very common fastening equipment used in modern track constructions (figure 6.5). These fasteners are used to fasten the rail to concrete track slabs. Standard resilient fasteners are rather stiff in the vertical direction, usually in the range of 40 kN/mm (dynamic stiffness), although they do provide vibration reduction compared to classical rigid fastening systems. Special fasteners with vertical dynamic stiffness in the range of 8 kN/mm will reduce vibration by as much as 15 dB at frequencies above 30 Hz. (Conservatively these could reduce vibrations by 5 to 10 dBs Refer DPR).

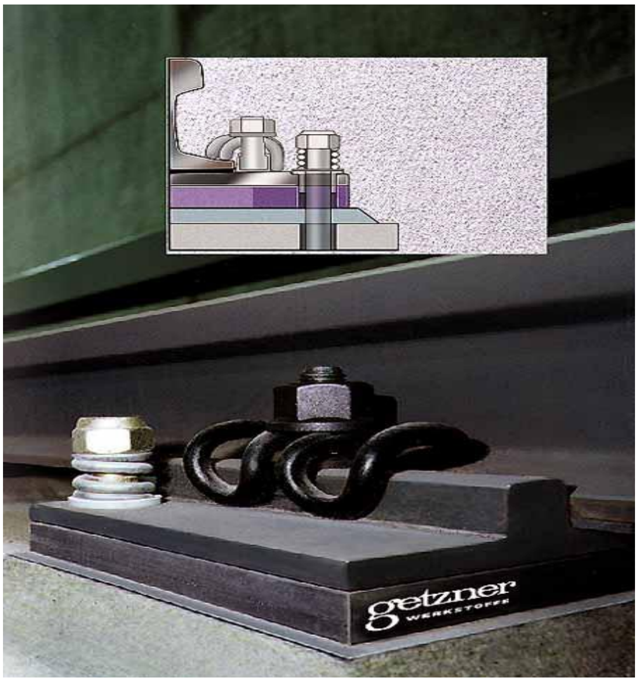


Figure 5.5 Relisant Fasteners

5.7 MITIGATION MEASURES FOR FLORA

Construction Phase

- Felling of 621 affected trees as shown in Table 6.4 will be undertaken only after obtaining clearance from the Forest Dept.
- Trees falling outside the RoW shall not be felled. However some trees may be pruned.
- Compensation must be provided before initiating construction activity.
- Fruit bearing trees shall be compensated including 5 years fruit yield.
- Compensatory afforestation against 621 trees shall be undertaken and completed within 2 years time from date of NOC from Forest Dept.

Operation Phase

No impact envisaged on flora during post construction phase however, development of green belt is suggested near stations and maintenance of plantation will be undertaken by DIMTS.

- The plantation will be done along alignment and as compensatory afforestation is likely to enhance the ecological condition of the area. Plantation of trees along RRTS corridor to be undertaken post-construction period against trees felled for clearing project site and completed within 2 year time.

- Proactive action of compensating the tree canopy lost due to trimming of trees along the corridors. The health of the trimmed trees can be further ensured by applying chemicals like copper sulphate in required quantities on the cut faces to inhibit sap loss, fungal attacks etc.

Table 5.4 Plantation which will be affected in RRTS Corridor

Sl. No	Localities	Total trees affected
1	Delhi Region	190
2	Haryana	431
Total		**621**

Total number of impacted trees along the project road stretch is 621. Nearly 1800 trees will be planted as a compensatory plantation. Species of high dust capturing herbs, shrubs and trees as given in Table 5.5 shall be selected for compensatory plantation.

Table 5.5 Species of High Dust Capturing Herbs, Shrubs and Trees

Dust collection Efficiency	Plant Species		
	Herbs	**Shrubs**	**Trees**
Low <10%	1. Amaranthus Hypchondriceus (Chaluai) 2. Gardenia Jasminoides (Crape Jasmine) 3. Cestrum noctumum (Rat Ki Rani) 4. Chrysanthemum Species	1. Thuja Species (Mayur Pankhi) 2. Ravvolfia Serpentine (sepagandha) 3. Withania somnifera (Ashawagandha) 4. Acanthus Species (Acanthus)	1. Nyctantheses arbotrities (Night Flowering) 2. Abies pindrow (Silver fir) 3. Accacia nilotica (Babool) 4. Holarrhena antidysentrica (Kurchi) 5. cherodenrum ineme (Glorry bower) 6. ficus bangalasis 7. Miliusa tomentosa (Kari leaves) 8. Thespesia populnea (ran Bhindi)

Medium 11 to 20%	1. Lilium Species (Lily) 2. Draceana Species 3. Helianthus Annuus (Sunflower) 4. Tegetes Patula (Genda) 5. Potnos aureus (Money Plant)	1. Bambusa species (Bamboo) 2. Lagerstroemia indica (Crape Myrtle) 3. Nerium Indicum (Kaner Pink) 4. Codium Variegates (Croton) 5. Thevetia peruviana (Kaner Yellow) 6. Wrightia arborea (Dudhi) 7. Rosa Indica (Rose) 8. Ipomea nil (Beshrum) 9. Tabernaemontane ana divaricate (chandani) 10. Acalypha hispid (Copper leaf) 11. Plumaria acuminate (Temple tree)	1. Leacena leucophloea (Shoe Babol) 2. Pinus Geranrdiana (Chilgoja) 3. Ficus elastica (India Rubber) 4. Annona Squamosa (Sugar Apple) 5. Mangifera Indica (Mango) 6. Argyreior roxburghira (Wooly Morning Glorry) 7. Ficus religiosa (Peepal) 8. Acacia farnesiana (Vilayati Kikkar) 9. psidium guajava (Amrood) 10. Prunus comminis (Plums) 11. Syzgium cumini 12. techtona grandis (Teak) 13. Citrus Lamina (Lemon) 14. Morus Alba (Mulberry) 15. Archise Sapota (Chikoo) 16. Anthocesephalus cadamba (kadamba) 17. Shorea robusta (Gulmohar) 18. Delonix regiosa (Gulmohar) 19. Albizzia lebbek (siris) 20. Artocarpus integrifilio (Jack Fuit) 21. Ixora parviflora (Torch Tree) 22. Bauhinia Variegate (kanchnar) 23. Maringa oleifera (Drum Stick) 24. Aegle marmelas (Beal) 25. Pithobium dule (Jangali Jalabi)

High >20%	1. Colocasia antiquorum (Elephants Ear) 2. Celosia Agrentea	1. Hibiscus rosa sinensis (Gurhal) 2. Bougainvillea glabra (Bougainvillea)	1. Cassia fistula (Amaltas) 2. Pinus Contorta (Pine) 3. Bombax Ceiba (Samal) 4. Butea monosperma (Palas) 5. Alstonia Scholaris (Satani) 6. Azardirachta indica (Neem) 7. Polyalthia longifolia (Ashoka) 8. callistemon citrinus (Bottle brush) 9. Termanilia catappal (Jangal Badam) 10. Terminalia arjuna (Arjun) 11. Melia Azedarch (Melia) 12. Phoenix dactylifera (Khajoor) 13. Ficus Infectoria (Pakhor) 14. Holiptelia integrifolia (papadi) 15. Eucalptus globulus (Blue Gum) 16. Madhuca Indica (Mahua) 17. Citrus Maxima (Chaktora) 18. Populus tremuloides (Quacking aspect)

CHAPTER- 6

ENVIRONMENTAL MONITORING PROGRAM

6.0 INTRODUCTION

To avoid / mitigate the potential adverse impacts and to implement the project with enhanced environmental attributes a management plan is formulated. The Environmental Management Plan is designed based on values of environmental parameters and various impacts due to project activities.

The development of RRTS involves civil work, including excavation, filling, and utility shifting etc., which are likely to cause some adverse impacts on natural and social environment. These impacts cannot be fully avoided; therefore, mitigation measures are suggested to minimize and compensate the potential adverse impacts and enhance positive impacts. Most of the adverse impacts identified are temporary (Short Term) in nature and are limited to the construction phase. These impacts can be significantly minimized and managed by proper planning and execution.

The environmental management plans includes activities for pre-construction phase, construction phase and operation phase. RRTS project shall be implemented in an eco-friendly manner with proper Management Plan. Overall, it is expected to enhance the environmental quality and facilitate traffic movement in and out of the project area.

To ensure the effective implementation of the EMP it is essential that an effective monitoring program be designed and carried out.

The monitoring includes:

- visual observations
- selection of environmental parameters at specific locations
- sampling and regular testing of these parameters

The process of implementing mitigation and compensatory measures, execution of these measures, agencies responsible for the implementation of these measures and indicative costs is governed by an Environmental Management System (EMS). There will be an SHE Manual, operating procedures etc with RRTS project.

EMS shall have following basic elements ascertaining the commitment by the proponent namely,

i) Resources Commitment and Policy

ii) Planning

iii) Implementation

iv) Measurement and Evaluation

v) Review and Improvement

6.1 ENVIRONMENTAL MONITORING PROGRAM

Monitoring of environmental factors and constraints will enable RRTS authorities to identify the changes in the environmental attributes at particular location. Monitoring results also indicate the appropriateness of mitigative measures practiced, effectiveness of standard design guidelines in finalization of alignment and factors considered for design. Monitoring & Evaluation of environmental parameters will also ensure that actions taken are in accordance with the construction contract and specifications. It provides a basis for evaluating the efficiency of mitigation and enhancement measures, and suggests further actions needed to be taken to achieve the desired effects. To ensure the effective implementation of the EMP it is essential that an effective monitoring program be designed and carried out.

The monitoring includes:

- Visual observations
- Selection of environmental parameters of relevance at specific locations
- Sampling and regular testing of these parameters

The environmental monitoring plan contains:

- Identifying the Performance indicators
- Environmental monitoring program
- Reporting system
- Budgetary provisions

6.1.1 Performance Indicators

The physical, biological and social components identified to be particularly significantly affecting the environment at critical locations have been suggested as Performance Indicators (PIs). The performance indicators will be evaluated under three heads:

a) Environmental condition indicators to determine efficiency of environmental management measures in control of air, noise, water and soil pollution.

b) Operational performance indicators that have been devised to determine efficiency and utility of the proposed mitigation measures.

The performance indicators and monitoring plans will be prepared for the project for effective monitoring.

6.1.2 Responsibilities for Monitoring

The responsibility for execution of the EMP will rest with the contractor. The monitoring of EMP will be done by Environmental Management Unit (EMU). Mitigation and enhancement measures adopted in final program will be explicitly identified under the Bill of Quantities (BOQ) so that performance and completion is readily documented. The NCRPB will continuously assess the progress of Environmental Management Unit and the work of contractors. If the level of impact is determined to be high, further monitoring will be done by a recognized 'A' category laboratory of the Delhi Pollution Control Committee (DPCC) and Haryana State Pollution Control Board (HSPCB) and assessed for verification of the increased or decreased emission level and pollutants along the project stretch.

6.1.3 Routine Monitoring

During the construction and post-construction phase, ambient air quality, water quality (surface and ground water), effluent (if any released from construction work site / camp) and noise level should be monitored as planned, depending upon the type, nature and duration of the project using CPCB recommended monitoring methodologies and laboratory testing facilities / techniques.

6.1.4 Methodology

Monitoring methodology covers the following key aspects:

- Environmental Components to be monitored
- Parameters for monitoring of the above components
- Monitoring frequency
- Test protocols & Standard Methods
- Responsibilities for monitoring
- Monitoring costs

6.1.5 Reporting Procedures

Mitigation and enhancement measures adopted in the final design have been identified in the Contract Documents and Bill of Quantities so that performance and completion is effective. The periodic site visits of the EO

(Environmental Officer) of the NCRPB and the EE of the PMU will keep a record of progress as well as the site-specific EMP implementation records. It is necessary that the EO of PIU should visit the sites for supervision of the Environmental Management with regard to the sitting of various construction requirements.

6.1.6 Preparing EMP monthly progress reports - Notes

The monthly report should be prepared by the EO of NCRPB. The monthly report should contain an introductory section which gives the basic information on the contract package, a brief description of the implementation progress made till date and, particularly, the progress made during the past month. The monthly report should contain separate sections for each of the following:

1. Quarries
2. Construction camps
3. Borrow areas
4. Sand mining
5. Spoils and debris disposal
6. Waste-Generation/ collection/ transfer/ disposal
7. Traffic management
8. Mitigation measures along the project Strech
9. Environmental parameter monitoring activities (air, noise and water quality)
10. Other issues along the project area.
11. The monthly report will contain information on the progress of all / each implementation arrangements. This section should include the environmental engineer’s work and timesheet. This should be a simple table that clearly indicates the activities carried out by the environmental engineer during the month. This table should include site visits to construction camps, quarries, borrow areas, disposal sites and accident prone areas. This section should also cover training / orientation activities that were carried out by the contractor’s team for the environmental parameter monitoring . (Table 6.1)

Table 6.1: Environmental Monitoring Plan

Environmental Component Parameters/Aspects to be analyzed	Means of Monitoring	Location	Frequency/ Duration	Institutional Responsibility Implementation/ Supervision
Pre Construction Stage				
Air Quality $PM_{2.5}$, PM_{10},SO_2, NO_X, CO, HC	High volume sampler to be located 50 m from the plant in the downwind direction. Use method specified by CPCB for analysis	Kashmeri Gate, Libaspur, Dumping yard near Mukarba Chowk Bhogarh, Nerela Kundali KMP Interchange, Rajeev Gandhi Education City	Continuous 24 hours or for full working day	NCRPB
Water Quality pH, SO4,TDS Chloride , Alkalinity ,Acidity, Volatile Residue ,fixed Residue, Conductivity, Total Hardness Ca , Mg	Analytical Methods outlined in CPCB Standard for Surface & Groundwater analysis	Carnal KMP Interchange, Budhpur , Kasmiri gate, Rajapura, KMP Interchange, Libaspur, Murthal , Canal 3 KM from Samalkha, Rajeev Gandhi Education City, Kundali , Chulkhana, Smalkhan , PaniPat , Ganour, Paanipat near NFL	Once before site works	NCRPB
Noise Quality Noise levels on dB (A) scale	Analytical Methods outlined in CPCB Standard for ambient Noise level Monitoring	Kashmiri Gate, Libaspur, Dumping yard near Mukarba Chowk Bhogarh, Nerela Kundali KMP Interchange, Rajeev Gandhi Education City	Continuous 24 hours or for full working day	NCRPB

Environmental Component Parameters/Aspects to be analyzed	Means of Monitoring	Location	Frequency/ Duration	Institutional Responsibility Implementation/ Supervision
Soil Quality Soil Texture, pH, CARBONATE, Chloride,TSS,Organic Content SO4	Analytical Methods outlined in CPCB Standard for Soil Analysis	Kundali , Ganour , Panipat (Asand road), Kasmiri Gate, Bhorgarh, Rajapura, Chulkhana(Smalkhan), Rajeev Gandhi Education City , KMP intercity, Panipat(near (NFL), Libaspur , Murthal	Once before site works	NCRPB
Construction Stage				
Air quality $PM_{2.5}$, PM_{10}, SO_2, NO_X, CO, HC	High volume Sampler to be located 40 m from the earthworks site downwind direction. Use method specified by CPCB for analysis	Batching Plant ,Stretch where construction is in progress	Half Yearly Continuous 24 hours or for 1 full working day	Agency
Water Quality P^H, BOD, COD, TDS, TSS, DO, Oil & Grease and Pb	Grab sample collected from source and analyze as per Standard Methods for Examination of Water and Wastewater	locations identified by the independent consultant	Half Yearly -	Agency
Noise levels On dB (A) scale	Free field at 1 m from the equipment whose noise levels are being determined	At equipment yards	Once in Three Month Reading to be taken at every hour and then averaged	Agency

Environmental Component Parameters/Aspects to be analyzed	Means of Monitoring	Location	Frequency/ Duration	Institutional Responsibility Implementation/ Supervision
Soil Turbidity in Storm Water Silt load in ponds, water courses	Grab sample collected from source and analyze as per Standard Methods	As specified by the engineer DIMTS / Independent Consultant, all along the project corridor	Pre-monsoon and post-monsoon seasons	Contractor
Plantation 75% Plant Survival	The success of tree planting. Rate of survival after six months, one year and 18 months in relation to total planted	All along the project corridor	Maintenance for three to five years after plantation	NCRPB
Monitoring Construction Sites and Construction Camps Storage Area Drainage Arrangements	The parameters as mentioned in chapter-4 but to be checked for adequacy.	At storage area and construction camps	Half yearly in the construction stage	Through approved agency
Operation Phase				
Air Quality $PM_{2.5}$, PM_{10}, SO_2, NO_X, CO, HC	High volume sampler to be located 50m from the plant in the downwind direction. Use method specified by CPCB for analysis	As specified by the Engineer DIMMTS	Two times in a year Continuous 24 hours or for 1 full working day	Contractor NCRPB

Environmental Component Parameters/Aspects to be analyzed	**Means of Monitoring**	**Location**	**Frequency/ Duration**	**Institutional Responsibility Implementation/ Supervision**
Water Quality Flooding and Cleaning of drains/water bodies	Flooding locations to be identified and choked drains, water bodies undergoing siltation and subject to debris disposal should be monitored under cleaning operations	As specified by the engineer	Twice in monsoon and post-monsoon seasons in a year -	Contractor NCRPB
Noise levels on dB (A) scale	Equivalent Noise levels using an integrated noise level meter kept at a distance of 15 m from source. Use methods specified by CPCB	As directed by the Engineer (At maximum 4 locations)	Twice a year for 2 years during the construction period Readings to be taken at every hour and then averaged.	Contractor NCRPB
Soil Quality Turbidity in Storm Water Silt load in ponds, water courses	Grab sample collected from source and analyze as per Standard Methods	As specified by the engineer DIMTS / Independent consultant, all along the project corridor	Twice a year	Contractor

CHAPTER- 7

ENVIRONMENTAL MANAGEMENT PLAN

7.0 INTRODUCTION

To avoid / mitigate the potential adverse impacts and to implement the project with enhanced environmental attributes a management plan is formulated. The Environmental Management Plan is designed based on values of environmental parameters and various impacts due to project activities.

The development of RRTS involves civil work, including excavation, filling, and utility shifting etc., which are likely to cause some adverse impacts on natural and social environment. These impacts cannot be fully avoided; therefore, mitigation measures are suggested to minimize and compensate the potential adverse impacts and enhance positive impacts. Most of the adverse impacts identified are temporary (Short Term) in nature and are limited to the construction phase. These impacts can be significantly minimized and managed by proper planning and execution.

The environmental management plans includes activities for pre-construction phase, construction phase and operation phase. RRTS shall be implemented in an eco-friendly manner with proper Management Plan. Overall, it is expected to enhance the environmental quality and facilitate traffic movement in and out of the project area.

The process of implementing mitigation and compensatory measures, execution of these measures, agencies responsible for the implementation of these measures and indicative costs is governed by an Environmental Management System (EMS). There will be an SHE Manual, operating procedures etc with RRTS project.

EMS shall have following basic elements ascertaining the commitment by the proponent namely,

i) Resources Commitment and Policy

ii) Planning

iii) Implementation

iv) Measurement and Evaluation

v) Review and Improvement

7.1 ENVIRONMENTAL MANAGEMENT PROCESS

The implementation of Environmental Management Process (EMP) requires the following:-

- ❖ An organizational structure
- ❖ Assign responsibilities
- ❖ Define timing of implementation
- ❖ Define monitoring responsibilities

Organizational Framework

The proposed EMS recommendations will be implemented by NCRPB through its Environmental Management Unit (EMU). The EMU will be coordinating with the field level implementing agencies such as the Engineers (Supervision Consultant), Contractor and field level NCRPB officials. Role and responsibilities of important officials are mentioned below.

Roles and Responsibilities of Officers

Officer	Responsibility
General Manager (EMU)	➢ Overview of the project implementation ➢ Ensure timely availability of resources like man power & budget for the EMP ➢ Coordination with different state level committee, to obtain regulatory clearances ➢ Participate in state level meetings ➢ Monthly review of the progress ➢ Reporting to various stakeholders about the status of EMP implementation
Chief Project Manager (EMU)	➢ Overall responsible for EMP implementation ➢ Coordination with PIU Staff. ➢ Responsible for obtaining regulatory Clearances ➢ Review of the progress made by contractors ➢ Ensure that BOQ items mentioned in EMP are provided and activity implemented as per contract document.
Environmental Officer (PIU)	➢ Assisting CPM in overall implementation of EMP ➢ Review of periodic reports on EMP implementation and advising

DIMTS

Officer	Responsibility
	➢ Appraising the Project Director about taking corrective measures. ➢ Conducting periodic field inspection of EMP implementation ➢ Assisting GM (NCRPB) by preparing periodic report/s for various stakeholders on status of EMP implementation ➢ Preparing environmental training program and conducting the same for field officers and engineers of contractor.
Engineer (Supervision Consultant)	➢ Act as an “Engineer” for supervising EMP implementation ➢ Responsible for maintaining quality of EMP envisioned in detailed project report ➢ Maintaining progress reports on EMP implementation ➢ Periodic reporting to PIU-NCRPB about the status of EMP implementation ➢ Work in close coordination with Asst. Project Manager (package unit) and contractor.
Deputy Chief Project Manager	➢ Conducting need-based site inspection and preparing compliance reports and forwarding the same to the Environmental Management Unit (EMU) ➢ Designing necessary training program on environmental issues.
Asst. Project Manager (Environment)	➢ Working as site-representative of Chief Project Manager ➢ Conducting regular site inspection/s of all onsite and offsite works ➢ Maintaining records of all necessary statutory compliance, to be obtained from contractor. ➢ Maintaining records of EMP implementation including photographic records ➢ Conducting environmental and social training programs ➢ Preparing periodic reports on EMP implementation and forwarding to EE.

Officer	Responsibility
Designated APM (Env)	➢ Will be responsible for field activity during construction period ➢ Report to APM (Env) of CPM's office
Contractor's Environment & Safety Manger	➢ Will be responsible for safety of workers during the construction phase.

7.2 EMP DURING CONSTRUCTION PHASE

The project activities will be executed in a phased manner being construction phase followed by operation phase.

Construction Phase

The environmental issues during construction phase generally involve equity, safety and public health issue. The contractor is required to comply with the laws with respect to environment protection, pollution prevention, resettlement, labor regulations, safety during construction and liability cover and any other applicable law/s. The EMP is an executable part of the project, and the activities are to be guided, controlled, monitored and managed as per the provisions. Following activities require attention during construction phase.

1. Social Impact Management Plan

Minimum land acquisition and disturbance to existing features will be prime objective of the design. Socially sensitive stretches have been avoided and alternatives have been selected with bypass around settlements and realignments. Rehabilitation of PAFs and removal of affected structures will be planed in consultation with the PAFs and local authorities to ensure minimum disturbance to the PAFs.

2. Land Acquisition Management Plan

Acquisition of land is necessary for construction of RRTS. The proposed alignment Involves acquisition of 1062.721 hectares of land, the acquisition of land and private property shall be carried out in accordance to the Resettlement Action Plan (RAP). It has to be ensured that all R&R activities including the payment of the compensation may be reasonably completed before the commencement of construction activities. No construction work should start- in the area of ousted persons, before total compensation has been paid to the PAPs.

3. Utility Shifting Plan

There are some utility services along the proposed RRTS alignment such as electric lines, telephone lines, cable line, water supply and distribution pipe lines, etc which may be shifted in consultation with the concerned department before commencement of construction activity. These services and installations will be shifted in consultation with the concerned departments.

4. Construction / Labor Camp Management

During the construction phase, the construction / labor camp will be located along the project area. Large numbers of labor are likely to move into the project area. A proper Construction Camp Development Plan has to be formulated to control degradation of the surrounding area due to the location of the proposed construction camp. The contractor must provide, construct and maintain necessary facilities for living healthy life and ancillary facilities. Following must be included in contract documents/ agreements entered into with the contractor.

- ❖ Sufficient supply of potable water must be provided at camps and working sites. If the drinking water is obtained from the intermittent public water supply, then storage tanks must be provided. All water supply storage may be at least 15 m away from the toilets or drains.
- ❖ Adequate and clean facilities for regular usage by labor for washing and bathing facilities must be provided that also have sufficient drainage.
- ❖ Adequate sanitary facilities may be provided within every camp. The place must be cleaned daily and maintain strict sanitary conditions. Adequate supply of water must also be provided.
- ❖ The contactor must ensure that there is proper drainage system to avoid creation of stagnant water/ water logging.
- ❖ Periodic health check ups will be conducted. These activities may be taken up by the construction contractor in consultation with State Public Health Department.
- ❖ At every camp, first aid facilities with suitable transport must be provided to take injured or ill person to the nearest hospital.
- ❖ Adequate supply of fuel in the form of kerosene or LPG may be provided to construction laborers, to avoid felling of trees for cooking and other household activities.

- The sites should be secured by barricading and provided with proper lighting.
- The construction contractor may ensure that all construction equipments and vehicle machinery may be stored at a separate place / yard.
- All the construction workers shall be provided with proper training which includes the following:-
    - Work permit system
    - Environmental awareness program
    - Medical surveillance
    - Engineering controls, work practices and protective equipment
    - Handling of raw and processed material
    - Emergency response

- It shall be ensured by the construction contractor that the camp area is cleared off and the debris and other wastes removed immediately after the shifting of construction labor camp sites. On completion of construction, the land area used for camp should be restored back to its original form.

5. Health and Safety Management Plan

The contractor will be required to comply with all the precautions required for the safety of the workmen. The contractor must comply with all regulation regarding scaffolding, ladders, working platform, excavation, etc. as per SHE manual of NCRPB.

- The contractor must supply safety goggles, helmets, earplugs and masks etc. to the workers and staff.
- Adequate precautions must be taken to prevent risk and hazards due to electrical equipments. Necessary light and fencing must be provided to protect the public.
- All machines and equipments used for construction purposes must conform to relevant Indian Standards (IS) codes. These equipments must be in good working condition, regularly inspected, and properly maintained.
- All laborers working on mixing of cement, lime mortars, concrete etc should be provided with protective footwear and protective goggles.

- Workers involved in welding work should be provided with welder's protective eye shields.
- No men below the age of 18 years or women of any age will be employed to work with paint products containing lead in any form. Face masks must be supplied to workers when they use any form of spray paint or work with surfaces that have been dry rubbed and scrapped with lead containing products.
- All reasonable measures must be taken to prevent any damage to the public from accidents and fire, etc.
- All necessary steps must be taken to provide first aid treatment for injuries that may be sustained during the course of work.
- The contractor must follow all the sanitation instructions, and take measures to prevent malarial including filling up of borrow pits.
- On completion of the works, all the temporary structures may be cleared off, all rubbish disposed, at disposal pits or trenches filled in and effectively sealed off and the entire site left clean and tidy.

6. Compensatory Afforestation

Plantation has been recommended as one of the major components of the EMP. It will enhance the environmental quality through:

1. Mitigation of air pollution problems
2. Attenuation of noise level
3. Maintain the Green area and improve aesthetics.

As far as gaseous pollutants are concerned, substantial evidence is available to support the fact that plants in general, and trees in particular, function as sinks for gaseous pollutants. This is achieved through various physiological processes occurring within the plant system.

The gaseous pollutants are transferred from the atmosphere to vegetation by the combined forces of diffusion and flowing air movement. Once the gaseous pollutants come in contact with the plants, they may be bound or dissolved on exterior surface or taken up by the plants via stomata. If the surface of the plant is wet and if the gas is water soluble, the former process can be very important. As a matter of fact, plants act as bio filters for the air pollutants and play a major role in safeguarding the environment and controlling the increasing level of air and noise pollution.

A. Preparation of the Plantation Area

Plantation will be proposed along the alignment. Plantation site should be cleared by weeding. Suitable soil and water conservation measures will be adopted, if required. The planting arrangement and size shall be based on the optimum use of the available land and available quantity of water.

B. Preparation of pits and sapling transplantation

The location of each pit should be marked according to the design and distance of the plantation. The size of the pits may vary with the type of trees. While digging the pit, care should be taken to place the topsoil on one side and bottom soil on the other side. Dug-out soil and pit should be exposed to weather for two to three months.

Such exposed pit should be filled two-third to three-fourth height with a mixture of topsoil and decayed farmyard manure. While planting the trees, care should be taken that the installed equipment & civil structure are covered by the foliage when seen from a point outside the green envelop. For preventing the horizontal dispersion of the pollutants, the trees should be planted in alternate rows along a straight line. Tree trunks are free from foliage up to a height of 2 –3 meters, it is advisable to grow shrubs in front of tree so as to provide coverage to the open portion.

While planting a plantation program it is important to consider the space above and below the ground. Do not place tall trees where high tension wires are running overhead. Medium sized trees at least 4 feet from each other and bigger ones at 8 feet from each other and 5 meters away from building foundations should be planted.

C. Time of Plantation

The most suitable time is monsoon between June – August (South Western Monsoon period) as the land is moist and rain waters plant. Moderate temperature and good rainfall are favorable for saplings to grow as they need time to root and acclimatize before summer's heat and dryness or winter's freezing temperatures.

D. Protection of Greenbelt

- No pruning or lopping of branches should be done within the greenbelt for at least 10 – 15 years
- Gap filling in the greenbelt should be done in the same season to avoid future gaps.

- Timely replacements of damaged plant and care thereafter are important.

E. Selection of Plant/ Tree Species

The plants which possess large surface area are preferred for pollution abatement. The effectiveness of plants to control pollution depends upon the physiological, morphological traits such as leaf epidermis, size, leaf orientation, internal enzyme system, etc. Systematic screening of plants for their ability to tolerate pollutant/s need be undertaken. For pollution abatement purposes tree species should be fast growing, wind firm, unpalatable to animals, hardy and pollutants tolerant/resistant. The plantation of local species in consultation with forest department will be taken up.

7.3 OPERATION PHASE

During operation phase, the noise and vibration control along the sensitive and residential area is most important. Regular monitoring will be done for these parameters, and appropriate mitigation measures as suggested in the report shall be implemented.

Water Management Plan

The proposed project requires water continuously in considerable quantities during both the construction and construction/operation phases. As the project area has limited surface water sources, the stress on existing water sources will consequently increase. To reduce the resultant stress, management plans for water resources for both construction and operation phases are given below separately.

Water Demand-Construction Phase

The estimated requirement of water during the construction phase is about 900 m^3 per day. Most of the demand for water during the construction phase will be at the offsite mixing plant, station sites and along the alignment for various purposes. To meet the demands, a contingent plan shall be worked out and any stress on the existing water distribution network system shall be avoided. To ease the burden, as an alternative it is suggested that, waste water that is being treated at various plants may be utilized for purposes like curing, dust suppression etc if found suitable.

Avoidance of Nuisance

During the construction, the concessionaire shall take all precautions to avoid any nuisance arising from its operations. This shall be carried by suppression of nuisance at source rather than abatement of nuisance once it is generated. Following site clearance and before construction, the construction concessionaire shall remove all the debris, muck and other vegetation. The concessionaire shall ensure that work place is free of trash, debris, weeds, rodents, flees, and pests etc. Concessionaire shall provide metal or heavy duty plastic 'Refuse Containers' with tight fitting lids for disposal of all garbage associated with food to ensure that rodents, flee and other pests are not harbored and attracted. These bins should be emptied at least once daily to maintain site sanitation. It is very necessary to keep the site and its environs in a clean condition and good standard of housekeeping. The public nuisance shall be minimized/ avoided by observing good housekeeping and control at site by avoiding open pits, slush, materials of construction coming in the way of road users.

Soil Management Plan

From the estimations made on the basis of preliminary drawings estimated total quantum of excavated soil and rock from the corridor will be approximately equivalent to about 3,51,680 cubic metres. Most of this can be used for backfilling. However, a major portion of the excavated soil has to be disposed from site in an environmental friendly manner. It is, therefore suggested that various locations such as abandoned quarry pits, low lying lands etc. may be selected for disposing this waste. Further, in case of low lying areas are chosen for disposal, it is suggested to preserve the top soil of the designated site which can be reused during reclaiming works.

Public Utility Management Plan

As the construction activities of the proposed project interfere with the existing network of various public utilities, it is suggested that before disconnecting the existing public utility network like water pipes, drainage pipes, telephone wires etc, the alternate arrangement preferably on a permanent basis must made proactively beforehand so as to cause least inconvenience to the community. The details can be worked out and developed in close association with respective concessionaire.

Traffic Diversions

The construction activities will entail considerable traffic diversions along the proposed alignment. Therefore, to facilitate smooth flow of the traffic along the proposed alignment, working plans should be developed in association with traffic control authorities. Suitable alternate roads shall be identified and traffic circulation plans may be prepared accordingly.

Labor Management Plan

Construction labors is an important and integral component of the unorganized labor. Recent National Labor Commission insists that welfare benefits already given to organized labor must be extended to unorganized labor in general and construction labor in particular. There are several labor legislations and Acts governing working hour, payment of wages, PF, ESI, safety, sanitation, housing, medical, insurance etc. Measures shall be adopted to ensure proper compliance of these legislations. The project implementation authority is advised to form a cell to monitor and to ensure that contractors follow the rules. General and special conditions of contract have to be strictly framed taking all labour related laws, safety codes, both during construction and operation phases.

Water Quality

The water quality is not expected to change much due to project execution. During the construction phase, the water requirement will be basically for processing at mixing plant, curing, dust suppression etc., with comparatively a small amount for sanitary purposes. There will be negligible liquid effluents from mixing plant; However, the sanitary effluents shall be discharged to existing sewer lines/sever drains.

During the operation phase, the water will be used for cleaning station premises, compartments and loco yards. Effluents from maintenance yards shall be treated appropriately before discharging.

Water Table Management

The ground water extracted during construction works, shall be appropriately used for recharging of the ground water table in the vicinity wherever possible. Every effort shall be made to avoid it drained out as it may adversely affect the ground water table in the area. In addition, suitable drainage network, collecting tanks and pumping system etc. are to be incorporated both during construction and operation phases to tackle the perennial seepage due to subsoil water.

Vibration Management Plan

Vibrations are expected due to the construction and operation of the proposed project. Various measures, such as electrometric bearing, separating the track deck and the pier, resilient rail fasteners (Spring

Clip, rail pad, elastic pad and compression spring), continuously welded rails etc., are suggested to prevent any anticipated damage. Use of suggested measures will reduce induced vibrations on the surrounding buildings. The quality of the track and the rolling stock is also important in controlling induced vibration in the nearby structures. Both the wheel and rail should be free from surface wear/ irregularities (corrugation/ flat etc.) and the defective units of the rolling stock should be removed from the operation.

Safety Management

Safety aspects shall be given high priority and various good practices like barricading, proper illumination, caution sign boards, proper use of safety equipment a round the clock should be strictly enforced. The safety system should consider the following four major components, viz,

i) safety for men, materials, machines engaged in construction activities,

ii) safety of general public, vehicles belonging to the general public during construction activities,

iii) safety of commuters during operation stages,

iv) safety of general public during operation stage of train.

Fire Management Plan

The key to prevention of fire accidents is a proper management plan, with which potential fire hazards can be identified and controlled effectively. A good plan should identify all the potential class of fires and source of accidents in buildings, process and operation procedures before laying out measures to minimize the risk of these. Every station building should be equipped with adequate resources both hardware and trained personnel to detect fires quickly and limit their spread in the event of accidents. The plans should also incorporate procedures to contain major contingencies and normalize the situation with minimum delay.

The inflammable materials to be used in the proposed stations will be the diesel running the emergency DG sets during the power failures. The two most important measures for handling these fires are insertion and pressure relief devices. Other precautions include ensuring absence of any sparking sources and electrical fires. Flame proof light fittings and fixtures are necessary for areas, where such materials are handled.

To minimize the fire accidents, it is suggested to keep all the required fire management systems (detection and fighting systems) in working condition for the project during both construction and operational stages.

For this, static sumps at stations, suitable types of hoses and extinguishers at elevated stations and inside the compartments shall be provided. Proper training for the personnel to meet such emergency situations shall be imparted on regular basis. Further, fire management system shall be suitably integrated with local firefighting authorities.

Poster and boards on safe working practices shall be displayed in the station premises to encourage safe working habits among the personnel. Periodic fire drill shall be carried out to keep the alarm systems and equipments in 'Fit to Use' condition.

On-Site Emergency Plan

The basic approach towards an On-Site Emergency Management Plan shall be governed by accident events like derailment, collision, fire incidents, power cuts, death on train, civil unrest, strike etc.

Emergency type of incidents can arise and develop in short periods of time, particularly involving fire incidents and other accidents etc., which could result in loss of lives, damage to property and communications network besides causing loss of productivity.

The project authorities shall provide and ensure availability of protective and combat equipment in good number to meet any kind of possible emergencies in the train, in stations and along the tracks. Every station should be equipped with adequate hardware and trained personnel to deal with fires and similar incidents and take necessary control measures. For e.g., effective on-site control of fire incidents, the following machinery in adequate number and appropriate locations shall be put in place:

(i) Static water tanks at strategic locations at each station, in a state of readings.

(ii) fire detection systems/smoke sensors/alarms at stations, trains, and provision of emergency escape routes.

(iii) first aid boxes, with full inventory of required medical items, shall be located at stations and trains (Note: First aid boxes will effectively serve other types of exigencies also) – They should be kept in good order by inspection at scheduled intervals.

Off-Site Emergency Plan

The offsite emergency plan deals with those incidents which may have the potential to harm the lives and resources of the neighborhood community. The offsite emergency manual should be a comprehensive document giving full details of responsibilities, actions and approaches by various agencies involved in damage mitigation and relief operations. It serves as an important ready reference document to all the agencies involved in emergency action measures, such as firefighting, medical, civil and agencies, district administration officials etc. It provides off site emergency plan for the individual role as well as collective role during emergencies.

The key feature of a good offsite plan is its flexibility in its application to various emergencies. The responsibilities for carrying out necessary actions under the off site plan will be likely to rest with the works management or with the local authority.

Aspects to be included in an offsite emergency plan:

Organization: Names and designation of incident controller, site main controller, their duties and other key personnel. Details of the command structure, warning systems, implementation procedures and emergency control centers will be included.

Communication: Identification of personnel involved, communication center, call signs, network, list of telephone numbers.

Special emergency equipment: Details of availability and location of heavy lifting gear, bulldozers, specified firefighting equipments, fire masks, and other protection gear.

Voluntary Organizations: Details of organizers, mobile numbers, resources etc.

Meteorological information: Arrangements for obtaining details of weather conditions prevailing at the time and weather forecast.

Humanitarian arrangements: Transport, evacuation centers, emergency feedings, treatment of injured, first aid, ambulances.

Public Information: Arrangements for dealing with the media- press and public address system.

7.4 ENVIRONMENTAL BUDGET

EMP Cost RRTS Project						
COMPONENT	**STAGE**	**ITEM**	**UNIT**	**UNIT COST (Rs.)**	**QUANTITY**	**TOTAL COST (INR)**
Flora	Pre Construction	Afforestation Cost	No.	1500	1863	27,94,500
	Construction	Irrigation Cost for 24 months	per Month per km	5000	111.8	1,24,16,000
Total Afforestation Cost						**151,14,500**
(A) Mitigation cost						
Air	Construction	Dust Management with sprinkling of water, covers for vehicles transporting construction material for about 20 months	per Month per km	5,000	111.8	111,80,000
Water	Construction	Oil interceptor at parking of construction vehicle and storage of diesel and lubricants 10 Nos	Each	1,00,000	10	10,00,000

					A-Total mitigation cost	**121,80,000**
(B) Monitoring costs						
Air Quality	Pre construction Stage	Monitoring along the corridor by contractor	No. of Samples	3000	At 12 locations ,once and for 24 hours in 3 shifts(Total 3*12 samples)	**1,08,000**
	Construction	Monitoring along the corridor by contractor	No. of Samples	3,000	At 5 locations, twice in a year for a period of 3 years and for 24 hours in 3 shifts (Total 5x18 = 90 Samples)	2,70,000
		Monitoring at Batch/ Casting plant (ambient air quality)	No. of Samples	3,000	At 5 locations once in a 3 months for 2 years, for 24 hours (Total 5x8=40 Samples)	1,80,000.00
Water Quality	Pre construction stage	Monitoring along the corridor	No. of Samples	3,000	At 22 locations once single sample was taken	66,000.00
	Construction	Drinking water quality monitoring of labour camps/ works site	No. of Samples	4,000	At 4 location, Twice in a year for 3 years(Total 4x3x2 = 24 samples)	96,000.00

Noise Quality	Pre construction stage	Monitoring along the corridor	No. of samples	1000	At 12 location, once for 24 hours in day time &night time (Total 12 Samples)	12,000.00
	Construction	Monitoring along the Batch plant	No. of Samples	1,000	At 4 location, Twice in a year for 3 years for 24 hours in day time & night time (Total 4x3x2 =24 Samples)	24, 000.00
	Operation	Monitoring along the corridor at locations where monitoring was done during constructions	No, of Samples	1,000	At 5 locations, Twice in a year for 1 years (Total 5x2x1 =10 Samples)	10,000
Soil Quality	Pre construction stage	Monitoring along the corridor	No, of Samples	2000	At 12 location, once	24,000
	Construction	Monitoring along batch plant	No of Samples	2,000	At 4 locations, twice in a year for 3 years (Total 4x3x2 = 24 samples)	48,000
					B-Total monitoring cost	**8,38,000**

(C) Training & Other costs				
Training & Mobilization costs	Construction and operation	As per modules developed	L.S.	**10,00,000**
C- Total Training & Mobilization costs				**10,00,000**
D-Total Reclamation cost for Muck disposal				**15,00,000**
SUMMARY OF ENVIRONMENTAL COSTS				
A-Total mitigation cost				**121,80,000**
B-Total monitoring cost				**8,38,000**
C- Total training & mobilization costs				**10,00,000**
D-Total reclamation cost for muck disposal				**15,00,000**
TOTAL				**1,56,73,350**
Total Afforestation Cost				**229,18,500**
Contingency @ 5%				**19,29,592.5**
TOTAL EMP BUDGETED COSTS				**1,64,18,044.00**

CHAPTER 08

PROJECT BENEFITS

8.0 GENERAL

The ultimate aim of all developmental activities, including the Rapid Rail Transit System, is to promote social welfare of the Delhi and Haryana States. The developments of the above project play a significant role in changing the socio-economic condition of the people of the regions through dynamic externalities resulted from such development. The benefit of proposed RRTS may also be seen from a different angle, viz., the local benefit and the wider regional or national level benefit. The entire regional and national economy lying beyond this neighborhood should also be benefit from the development. Such effects may be called the regional or national level benefits. Further the benefits may be direct or indirect in nature. All these should have a bearing on the level of well being of the households; which would, in turn lead to changes in the level of well-being and human development, through their benefit on consumption level, educational attainment, health status etc.

8.1 TOURISM DEVELOPMENT

Delhi& Haryana are both important tourist destinations in India. The proposed project will give important connection to other places of Haryana/Delhi Border and the project will provide a better connectivity within the National Capital Region.

8.2 ECONOMIC DEVELOPMENT

RRTS can contribute to economic development by encouraging the attraction of businesses to sites equipped with good access and by improving the travel efficiencies of existing businesses and to start a new avenue also help for:

- the development of new project sites,
- development of small scale industrial areas.
- the development of industrial parks,
- infrastructure projects and
- development of IT parks,

8.3 REDUCTIONS IN ACCIDENTS, MORBIDITY AND MORTALITY

Commuters likely to be shifted from road based transport system to RRTS and thus will partly vacate the road space and requirement for transport by them has also reduced. As traffic on roads will be replaced by RRTS, accidents will be automatically reduced.

8.4 INDIRECT BENEFITS

In addition to direct impacts, a number of indirect benefits may be attributed to the RRTS project. Lowering of transportations cost for users and improved access to goods and services enables new and increased economic and social activity. Over time, individuals, households and firms adjusts to take the advantage of those benefits, leading to several indirect impacts. These indirect impacts include changes in land use and development, changes in decision to locate houses and small venders areas where houses and land are less expensive or more desirable, and changes in warehouse and delivery procedure for businesses in order to take advantage of improved speed and reliability in the transportation system. These impacts then lead to increased property values, increased productivity, employment and economic growth.

The change in land use pattern in the areas that have greater connectivity due to the project, since there will be a change in the patterns of settlement, agricultural land use and location of industries, trading and other services and non-farm unorganized sector activities. The transit oriented development zones will facilitate deployment of townships within NCR and hence dissipation population. All the above would reflect in the pattern of economic activities, income generation, price evolution, employment condition and ground rent prevailing in the connected area which may in turn induce greater accessibility to the job market, health and educational facilities etc. It will also attract investment for development of feeder roads, power distribution networks, telecommunication facilities etc

8.5 ENVIRONMENTAL BENEFITS

Reduction in emissions, noise levels and travel time are the direct benefits of proposed RRTS project. However to quantify and value these benefits is difficult; as a result, they are less often included in cost-benefit analysis of transportation investment.

Daily commuters are likely to be shifted from road based transport system to RRTS and thus will partly vacate the road space. The requirement for transport by daily commuters shall reduce.

The secondary benefits due to less congestion are therefore going to the road space users, which are reflected by

(1) Reduction in accidents.

(2) Savings in fuel consumption, and reduction of emissions.

(3) Saving of time due to better speed,

(4) No. of Vehicles running on road will be reduced because of RRTS reduing gaseous emission.

Reduction of Daily Vehicle KM and Vehicles:

Commuters are likely to be shifted from road based transport system to metro and thus will partly vacate the road space and requirement for transport by them has also reduced. The amount of reduction is reflected by (Table 8.1)

Table 8.1 Daily Vehicle KM saved by RRTS passengers

Mode	Veh.km saved			
	2016	2021	2031	2041
Car	298176	386435	697776	903311
Two Wheeler	495689	642409	1159984	1501666
Bus	41039	47623	76795	101366
IPT	1314582	1659558	2864277	3669798
Total	2149486	2736025	4798833	6176141

This vehicle km is generated from the vehicular trips which are transferred to RRTS. As a result, a part of daily vehicular trips are off the road.

Table 8.2 Total Projected Demand and Shift%

Mode	Total Demand considered (vehicles)				Shifts (%) realistic case				
	2016	2021	2031	2041	mode	2016	2021	2031	2041
Car	22369	28990	52346	65648	Car	69	69	69	68
Two Wheeler	37186	48193	87021	109133	TW	69	69	69	68
Bus	1801	2051	3307	4286	Bus	47	46	46	45
IPT	61143	75675	130610	164123	IPT	50	49	49	48
Total	122499	154909	273284	343190	Rail (EMU)	40	41	41	41

Saved Fuel Consumption and Journey Time due to Speed Change

When vehicles are reduced on roads due to shifting of commuters to RRTS, congestion level is reduced and speeds go up although very little. It is seen (by using traffic assignment program) that average speed on nearby roads sections are increased between 2%-4%.

Annual and Daily Saved Emission due to RRTS:

As discussed in above paragraphs, No. of vehicles running on road will be reduced because of RRTS. It will reduce gaseous emission. For quantification, emission factors have been used.

Annual Vehicle Emission in tones due to RRTS is given in Table 8.4 and Daily Vehicle Emission in tones due to RRTS is given in Table 8.5

Table 8.4 Annually saved emission due to RRTS Project in Tons

Year	CO	HC	NOX	TSPM	SOx	Pb
2016	12886.58	4062.59	671.57	4.12	7.48	6.96
2021	16399.83	5171.06	840.89	4.78	60.41	8.86
2031	28721.80	9058.91	1452.67	7.71	102.26	15.49
2041	36932.39	11649.22	1875.52	10.17	132.83	19.91

Table 8.5:Daily saved emission due to RRTS Project in Tons

Car	CO	HC	NOX	TSPM	SOx	Pb
2016	35.31	11.13	1.84	0.01	0.02	0.02
2021	44.93	14.17	2.30	0.01	0.17	0.02
2031	78.69	24.82	3.98	0.02	0.28	0.04
2041	101.18	31.92	5.14	0.03	0.36	0.05

CHAPTER – 09

CONCLUSIONS

9.0 CONCLUSIONS

Railway projects generally promote access and opportunities by facilitating movement of persons and goods. On the basis of data analysis, nature of impacts and observations of all stakeholders involved in the project, it is concluded that the proposed RRTS scheme can be developed without causing significant adverse environmental impacts to the physical, socio - economic and Ecological environment. This in turn enhances the demand for transport.

During the assessment it was found that:

- The surface water and ground water quality were found to be within the prescribed limits.
- Approximately 621 trees and 457 structures will be affected during the construction phase of the project.
- The ambient air quality along the project stretch revealed that the $PM_{2.5}$ and PM_{10} levels were exceeding the maximum limits (NAAQS-National Ambient Air Quality Standards) at all locations.
- Bored cast in-situ piles will produce noise levels up to 100 dB (A) at a distance of 25-m from site. Suitable noise barriers can reduce the noise levels to 70 dB (A) at a distance of 25m from the piles. Safety precautions as stipulated in IS: 5121 (1969) 'Safety Code for Piling and other deep foundation' will be adopted.
- In areas of noise sensitivity, noise mitigation could be carried out by providing parabolic noise barriers on each side of the viaduct.
- Provision of adequate and frequent public transport will discourage personal vehicles on the roads ; in addition RRTS public transport on dedicated corridors is able to move faster than transport on non-dedicated corridors. Introduction of High speed Rail Transit services in the city (NCR) will benefit daily commuters in terms of time and money.
- Improving mass transportation will significantly reduce air pollution by reducing the number of cars on the busy roads, which will increase the life span of flora and fauna and the health of NCR's inhabitants,

especially old people and children. Reduction in numbers of cars will also reduce noise levels considerably.

- The growth of RRTS will bring many benefits to the end-users but is accompanied by other development induced factors such as land acquisition for common gains. These impacts need to be managed and balanced while protecting the amity and wellbeing of the local community.

Assuming that the environmental impacts identified and mitigation measures suggested in this EIA are incorporated into design and implementation phases, it is expected that RRTS project will improve quality of life for local residents, and also the commuters on this corridor.

CHAPTER-10

Compliance of Comments issued on 22.11.2013 Draft EIA/EMP Report

S.No.	Comments	Compliance
1.	In chapter 1 various classifications and standards have been included. This can be given as annexure at the end of the report	Complied: All the classifications and standards are given as Annexure 1 at the end of the report.
2.	Figure showing cross sections of the RRTS line and trains may be added to the introduction chapter.	Complied: All the cross sections of the RRTS are given as Annexure 2 at the end of the report.
3.	Landuse map along the corridor should be included in the report.	Complied: Landuse / Landcover Map map along the corridor has been attached as Fig. 3.5 Landuse / Land cover Map RRTS Delhi-Panipat
4.	Alignment of Wazirabad drain can be shown on the landuse map mentioned under item 2.	Complied: As above
5.	Page 42,43 Chapter 3 Term “Project Roads” should be “Proposed rail line”.	Complied
6.	Map from the site www.mapsofindia.com have been used if payments for these maps are done the name of www.mapsofindia.com should not be used on the maps. (Copy right issues)	Complied
7.	In para 3.2 of Chapter 3 Project Influence Area under is 10m on East and 20m on West from the Centre Line. The reason for the difference in the length of this area on E and W, should be clearly mentioned.	Complied Detail of Project Influence area has already being mentioned in Chapter 3 under the heading 3.2 Project Influence area. The areas of direct influence will be confined in a linear fashion along the corridor, where the construction activities take place. In case of the alignment adjacent to NH-1, the area of direct influence is 10 m towards the east side of the central line of the proposed RRTS corridor and 20 m towards the west side of the

		proposed centre- line, for other areas, 15 m on either side of the centre line will be influenced by the project. Adjacent to 60m RoW of NH-1 30m width of land is available for RRTS including green belt developed by HUDA (20m wide). Hence the centre line of RRTS is eccentrically placed with 10m width towards NH-1 and 20m width towards HUDA green belt. This has been done to minimize the acquisition of private land.
8.	NAAQs (page 54) should be placed as annexure at the end of the report.	Complied: All the classifications and standards are given as Annexure 1 at the end of the report.
9.	CPCB standards (page 71) should be placed as annexure at the end of the report.	Complied: All the classifications and standards are given as Annexure 1 at the end of the report.
10.	In para 4.2.1 Chapter 4 Land Clearing there is no mention of the impact of tunnel Land.	Complied: A tunnel of 2.35 km length and 14 m diameter will generate spoil of 3,55,000 m^3 (muck) will also require clearing and proper disposal by concessionaire.
11.	Para 4.2.5 Chapter 4 has some quantification of vibrations during construction and operational phase could be added to Vibrations.	Complied: No significant vibration impacts are expected to travel to adjoining structures once the RRTS system is in operation. Vibration from the operation of the trains shall not be significant due to the resilient fasteners, elastomeric pads under the rail and the continuous welded rail. However, there may be a “rumble” noise from the trains heard from the ventilation systems. Review of literature * concludes that High speed trains generate ground vibrations of less than 0.5mm/s magnitude . It is probable that some isolated areas may be impacted during the operational phase by low

		frequency noise caused by the ground-borne vibration. The extent of this impact will be limited and it may be possible to mitigate the effect by adopting suitable mitigation steps. *1.American National Standards Institute, Guide to the Evaluation of Human Exposure to Vibration in Buildings. ANSI S3.29-1983 2. International Organization for Standardization, "Evaluation of Human exposure to whole body vibration: Part 2 – Continuous and shock-induced vibration in buildings (1 – 80 Hz), ISO 2361-2- 1989 3. International Organization for Standardization, "Mechanical Vibration and Shock : Evaluation of human exposure to whole body vibration: Part 2 – Vibration in buildings (1 to 80 Hz), ISO 2631-2-2003. 4. J. T. Nelson, H. J. Saurenman, "State-of-the-Art Review: Prediction and Control of Ground borne Noise and Vibration from Rail Transit Trains," U.S. Department of Transportation, Urban Mass Transportation Administration, Report Number UMTA-MA-06-0049-83-4, DOT-TSC-UMTA- 83-3, December 1983. 5. Y. Tokita, "Vibration Pollution Problems in Japan," In Inter-Noise 75, Sendai, Japan, pp. 465- 472, 1975.
12.	Table 5.1 of Chapter 5 item no 3 includes "sacrificed bitumen wastes" and "hot mix" source of this is not mentioned in the report.	Complied: Production of hot mix is required for approach roads development in station area.
13.	Table 5.2 Chapter 5 item no 4 includes "sacrificed bitumen wastes" and "Hot mix" source of this is not mentioned in the report.	Complied: As above
14.	In para 8.5 Chapter 8 page 136 it is mentioned "Commuters are likely to shift	Complied;

	from road based transport system to metro" it should be RRTS instead of metro. It should be corrected.	
15.	Information regarding : A. Environment clearance required for RRTS B. Central Ground Water Authority (CGWA) permission. C. SPCB Consent to Establish and Consent to Operate.	The clearances/ permissions/ approvals under various acts, rules and guidelines are required for proposed project during pre-construction and construction phases are given in Chapter-1 as Table 1.1. and Table 1.2

Annexure 1.0: Standards for Air / Noise / Water quality monitoring

The surface water bodies have been graded on the basis of its quality.

The wastewater discharge standards are specified and given below:

Classification of Water Bodies according to the Primary Water Quality

S. No	Designated Best Use	Class of Water	Criteria
1	Drinking Water source (with conventional treatment)	A	1. Total Coliforms MPN/100 ml shall be 50 or less 2. pH between 6.5 to 8.5 3. Dissolved Oxygen 6 mg / l or more 4. Biochemical Oxygen demand (BOD) 5 days 20^{0}C 2 mg/l or less
2	Outdoor bathing (organized)	B	1. Total Coliforms MPN/100 ml shall be 500 or less 2. pH between 6.5 to 8.5 3. Dissolved Oxygen 5 mg / l or more 4. Biochemical Oxygen demand (BOD) 5 days 20^{0}C 3 mg/l or less
3.	Drinking Water source (without conventional treatment)	C	1. Total Coliforms MPN/100 ml shall be 5000 or less 2. pH between 6 to 9 3. Dissolved Oxygen 4 mg / l or more 4. Biochemical Oxygen demand (BOD) 5 days 20^{0}C 3 mg/l or less
4.	Propagation of Wildlife	D	1. pH between 6.5 to 8.5 for fisheries 2. Dissolved Oxygen 4 mg/l or more Free Ammonia (as N) l.2 mg/l or less
5.	Irrigation, Industrial Cooling, Controlled Waste	E	1. pH between 6.0 to 8.5 2. Electrical Conductivity at 25^0 C µmhos/cm Max. 2250 3. Sodium absorption ratios Max. 26 4. Boron, Max.2 mg/l

Ref:Bio-mapping of rivers. Parivesh New Letter,5(IV), Central Pollution Control Board, (I999).PP.20

Wastewater Discharge Standards[1]

S. No.	PARAMETERS	Unit	Standard (Inland surface water)
1	Colour & Odour	All efforts should be made to remove color and unpleasant odour as far as practicable	
2	Suspended Solids	mg/l	100
3	Particle Size of Suspended Solids	-	Shall pass 850 micron IS sieve
4	pH		5.5 to 9.0
5	Temperature	^{0}C	Shall not exceed 5 ^{0}C above the receiving water body temperature.
6	Oil & Grease	mg/l	10.0 (Max.)
7	Total Residual Chlorine	mg/l	1.0 (Max.)
8	Ammoniacal Nitrogen	mg/l	50.0 (Max.)
9	Total Kjeldahl Nitrogen	mg/l	100.0 (Max.)
10	Free Ammonia (as NH_3)	mg/l	5.0 (Max.)
11	Biochemical Oxygen Demand	mg/l	30.0 (Max.) (5 days at 20 ^{0}C)
12	Chemical Oxygen Demand	mg/l	250.0 (Max.)
13	Arsenic (as As)	mg/l	0.2 (Max.)
14	Mercury (as Hg)	mg/l	0.01 (Max.)
15	Lead (as Pb)	mg/l	0.1 (Max.)
16	Cadmium (as Cd)	mg/l	2.0 (Max.)
17	Hexavalent Chromium (as Cr^{+6})	mg/l	0.1 (Max.)
18	Total Chromium (as Cr)	mg/l	2.0 (Max.)
19	Copper (as Cu)	mg/l	3.0 (Max.)
20	Zinc (as Zn)	mg/l	5.0 (Max.)
21	Selenium (as Se)	mg/l	0.05 (Max.)

[1] Central Pollution Control Board, 1998: Gazette of India, Part III, Section 4 dated 23.4.1988

S. No.	PARAMETERS	Unit	Standard (Inland surface water)
22	Nickel (as Ni)	mg/l	3.0 (Max.)
23	Cyanide as (CN)	mg/l	0.2 (Max.)
24	Fluorides (as F)	mg/l	2.0 (Max.)
25	Dissolved phosphates (as PO_4^{-3})	mg/l	5.0 (Max.)
26	Sulphides (as S)	mg/l	2.0 (Max.)
27	Phenolic compounds (as C_6H_5OH)	mg/l	1.0 (Max.)
28	Radioactive Materials (i) Alpha emitters (ii) Beta Emitters	µ ci/ml	10^{-7} Max. 10^{-6} Max
29	Bio Assay tests	90% Survival of fish after 96 hours in 100% effluent	
30	Manganese as Mn	mg/l	2.0
31	Iron as Fe	mg/l	3.0
32	Vanadium as V	mg/l	0.2
33	Nitrate Nitrogen	mg/l	10.0

DRINKING WATER SPECIFICATION: IS: 10500, 1992

(Reaffirmed 1993)

TOLERANCE LIMITS

S. No	Parameter	IS: 10500 Requirements (Desirable limit)	Undesirable effect outside the desirable limit	IS: 10500 Permissible limit in the absence of alternate source
Essential Characteristics				
1.	pH	6.5 – 8.5	Beyond this range the water will affect the mucous membrane and / or water supply system	No relaxation
2.	Colour (Hazen Units), Maximum	5	Above 5, consumer	25
3.	Odour	Unobjectionable	--	--
4.	Taste	Agreeable	--	--
5.	Turbidity, NTU,	5	Above 5, consumer	10
Following Results are expressed in mg/1 :				
6.	Total hardness as $CaCO_3$, Max	300	Encrustation in water supply structure and adverse effects on domestic use	600
7.	Iron as Fe, Max	0.30	Beyond this limit taste/appearance are affected, has adverse effect on domestic uses and water supply structures, and promotes iron bacteria.	1.0
8.	Chlorides as Cl, Max	250	Beyond this limit taste, corrosion and palatability are effected	1000
9.	Residual, Free Chlorine, Min	0.20	--	--
Desirable Characteristics				
10.	Dissolved solids, Max	500	Beyond this palatability decreases and may cause gastro intentional irritation	2000

S. No	Parameter	IS: 10500 Requirements (Desirable limit)	Undesirable effect outside the desirable limit	IS: 10500 Permissible limit in the absence of alternate source
11.	Calcium as Ca, Max	75	Encrustation in water supply structure and adverse effects on domestic use	200
12.	Magnesium as Mg, Max	30	--	100
13.	Copper as Cu, Max	0.05	Astringent taste, discoloration and corrosion of pipes, fitting and utensils will be caused beyond this limit	1.5
14.	Manganese as Mn, Max	0.1	taste/appearance are affected, has adverse effect on domestic uses and water supply structures	0.3
15.	Sulphate as SO4 Max	200	Beyond this causes gastro intentional irritation when magnesium or sodium are present	400
16.	Nitrates as NO3	45	Beyond this methanemoglobinemia takes	100
17.	Fluoride, Max	1.0	Fluoride may be kept as low as possible. High fluoride may cause fluorosis	1.5
18.	Phenolic compounds as C6H5OH, Max	0.001	Beyond this, it may cause objectionable taste and odour	0.002
19.	Mercury as Hg, Max	0.001	Beyond this, the water becomes toxic	No relaxation
20.	Cadmium as Cd, Max	0.01	Beyond this, the water becomes toxic	No relaxation
21.	Selenium as Se, Max	0.01	Beyond this, the water becomes toxic	No relaxation
22.	Arsenic as As, Max	0.05	Beyond this, the water becomes toxic	No relaxation
23.	Cyanide as CN, Max	0.05	Beyond this, the water becomes toxic	No relaxation
24.	Lead as Pb, Max	0.05	Beyond this, the water becomes toxic	No relaxation
25.	Zinc as Zn, Max	5	Beyond this limit it can cause astringent taste and an opalescence in water	15
26.	Anionic detergents as MBAS, Max	0.2	Beyond this limit it can cause a light froth in water	1.0

S. No	Parameter	IS: 10500 Requirements (Desirable limit)	Undesirable effect outside the desirable limit	IS: 10500 Permissible limit in the absence of alternate source
27.	Chromium as Cr6+, Max	0.05	May be carcinogenic above this limit	No relaxation
28.	Ploynuclear aromatic hydrocarbons as PAH, Max	--	May be carcinogenic	--
29.	Mineral Oil, Max	0.01	Beyond this limit undesirable taste and odour after chlorination take place	0.03
30.	Pesticides, Max	Absent	Toxic	0.001
31.	Radioactive materials a) α emitters, Bq/1, Max b) β emitters Pci/1, Max	 -- --	 -- --	 0.1 1
32.	Alkalinity, Max	200	Beyond this limit taste becomes unpleasant	600
33.	Aluminum as Al, Max	0.03	Cumulative effect is reported to cause dementia	0.2
34.	Boron, Max	1	--	5

Source: Indian Standard Drinking Water Specification – IS 10500, 1991

General Standards for Discharge of Environmental Pollutants

Part – A: Effluents

Sl. No.	Parameter	Standards			
		Inland Surface water	Public Sewers	Land of irrigation	Marine/ Costal areas
1.	Colour and odour	Of Annexure-1	--	See 6 of Annexure -1	See 6 of Annexure -1
2.	Suspended solids mg/1, max.	100	600	200	a. For process waste water 100 b. For cooling water effluent 10 per cent above total suspended mater of influent
3.	Particle size of suspended solids	Shall pass 850 micron IS Sieve	--		a. Floatable solids, solids max. 3 mm b. Settleable solids. Max 856 microns
4.	pH value	5.5 to 9.0	5.5 to 9.0	5.5 to 9.0	5.5 to 9.0
5.	Temperature	Shall not exceed 5^{o}C above the receiving water temperature	--	--	Shall not exceed 5^{o}C above the receiving water temperature
6.	Oil and grease, mg/1 max.	10	20	10	20
7.	Total residual chlorine, mg/1 max	1.0	--	--	1.0
8.	Ammonical nitrogen (as N), mg/l, max.	50	50	--	50
9.	Total nitrogen (as N), mg/l, max.	100	--	--	100
10.	Free ammonia (as NH_3), mg/l, max	5.0	--	--	5.0

Sl. No.	Parameter	Standards			
		Inland Surface water	Public Sewers	Land of irrigation	Marine/ Costal areas
11.	Biochemical oxygen demand (3 days at 27^{0}C), mg/l, max	30	350	100	100
12.	Chemical oxygen demand, mg/l, max	250	--	--	250
13.	Arsenic (as As) mg/l, max	0.2	0.2	0.2	0.2
14.	Mercury (as Hg), mg/l, max	0.01	0.01	--	0.01
15.	Lead (as Pb), mg/l, max	0.1	0.1	--	2.0
16.	Cadmium (as Cd), mg/l, max	2.0	1.0	--	2.0
17.	Hexavalent chromium (as Cr+6), mg/l, max	0.1	2.0	--	1.0
18.	Total chromium (as Cr), mg/l, max	2.0	2.0	--	2.0
19.	Copper (as Cu), mg/l, max	3.0	3.0	--	30
20.	Zinc (as Zn), mg/l, max	5.0	15	--	15
21.	Selenium (as Se), mg/l, max	0.05	0.05	--	0.05
22.	Nickel (as Ni), mg/l, max	3.0	3.0	--	50
23.	Cyanide (as CN), mg/l, max	0.2	2.0	0.2	0.2
24.	Fluoride (as F), mg/l, max	2.0	15	--	15
25.	Dissolved phosphates (as P), mg/l, max	5.0	--	--	--

Sl. No.	Parameter	Standards			
		Inland Surface water	Public Sewers	Land of irrigation	Marine/ Costal areas
26.	Sulphide (as S), mg/l, max	2.0	--	--	5.0
27.	Phenolic compounds (as C_6H_5OH), mg/l, max	1.0	5.0	--	5.0
28.	Radioactive Materials				
	a. α emitters micro cure mg/l, max	10^{-7}	10^{-7}	10^{-8}	10^{-7}
	b. β emitters micro curemg/l, max	10^{-7}	10^{-6}	10^{-7}	10^{6}
29.	Bio-assay test	90 % survival of fish after 96 hours in 100 % effluent	90 % survival of fish after 96 hours in 100 % effluent	90 % survival of fish after 96 hours in 100 % effluent	90 % survival of fish after 96 hours in 100 % effluent
30.	Manganese (as Mn)	2 mg/l	2 mg/l	2 mg/l	2 mg/l
31.	Iron (as Fe)	3 mg/l	3 mg/l	3 mg/l	3 mg/l
32.	Vanadium (as V)	0.2 mg/l	0.2 mg/l	--	0.2 mg/l
33.	Nitrate Nitrogen	10 mg/l	--	--	20 mg/l

* These standards shall be applicable for industries, operations or processes other than those industries. Operations or process for which standards have been specified in Schedule of the Environment Protection Rules 1989.

NATIONAL AMBIENT AIR QUALITY STANDARDS (NAAQS)

S. No.	Pollutant	Time Weighted Average	Concentration in Ambient Air		
			Industrial, Residential, Rural and other areas	Notified Ecologically Sensitive area	Methods of measurement
(1)	(2)	(3)	(4)	(5)	(6)
1.	Sulphur Dioxide (SO_2), $\mu g/m^3$	Annual*	50	20	-Improved West & Gaeke -Ultraviolet fluorescence
		24 hours**	80	80	
2.	Nitrogen Dioxide (NO_2), $\mu g/m^3$	Annual*	40	30	-Modified Jacob & Hochheiser (Na-Arsenite) -Chemiluminescence
		24 hours**	80	80	
3.	Particulate Matter (Less than 10 micron) PM_{10} $\mu g/m^3$	Annual*	60	60	- Gravimetric - TOEM - Beta attenuation
		24 hours**	100	100	
4.	Particulate Matter (Less than 2.5 micron) $PM_{2.5}$ $\mu g/m^3$	Annual*	40	40	- Gravimetric - TOEM - Beta attenuation
		24 hours**	60	60	
5.	Carbon Monoxide (CO) mg/m^3	8 hours**	02	02	-Non Dispersive Infra-red Spectroscopy (NDIR)
		1 hours**	04	04	
		24 hours**	500 & 200	100	

(Source: National Ambient Air Quality Standards, CPCB Notification dated 18th November 2009)

* Annual average: Annual arithmetic mean of minimum 104 measurements in a year at a particular site taken twice a week 24 hourly at uniform intervals

** 24 hourly or 08 hourly or 01 hourly monitored values, as applicable, shall be complied with 98% of the time in a year. 2% of the time, they may exceed the limits but not on two consecutive days of monitoring.

AMBIENT NOISE STANDARDS

Ministry of Environment & Forests (MoEF) has notified the noise standards vide. Gazette notification dated February 14, 2000 for different zones under the Environment Protection Act (1986). These standards are as follows:

Ambient Noise Quality Standards

Area Code	Category of Area	Noise dB(A) L_{eq}	
		Day time*	Night time*
A	Industrial Area	75	70
B	Commercial Area	65	55
C	Residential Area	55	45
D	Silence Zone	50	40

Note: Daytime is from 6.00am to 10.00 pm and Nighttime is from 10.00 pm to 6.00 am. Silence zone is defined as area up to 100 meters around premises of hospitals, educational institutions and courts. Use of vehicle hours, loud speakers and bursting of crackers are banned in these zones.

Annexure 2.0: Various cross sections of RRTS Delhi-Panipat

A. Cross Section of Tunnel Section

Currently it is proposed that the RRTS tracks will run in twin bore tunnels with an external diameter of 7.70m. The possibility of running the tracks within a single bore tunnel with an external diameter of 10-12m has been assessed but at this time it is not thought practicable to use such geometry namely because;

- A twin bore solution requires tunnels of a smaller diameter and hence allows deeper ground cover to be maintained at the sensitive area around the northern portal and along the alignment. Given the urban setting of the site and proximity of sensitive structures, a thicker ground cover will be beneficial as this can increase the stability of the tunnel excavation and will reduce the above ground settlements.
- A twin bore tunnel solution is more favourable given current fire and safety regulations and current best practice as the separate bores act as evacuation routes which can be sealed off from one another in the case of fire. If a single bore tunnel were to be adopted it may be necessary to construct a deep shaft to allow for intermediate emergency evacuation routes.

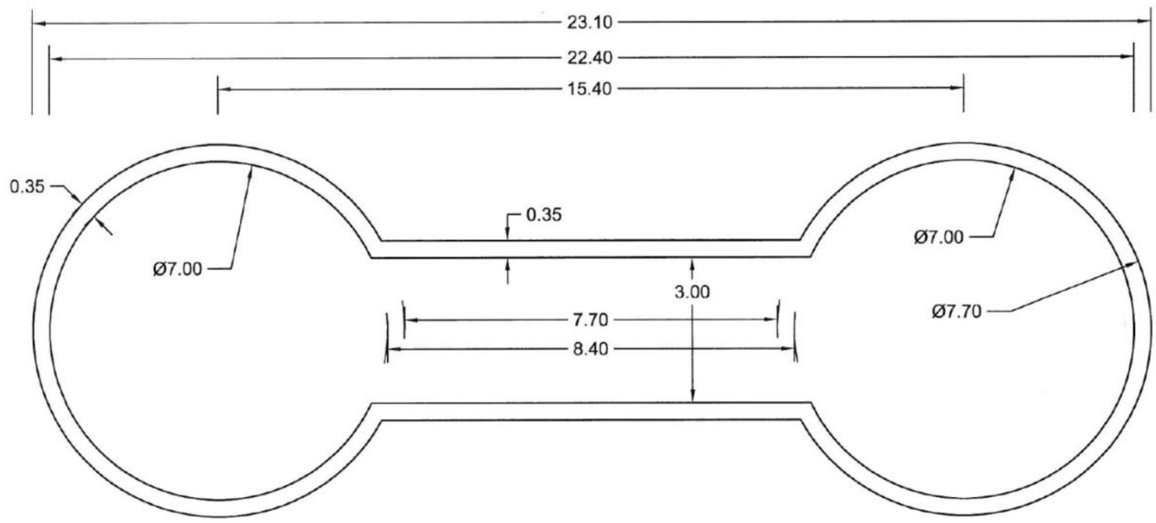
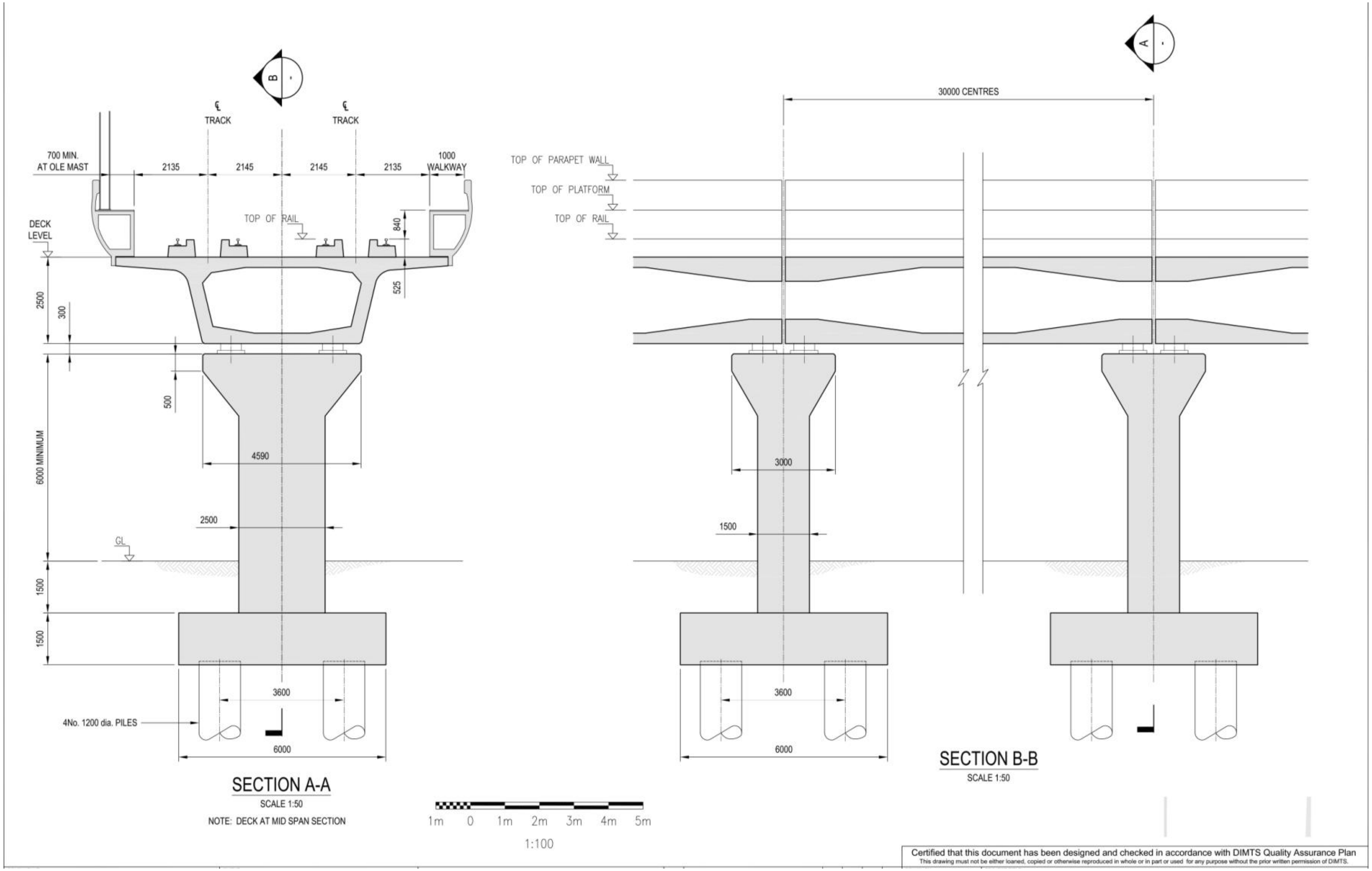


Figure Showing Schematic of the Twin Bore Tunnel Section

B. Elevated Section



ID	Task Name	Duration	Start	Finish
1	**Tender Process and Contract Award**	**280 days**	**Tue 01/04/14**	**Mon 27/04/15**
2	Tender Preparation	32 days	Tue 01/04/14	Wed 14/05/14
3	Tendering Process	60 days	Thu 15/05/14	Wed 06/08/14
4	Client Review of Tender Documents	40 days	Thu 07/08/14	Wed 01/10/14
5	Contract Award (Design & Build)	0 days	Wed 01/10/14	Wed 01/10/14
6	**Land Acquisition (inc R&R)**	**280 days**	**Tue 01/04/14**	**Mon 27/04/15**
7	Piers	60 days	Tue 01/04/14	Mon 23/06/14
8	KG Station Box	40 days	Tue 24/06/14	Mon 18/08/14
9	Portal	40 days	Tue 01/04/14	Mon 26/05/14
10	Depots	40 days	Tue 27/05/14	Mon 21/07/14
11	Stations	40 days	Tue 22/07/14	Mon 15/09/14
12	R&R	240 days	Tue 27/05/14	Mon 27/04/15
13				
14	**Design**	**720 days?**	**Thu 02/10/14**	**Tue 04/07/17**
15	Mobilise Design Team	20 days	Thu 02/10/14	Wed 29/10/14
16	Initial Detail Design	125 days?	Thu 30/10/14	Wed 22/04/15
17	Freeze Design Concepts & Sizes	0 days?	Wed 21/01/15	Wed 21/01/15
18	Prepare Procurement Documents (for Sub-Suppliers) with Early Potential Supplier Involvement	40 days	Thu 22/01/15	Wed 18/03/15
19	**Tendering Process for Equipment**	**60 days**	**Thu 19/03/15**	**Wed 10/06/15**
20	Trains	60 days	Thu 19/03/15	Wed 10/06/15
21	TBM	40 days	Thu 19/03/15	Wed 13/05/15
22	Moulds	40 days	Thu 19/03/15	Wed 13/05/15
23	**Client Review of Tenders**	**80 days**	**Thu 14/05/15**	**Wed 02/09/15**
24	Trains	60 days	Thu 11/06/15	Wed 02/09/15
25	TBM	40 days	Thu 14/05/15	Wed 08/07/15
26	Moulds	40 days	Thu 14/05/15	Wed 08/07/15
27	**Trains**	**480 days**	**Wed 02/09/15**	**Tue 04/07/17**
28	Place Order	0 days	Wed 02/09/15	Wed 02/09/15
29	Deliver Trains	300 days	Thu 12/05/16	Tue 04/07/17
30	**TBM**	**180 days**	**Wed 08/07/15**	**Wed 16/03/16**
31	Place Order	0 days	Wed 08/07/15	Wed 08/07/15
32	Manufacture TBM	120 days	Thu 09/07/15	Wed 23/12/15
33	Deliver TBM	60 days	Thu 24/12/15	Wed 16/03/16
34	**Precasting Moulds**	**90 days**	**Wed 08/07/15**	**Wed 11/11/15**
35	Place Order	0 days	Wed 08/07/15	Wed 08/07/15
36	Manufacture Moulds	60 days	Thu 09/07/15	Wed 30/09/15
37	Deliver Moulds	30 days	Thu 01/10/15	Wed 11/11/15
38				
39	Final Detail Design (Structure)	200 days	Thu 23/04/15	Wed 27/01/16
40				
41	**Construction DP Infraco**	**795 days?**	**Thu 02/10/14**	**Tue 17/10/17**
42	Mobilsation	60 days	Thu 02/10/14	Wed 24/12/14
43	Demolition of buildings to accommodate piers	200 days	Thu 30/10/14	Wed 05/08/15
44				

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Task	Milestone	Project Summary	External Milestone	Deadline
Split	Summary	External Tasks	Progress	

ID		Task Name	Duration	Start	Finish
45		Service Diversions	300 days	Thu 22/01/15	Wed 16/03/16
46		Substations	60 days	Thu 01/09/16	Tue 22/11/16
47					
48		**Kashmere Gate Station Box (TBM Reception Chamber)**	**445 days**	**Thu 30/10/14**	**Wed 13/07/16**
49		**Road Diversion**	**255 days**	**Thu 30/10/14**	**Wed 21/10/15**
50		Road Closure	255 days	Thu 30/10/14	Wed 21/10/15
51		Existing section removed and diversion constructed	25 days	Thu 30/10/14	Wed 03/12/14
52		Road Reinstatement	30 days	Thu 10/09/15	Wed 21/10/15
53		**Park (Site Preparation)**	**265 days**	**Thu 30/10/14**	**Wed 04/11/15**
54		Clear up	20 days	Thu 30/10/14	Wed 26/11/14
55		Levelling	30 days	Thu 27/11/14	Wed 07/01/15
56		Park reinstatement	30 days	Thu 24/09/15	Wed 04/11/15
57		**Park Section and Road NH24 - Diaphragm Wall**	**210 days**	**Thu 04/12/14**	**Wed 23/09/15**
58		East Wall Ch 690 to 1000	130 days	Thu 04/12/14	Wed 03/06/15
59		West Wall Ch 690 to 1000	130 days	Thu 18/12/14	Wed 17/06/15
60		North Headwall (35m)	15 days	Thu 04/06/15	Wed 24/06/15
61		Excavation (Including Propping)	100 days	Thu 26/02/15	Wed 15/07/15
62		Base Slab	40 days	Thu 04/06/15	Wed 29/07/15
63		Roof Slab - North Section	40 days	Thu 30/07/15	Wed 23/09/15
64		**South Section (South of Road NH24) - Diaphragm Wall**	**190 days**	**Thu 22/10/15**	**Wed 13/07/16**
65		South Headwall (45m)	19 days	Thu 22/10/15	Tue 17/11/15
66		East Wall Ch 560 to 690	55 days	Wed 18/11/15	Tue 02/02/16
67		West Wall Ch 560 to 690	55 days	Wed 02/12/15	Tue 16/02/16
68		Excavation (Including Propping)	100 days	Thu 31/12/15	Wed 18/05/16
69		Base Slab	40 days	Thu 21/04/16	Wed 15/06/16
70		Roof Slab South Section including Escape Stairs	20 days	Thu 16/06/16	Wed 13/07/16
71		Station Box Complete	0 days	Wed 13/07/16	Wed 13/07/16
72					
73		**Northern Portal (TBM Launch Chamber)**	**525 days**	**Thu 30/10/14**	**Tue 01/11/16**
74		Headwall (45m)	12 days	Thu 30/10/14	Fri 14/11/14
75		Launch Chamber East Wall Ch 2560 to 2660	17 days	Thu 06/11/14	Fri 28/11/14
76		Launch Chamber West Wall Ch 2560 to 2660	17 days	Mon 17/11/14	Tue 09/12/14
77		Excavation (Including Propping)	20 days	Wed 10/12/14	Tue 06/01/15
78		Base Slab	20 days	Wed 07/01/15	Tue 03/02/15
79		East Wall Ch 2660 to 3300	109 days	Mon 01/12/14	Thu 30/04/15
80		West Wall Ch 2660 to 3300	109 days	Wed 10/12/14	Mon 11/05/15
81		Excavation (Including Propping)	100 days	Thu 19/03/15	Wed 05/08/15

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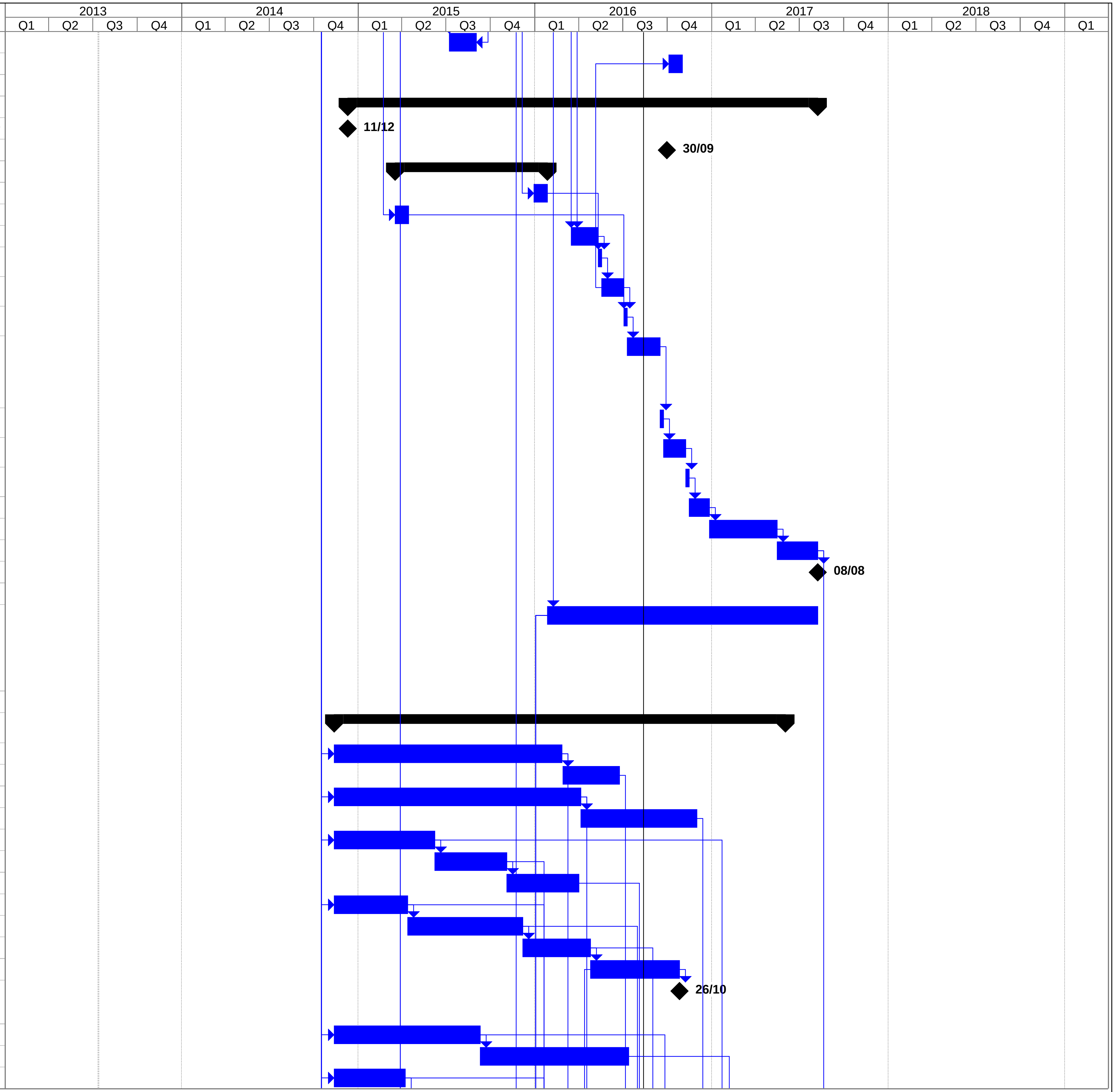
Task | Split | Milestone | Summary | Project Summary | External Tasks | External Milestone | Progress | Deadline

ID	Indicators	Task Name	Duration	Start	Finish
82		Base Slab	40 days	Thu 09/07/15	Wed 02/09/15
83		Roof Slab	20 days	Wed 05/10/16	Tue 01/11/16
84					
85		**Tunnel**	**695 days?**	**Thu 11/12/14**	**Tue 08/08/17**
86		Tunnel	0 days?	Thu 11/12/14	Thu 11/12/14
87		Tunnel	0 days?	Fri 30/09/16	Fri 30/09/16
88		**Ground Treatment**	**225 days**	**Thu 19/03/15**	**Wed 27/01/16**
89		South End	20 days	Thu 31/12/15	Wed 27/01/16
90		North End	20 days	Thu 19/03/15	Wed 15/04/15
91		TBM Assembly & Testing	40 days	Thu 17/03/16	Wed 11/05/16
92		Tunnel Boring (West Bore) - Start	21 days	Wed 11/05/16	Wed 18/05/16
93		Tunnel Boring (West Bore)	138 days	Wed 18/05/16	Sun 03/07/16
94		Tunnel Boring (West Bore) - Finish	21 days	Sun 03/07/16	Sun 10/07/16
95		TBM Removal, Dismantling, Transportation to North Portal, Assembly and Installation	50 days	Mon 11/07/16	Fri 16/09/16
96		Tunnel Boring (East Bore) - Start	21 days	Fri 16/09/16	Fri 23/09/16
97		Tunnel Boring (East Bore)	138 days	Fri 23/09/16	Tue 08/11/16
98		Tunnel Boring (East Bore) - Finish	21 days	Tue 08/11/16	Tue 15/11/16
99		TBM Demobilisation	30 days	Wed 16/11/16	Tue 27/12/16
100		Cross Tunnels	100 days	Wed 28/12/16	Tue 16/05/17
101		Tunnel Civil Fit Out	60 days	Wed 17/05/17	Tue 08/08/17
102		Tunnel Complete	0 days	Tue 08/08/17	Tue 08/08/17
103					
104		**Precast Works (Minor - viaduct parapet and walkway structure, props, stations, headhouse and escape stairs)**	400 days	Thu 28/01/16	Tue 08/08/17
105					
106		**Pier Construction (22 indicative main fronts)**	**668 days?**	**Thu 13/11/14**	**Fri 02/06/17**
107		Ch 3,330 to 4,400	337 days?	Thu 13/11/14	Fri 26/02/16
108		Ch 4,470 to 4560	85 days?	Mon 29/02/16	Fri 24/06/16
109		Ch 4,590 to 5,760	364 days?	Thu 13/11/14	Tue 05/04/16
110		Ch 5,790 to 6,330	173 days?	Wed 06/04/16	Thu 01/12/16
111		Ch 6,360 to 6,540	148 days?	Thu 13/11/14	Mon 08/06/15
112		Ch 6,570 to 8,680	107 days	Tue 09/06/15	Wed 04/11/15
113		Ch 8,710 to 10,820	107 days	Thu 05/11/15	Fri 01/04/16
114		Ch 10,850 to 12,900	108 days	Thu 13/11/14	Mon 13/04/15
115		Ch 12,930 to 13,290	170 days?	Tue 14/04/15	Mon 07/12/15
116		Ch 13,320 to 13,620	100 days?	Tue 08/12/15	Mon 25/04/16
117		Ch 13,650 to 14,550	133 days	Tue 26/04/16	Wed 26/10/16
118		**Kasmere Gate to Mukarba Chowk Piers Completed**	0 days	Wed 26/10/16	Wed 26/10/16
119		Ch 14,580 to 16,020	216 days	Thu 13/11/14	Thu 10/09/15
120		Ch 16,050 to 17,460	219 days?	Fri 11/09/15	Wed 13/07/16
121		Ch 17,490 to 17,700	105 days?	Thu 13/11/14	Wed 08/04/15



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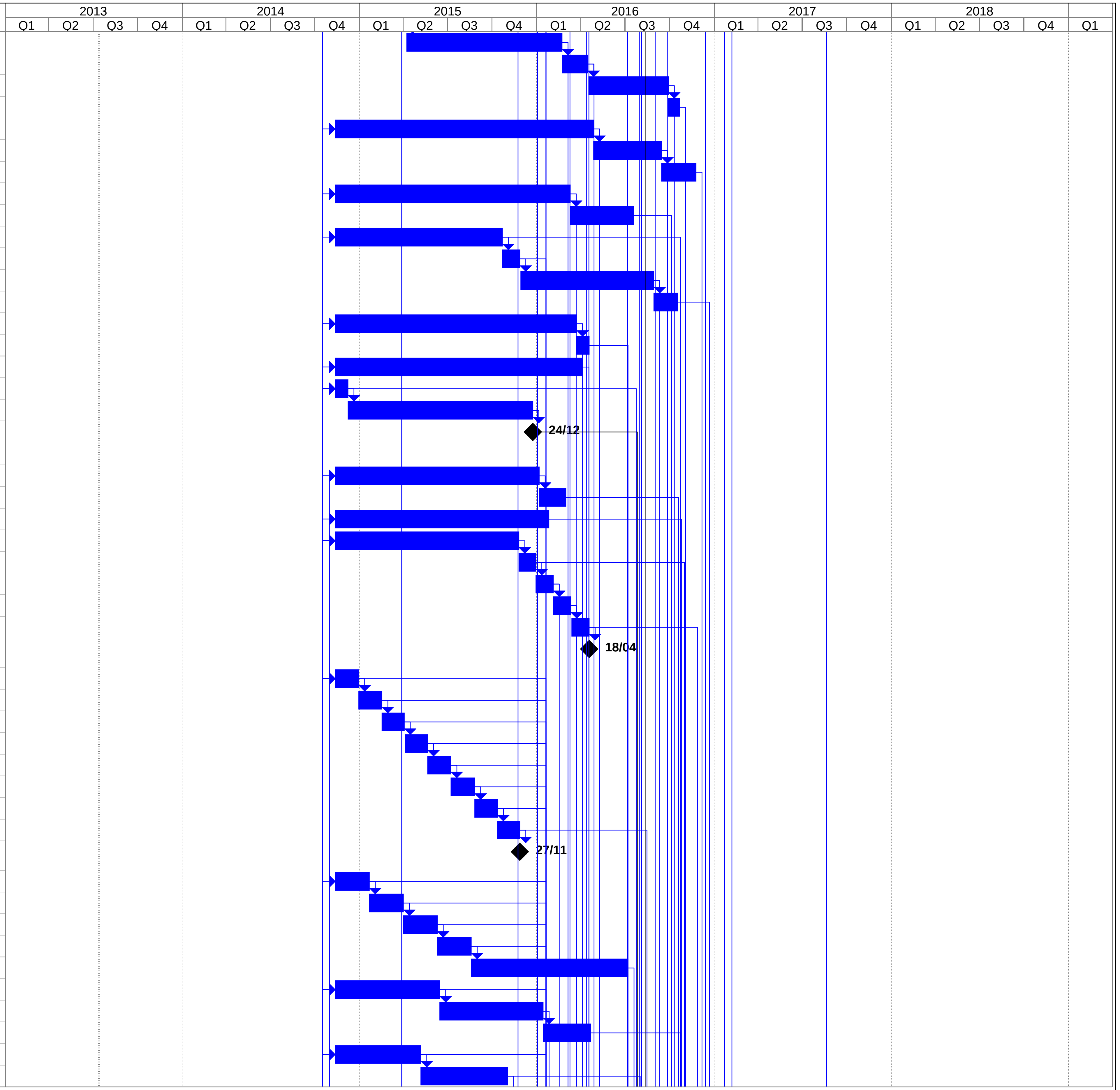
Task		Milestone		Project Summary		External Milestone		Deadline	
Split		Summary		External Tasks		Progress			

ID		Task Name	Duration	Start	Finish
122		Ch 17,730 to 18,450	228 days?	Thu 09/04/15	Mon 22/02/16
123		Ch 18,480 to 18,540	39 days?	Tue 23/02/16	Fri 15/04/16
124		Ch 18,570 to 18,930	118 days?	Mon 18/04/16	Wed 28/09/16
125		Ch 18,960 to 18,990	18 days?	Thu 29/09/16	Fri 21/10/16
126		Ch 19,020 to 19,860	380 days?	Thu 13/11/14	Wed 27/04/16
127		Ch 19,890 to 20,190	100 days?	Thu 28/04/16	Wed 14/09/16
128		Ch 20,220 to 20,310	52 days?	Thu 15/09/16	Thu 24/11/16
129		Ch 20,340 to 22,590	346 days?	Thu 13/11/14	Thu 10/03/16
130		Ch 22,620 to 22,800	92 days?	Fri 11/03/16	Mon 18/07/16
131		Ch 22,830 to 23,610	246 days?	Thu 13/11/14	Thu 22/10/15
132		Ch 23,640 to 23,670	26 days?	Fri 23/10/15	Fri 27/11/15
133		Ch 23,700 to 24,960	196 days?	Mon 30/11/15	Mon 29/08/16
134		Ch 24,990 to 25,080	36 days?	Tue 30/08/16	Mon 17/10/16
135		Ch 25,110 to 26,250	355 days?	Thu 13/11/14	Wed 23/03/16
136		Ch 26,280 to 26,310	18 days?	Thu 24/03/16	Mon 18/04/16
137		Ch 26,340 to 27,510	364 days?	Thu 13/11/14	Tue 05/04/16
138		Ch 27,540 to 27,570	18 days?	Thu 13/11/14	Mon 08/12/14
139		Ch 27,600 to 29,370	273 days?	Tue 09/12/14	Thu 24/12/15
140		**Mukarba Chowk to Kundi Piers Completed**	0 days	Thu 24/12/15	Thu 24/12/15
141		Ch 29,400 to 32,340	300 days?	Thu 13/11/14	Wed 06/01/16
142		Ch 32,370 to 32,430	39 days?	Thu 07/01/16	Tue 01/03/16
143		Ch 32,460 to 34,500	314 days?	Thu 13/11/14	Tue 26/01/16
144		Ch 34,530 to 37,590	270 days?	Thu 13/11/14	Wed 25/11/15
145		Ch 37,620 to 40,410	25 days	Thu 26/11/15	Wed 30/12/15
146		Ch 40,440 to 43,230	26 days	Thu 31/12/15	Thu 04/02/16
147		Ch 43,260 to 46,050	26 days	Fri 05/02/16	Fri 11/03/16
148		Ch 46,080 to 48,775	26 days	Mon 14/03/16	Mon 18/04/16
149		**Kundi to Murthal Piers Completed**	0 days	Mon 18/04/16	Mon 18/04/16
150		Ch 48,805 to 52,070	34 days	Thu 13/11/14	Tue 30/12/14
151		Ch 52,100 to 55,370	34 days	Wed 31/12/14	Mon 16/02/15
152		Ch 55,400 to 58,670	34 days	Tue 17/02/15	Fri 03/04/15
153		Ch 58,700 to 62,000	34 days	Mon 06/04/15	Thu 21/05/15
154		Ch 62,030 to 65,300	34 days	Fri 22/05/15	Wed 08/07/15
155		Ch 65,330 to 68,400	35 days	Thu 09/07/15	Wed 26/08/15
156		Ch 68,430 to 70,640	33 days	Thu 27/08/15	Mon 12/10/15
157		Ch 70,670 to 72,850	34 days	Tue 13/10/15	Fri 27/11/15
158		**Murthal to Samalkha Piers Completed**	0 days	Fri 27/11/15	Fri 27/11/15
159		Ch 72,850 to 76,140	50 days	Thu 13/11/14	Wed 21/01/15
160		Ch 76,170 to 79,460	50 days	Thu 22/01/15	Wed 01/04/15
161		Ch 79,490 to 82,780	50 days	Thu 02/04/15	Wed 10/06/15
162		Ch 82,810 to 86,010	50 days	Thu 11/06/15	Wed 19/08/15
163		Ch 86,040 to 87,600	231 days?	Thu 20/08/15	Thu 07/07/16
164		Ch 87,630 to 90,645	153 days	Thu 13/11/14	Mon 15/06/15
165		Ch 90,675 to 93,660	153 days	Tue 16/06/15	Thu 14/01/16
166		Ch 93,690 to 93,810	70 days?	Fri 15/01/16	Thu 21/04/16
167		Ch 93,840 to 95,910	126 days	Thu 13/11/14	Thu 07/05/15
168		Ch 95,940 to 97,980	127 days	Fri 08/05/15	Mon 02/11/15



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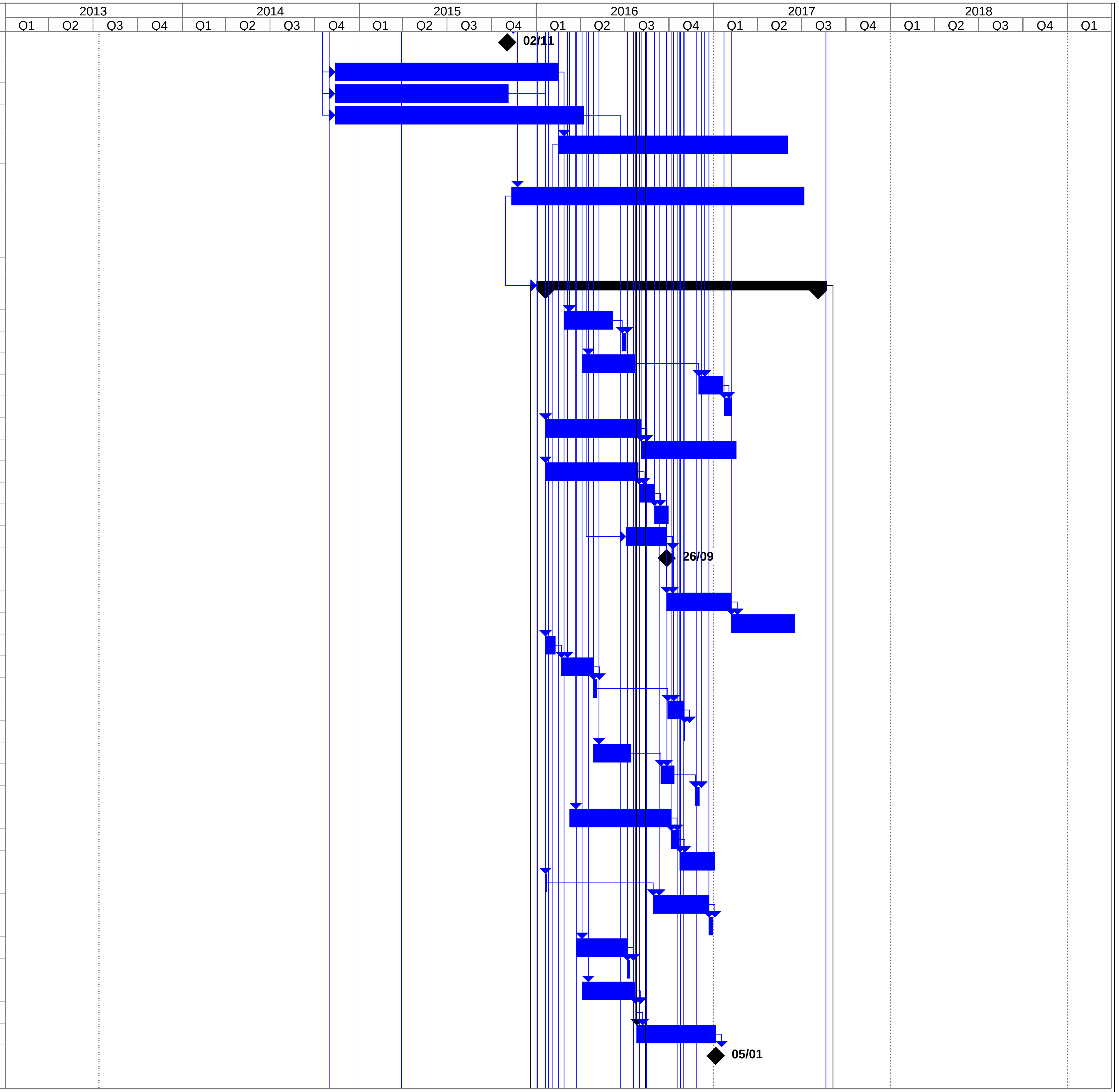
Task		Milestone		Project Summary		External Milestone		Deadline	
Split		Summary		External Tasks		Progress			

ID		Task Name	Duration	Start	Finish
169		**Main Line Piers Completed**	0 days	Mon 02/11/15	Mon 02/11/15
170		Branch Ch 0 to 510	328 days?	Thu 13/11/14	Mon 15/02/16
171		Branch Ch 540 to 2,190	255 days?	Thu 13/11/14	Wed 04/11/15
172		Branch Ch 540 to 2,190 (High)	367 days?	Thu 13/11/14	Fri 08/04/16
173		Branch Ch 2,220 to 5,550	340 days?	Tue 16/02/16	Fri 02/06/17
174					
175		**Precast Deck Production including mobilisation of yards (8 Indicative Casting Yards)**	432 days	Thu 12/11/15	Thu 06/07/17
176					
177		**Deck Erection (33 Launchers)**	**403 days**	**Thu 21/01/16**	**Fri 04/08/17**
178		Ch 3,330 to 4,400	72 days	Mon 29/02/16	Tue 07/06/16
179		Ch 4,470 to 4560	6 days	Mon 27/06/16	Mon 04/07/16
180		Ch 4,590 to 5,760	78 days	Wed 06/04/16	Fri 22/07/16
181		Ch 5,790 to 6,330	36 days	Fri 02/12/16	Fri 20/01/17
182		Ch 6,360 to 6,540	12 days	Mon 23/01/17	Tue 07/02/17
183		Ch 6,570 to 8,680	141 days	Thu 21/01/16	Thu 04/08/16
184		Ch 8,710 to 10,820	141 days	Fri 05/08/16	Thu 16/02/17
185		Ch 10,850 to 12,900	137 days	Thu 21/01/16	Fri 29/07/16
186		Ch 12,930 to 13,290	24 days	Mon 01/08/16	Thu 01/09/16
187		Ch 13,320 to 13,620	20 days	Fri 02/09/16	Thu 29/09/16
188		Ch 13,650 to 14,550	60 days	Tue 05/07/16	Mon 26/09/16
189		**Kasmere Gate to Mukarba Chowk Deck Completed**	0 days	Mon 26/09/16	Mon 26/09/16
190		Ch 14,580 to 16,020	96 days	Tue 27/09/16	Mon 06/02/17
191		Ch 16,050 to 17,460	94 days	Tue 07/02/17	Fri 16/06/17
192		Ch 17,490 to 17,700	14 days	Thu 21/01/16	Tue 09/02/16
193		Ch 17,730 to 18,450	48 days	Tue 23/02/16	Thu 28/04/16
194		Ch 18,480 to 18,540	4 days	Fri 29/04/16	Wed 04/05/16
195		Ch 18,570 to 18,930	24 days	Thu 29/09/16	Mon 31/10/16
196		Ch 18,960 to 18,990	2 days	Tue 01/11/16	Wed 02/11/16
197		Ch 19,020 to 19,860	56 days	Thu 28/04/16	Thu 14/07/16
198		Ch 19,890 to 20,190	20 days	Thu 15/09/16	Tue 11/10/16
199		Ch 20,220 to 20,310	6 days	Fri 25/11/16	Fri 02/12/16
200		Ch 20,340 to 22,590	150 days	Fri 11/03/16	Wed 05/10/16
201		Ch 22,620 to 22,800	12 days	Thu 06/10/16	Fri 21/10/16
202		Ch 22,830 to 23,610	52 days	Mon 24/10/16	Tue 03/01/17
203		Ch 23,640 to 23,670	2 days	Thu 21/01/16	Fri 22/01/16
204		Ch 23,700 to 24,960	84 days	Tue 30/08/16	Thu 22/12/16
205		Ch 24,990 to 25,080	6 days	Fri 23/12/16	Fri 30/12/16
206		Ch 25,110 to 26,250	76 days	Thu 24/03/16	Thu 07/07/16
207		Ch 26,280 to 26,310	2 days	Fri 08/07/16	Mon 11/07/16
208		Ch 26,340 to 27,510	78 days	Wed 06/04/16	Fri 22/07/16
209		Ch 27,540 to 27,570	2 days	Mon 25/07/16	Tue 26/07/16
210		Ch 27,600 to 29,370	118 days	Wed 27/07/16	Thu 05/01/17
211		**Mukarba Chowk to Kundi Deck Completed**	0 days	Thu 05/01/17	Thu 05/01/17



Project: Delhi RRTS Construction Prog
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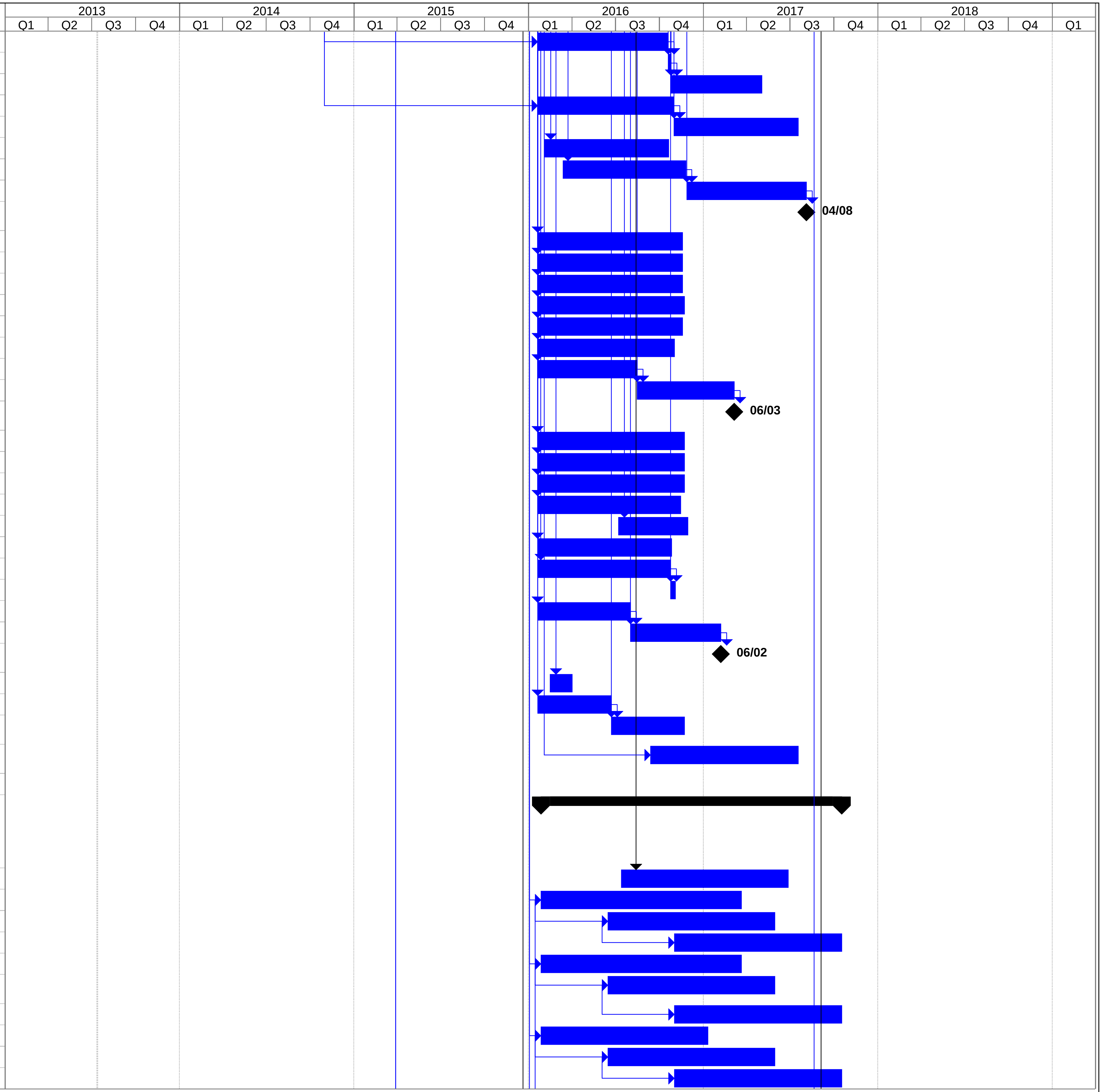
Task	Milestone	Project Summary	External Milestone	Deadline
Split	Summary	External Tasks	Progress	

ID	Task Name	Duration	Start	Finish
212	Ch 29,400 to 32,340	196 days	Thu 21/01/16	Wed 19/10/16
213	Ch 32,370 to 32,430	4 days	Thu 20/10/16	Tue 25/10/16
214	Ch 32,460 to 34,500	136 days	Wed 26/10/16	Wed 03/05/17
215	Ch 34,530 to 37,590	204 days	Thu 21/01/16	Mon 31/10/16
216	Ch 37,620 to 40,410	186 days	Tue 01/11/16	Tue 18/07/17
217	Ch 40,440 to 43,230	186 days	Fri 05/02/16	Thu 20/10/16
218	Ch 43,260 to 46,050	186 days	Mon 14/03/16	Fri 25/11/16
219	Ch 46,080 to 48,775	180 days	Mon 28/11/16	Fri 04/08/17
220	**Kundi to Murthal Deck Completed**	0 days	Fri 04/08/17	Fri 04/08/17
221	Ch 48,805 to 52,070	218 days	Thu 21/01/16	Fri 18/11/16
222	Ch 52,100 to 55,370	218 days	Thu 21/01/16	Fri 18/11/16
223	Ch 55,400 to 58,670	218 days	Thu 21/01/16	Fri 18/11/16
224	Ch 58,700 to 62,000	220 days	Thu 21/01/16	Tue 22/11/16
225	Ch 62,030 to 65,300	218 days	Thu 21/01/16	Fri 18/11/16
226	Ch 65,330 to 68,400	205 days	Thu 21/01/16	Tue 01/11/16
227	Ch 68,430 to 70,640	148 days	Thu 21/01/16	Mon 15/08/16
228	Ch 70,670 to 72,850	146 days	Tue 16/08/16	Mon 06/03/17
229	**Murthal to Samalkha Deck Completed**	0 days	Mon 06/03/17	Mon 06/03/17
230	Ch 72,850 to 76,140	220 days	Thu 21/01/16	Tue 22/11/16
231	Ch 76,170 to 79,460	220 days	Thu 21/01/16	Tue 22/11/16
232	Ch 79,490 to 82,780	220 days	Thu 21/01/16	Tue 22/11/16
233	Ch 82,810 to 86,010	214 days	Thu 21/01/16	Mon 14/11/16
234	Ch 86,040 to 87,600	104 days	Fri 08/07/16	Tue 29/11/16
235	Ch 87,630 to 90,645	201 days	Thu 21/01/16	Wed 26/10/16
236	Ch 90,675 to 93,660	199 days	Thu 21/01/16	Mon 24/10/16
237	Ch 93,690 to 93,810	8 days	Tue 25/10/16	Thu 03/11/16
238	Ch 93,840 to 95,910	138 days	Thu 21/01/16	Mon 01/08/16
239	Ch 95,940 to 97,980	136 days	Tue 02/08/16	Mon 06/02/17
240	**Main Line Deck Completed**	0 days	Mon 06/02/17	Mon 06/02/17
241	Branch Ch 0 to 510	34 days	Tue 16/02/16	Fri 01/04/16
242	Branch Ch 540 to 2,190	110 days	Thu 21/01/16	Wed 22/06/16
243	Branch Ch 540 to 2,190 (High)	110 days	Thu 23/06/16	Tue 22/11/16
244	Branch Ch 2,220 to 5,550	222 days	Tue 13/09/16	Tue 18/07/17
245				
246	**Station Construction (including pause whilst deck erection takes place through the station)**	**450 days**	**Thu 28/01/16**	**Tue 17/10/17**
247	Kashmere Gate	250 days	Thu 14/07/16	Tue 27/06/17
248	Mukarba Chowk	300 days	Thu 28/01/16	Tue 21/03/17
249	Narela	250 days	Thu 16/06/16	Tue 30/05/17
250	Kundi - Delhi Border	250 days	Wed 02/11/16	Tue 17/10/17
251	KMP Interchange	300 days	Thu 28/01/16	Tue 21/03/17
252	Rajiv Gandhi Educational City	250 days	Thu 16/06/16	Tue 30/05/17
253	Murthal	250 days	Wed 02/11/16	Tue 17/10/17
254	Ganaur Terminus	250 days	Thu 28/01/16	Tue 10/01/17
255	Ganaur	250 days	Thu 16/06/16	Tue 30/05/17
256	Samalkha	250 days	Wed 02/11/16	Tue 17/10/17



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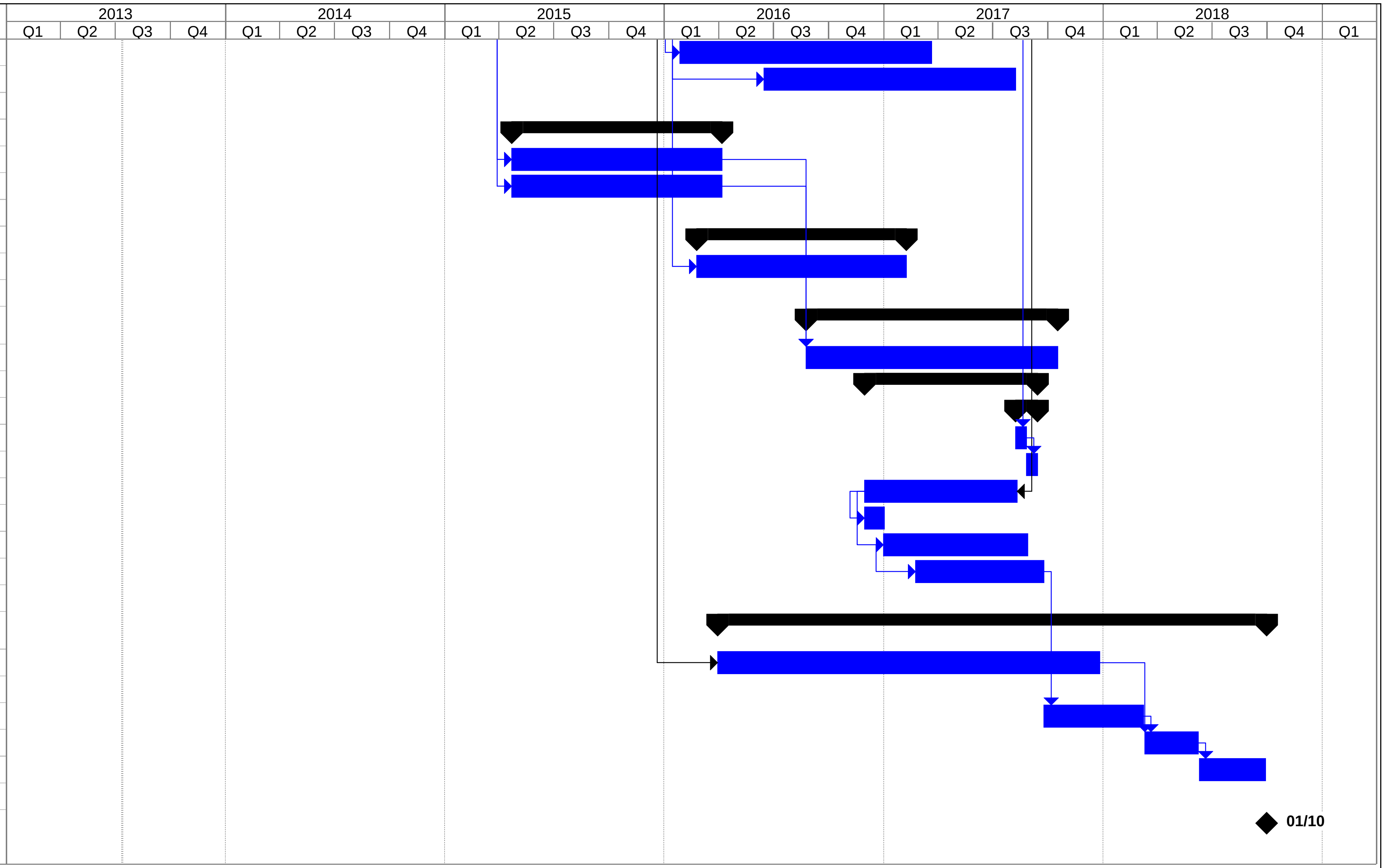
ID		Task Name	Duration	Start	Finish
257		Panipat	300 days	Thu 28/01/16	Tue 21/03/17
258		IOCL Panipat	300 days	Thu 16/06/16	Tue 08/08/17
259					
260		**Depot Construction**	**250 days**	**Thu 23/04/15**	**Wed 06/04/16**
261		Intermediate Depot	250 days	Thu 23/04/15	Wed 06/04/16
262		Main Depot	250 days	Thu 23/04/15	Wed 06/04/16
263					
264		**M&E**	**250 days**	**Thu 25/02/16**	**Tue 07/02/17**
265		Fit Out	250 days	Thu 25/02/16	Tue 07/02/17
266					
267		**Rolling Stock and Permanent Way**	**300 days**	**Thu 25/08/16**	**Tue 17/10/17**
268		Deliver Trains	300 days	Thu 25/08/16	Tue 17/10/17
269		**Track Laying**	**206 days**	**Wed 30/11/16**	**Thu 14/09/17**
270		**Tunnel**	**26.13 days**	**Tue 08/08/17**	**Thu 14/09/17**
271		North Bound Bore	55 days	Tue 08/08/17	Sun 27/08/17
272		South Bound Bore	55 days	Sun 27/08/17	Thu 14/09/17
273		Viaduct	762 days	Wed 30/11/16	Fri 11/08/17
274		At grade	23 days	Wed 30/11/16	Mon 02/01/17
275		OHLE	720 days	Sun 01/01/17	Tue 29/08/17
276		Signalling	640 days	Thu 23/02/17	Sun 24/09/17
277					
278		**Testing and Commissioning**	**653 days?**	**Thu 31/03/16**	**Mon 01/10/18**
279		Railway Fit Out	455 days	Thu 31/03/16	Tue 26/12/17
280					
281		Sub-System Testing	120 days	Mon 25/09/17	Fri 09/03/18
282		Integration Testing	65 days	Mon 12/03/18	Fri 08/06/18
283		Trial Running	80 days	Mon 11/06/18	Fri 28/09/18
284					
285		Commercial Operating Date (COD) (Opening of Railway)	0 days?	Mon 01/10/18	Mon 01/10/18



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Task | Split | Milestone | Summary | Project Summary | External Tasks | External Milestone | Progress | Deadline