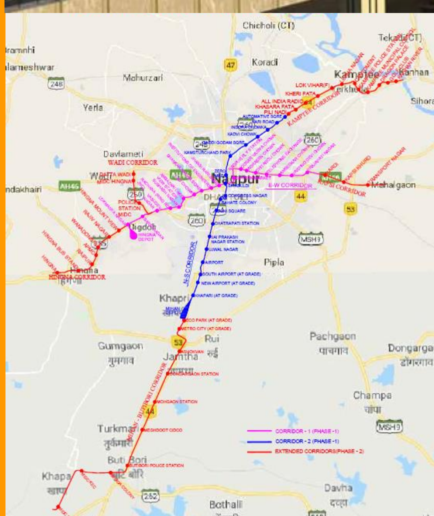
MAHARASHTRA METRO RAIL CORPORATION LIMITED

DETAILED PROJECT REPORT
FOR
EXTENSION OF NAGPUR METRO RAIL PHASE 2



JULY 2018

(A Government of India Enterprise)

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SALIENT FEATURES

1. **GAUGE (STANDARD)** : 1435MM

2. **DESIGN SPEED** : 90 KMPH

3. **CORRIDORS AND ROUTE LENGTH**

Corridor	Phase-I						Phase-II			Grand Total
	As per DPR (A)			As per Execution (B)			DPR (C)			
	Elevated	At Grade	Total (B)	Elevated	At Grade	Total (B)	Elevated	At Grade	Total (C)	(B+C)
Kanhan River to MIDC ESR (NS Corridor)	15.06	4.60	19.66	15.39	5.15	20.54*	30.45	1.25	31.70	**52.24**
Transport Nagar to Hingna (EW Corridor)	18.56	-	18.56	19.41	-	19.41#	12.10	-	12.10	**31.51**
Wadi Corridor	-	-	-	-	-	-	4.49	-	4.49	**4.49**
Total	**33.62**	**4.60**	**38.22**	**34.80**	**5.15**	**39.95**	**47.04**	**1.25**	**48.29**	**88.24**

**Increase in Length due to change in Alignment near Central Jail*

 # Increase in Length due to additional depot connection (entry/exit)

4. **NUMBER OF STATIONS**

Corridor	Phase I		Total (A)	Phase II		Total (B)	Grand Total (A+B)
	Elevated	At Grade		Elevated	At Grade		
Kanhan River to MIDC ESR(NS Corridor)	15	3	18	20	2	22	40
Transport Nagar to Hingna (EW Corridor)	20	-	20	10	-	10	30
Wadi Corridor	-	-	-	3	-	3	3
Total	**35**	**3**	**38**	**33**	**2**	**35**	**73**

5. **TRAFFIC FORECAST (RIDERSHIP PHASE 1 + PHASE 2)**

Phase	Corridor Details	Maximum PHPDT		
		2024	**2031**	**2041**
1	Automotive Square to MIHAN	12,952	13,407	15,743
	Prajapati Nagar to Lokmanya Nagar	10,195	11,411	16,889
2	1A - MIHAN to MIDC ESR	3,501	4,387	5,695
	2A - Automotive Square to Kanhan River	9,012	9,546	11,445
	3A - Lokmanya Nagar to Hingna	3,462	3,887	5,137
	4A - Prajapati Nagar to Transport Nagar	3,511	3,858	5,213
	5 - Vasudev Nagar to Dattawadi	3,806	4,862	5,835

S.No.	Corridor	Daily Ridership (Lakh)		
		2024	**2031**	**2041**
1	Kanhan River - Automotive Square – MIHAN - MIDC ESR	2.61	3.00	3.73
2	Transport Nagar - Prajapati Nagar - Lokmanya Nagar – Hingna	2.58	2.98	3.62
3	Vasudev Nagar - Dattawadi	0.30	0.35	0.39
	Total Trips	**5.49**	**6.33**	**7.75**
	Daily Total Interchange Trips	1.31	1.54	1.83
	Total Boarding	**6.80**	**7.87**	**9.58**

Incremental Daily Ridership due to Phase 2

Horizon Year	Daily Passenger Trips		
	Phase 1 as per DPR prepared by DMRC, 2013	**Full Network (Ph 1 & Ph 2) as per RITES Model**	**Incremental ridership on Ph 1 due to Ph 2 Extensions**
2024	259,892	549,389	289,497
2031	294,241	632,894	338,653
2041	366,121	774,614	408,493

6. TRAIN OPERATION PLAN

Train Operation/ Corridors	Items		Year		
			2024	**2031**	**2041**
N-S Corridor					
Kanhan River to MIDC ESR	Cars/ Train		3	3	3
	Headway (Sec.)		900	900	600
	Trains/hr		4	4	6
	Capacity Provided	3064	3064	4596	4596
		3900	3900	5850	5850
	PHPDT Demand		3246	3921	5126
Kamptee Police Station to Ashokvan	Cars/ Train		3	3	3
	Headway (Sec.)		360	360	327
	Trains/hr		10	10	11
	Capacity Provided	7660	7660	8426	8426
		9750	9750	10725	10725
	PHPDT Demand		12952	13407	15743
E-W Corridor					
Transport Nagar to Hingna	Cars/ Train		3	3	3
	Headway (Sec.)		900	900	900
	Trains/hr		4	4	4
	Capacity Provided	3064	3064	3064	3064
		3900	3900	3900	3900
	PHPDT Demand		1063	3032	3571
Transport Nagar to Dattawadi	Cars/ Train		3	3	3
	Headway (Sec.)		900	720	600

Train Operation/ Corridors	Items		Year		
			2024	2031	2041
	Trains/hr		4	5	6
	Capacity Provided	3064	3830	4596	4596
		3900	4875	5850	5850
	PHPDT Demand		3806	4862	5835
Transport Nagar to Hingna Mount View	Cars/ Train		3	3	3
	Headway (Sec.)		1200	900	450
	Trains/hr		3	4	8
	Capacity Provided	2298	3064	6128	6128
		2925	3900	7800	7800
	PHPDT Demand		10195	11411	16889

A) Train Frequency

North –South Corridor (Including Phase 2 Extensions)

Sections	2024		2031		2041	
	Peak Hour h/w	Lean Hour h/w	Peak Hour h/w	Lean Hour h/w	Peak Hour h/w	Lean Hour h/w
Kanhan River to MIDC ESR	15 min	20 to 30 min	15 min	20 to 30 min	10 min	12 to 30 min
Kamptee Police Station to Ashokvan	6 min	8 to 30 min	6 min	7.5 to 30 min	5.5 min	6.7 to 30 min

East-West Corridor (Including Phase 2 Extensions)

Sections	2024		2031		2041	
	Peak Hour h/w	Lean Hour h/w	Peak Hour h/w	Lean Hour h/w	Peak Hour h/w	Lean Hour h/w
Transport Nagar to Hingna	15 min	20 to 30 min	15 min	20 to 30 min	15 min	20 to 30 min
Transport Nagar to Dattawadi	15 min	20 to 30 min	12 min	15 to 30 min	10 min	12 to 30 min
Transport Nagar to Hingna Mount View	20 min	20 to 30 min	15 min	20 to 30 min	7.5 min	10 to 30 min

B) Rake Requirement (Phase 1)

Corridor	Year	No. of Rakes	Rake Consist	No. of cars
North - South Corridor	2024	21	3 car	63
	2031	22	3 car	66
	2041	25	3 car	75

Corridor	Year	No. of Rakes	Rake Consist	No. of cars
East - West Corridor	2024	16	3 car	48
	2031	18	3 car	54
	2041	25	3 car	75

C) Rake Requirement (Phase 1 + Phase 2)

Corridor	Year	No. of Rakes	Rake Consist	No. of cars
North - South Corridor (Phase 1+ Phase 2 Extension)	2024	35	3 car	105
	2031	36	3 car	108
	2041	45	3 car	135
East - West Corridor (Phase 1+ Phase 2 Extension)	2024	20	3 car	60
	2031	25	3 car	75
	2041	35	3 car	105

D) Incremental Rake Requirement

Corridor	Year	No. of Rakes	Rake Consist	No. of cars
Phase 2 Extension (North - South Corridor)	2024	14	3 car	42
	2031	14	3 car	42
	2041	20	3 car	60
Phase 2 Extension (East - West Corridor)	2024	4	3 car	12
	2031	7	3 car	21
	2041	10	3 car	30

7. POWER SUPPLY & TRACTION

a) Voltage : 25kV AC OHE

b) Current Collection : Overhead Current Collection System

c) SCADA System : Provided

d) Sub Stations

RSS for Metro System		Feeding Zone
Phase 1	Morris College Ground RSS near Sitabuldi Station (132/33/25 kV)	N-S Corridor (MIDC ESR to Sitabuldi Station)
New proposed	Kanhan River RSS (132/33/25 kV)	N-S Corridor (Sitabuldi to Kanhan River Station)

RSS for Metro System		Feeding Zone
Phase 1	Jhansi Rani RSS beside Jhansi Rani Station (132/33/25 kV)	E-W Corridor (including Phase 2 extension)

POWER DEMAND ESTIMATION (MVA)

A) Phase 1

Corridor		Year		
		2024	**2031**	**2041**
North - South Corridor	Traction	7.89	8.59	9.75
	Auxiliary	5.48	6.88	8.17
	Total	**13.37**	**15.47**	**17.92**
East - West Corridor	Traction	6.69	7.37	9.79
	Auxiliary	5.83	7.35	8.75
	Total	**12.52**	**14.72**	**18.54**

B) Phase 1 + Phase 2

Corridor		Year		
		2024	**2031**	**2041**
North - South Corridor (Phase 1+ Phase 2 Extension)	Traction	14.10	14.34	17.59
	Auxiliary	9.33	12.02	14.58
	Total	**23.43**	**26.36**	**32.17**
East - West Corridor (Phase 1+ Phase 2 Extension)	Traction	8.44	9.75	12.65
	Auxiliary	8.11	10.38	12.54
	Total	**16.55**	**20.13**	**25.19**

C) Incremental Power Demand

Corridor		Year		
		2024	**2031**	**2041**
Phase 2 Extension (North - South Corridor)	Traction	6.21	5.75	7.84
	Auxiliary	3.85	5.13	6.42
	Total	10.06	10.88	14.26
Phase 2 Extension (East - West Corridor)	Traction	1.74	2.39	2.85
	Auxiliary	2.28	3.03	3.79
	Total	4.02	5.42	6.64

8. ROLLING STOCK

A) Broad Features of Rolling Stock

S. No.	Parameter	Corridor
1	Basic Unit	3 Car basic unit 2 DMC and 1 TC Every coach should be fully interchangeable with

S. No.	Parameter	Corridor
		any other coach of same type.
2	Train Composition	3 Car: DMC+TC+DMC
3	Sitting Arrangement	Longitudinal
4	Coach construction	Light weight stainless steel/ Aluminum body
5	Axle load	≤16 T
6	Braking System	Regenerative Braking
7	Propulsion system	3 phase drive system with VVVF control
8	Type of traction supply	25 kV AC OHE System

DMC – Driving Motor Car, TC – Trailer Car

B) Coach Dimensions

Type of Coach	Length	Width	Height
Driving Motor Car (DMC)	21.64 m	2.9 m	3.9 m
Trailer car (TC)	21.34 m	2.9 m	3.9 m

*Maximum length of coach over couplers/buffers = 22.6 m

C) Carrying Capacity

Description	Driving Motor Car (DMC)			Trailer Car (TC)			3 Car Train		
	Normal	Crush	Dense Crush	Normal	Crush	Dense Crush	Normal	Crush	Dense Crush
Seated	43	43	43	50	50	50	136	136	136
Standing	137	205	273	147	220	293	421	630	839
Total	180	248	316	197	270	343	557	766	975

Normal - 4 Per/ Sqm of standee area, **Crush** - 6 Per/ Sqm of standee area, **Dense Crush** - 8 Per/ Sqm of standee area

D) Speed

a) Design Speed : 90 Kmph
b) Max. Operational Speed : 80 Kmph
c) Schedule Speed : 34 Kmph
d) Max. Acceleration : 1.0 m/s^2
e) Max. Deceleration : 1.1 m/s^2

9. DEPOTS

a) Maintenance Depot for N-S Corridor: MIHAN Depot
b) Maintenance Depot for E-W Corridor: Hingna Depot

10. SIGNALLING & TELECOMMUNICATION

a) Type of Signaling: The Communication based Train Control (CBTC) signaling system provides adequate safety level of CENELEC SIL-4 (Safety Integrity Level) and permits an operational headway of 90 seconds with continuous automatic train control.

b) Telecommunication: Integrated IPGE based System.

11. FARE COLLECTION

Automatic Fare Collection System with the features of recharging of Travel Cards using Cash, Debit/Credit Cards and Net-banking/web portal etc.

12. CONSTRUCTION METHODOLOGY

Viaduct: Pre-stressed concrete "Box" shaped Girders/Double U-Girder on Single pier with pile / Open foundations.

13. ENVIRONMENTAL AND SOCIAL IMPACT

Estimated cost of Environmental Management Plan and Environmental Monitoring (both during construction and operation) is Rs **13.08 Crore.**

Resettlement and Rehabilitation cost are calculated as **12.46 Crore** for Phase II corridors.

A) Summary of trees to be cut

Sr	Name of Alignment	Alignment	Stations	Parking
1	Automotive Square To Kanhan River	15	462	38
2	Prajapati Nagar To Transport Nagar	0	11	0
3	Vasudev Nagar To Dattawadi	58	60	01
4	Lokamanya Nagar To Hingna	14	31	0
5	Mihan to MIDC ESR-I	383	34	01
Total		**470**	**598**	**40**

B) Summary of Affected Structures and PAFs

Name of Corridor	Affected Structures	Total PAFs	Total PAPs*	Average family size
Mihan to MIDC ESR	7	8	37	4.6
Automotive Square to Kanhan River	20	17	63	3.7
Lokmanya Nagar to Hingna	18	27	185	6.9
Prajapati Nagar to Transport Nagar	5	5	22	4.4
Vasudev Nagar to Dattawadi	11	25	144	5.8
Total	**61**	**82**	**451**	**5.5**

14. PROJECT COST

A. Total Completion Cost (Rs.in Crore)

Completion Cost	Amount
Cost without taxes & Land & R&R	9490
Cost With Central Taxes and without Land & R&R	10288
Cost with all taxes and Land & R&R*	11216

*Additional Rs 23 Crore is towards IDC

B. Corridor wise Capital Cost (April 18 prices) (Rs.in Crore)

Corridor No.	Corridor Description	Cost Estimate with Land Cost and Central Taxes (Crore)	Cost Estimate with Land Cost and State & Central Taxes (Crore)
1A	MIHAN to MIDC ESR	2917.30	3103.28
2A	Automotive Square to Kanhan River	2743.99	2925.19
3A	Prajapati Nagar to Transport Nagar	1378.28	1466.17
4A	Lokmanya Nagar to Hingna	905.25	962.87
5	Vasudev Nagar to Dattawadi	812.97	865.39
Total		**8757.78**	**9322.90**

C. Funding Pattern

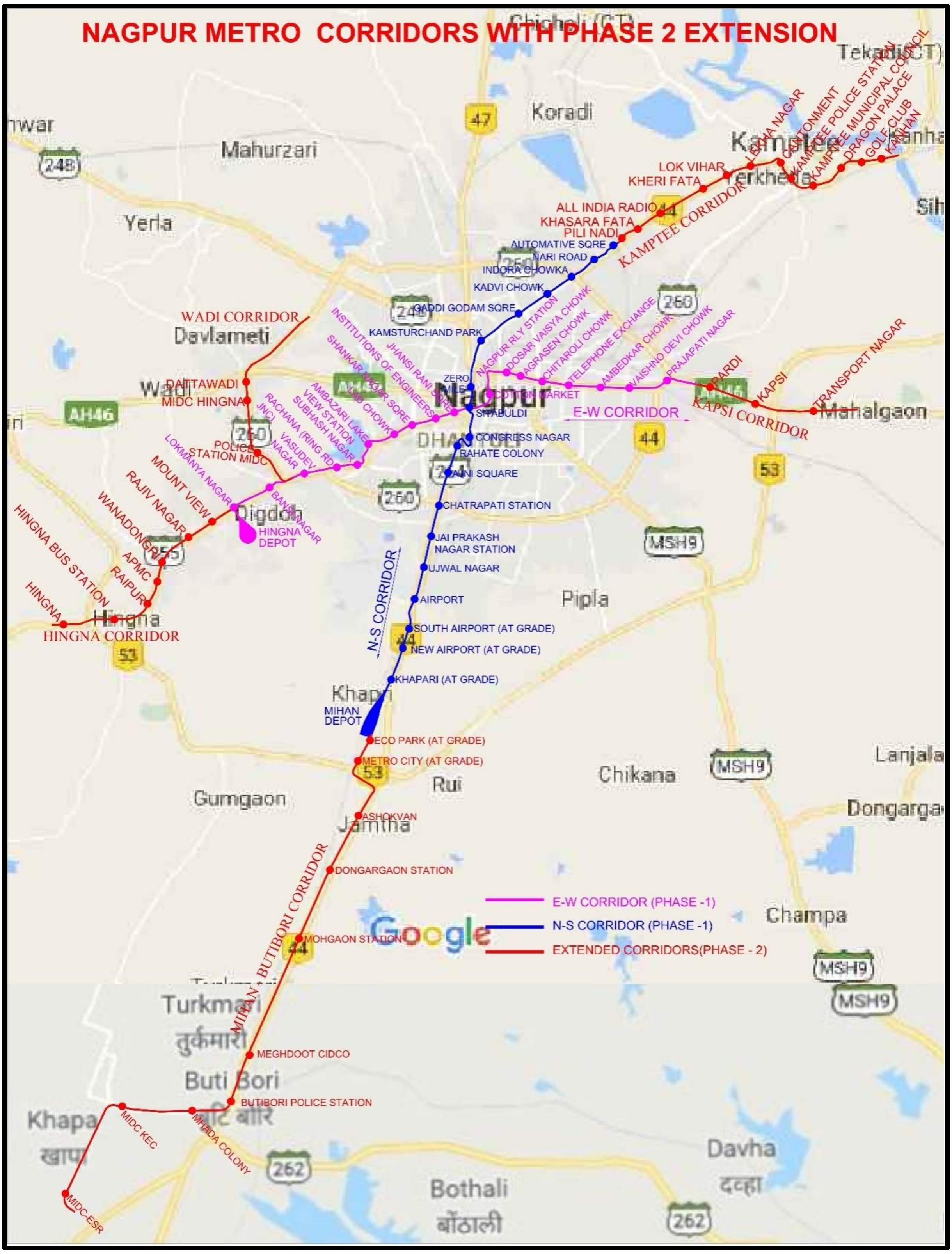
Particulars	Amount (Rs in Cr)	% Share
Equity by GoI	1658	16.12%
Equity by GoM	1658	16.12%
SD for CT by GoI	399	3.88%
SD for CT by GoM	399	3.88%
Grant by MADC	194	1.88%
Soft Loans	5980	58.12%
Total	**10288**	**100%**
Grant by MIDC for Land and R&R	246	
Grant by MIDC towards State Taxes	315	
Grant by MADC towards State Taxes	367	
IDC by State Government for JICA Step Loan @0.1% &Front End Fee @0.2%	23	
Total Cost	**11239**	-

SD: Subordinate Debt, CT: Central Taxes, IDC: Interest During Construction

15. FINANCIAL INDICES

Sr. No.	Indices	Values
1	EIRR	14.40%
2	FIRR	7.72%

Key-plan of Nagpur Metro Rail Project showing Phase 2 & Phase 1



EXECUTIVE SUMMARY

EXECUTIVE SUMMARY

0.1 PROFILE OF THE CITY

Nagpur, the Orange city of India, is third largest city in Maharashtra and second capital of the State. It is the seat of annual winter session of the Maharashtra State Vidhan Sabha. It is a major commercial and political centre of the Vidarbha region of Maharashtra.

Based on the proposals from Comprehensive Mobility Plan (CMP), an Alternative Analysis has been carried out to identify the most viable mass transit system along identified major travel corridors. Alternatives Analysis Report recommends extension of mass transit corridors of Phase 1 in order to meet the future traffic demand. Nationally and globally it is seen that the metro network expands progressively to cover entire city. Hence, it is essential that in Nagpur also, such expansion of Metro Rail network is taken up in time, so that before fully commissioning of Phase 1, Phase 2 construction is commenced. Maha Metro has engaged RITES Ltd. to prepare a 'Detailed Project Report (DPR) for Extension of Nagpur Metro Rail System Phase 2'.

The Study Area comprise of about 1550 sq km out of total NMA area of 3567sq km. **Figure 0.1** shows that the majority of population of the study area resides within NMC area.

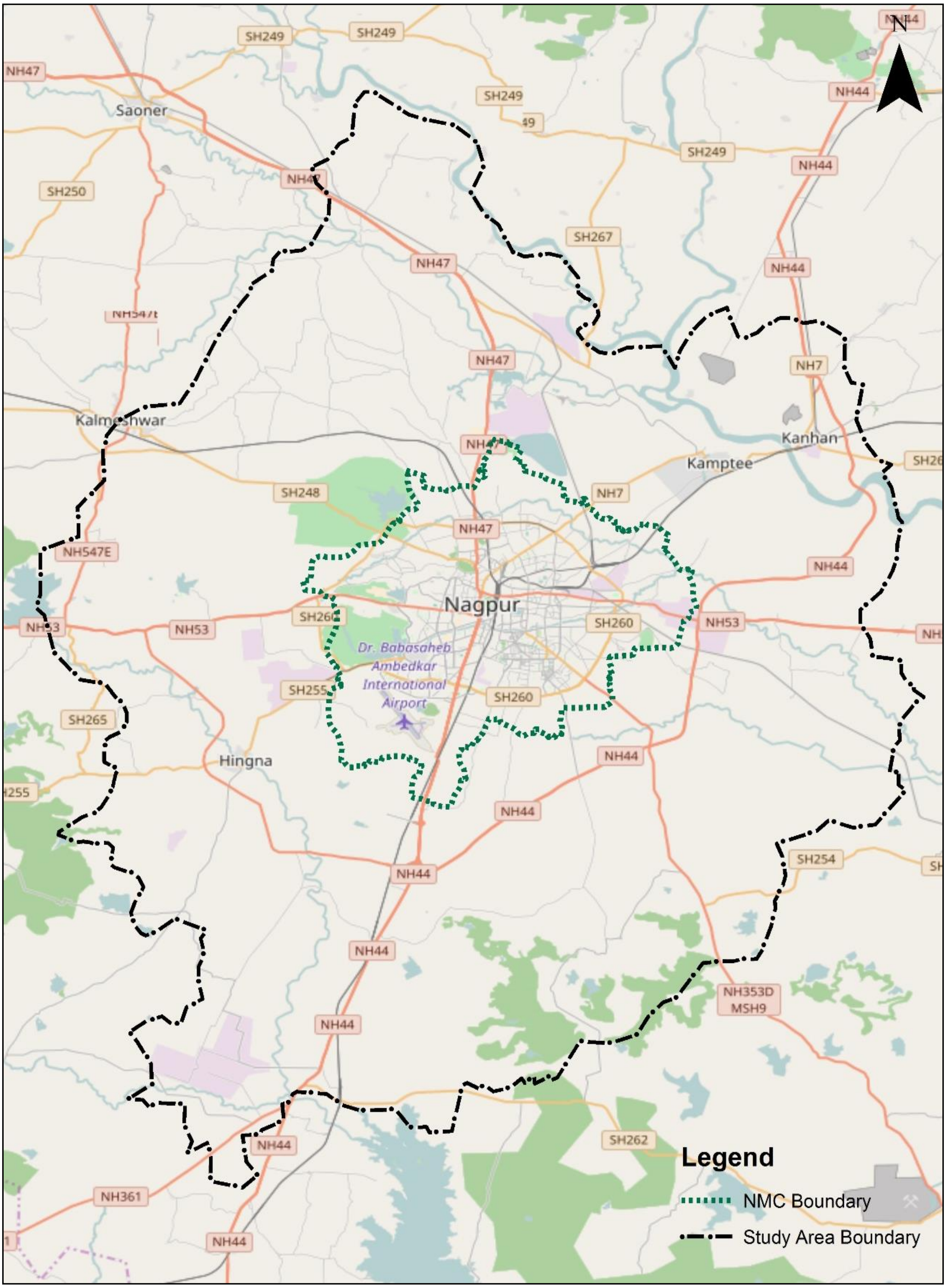
0.2 EXISTING TRANSPORT SYSTEM

0.2.1. About 22% of the total surveyed road network (767 kms) has less than 20 m ROW, and about 19% of the road has ROW more than 40 m. 20% of the road network has footpath available along the road. Average Journey Speed during peak and off-peak period for City as a whole is observed to be 23.4 kmph and 27.1 kmph respectively. The journey speed observed is about 19 kmph in core area, 34 kmph in outer area during peak hours.

0.2.2. Study area is served majorly by 5 railway stations and 8 major bus terminals in the City which provide connectivity to major cities.

0.2.3. The present intra city bus system comprises of about 350 buses operating on nearly 97 routes. The supply of buses per lakh populations is only ten buses which is inadequate for satisfying the current travel demand.

FIGURE 0.1: STUDY AREA MAP



0.3 TRAVEL CHARACTERISTICS AND DEMAND

0.3.1. A total of 182 internal zones inside study area and 12 external zones have been considered for the Study. The projected population, employment in the years 2021, 2031 and 2041 is presented in the **Table 0.1.**

TABLE 0.1: STUDY AREA POPULATION FORECAST FOR HORIZON YEARS

S.No.	Area	Population (Lakh)			
		2018	2021	2031	2041
1	Nagpur Municipal Corporation	26.5	27.6	31.1	34.8
2	Other than NMC Areas Including Kamptee, Kalmeshwar, Hingna and surrounding villages	7.8	8.6	12.3	15.5
	Total	**34.3**	**36.2**	**43.4**	**50.3**

0.3.2. A four stage travel demand model has been developed for transport demand forecasting. The maximum peak hour peak direction trips (PHPDT) and the daily ridership for horizon years 2024, 2031 and 2041 are shown in the Table 0.2 and Table 0.3 respectively.

TABLE 0.2: MAXIMUM PHPDT ON PHASE 1 & 2 NAGPUR METRO CORRIDORS

Phase	Corridor Details	Maximum PHPDT		
		2024	2031	2041
1	Automotive Square to MIHAN	12,952	13,407	15,743
	Prajapati Nagar to Lokmanya Nagar	10,195	11,411	16,889
2	1A - MIHAN to MIDC ESR	3,501	4,387	5,695
	2A - Automotive Square to Kanhan River	9,012	9,546	11,445
	3A - Lokmanya Nagar to Hingna	3,462	3,887	5,137
	4A - Prajapati Nagar to Transport Nagar	3,511	3,858	5,213
	5 - Vasudev Nagar to Dattawadi	3,806	4,862	5,835

TABLE 0.3: DAILY RIDERSHIP IN NAGPUR PHASE 1 & 2 METRO CORRIDORS

S. No.	Corridor	Daily Ridership (Lakh)		
		2024	2031	2041
1	Kanhan River - Automotive Square – MIHAN - MIDC ESR	2.61	3.00	3.73
2	Transport Nagar - Prajapati Nagar - Lokmanya Nagar – Hingna	2.58	2.98	3.62
3	Vasudev Nagar – Dattawadi	0.30	0.35	0.39
	Total Trips	**5.49**	**6.33**	**7.75**
	Daily Total Interchange Trips	1.31	1.54	1.83
	Total Boarding	**6.80**	**7.87**	**9.58**

TABLE 0.4: INCREMENTAL DAILY RIDERSHIP DUE TO PHASE 2

Horizon Year	Daily Passenger Trips		
	Phase 1 as per DPR prepared by DMRC, 2013	Full Network (Ph 1 & Ph 2) as per RITES Model	Incremental ridership on Ph 1 due to Ph 2 Extensions
2024	259892	549389	289497
2031	294241	632,894	338653
2041	366121	774,614	408493

0.4 SYSTEM & TECHNOLOGY SELECTION

The urban transport requirements of Nagpur City have been evaluated based on projected traffic demand. Considering the city specific characteristics, traffic demand, availability of right of way, Medium Capacity Metro rail system with 3 car train composition, which can cater to design capacity of about 17000 PHPDT, is proposed to be adopted for Nagpur Metro Phase 2.

0.5 CIVIL ENGINEERING & ALIGNMENT DETAILS

0.5.1. Geometric Design Parameters

TABLE 0.5: DESIGN CRITERIA

S. No.	Criteria	Dimension
1	Gauge	1435 mm
2	Design Speed	90 Kmph
3	Maximum Operational Speed	80 Kmph
4	Maximum Axle Load	16T
5	Electric Power Collection	25 KV AC (OHE)

TABLE 0.6: HORIZONTAL CURVE PARAMETERS

Description	Elevated Section
Desirable Minimum Radius	200 m
Absolute minimum Radius	120 m
Minimum curve radius at stations	1000 m
Maximum permissible cant (Ca)	110 mm*
Maximum cant deficiency (Cd)	85 mm

* The applied cant will be decided in relation to normal operating speeds at specific locations like stations/vicinity to stations.

TABLE 0.7: TRACK CENTRE AND HEIGHT IN ELEVATED SECTION

Parameter	Minimum Track Centre	Minimum Rail Level above Ground Level
Mid-Section	4.10 m	9.50 m
Station w/o Scissor Cross-over	4.10 m	13.50 m
Station with Scissor Cross-over	4.50 m	13.50 m

TABLE 0.8: GRADIENT PARAMETERS

Description	Desirable	Absolute Minimum
Gradient at Mid-Section	Upto 2%	Upto 4% (compensated)
Gradient at Stations	Level	Upto 0.25%

TABLE 0.9: VERTICAL CURVE PARAMETERS

Parameter	Vertical Curve
Desirable Radius on Main line	2500 m
Absolute Minimum Radius on Main line	1500 m
Minimum Length of Vertical Curve	20 m

0.5.2. Engineering Survey

Topographical Surveys for all the five corridors were conducted based on differential GPS.

0.5.3. Geotechnical Investigations

In total, 55 BHs were drilled for 30 m depth each, all along the length of proposed Metro corridors. 22 BHs in Corridor-1A (MIHAN – MIDC ESR), 13 BHs were drilled in Corridor-2A (Automotive Square - Kanhan River), 9 BHs in Corridor-3A (Lokmanya Nagar - Hingna), 6 BHs in Corridor-4A (Prajapati Nagar to Transport Nagar) & 5 BHs in Corridor-5 (Vasudev Nagar to Dattawadi).

0.5.4. Alignment Description

Corridor-1A: MIHAN – MIDC ESR (Table 0.10).

TABLE 0.10: ALIGNMENT DESCRIPTION OF CORRIDOR-1A

Description	Station	Chainage (m)	Intermediate Distance (m)
Start Point		20200	--
Stations	ECO Park (at-grade)	20462	62
	Metro City (at-grade)	21058	596
	Ashokvan	23843	2593
	Dongargaon	26693	2850
	Mohgaon	29878	3185
	Meghdoot CIDCO	32802	2924
	Butibori Police Station	33540	738
	MHADA Colony	34233	693
	MIDC KEC	37360	3127
	MIDC ESR	38352	992
Terminal Point		38852	500
Total		**18652 m**	

The total length of Corridor-1A is about 18.768 Km, out of which 1.25 Km is at-grade and 17.518m elevated.

Total 10 stations have been proposed in Corridor-1A out of which 2 stations are proposed as at-grade & 8 stations are proposed as elevated.

TABLE 0.11: ABSTRACT OF HORIZONTAL CURVES – CORRIDOR 1A

S.No.	Curve Radius	No. of Occurrences	Length	Percentage
1	≤150	3	824.68	16.72
2	>150 <300	3	938.15	19.02
3	≥300 ≤ 500	3	543.34	11.02

S.No.	Curve Radius	No. of Occurrences	Length	Percentage
4	>500 ≤ 800	2	283.32	5.75
5	>800 ≤ 1000	5	746.97	15.15
6	>1000	13	1594.84	32.34
	Total	**29**	**4931.30**	**100.00**

TABLE 0.12: ABSTRACT OF GRADIENTS – CORRIDOR 1A

S. No.	Description	No. of Occurrences	Length (m)	Percentage
1	Level (0%)	17	9341.26	50.63
2	>0% to 1%	10	4849.95	26.28
3	>1% to 2%	10	4023.92	21.81
4	>2% to 3%	0	0.00	0.00
5	>3%	1	236.57	1.28
	Total	**38**	**18452**	**100.00**

Corridor-2A: Automotive Square - Kanhan River (Table 0.13).

TABLE 0.13: ALIGNMENT DESCRIPTION OF CORRIDOR-2A

Description	Station	Chainage (m)	Intermediate Distance (m)
Start Point		-575	-
Stations	Pili Nadi	-1409	909
	Khasara Fata	-2286	877
	All India Radio	-3314	1028
	Khairi Fata	-5250	1936
	Lok Vihar	-6176	926
	Lekha Nagar	-7199	1023
	Cantonment	-8681	1482
	Kamptee Police Station	-9410	729
	Kamptee Municipal Council	-10225	815
	Dragon Palace	-11196	971
	Golf Club	-12468	1272
	Kanhan River	-13324	856
Termination Point		-13500	176
Total		**12925 m**	

The Corridor-2A is proposed as elevated with total length of 12.925 Km and 12 stations.

TABLE 0.14: ABSTRACT OF HORIZONTAL CURVES – CORRIDOR 2A

S. No.	Curve Radius	No. of Occurrences	Length	Percentage
1	≤150	1	272.96	4.95
2	>150 <300	9	1681.92	30.53
3	≥300 ≤ 500	2	333.05	6.05
4	>500 ≤ 800	2	397.76	7.22

S. No.	Curve Radius	No. of Occurrences	Length	Percentage
5	>800 ≤ 1000	2	553.07	10.04
6	>1000	14	2270.65	41.21
	Total	**30**	**5509.40**	**100.00**

TABLE 0.15: ABSTRACT OF GRADIENTS – CORRIDOR 2A

S. No.	Description	No's of Occurrences	Length (m)	Percentage
1	Level (0%)	24	6796.07	52.28
2	>0% to 1%	4	468.55	3.60
3	>1% to 2%	18	4966.82	38.21
4	>2% to 3%	2	768.56	5.91
5	>3%	0	0.00	0.00
	Total	**48**	**13000**	**100.00**

Corridor-3A: Lokmanya Nagar – Hingna (Table 0.16).

TABLE 0.16: ALIGNMENT DESCRIPTION OF CORRIDOR-3A

Description	Station	Chainage (m)	Intermediate Distance (m)
Start Point		18218	--
Stations	Hingna Mountview	18761	543
	Rajiv Nagar	19607	846
	Wanadongri	21006	1399
	APMC	21715	709
	Raipur	22823	1108
	Hingna Bus Station	23625	802
	Hingna	24504	879
Terminal Point		24875	371
Total		**6657 m**	

The Corridor-3A is proposed as elevated with total length of 6.657 Km and 7 stations.

TABLE 0.17: ABSTRACT OF HORIZONTAL CURVES – CORRIDOR 3A

S. No	Curve Radius	No. of Occurrences	Length	Percentage
1	≤150	3	593.78	25.93
2	>150 <300	3	721.62	31.51
3	≥300 ≤ 500	1	179.65	7.85
4	>500 ≤ 800	2	338.10	14.77
5	>800 ≤ 1000	0	0.00	0.00
6	>1000	4	456.72	19.95
	Total	**13**	**2289.87**	**100.00**

TABLE 0.18: ABSTRACT OF GRADIENTS – CORRIDOR 3A

S. No.	Description	Nos. of Occurrences	Length (m)	Percentage
1	Level (0%)	9	3690	55.43
2	>0% to 1%	0	0	0.00
3	>1% to 2%	7	2042	30.68
4	>2% to 3%	2	728	10.94
5	>3%	1	197	2.95
	Total	**19**	**6657**	**100.00**

Corridor-4A: Prajapati Nagar - Transport Nagar (Table 0.19).

TABLE 0.19: ALIGNMENT DESCRIPTION OF CORRIDOR-4A

Description	Station	Chainage (m)	Intermediate Distance (m)
Start Point		-580	--
Stations	Pardi	-1365	965
	Kapsi Khurd	-3200	1835
	Transport Nagar	-5126	1926
Terminal Point		-6021	895
Total		**5441 m**	

The Corridor-4A is proposed as elevated with total length of 5.441 Km and 3 stations.

TABLE 0.20: ABSTRACT OF HORIZONTAL CURVES – CORRIDOR 4A

S. No.	Curve Radius	No. of Occurrences	Length	Percentage
1	≤150	0	0.00	0.00
2	>150 <300	0	0.00	0.00
3	≥300 ≤ 500	3	706.97	46.59
4	>500 ≤ 800	3	514.43	33.90
5	>800 ≤ 1000	0	0.00	0.00
6	>1000	4	295.92	19.50
	Total	**10**	**1517.32**	**100.00**

TABLE 0.21: ABSTRACT OF GRADIENTS – CORRIDOR 4A

S. No.	Description	No's of Occurrences	Length (m)	% Length
1	Level (0%)	5	2700	48.03
2	>0% to 1%	3	943	16.78
3	>1% to 2%	4	1531	27.24
4	>2% to 3%	2	447	7.94
5	>3%	0	0	0.00
	Total	**14**	**5621**	**100.00**

Corridor-5: Vasudev Nagar – Dattawadi (Table 0.22).

TABLE 0.22: ALIGNMENT DESCRIPTION OF CORRIDOR-5

Description	Station	Chainage (m)	Intermediate Distance (m)
Start Point		15600	--
Stations	Police Station MIDC	16838	1238
	MIDC Hingna	19173	2335
	Dattawadi	19831	658
Terminal Point		20089	258
Total		**4489 m**	

The Corridor-5 is proposed as elevated with total length of 4.489 Km and 3 stations.

TABLE 0.23: ABSTRACT OF HORIZONTAL CURVES – CORRIDOR 5

S. No.	Curve Radius	No. of Occurrences	Length	Percentage
1	≤150	1	191.30	16.26
2	>150 <300	4	631.63	53.68
3	≥300 ≤ 500	1	116.13	9.87
4	>500 ≤ 800	0	0.00	0.00
5	>800 ≤ 1000	1	110.11	9.36
6	>1000	2	127.40	10.83
	Total	**9**	**1176.57**	**100.00**

TABLE 0.24: ABSTRACT OF GRADIENTS – CORRIDOR 5

S. No.	Description	No's of Occurrences	Length (m)	Percentage
1	Level (0%)	2	1232.75	27.71
2	>0% to 1%	3	1165.77	26.20
3	>1% to 2%	4	1720.29	38.67
4	>2% to 3%	1	330.02	7.42
5	>3%	0	0.00	0.00
	Total	**10**	**4449**	**100.00**

0.5.6 Land Requirement

Land will be required for the following main components of MRTS;

- MRTS Structure (including Route Alignment), Station Building, Platforms, Entry/Exit Structures, Traffic Integration Facilities, Depots, etc.
- Receiving/Traction Sub-stations
- Radio Towers
- Temporary Construction Depots and work sites.

Abstract of land requirements for different components of corridors are given in **Table 0.25**.

TABLE 0.25: LAND & STRUCTURES REQUIREMENT (IN HA): CORRIDOR I – V

Ownership	Purpose	Permanent Land (In HA)	Temporary Land (In HA)	Structures (Floor area) (In HA)
Central Govt	Alignment / Stations, ancillary building, Misc., etc	0.6175	0	0
	Parking cum PD	0.6397	0	0
	Total	**1.2572**	**0**	**0**
State Govt	Alignment / Stations, ancillary building, Misc., etc	0.8552	0	0.088
	Parking cum PD	0.9154	0	0
	Casting Yard (Approx.)	0	50	0
	Total	**1.7706**	**50**	**0.088**
Private	Alignment / Stations, ancillary	6.9708	0	0.6803

Ownership	Purpose	Permanent Land (In HA)	Temporary Land (In HA)	Structures (Floor area) (In HA)
	building, Misc., etc			
	Parking cum PD	0.2467	0	0
	Total	**7.2175**	**0**	**0.6803**
Grand Total		**10.2453**	**50**	**0.7683**

0.6 STATION PLANNING

0.6.1 Station Planning

The stations have been planned on the basis of following parameters:

a. Peak hour traffic load for each station.
b. 3 cars train
c. The total evacuation time for the movement of all passengers in an emergency from platform level to the landing at the point of safety does not exceed 4.0 minutes (as per "NFPA 130 Guidelines").
d. The station planning is in compliance to the "Guidelines and space Standards for Barrier Free Built Environment for Disabled and Elderly persons" published by the Ministry of Urban Affairs and Employment India in 1998.

A typical design has been suggested (**Table 0.26**) and this will form basis for planning of all the stations (**Table 0.27**).

TABLE 0.26: TYPICAL DESIGN

Sr. No.	Proposed Type	Elevated/UG	Remarks
1	Type 1	Elevated	79.00m x 20.85m

TABLE 0.27: INTER-STATION DISTANCE AND TYPE OF PROPOSED STATIONS

Sr. No.	Station Name	Chainages (m)	Inter-station Distance (m)	Cumulative Distance (m)	Elevated/ Underground
Corridor-1A: MIHAN to MIDC ESR					
1	ECO Park Station	20462	-	0	At grade
2	Metro City Station	21057	595	595	At grade
3	Ashokvan	23843	2786	3381	Elevated
4	Dongargaon	26693	2850	6231	Elevated
5	Mohgaon	29878	3185	9416	Elevated
6	Meghdoot CIDCO	32802	2924	12340	Elevated
7	Butibori Police Station	33540	738	13078	Elevated
8	MHADA Colony	34233	693	13771	Elevated
9	MIDC KEC	37360	3127	16898	Elevated
10	MIDC ESR	38352	992	17890	Elevated

Sr. No.	Station Name	Chainages (m)	Inter-station Distance (m)	Cumulative Distance (m)	Elevated/ Underground
Corridor-2A: Automotive Square to Kanhan River					
1	Pili Nadi	-1409	-	0	Elevated
2	Khasara Fata	-2286	877	877	Elevated
3	All India Radio	-3314	1028	1905	Elevated
4	Khairi Fata	-5250	1936	3841	Elevated
5	Lok Vihar	-6176	926	4767	Elevated
6	Lekha Nagar	-7199	1023	5790	Elevated
7	Cantonment	-8681	1482	6850	Elevated
8	Kamptee Police Station	-9410	729	8001	Elevated
9	Kamptee Municipal Council	-10225	815	8816	Elevated
10	Dragon Palace	-11196	971	9787	Elevated
11	Golf Club	-12468	1272	11059	Elevated
12	Kanhan River	-13324	856	11915	Elevated
Corridor-3A: Lokmanya Nagar to Hingna					
1	Hingna Mount View	18761	-	0	Elevated
2	Rajiv Nagar	19607	846	846	Elevated
3	Wanadongri	21006	1399	2245	Elevated
4	APMC	21715	709	2954	Elevated
5	Raipur	22823	1108	4062	Elevated
6	Hingna Bus Station	23625	802	4864	Elevated
7	Hingna	24532	907	5771	Elevated
Corridor-4A: Prajapati Nagar to Transport Nagar					
1	Pardi	-1365	-	0	Elevated
2	Kapsi Khurd	-3200	1835	1835	Elevated
3	Transport Nagar	-5026	1826	3661	Elevated
Corridor-5: Vasudev Nagar to Dattawadi					
1	Police Station MIDC	16831	-	0	Elevated
2	MIDC Hingna	19162	2331	2331	Elevated
3	Dattawadi	19838	676	3007	Elevated

0.6.2 NMV and Pedestrian Facilities

Pedestrian facilities like continuous footpath of 2m wide, demarcation of pick and drop for PT/IPT, Zebra crossing at intersections, table top crossings, relocation of encroachments, strengthen of ROW have been proposed near the station influence area for ease for pedestrian movement. For non motorized vehicles facilities like cycle tracks have been planned on the basis of land availability near the station for seamless movement.

0.6.3 Accessibility for Differently-abled

The Metro Rail system has been planned user-friendly ensuring accessibility to persons with disabilities, people travelling with small children or are carrying luggage, as well as people with temporary mobility problems and the elderly persons. The standards are extracted from 'Guidelines for Pedestrian Facilities' and 'NFPA Guidelines', 'Space Standards for Barrier Free Built Environment for differently-abled and Elderly Persons' etc. Standards for differently-abled facilities within station areas have been provided for seamless movement.

0.6.4 Parking at Stations

Dedicated parking provision for commuters is one of the key factors determining success of the metro system. Parking provisions along with priority to pedestrians through Foot Over Bridges and Bus feeder services have been planned to encourage more commuters to use the metro system who could safely park their vehicles at the nearest station, walk to the station or rely on feeder connectivity. Details of parking provided for different corridors are shown in **Table 0.28.**

TABLE 0.28: DETAILS OF PARKING FOR NAGPUR PH-2 CORRIDORS

Sr. No.	Station/Location	Parking Area in Sqm
Corridor-1A : MIHAN to MIDC ESR		
1	Ashokvan	1312
2	MIDC ESR	1155
Corridor-2A : Automotive Square to Kanhan River		
1	Cantonment	4413
2	Kanhan River	2200
Corridor-3A : Lokmanya Nagar to Hingna		
1	Hingna Mount View	2000
2	Hingna	614
Corridor-4A : Prajapati Nagar to Transport Nagar		
1	Pardi	460
2	Transport Nagar	1800
Corridor-5 : Vasudev Nagar to Dattawadi		
1	Dattawadi	2900

0.7 INTERMODAL INTEGRATION

0.7.1 Intermodal Integration with Existing Modes

The intermodal integration proposals have been formulated for facilitating traffic dispersal and circulation facilities based on the following considerations:

- Minimizing pedestrian/vehicle conflicts and effective passenger interchange with feeder modes.
- Facilitating passenger interchange with other transit systems
- Circulation area with adequate parking space, designated space for embarking and disembarking for vehicular traffic

- Availability of total carriageway and footpath widths required to cater to the proposed traffic volumes and relocation of vendors/hawkers

0.7.2 Feeder Services

The feeder buses have been proposed of high quality, ultra-modern and customer oriented that can deliver fast, comfortable and cost-effective urban mobility. Easy-to-board (low floor), attractive and environmentally friendly buses with air conditioning having capacity of 35 (Mini-buses) are proposed for feeder system.

The facilities of feeder buses have been estimated for peak hours of various horizon years 2024, 2031 and 2041. The total number of buses required are 133, 158 and 193 in the year 2024, 2031 and 2041 respectively. Public bicycle sharing is provided for the passengers for about 2 km of the LRT stations influence area. The total number of public bicycle required in the year 2041 is 884.

The essential features of an integrated multi-modal urban transport system including physical integration of public transport services, fares, ticketing, infrastructure provision, management, pricing, and integration of transport authorities have been proposed.

0.8 TRAIN OPERATION PLAN

The underlying operation philosophy is to provide mass rapid transit services at economical cost with optimal utilization of fixed Infrastructure and rolling stock planning.

- The frequency of train services is optimized to provide sectional capacity commensurate with the peak direction traffic demand during peak hours.
- A minimum train service frequency is provided during lean period so as to keep the option of this service attractive during lean period as well.
- The frequency of services is regulated to meet the growing traffic demand in horizon years.
- Basic unit selected is two motor car and one trailer car.

The train operation plan for the proposed corridors is based on the following salient features:

- Running of services for 19 hours of a day (5:00 hrs to 00:00 hrs) with a station dwell time of 20-30 second.
- Scheduled speed of 34 kmph.

- Make up time of 5% with 8% coasting.
- Adequate services to ensure comfortable journey for commuters even during off peak periods.

The train composition, capacity and headway required for the operation in proposed corridors is given below:

i. Composition

The proposed car composition is given below-

DMC : Driving Motor Coach

TC : Non Driving Trailer Coach

3-Car Rake Composition: ***DMC-TC-DMC***

Driving Motor Coach (DMC): 248 (43 seated + 205 standing) @ 6 passengers/m^2

: 316 (43 seated + 273 standing) @ 8 passengers/m^2

Trailer Coach (TC) : 270 (50 seated + 220 standing) @ 6 passengers/m^2

: 343 (50 seated + 293 standing) @ 8 passengers/m^2

3 Car Train : 766 (136 seated + 630 standing) @ 6 passengers/m^2

: 975 (136 seated + 839 standing) @ 8 passengers/m^2

Every coach shall be fully interchangeable with any other coach of same type.

The train operation plan envisaged for N-S and E-W corridors including Nagpur Metro Phase 2 extensions is given in **Table 0.29** and **Table 0.30.**

TABLE 0.29: TRAIN OPERATION PLAN FOR N-S CORRIDOR

Train Operation/ Corridors	Items		Year		
			2024	2031	2041
Kanhan River to MIDC ESR	Cars/ Train		3	3	3
	Headway (Sec.)		900	900	600
	Trains/hr		4	4	6
	Capacity Provided	@6p/m^2	3064	3064	4596
		@8p/m^2	3900	3900	5850
	PHPDT Demand		3246	3921	5126
Kamptee Police Station to Ashokvan	Cars/ Train		3	3	3
	Headway (Sec.)		360	360	327
	Trains/hr		10	10	11
	Capacity Provided	@6p/m^2	7660	7660	8426
		@8p/m^2	9750	9750	10725
	PHPDT Demand		12952	13407	15743

TABLE 0.30: TRAIN OPERATION PLAN FOR E-W CORRIDOR

Train Operation/ Corridors	Items		Year		
			2024	2031	2041
Transport Nagar to Hingna	Cars/ Train		3	3	3
	Headway (Sec.)		900	900	900
	Trains/hr		4	4	4
	Capacity Provided	@6p/m^2	3064	3064	3064
		@8p/m^2	3900	3900	3900
	PHPDT Demand		1063	3032	3571
Transport Nagar to Dattawadi	Cars/ Train		3	3	3
	Headway (Sec.)		900	720	600
	Trains/hr		4	5	6
	Capacity Provided	@6p/m^2	3064	3830	4596
		@8p/m^2	3900	4875	5850
	PHPDT Demand		3806	4862	5835
Transport Nagar to Hingna Mount View	Cars/ Train		3	3	3
	Headway (Sec.)		1200	900	450
	Trains/hr		3	4	8
	Capacity Provided	@6p/m^2	2298	3064	6128
		@8p/m^2	2925	3900	7800
	PHPDT Demand		10195	11411	16889

Based on the above train operation, the section wise headway and capacity provided for N-S and E-W corridors for various horizon years are as given in **Table 0.31** and **Table 0.32.**

TABLE 0.31: HEADWAY AND CAPACITY PROVIDED FOR N-S CORRIDOR

Sections	Items		Year		
			2024	2031	2041
Kanhan River to Kamptee Police Station	Cars/ Train		3	3	3
	Headway (Sec.)		900	900	600
	Trains/hr		4	4	6
	Capacity Provided	@6p/m^2	3064	3064	4596
		@8p/m^2	3900	3900	5850
	PHPDT Demand		1136	1165	1366
Kamptee Police Station to Ashokvan	Cars/ Train		3	3	3
	Headway (Sec.)		257	257	212
	Trains/hr		14	14	17
	Capacity Provided	@6p/m^2	10724	10724	13022
		@8p/m^2	13650	13650	16575
	PHPDT Demand		12952	13407	15743
Ashokvan to MIDC ESR	Cars/ Train		3	3	3
	Headway (Sec.)		900	900	600
	Trains/hr		4	4	6
	Capacity Provided	@6p/m^2	3064	3064	4596
		@8p/m^2	3900	3900	5850
	PHPDT Demand		3246	3921	5126

TABLE 0.32: HEADWAY AND CAPACITY PROVIDED FOR E-W CORRIDOR

Sections	Items		Year		
			2024	2031	2041
Transport Nagar to Vasudev Nagar	Cars/ Train		3	3	3
	Headway (Sec.)		327	277	200
	Trains/hr		11	13	18
	Capacity Provided	@6p/m^2	8426	9958	13788
		@8p/m^2	10725	12675	17550
	PHPDT Demand		10195	11411	16889
Vasudev Nagar to Hingna Mount View	Cars/ Train		3	3	3
	Headway (Sec.)		514	450	300
	Trains/hr		7	8	12
	Capacity Provided	@6p/m^2	5362	6128	9192
		@8p/m^2	6825	7800	11700
	PHPDT Demand		3825	5627	8125
Vasudev Nagar to Dattawadi	Cars/ Train		3	3	3
	Headway (Sec.)		900	720	600
	Trains/hr		4	5	6
	Capacity Provided	@6p/m^2	3064	3830	4596
		@8p/m^2	3900	4875	5850
	PHPDT Demand		3806	4862	5835
Hingna Mount View to Hingna	Cars/ Train		3	3	3
	Headway (Sec.)		900	900	900
	Trains/hr		4	4	4
	Capacity Provided	@6p/m^2	3064	3064	3064
		@8p/m^2	3900	3900	3900
	PHPDT Demand		1063	3032	3571

The above train operation and headway for different horizon years is proposed to meet the Peak hour peak direction traffic demand (PHPDT) with standees @ 6 passengers/m^2 in most of the sections, except in small section (few stations) meeting with standees @ 8 passengers/m^2. This arrangement will optimize the rolling stock requirement.

Rolling Stock requirement for different horizon years has been calculated based on the train operation plan. The rake requirement for the corridors of Phase 1 of Nagpur Metro is given in **Table 0.33**.

TABLE 0.33: RAKE REQUIREMENT FOR NAGPUR PHASE 1 CORRIDORS

Corridor	Year	No. of Rakes	Rake Consist	No. of cars
North - South Corridor	2024	21	3 car	63
	2031	22	3 car	66
	2041	25	3 car	75
East - West Corridor	2024	16	3 car	48
	2031	18	3 car	54
	2041	25	3 car	75

The rake requirement for the corridors of Phase 1 + Phase 2 of Nagpur Metro is given in **Table 0.34.**

TABLE 0.34: RAKE REQUIREMENT FOR NAGPUR PHASE 1 + PHASE 2 CORRIDORS

Corridor	Year	No. of Rakes	Rake Consist	No. of cars
North - South Corridor (Phase 1+ Phase 2 Extension)	2024	35	3 car	105
	2031	36	3 car	108
	2041	45	3 car	135
East - West Corridor (Phase 1+ Phase 2 Extension)	2024	20	3 car	60
	2031	25	3 car	75
	2041	35	3 car	105

The rake requirement for the corridors of Phase 2 of Nagpur Metro is given in **Table 0.35.**

TABLE 0.35: RAKE REQUIREMENT FOR NAGPUR PHASE 2 CORRIDORS

Corridor	Year	No. of Rakes	Rake Consist	No. of cars
Phase 2 Extension (North - South Corridor)	2024	14	3 car	42
	2031	14	3 car	42
	2041	20	3 car	60
Phase 2 Extension (East - West Corridor)	2024	4	3 car	12
	2031	7	3 car	21
	2041	10	3 car	30

0.9 SIGNALING AND TELECOMMUNICATION

0.9.1 SIGNALING SYSTEM

The signaling system shall provide the means of an efficient train control ensuring safety in train movements. It assists in optimization of metro infrastructure investment and running of efficient train services on the network. **Table 0.36** below shows the standards that have been adopted with regard to the Signaling system.

TABLE 0.36: STANDARDS PROPOSED TO BE ADOPTED FOR SIGNALING SYSTEM

Description	Standards
CBTC System	IEEE 1474.1
Interlocking	Computer Based Interlocking (CBI) adopted for station having switches and crossing shall be Hot Standby system with object controller conforming to SIL4 level of CENELEC standards EN 50126, EN 50128 and EN 50129.
Operation of Points	With Direct current 110V D.C. point machines or 380 volts 3 phase, 50 Hz. AC point machines.
Signals at Stations with point & crossings	Line Side signals to protect the points (switches). LED type signals for increased reliability and less maintenance efforts.

Description	Standards
Train Protection Systems (ATP)	Automatic train protection system conforming to SIL4 level of CENELEC standards EN 50126, EN 50128 and EN 50129.
ATS	Automatic Train Supervision System, movement of all trains to be logged on to a central computer and displayed on workstations in operation control center (OCC) and at SCR. Remote control of stations from the OCC as well as local control from the interlocked stations. ATS/ATO will conform to SIL2 level of CENELEC standards EN 50126, EN 50128 and EN 50129.
Immunity to External Interference.	All data transmission on Optical Fiber Cables/Radio. All signaling cables will be separated from power cables. CENELEC standards EN50121-2&4 and EN50082-2 and EN 50081-2 as applicable for EMI/EMC.
Fail Safe Principles	SIL4 safety levels as per CENELEC standard for signal application.
Fall back system	Digital Axle Counter
Other Items	Suitable International Standards like CENELEC etc. shall be followed as per good industry practices.
Maintenance philosophy	Philosophy of continuous monitoring of system status and preventive &corrective maintenance of signaling equipment shall be followed. Card / module / sub-system level replacement shall be done in the field and repairs under taken in the central laboratory/manufacturer’s premises.

0.9.2 TELECOMMUNICATION SYSTEM

The telecommunication system acts as communication backbone for signaling and other systems and provides telecommunication services to meet operational and administrative requirements of metro network. The proposed telecom system and transmission media will have following sub-systems:

- IP, GE based Transmission System
- Telephone Exchange
- Mobile Radio Communication System
- Public Address System
- Centralized Clock System
- Passenger Information Display System
- Close Circuit Television
- Central Voice Recording System (CVRS) and
- Supervisory Control and Data Acquisition (SCADA) System
- Wi-Fi Services
- LED Display Walls

0.10 FARE COLLECTION SYSTEM

0.10.1 Mass Rapid Transit Systems handle a large number of passengers. Ticket issue and fare collection play a vital role in the efficient and proper operation of the system. To achieve this objective, ticketing system shall be simple, easy to use/operate, easy on accounting facilities, capable of issuing single/multiple journey tickets, amenable for quick fare changes and require overall lesser manpower. Automatic fare collection system meets these requirements.

The AFC system shall have functionality of interface to CCHS (Central Clearing House System) facility with provision of integration with other transit (metro, bus etc) and non-transit (parking, toll etc.) which may be planned in future in line with the state/ national policy. In addition, the proposed AFC system shall also be NFC (Near Field Communication) enabled so that customers can use their NFC enabled Mobile phones for metro travel. Facility of recharging of Travel Cards using Cash, Debit/Credit Cards and Net-banking /web portal shall also be available. AFC system shall also support offsite sales terminals also, wherein cards and tokens can be dispensed at locations outside metro premises.

0.10.2 PLATFORM SCREEN DOORS (PSD)

Platform Screen Doors (PSD) are proposed at stations to screen the passengers on the platform from the track. These glass doors shall be powered for automatic operation and located along the platform at the platform edge throughout the passenger area. The door locations will be corresponding to the train car passenger door locations. Opening/ closing of the PSD will be after receipt of the doors open/ doors close command signals from the Signalling Link. Signalling link enables automatic operation of PSD only when the train stops within ±300mm limits.

It is recommended to provide half height Platform Screen Doors at all the stations of Nagpur Metro Phase 2 Corridors.

0.11 ROLLING STOCK

a) Rolling Stock proposed for the Nagpur Phase 2 corridors will be similar to Phase 1 (**Table 0.37)**.

b) Coach Dimensions: The following coach dimensions are proposed for Phase 2 corridors as mentioned in **Table 0.38.**

TABLE 0.37: BROAD FEATURES OF ROLLING STOCK

S. No.	Parameter	Corridor
1	Basic Unit	3 Car basic unit 2 DMC and 1 TC Every coach should be fully interchangeable with any other coach of same type.
2	Train Composition	3 Car: DMC+TC+DMC
3	Coach construction	Light weight stainless steel/ Aluminum body
4	Axle load	≤16 T
5	Braking System	Regenerative Braking
6	Propulsion system	3 phase drive system with VVVF control
7	Type of traction supply	25 kV AC OHE System

TABLE 0.38 : COACH DIMENSIONS

Type of Coach	Length	Width	Height
Driving Motor Car (DMC)	21.64 m	2.9 m	3.9 m
Trailer car (TC)	21.34 m	2.9 m	3.9 m

**Maximum length of coach over couplers/buffers = 22.6 m*

c) Passenger Carrying Capacity

In order to maximize the passenger carrying capacity, longitudinal seating arrangement shall be adopted. The whole train shall be vestibule to distribute the passenger evenly in all the coaches. Criteria for the calculation of standing passengers are 4 persons per square meter of standing floor area in normal state, 6 persons in crush state of peak hour and 8 persons in dense crush state of peak hour.

The Phase-1 corridors are planned with 3 car train configuration (DMC-TC-DMC) for operation till the design year. Since, continuity in operation is proposed between the two Phases, similar train configuration is proposed for Phase 2 corridors. The stations have been designed considering 3 car length. The carrying capacity of Metro Rail Vehicle is indicated in **Table 0.39.**

TABLE 0.39: CARRYING CAPACITY OF METRO RAIL

Description	Driving Motor Car (DMC)			Trailer Car (TC)			3 Car Train		
	Normal	Crush	Dense Crush	Normal	Crush	Dense Crush	Normal	Crush	Dense Crush
Seated	43	43	43	50	50	50	136	136	136
Standing	137	205	273	147	220	293	421	630	839
Total	**180**	**248**	**316**	**197**	**270**	**343**	**557**	**766**	**975**

Normal - 4 Per/ Sqm of standee area, **Crush**- 6 Per/ Sqm of standee area, **Dense Crush** – 8 Per/ Sqm of standee area.

0.12 POWER SUPPLY AND TRACTION

Nagpur Metro Phase-1 corridors are planned with 25kV OHE traction system. To ensure continuity and compatibility of systems, 25kV OHE traction system is proposed for Phase-2 corridors of Nagpur Metro. Since complete elevated corridor is planned for Phase 2, flexible Overhead Equipment (OHE) will be provided.

The Power supply system design has been conceptualized considering 3 car rake composition and train operation at peak headway for the corridors. The ultimate (design) power requirement for these corridors is conceptualized considering following norms, directives/ guidelines:

- Train operation with 3 car rakes with carrying capacity of 766 passengers (standing @ 6 passengers/ m^2).
- Peak period headway for N-S and E-W corridors.
- Specific energy consumption of rolling stock – 75 KWh/ 1000 GTKM
- Regeneration @ 30%
- Elevated station load – initially 150 kW, ultimate design 250 kW
- Depot auxiliary load – initially 2000 kW, ultimate design 2500 KW
- Power factor of load – 0.9
- Transmission losses @ 5%

Keeping in view of the above norms, power demand estimation for the proposed corridors of Nagpur Metro Phase 1 and Phase 2 is given in **Table 0.40.**

TABLE 0.40: POWER DEMAND ESTIMATION (MVA) OF PHASE 1 & PHASE 2 CORRIDORS

Corridor	N-S Corridor (in MVA)			E-W Corridor (in MVA)		
Year	**2024**	**2031**	**2041**	**2024**	**2031**	**2041**
Traction	14.10	14.34	17.59	8.44	9.75	12.65
Auxiliary	9.33	12.02	14.58	8.11	10.38	12.54
Total	**23.43**	**26.36**	**32.17**	**16.55**	**20.13**	**25.19**

Power demand estimation for the corridors of Nagpur Metro Phase 1 is given in **Table 0.41.**

TABLE 0.41: POWER DEMAND ESTIMATION OF PHASE 1 CORRIDORS

Corridor	N-S Corridor (in MVA)			E-W Corridor (in MVA)		
Year	**2024**	**2031**	**2041**	**2024**	**2031**	**2041**
Traction	7.89	8.59	9.75	6.69	7.37	9.79
Auxiliary	5.48	6.88	8.17	5.83	7.35	8.75
Total	**13.37**	**15.47**	**17.92**	**12.52**	**14.72**	**18.54**

Additional power demand estimation for the proposed corridors of Nagpur Metro Phase 2 is given in **Table 0.42.**

TABLE 0.42: POWER DEMAND ESTIMATION OF PHASE 2 CORRIDORS

Corridor	N-S Corridor (in MVA)			E-W Corridor (in MVA)		
Year	**2024**	**2031**	**2041**	**2024**	**2031**	**2041**
Traction	6.21	5.75	7.84	1.74	2.39	2.85
Auxiliary	3.85	5.13	6.42	2.28	3.03	3.79
Total	**10.06**	**10.88**	**14.26**	**4.02**	**5.42**	**6.64**

0.12.1 SOURCES OF POWER SUPPLY

Nagpur City has 220kV, 132kV, 33kV power transmission and distribution network to cater to various types of demand in the vicinity of the proposed corridors. Two Receiving Substations (RSS) (one RSS for each corridor) have been planned to cater to the requirement of both the N-S and E-W corridors in Phase 1. Considering the increased power demand of corridors due inclusion of Phase 2 extension corridors, one additional RSS is required to meet the requirement. The additional RSS is proposed near Kanhan River station.

The Receiving Substations planned for the power requirements of the corridors of Nagpur Metro Phase 1 and Phase 2 have been given in the **Table 0.43.**

TABLE 0.43: SOURCES OF POWER SUPPLY

RSS for Metro System		Feeding Zone
Phase 1	Morris College Ground RSS near Sitabuldi Station (132/33/25 kV)	N-S Corridor (MIDC ESR to Sitabuldi Station)
New proposed	Kanhan River RSS (132/33/25 kV)	N-S Corridor (Sitabuldi to Kanhan River Station)
Phase 1	Jhansi Rani RSS beside Jhansi Rani Station (132/33/25 kV)	E-W Corridor (including Phase 2 extension)

The capacity for each RSS for each corridor has been planned as 2 nos. 21.6/ 30.24 MVA Traction transformer and 2 nos. 20/ 25 MVA Auxiliary main transformer.

When RSS of one corridor fails, the traction supply will be maintained by extending feed from RSS of the other corridor. This ensures the reliability of power supply arrangement. However, in case of total grid failure, all trains may come to a halt, but emergency lighting, fire, hydraulics and other essential services can be catered to by stand-by UPS/ DG sets.

0.12.2 AUXILIARY SUPPLY ARRANGEMENTS AND STANDBY POWER SUPPLY

Auxiliary sub-stations (ASS) are envisaged to be provided at each station for stepping down 33kV supply to 415V for auxiliary applications. The ASS will be located at mezzanine or platform level inside a room. The demand of power at each elevated station is expected to be about 150 kW in the initial years and is likely to reach 250 kW in the horizon year. The average load considered for elevated station will have to be fine-tuned to suit station requirement during detailed design stage.

Each elevated station has been provided with an Auxiliary Substation with two 33kV/ 415V, 3-phase, 315 kVA dry type cast resin transformers (one transformer as standby) and the associated HT & LT switchgear. In addition, provision shall be made for one DG set at each station for emergency loads.

0.12.3 SOLAR ENERGY HARNESSING SYSTEM

Provision of a grid connected solar photovoltaic power plant utilizing all possible areas viz. roof top of stations is proposed for Nagpur Phase 2 corridors. Based on the solar radiation intensity in the city of Nagpur, the peak solar power generation of Nagpur Metro corridor is expected to be about 50 kWp for the elevated stations.

0.13 VENTILATION AND AIR-CONDITIONING SYSTEM

The air conditioning and ventilation requirement in the elevated stations of the Phase 2 corridors is mainly for the ancillary spaces such as staff room, equipment rooms etc. It is essential to maintain an acceptable environment for the operating and maintenance personnel, to prolong the life of equipment by proper control of temperature, pressure, and humidity, and to mitigate possible gas accumulation.

0.14 MAINTENANCE DEPOT

For the North-South corridor, maintenance depot has been planned at MIHAN Depot and the maintenance depot for the East-West corridor of Nagpur Metro Phase 1 has been planned at Hingna Depot.

The depots will have infrastructure to maintain the rakes with necessary facilities viz stabling lines, scheduled inspection lines, workshop for overhaul, unscheduled maintenance including major repairs, wheel profiling, heavy interior/under frame/roof cleaning etc. for the rolling stock operational on the corridor as well as maintenance facilities for Civil – track, buildings, water supply; Electrical – Traction, E&M; Signalling & Telecomm.; Automatic Fare Collection etc.

The major infrastructure facilities planned at MIHAN Depot and Hingna Depot are summarized in **Table 0.44** and **Table 0.45**.

TABLE 0.44: INFRASTRUCTURE FACILITIES PLANNED AT MIHAN DEPOT

Facility	Phase 1	Future (Phase 2)
Stabling Lines	3 lines of 6 car length	3 lines of 6 car length
Inspection Lines	3 lines of 3 car length	3 lines of 3 car length
Workshop Lines	2 lines of 3 car length	2 lines of 3 car length

TABLE 0.45: INFRASTRUCTURE FACILITIES PLANNED AT HINGNA DEPOT

Facility	Phase 1	Future (Phase 2)
Stabling Lines	3 lines of 6 car length	8 lines of 6 car length
Inspection Lines	3 lines of 3 car length	3 lines of 3 car length
Workshop Lines	2 lines of 3 car length	2 lines of 3 car length

0.15 ENVIRONMENTAL IMPACT ASSESSMENT

0.15.1 ENVIRONMENTAL IMPACT ASSESSMENT (EIA)

Baseline data has been collected from primary and secondary sources. Both negative and positive impacts have been identified and appraised.

The negative impacts due to location of the proposed metro corridors include: Project Affected People (PAPs), Change of Land use, Loss of trees/forest and Utility/Drainage Problems. The inventory of trees in the corridors (viaduct), at station location and proposed parking spaces are likely to be felled is summarized in **Table 0.46**. The impacts due to construction include: Soil erosion, pollution (water, air & noise) and health risk at construction site, Traffic diversion and risk to existing buildings, excavated soil disposal problems, dust generation, impact due to labour camp, increased water demand, impact due to supply of construction material. Anticipated Impacts due to operation are: noise pollution, water supply and sanitation at stations etc.

TABLE 0.46: SUMMARY OF TREE LIKELY TO BE CUT

Sr	Name of Alignment	Alignment	Stations	Parking
1	Automotive Square To Kanhan River	15	462	38
2	Prajapati Nagar To Transport Nagar	0	11	0
3	Vasudev Nagar To Dattawadi	58	60	01
4	Lokamanya Nagar To Hingna	14	31	0
5	Mihan to MIDC ESR-I	383	34	01
Total		**470**	**598**	**40**

A lot of positive impacts are anticipated which include employment opportunities, benefits to economy; quick service and safety; reduced fuel consumption and reduction in air pollution. The reduction of air pollutants with the present corridors are presented in **Table 47**.

TABLE 47: POLLUTION REDUCTION (TON/YEAR)

Pollutant	Horizon Year		
	2024	2031	2041
Carbon Monoxide (CO)	490.07	579.50	724.11
Hydro-Carbons (HC)	197.68	233.50	289.01
Nitrogen Oxide (NOx)	138.32	156.42	181.16
Particulate Matter (PM)	17.43	20.48	25.03
Carbon Dioxide (CO_2)	20506.09	23679.82	27238.50
Treatment cost Rs (Lakh)	946.03	1108.30	1355.49

Mitigation measures and management plan for Compensatory Afforestation, Construction Material, Labour Camp, Energy Management, Hazardous Waste, Housekeeping, Air Pollution Control, Noise and vibration Control, Traffic Diversion/Management, Soil Erosion Control, Water Supply, Sanitation and Solid Waste, Rain water harvesting, Construction Waste has been prepared. Estimated cost of environmental management plan and environmental monitoring (both during construction and operation) have been worked out **Rs 13.08 Crore.**

0.15.2 SOCIAL IMPACT ASSESSMENT

The SIA which includes Resettlement Action Plan (RAP) has been prepared in Right to Fair Compensation and Transparency in land acquisition, Rehabilitation and Resettlement Act, 2013.

The project shall require the acquisition/transfer of 10.25 ha of land. Out of this total land, 7.23 ha is private land and 3.03 ha land is government land. About 82 families consisting 451 persons shall be affected due to the proposed metro project. The number of affected structures and PAFs as identified are summarized in **Table 0.48**.

TABLE 0.48: IMPACT ON PAFs AND PAPs

Name of Corridor	Total affected structures	Total PAFs	Total PAPs*	Average family size
Mihan to MIDC ESR	7	8	37	4.6
Automotive Square to Kanhan River	20	17	63	3.7
Lokmanya Nagar to Hingna	18	27	185	6.9
Prajapati Nagar to Transport Nagar	5	5	22	4.4
Vasudev Nagar to Dattawadi	11	25	144	5.8
Total	**61**	**82**	**451**	**5.5**

The number of PAPs were enquired and analysed from field survey

Compensation for land acquisition, resettlement and rehabilitation shall be considered as per Right to Fair Compensation and Transparency in land acquisition, Rehabilitation and Resettlement Act, 2013 (RTFCTLARR Act).

Maha Metro shall be responsible for implementation of the proposed four corridors of metro rail project. The Managing Director (MD) will be the in charge of the overall project activities and will facilitate land acquisition, capacity building and implementation of RAP. Maha Metro shall be responsible for coordinating with other concerned government departments, NGO, and R&R Supervision Consultant for land acquisition, planning and implementation of RAP which will include the disbursement of compensation, assistance, shifting and relocation of affected people. The period for implementation of RAP has been taken as approx. two and half years. Tentative cost of Resettlement and Rehabilitation is calculated as **12.46 Crore** for Phase 2 corridors.

0.16 DISASTER MANAGEMENT AND SECURITY MEASURES

0.16.1 DISASTER MANAGEMENT MEASURES

An effective system needs to be in place under the provision of 'Disaster Management Act, 2005'. Provisions at metro stations include Fire Detection and Suppression System, Environmental Control System (ECS), Tunnel Ventilation System, Track-way Exhaust System (TES), Power Supply System, DG Sets & UPS, Water Supply and Drainage System, Lights and other facilities which may be deemed necessary. In order to be prepared for any disaster, it is essential to train the concerned staff in situations such as fire, rescue of disabled trains, evacuation, etc. and mock drills need to be conducted.

0.16.2 SECURITY MEASURES

Security system for metro system plays an important role in helping the system to become the preferred mode choice for commuters. The three phases of security system followed include Prevention, Preparedness and Recovery. Various provisions like CCTV cameras, baggage scanners, metal detectors, bomb detection equipment, wireless sets, snuffer dogs and related facilities will be part of station security system.

0.17 DETAILED PROJECT COST ESTIMATE

0.17.1 Capital Cost Estimate

Cost estimate for Nagpur Metro corridors has been prepared covering civil, electrical, signaling and telecommunications works, rolling stock, environmental protection, rehabilitation, etc. at April 2018 price level is presented in **Table 0.49**.

In order to arrive at realistic cost of various items, costs have been assessed on the basis of recently awarded rates of Nagpur Metro, Ahmedabad Metro, DPR of DMRC Ph-IV, Lucknow Metro and other various Metros and suitable escalation factor has been applied to bring these costs to April'2018 price level.

Basic cost is exclusive of taxes and duties. i.e. GST and Custom duty. Taxes and duties mainly comprising of latest prevalent GST & Custom duty are worked out for each corridor. Current rates of Taxes have been taken into consideration.

TABLE 0.49: ABSTRACT OF COST ESTIMATE OF CORRIDOR-1 & 2

April 2018 Price Level (Rs. In Crores)

SN	ITEM	Corr-1A	Corr-2A	Corr-3A	Corr-4A	Corr-5	Total
1	Land	99.43	33.59	33.74	27.35	22.26	216.36
2	Alignment and Formation	739.16	514.76	276.84	245.64	170.08	1946.49
3	Station Buildings incl. Civil works, EM works, ECS, TVS, Lift, escalators & Architectural Finishes etc	539.49	647.39	376.42	161.85	161.85	1887.00
4	Depot including civil, EM, Machinery & plants, general works	60.00	40.00	60.00	20.00	20.00	200.00
5	P-Way for main line, depot and depot connectivity	176.26	118.04	64.08	51.04	40.76	450.18
6	Traction & power supply for main line and depot incl. OHE, ASS, GIS etc.	203.72	196.24	74.57	56.21	44.89	575.63
7	Signalling and Telecom. Incl. AFC, Platform screen doors, CCHS etc.	275.87	254.71	140.85	83.48	74.02	828.93
8a	Environmental	44.10	33.87	20.43	16.05	15.41	129.86
8b	R & R incl. Hutments etc.	1.70	1.86	4.93	1.67	2.30	12.46
9	Misc. Utilities, road works, Topographic Surveys, Geotechnical Investigation, Barricading, Tree Cutting and replanting, other civil works such as signage's, Environmental protection and traffic management	152.14	112.19	54.89	51.35	52.01	422.58
10	Capital Expenditure on Security including civil and EM works	3.75	4.50	2.63	1.13	1.13	13.13

SN	ITEM	Corr-1A	Corr-2A	Corr-3A	Corr-4A	Corr-5	Total
11	Staff Quarters and buildings including civil, electrical works and green building concept (Cost of OCC building is included in corridor-1 only)	40.56	31.53	21.02	19.31	17.43	129.85
12	Capital Expenditure on Inter modal integration including Footpath for pedestrians, Feeder Buses and Bicycles @2% of Total Cost excluding Land, R&R and Rolling Stock	44.70	39.06	21.83	14.12	11.95	131.67
13	Total of all items except Land, R&R and Rolling Stock	2279.76	1992.29	1113.56	720.16	609.54	6715.31
14	General Charges incl. Design charges, including Metro Bhawan, (Civil+EM works) @ 5% on all items except land, R&R and Rolling Stock. (Metro Bhawan is charged to coridor-1 only and it will cater to both the corridors)	113.99	99.61	55.68	36.01	30.48	335.77
15	Total of all items including G. Charges	2393.75	2091.90	1169.24	756.17	640.01	7051.07
16	Rolling Stock	130.32	325.80	32.58	32.58	65.16	586.44
17	Total of 15 + 16	2524.07	2417.70	1201.82	788.75	705.17	7637.51
18	Contingencies @ 3 %on all items except land and R&R	75.72	72.53	36.05	23.66	21.16	229.13
Gross Total including Contingencies (excluding Land and R&R Cost)		**2599.79**	**2490.23**	**1237.88**	**812.41**	**726.33**	**7866.64**
Gross Total including Contingencies (including Land and R&R Cost)		**2700.93**	**2525.68**	**1276.54**	**841.43**	**750.88**	**8095.46**
Central Taxes & Duties		**216.28**	**216.64**	**100.58**	**66.79**	**61.55**	**661.84**
State Taxes & Duties		**185.85**	**180.85**	**87.71**	**58.08**	**52.41**	**564.90**
Total Cost including Taxes & Duties		**3103.05**	**2923.16**	**1464.83**	**966.30**	**864.84**	**9322.19**

0.18 TRANSIT ORIENTED DEVELOPMENT PLAN

The study of Transit Oriented Development (TOD) has been divided into following two components:

- Conceptual Urban Design Plans for TOD at identified typical Phase 2 metro stations
- Estimation of revenue potential from TOD along Phase 2 metro corridors

0.18.1 Two sites have been recommended for preparation of conceptual urban design plans. With a view to generate revenue in addition to fare box revenue, Transit Oriented Development (TOD) planning initiatives through various value capture techniques have to be taken. For that purpose, revenue has been estimated through sale of additional FSI, additional cess on stamp duty and development charge

0.18.2 Revenue estimation has been done both for supply side and demand side dynamics. The supply side, on one end highlights the total revenue potential of land situated within the TOD zone, the demand side highlights the actual organic growth in demand for Built up area. The demand side estimation takes into account the population growth trends of the city prevailing over the past and hence is a more realistic approach towards demand estimation. It has been observed that demand for absorbing the market is only 35% of the supply.

As revenue from VCF tools is expected to be shared for other infrastructure projects, it is expected that 50% of the revenue earned from sale of additional FSI and 100% of revenue from cess on stamp duty and development charge will come to Nagpur metro.

Two options for assessment of revenue from TOD (Value Capture Finance) are being proposed for consideration of Maha Metro.

- Option 1: Revenue from sale of FSI & development charge based on Demand Scenario and 1% Cess on Stamp Duty estimation based on existing collection in NMA.
- Option 2: Revenue from sale of FSI, development charge and 1% Cess on Stamp Duty in TOD Influence Area based on Demand Scenario

The comparative table of revenue assessment for both options 1 and 2 is presented in **Table 0.50.**

TABLE 0.50: REVENUE ASSESSMENT FROM TOD IN OPTION 1 & 2

Year	Revenue (Rs. In Crores)							
	Option 1				Option 2			
	Premium on Additional FSI	1% Cess on Stamp Duty in NMA	Development Charge	Total	Premium on Additional FSI	1% Cess on Stamp Duty in TOD Influence Area	Development Charge	Total
2024-25	4.20	20.33	0.83	25.36	4.20	1.02	0.83	6.05
2031-32	7.40	28.61	1.46	37.46	7.40	1.78	1.46	10.64
2041-42	9.29	46.60	1.85	57.73	9.29	2.30	1.85	13.44
2048-49	12.64	65.57	2.51	80.71	12.64	3.15	2.51	18.29

0.19 FINANCIAL ANALYSIS AND NON FARE BOX REVENUE ASSESSMENT

0.19.1 INPUT FOR FINANCIAL ANALYSIS

The total cost of project without land & R&R cost is estimated at Rs. **8528 Crore**. The Central and State GST amount to Rs. **1,227 Crore**. The capital cost components at April '18 prices are given in **Table 0.51.**

TABLE 0.51 CAPITAL COSTS (RS. IN CRORE)

S.No	Cost Component	Total
1	Construction Cost without Land & R&R	7867
2	Central GST and Basic Custom Duties	662
3	**Construction Cost without land & R&R but with Central GST**	**8528**
4	Land Cost & R&R	229
5	State GST	565
6	**Total Construction Cost with Land, R&R, central GST and State GST**	**9322**

With escalation factor of 5% p.a., the Completion Cost of the project excluding land & R&R is estimated to be **Rs.9,490 Crore** and with central taxes it is estimated at Rs **10288 Crore.** The Completion cost of the project including land, R&R, Central Taxes and State Taxes is estimated at **Rs. 11,216 Crore**. It is proposed to start land acquisition prior to Year 2019 and complete the same by Year 2021.

The O&M cost of the metro system is another input for the financial analysis. The total O&M cost in the year **2024** is estimated at **Rs. 267 Crore.** The total O&M cost in the year **2031** is estimated at **Rs. 438 Crore**.

The replacement cost for the corridors is estimated to be **Rs. 2639 Crore** in the year **2044**.

0.19.2 MEANS OF FINANCE

The Revenue for Nagpur metro will mainly consists of fare box collection and revenue from other non-fare box sources such as property development, advertisement, parking, taxes etc. The total annual revenue through the fare box and other sources is given in **Table 0.52.**

TABLE 0.52: TOTAL REVENUE COLLECTION (RS. IN CRORE)

Source of Revenue	2024	2031	2041
Fare Box Revenue	474	895	2159
Non Fare Box Revenue	198	632	1066
Total Revenue	**672**	**1527**	**3225**

0.19.3 OPERATIONAL VIABILITY

The FIRR for the project with capital costs including Central taxes and revenue from fare box and non-fare box sources works out to be 7.72% and FIRR with capital cost including central taxes is 8.21%. The FIRR is found to be more sensitive to ridership variations than to variations in costs.

0.19.4 ALTERNATE MEANS OF FINANCING

As per Metro Rail Policy '2017, the models considered for financing the Nagpur Metro Phase 2 are:

- Equity Sharing Model- Special Purpose Vehicle (SPV) fully under Government Control
- Public Private Partnership (PPP)
- Grant by the Central Government

As per the prevalent practice, Central Government contribute 20% of the project cost excluding land and state taxes as its equity contribution. An equal amount will be contributed by State Government aggregating the total equity to 40%. In addition to equity, Govt of Maharashtra will also fund the cost of land and state taxes. During Stake holder consultations, it was agreed that local bodies in the city would contribute towards funding of the metro in the city by giving land for the project free of cost. Remaining amount shall be arranged as soft loan from funding agencies.

Soft loan (ODA Loan) from three funding agencies namely JICA, AFD and KFW has been considered **(Table 0.53).**

TABLE 0.53: LOAN CONDITIONS OF FUNDING AGENCIES

S.N	Agency	Loan period	Moratorium period	Interest rate	Commitment fee
1	JICA	30	10	0.3%	0.2% of loan to be paid in 1st year
2	KFW	20	5	1.25%+6 monthly Euribor	Nil
3	AFD	20	5	0.6%+6 monthly Euribor	

In case of KFW and AFD, the loan interest rate has fixed and floating components, Euribor rate is floating component in the interest rate. A positive Euribor rate gets added to the interest rate to determine final loan interest rate whereas negative Euribor has no effect on fixed rate of interest. 6 monthly Euribor rate has been negative since 2015. The funding pattern developed under this model for JICA is placed in **Table 0.54.**

Total cost of the project is comparable in all the cases but JICA loan with lowest interest rate and higher moratorium period has lowest project cost.

TABLE 0.54: FUNDING PATTERN UNDER EQUITY SHARING MODEL (PROJECT COST WITH CENTRAL TAXES) - JICA LOAN

Particulars	Amount (Rs in Cr)	% Share
Equity by GoI	1658	16.12%
Equity by GoM	1658	16.12%
SD for CT by GoI	399	3.88%
SD for CT by GoM	399	3.88%
Grant by MADC	194	1.88%
Soft Loans	5980	58.12%
Total	**10288**	**100%**
Grant by MIDC for Land and R&R	246	
Grant by MIDC towards State Taxes	315	
Grant by MADC towards State Taxes	367	
IDC by State Government for JICA Step Loan @0.1% &Front End Fee @0.2%	23	
Total Cost	**11239**	**-**

SD: Subordinate Debt, CT: Central Taxes, IDC: Interest During Construction

As per new Metro Rail Policy 2017, it is essential to explore private participation either for complete provisioning of metro rail or for some unbundled components of operations and maintenance costs of metro rail. Accordingly, under SPV model for implementation of Nagpur Metro project following activities have been identified for private participation:

i. Private sector participation in Automatic Fare System by completely outsourcing operation of Ticket Operating Machines (TOMs), Ticket Vending Machines (TVMs) and Card Recharge Machines including Smart Cards provisions and Merchant Acquirer functions on similar lines as Lucknow Metro.
ii. Maintenance contracts with System suppliers for Rolling Stock and Signaling systems in place of in house maintenance.
iii. Station Civil and E&M maintenance and parking management.
iv. Exploring long term lease of Elevators at Metro Stations

0.20 ECONOMIC ANALYSIS

The economic appraisal has been carried out within the broad framework of Social Cost – Benefit Analysis Technique. **Table 0.55** gives the estimated traffic and modal share in different horizon years for Metro used for cost and benefit analysis. It is based on the incremental costs and benefits and involves comparison of project costs and benefits in economic terms under the “with” and “without” project scenario. In the analysis, the cost and benefit streams arising under the above project scenarios have been estimated in terms of market prices and economic values have been computed by converting the former using appropriate shadow prices.

TABLE 0.55: ESTIMATED DEMAND & MODAL SHARE IN "WITH" AND "WITHOUT SCENARIO"

Mode	Trips Without Phase II MRTS Extension (Lakh)			Trips with Phase II MRTS Extension (Lakh)		
	2024	**2031**	**2041**	**2024**	**2031**	**2041**
Bus	4.84	5.28	5.82	3.78	4.13	4.60
Car	4.80	5.66	7.00	4.59	5.42	6.68
2-Wheelers	32.66	37.72	43.53	31.61	36.50	42.04
Auto Rickshaw	5.39	6.41	9.12	5.25	6.25	8.89
Shared Auto	1.98	2.84	3.88	1.54	2.23	3.06
MRTS	2.60	2.94	3.66	5.49	6.33	7.75
Total	**52.27**	**60.86**	**73.02**	**52.27**	**60.86**	**73.02**

This has been done to iron out distortions due to externalities and anomalies arising in real world pricing systems. The annual streams of project costs and benefit have been compared over the analysis period of 30 years to estimate the net cost / benefit and to calculate economic viability of the project in terms of EIRR & ENPV.

The EIRR works out to 14.40%, ENPV for the system have been calculated on both the rates metro rail policy 2017 prescribes 14% as acceptable EIRR rate for metro project, same has been considered as the social cost of capital. The government security rate in May '2018 is 7.76% accordingly. The EIRRs under these scenarios are given in **Table 0.56.**

TABLE 0.56: SENSITIVITY ANALYSIS

S. No.	Factor	Range		
		5%	**10%**	**15%**
1	Cost overruns due to delay or other factors	13.81	13.25	12.73
2	Increase in Maintenance Cost	14.30	14.19	14.09
3	Reduction in Ridership	14.08	13.75	13.41
4	Reduction in benefits	13.67	12.92	12.14
5	Combination of reduction in benefits and increase in cost	13.09	11.83	10.61

0.21 IMPLEMENTATION PLAN

0.21.1 Project Implementation Plan

The appointment of Interim and General Consultants may be initiated for project management including preparation of tender documents – as soon as DPR is approved by Government of Maharashtra (GoM), and Maha Metro. The possible dates of important milestones are given in **Table 0.57**.

TABLE 0.57: PROJECT IMPLEMENTATION SCHEDULE

S. No.	Tasks	Timelines
1	Final DPR	July, 2018
2	State Government Approval of DPR	November, 2018
3	Final Approval by GoI	January, 2019
4	Appointment of Interim Consultant	February, 2019
5	Appointment of DDC for Civil Works	March, 2019
6	Packaging and Invitation of Bids	April, 2019
7	Appointment of General Consultants	June, 2019
8	Commencement of Civil Works	July, 2019
9	Commencement of Operation	April, 2024

0.21.2 Implementation Structure

Maharashtra has a successful example of metro operation in Mumbai on SPV model by Mumbai Metro Rail Corporation Limited (MMRCL). Nagpur Metro Rail Phase-1 project is also implemented on SPV model by Maha Metro. Similarly, Nagpur Metro Phase 2 project may also be implemented on SPV model. However, some subcomponents of operations & maintenance may be taken up with private sector participation (PPP) model. The PPP model to be adopted and implementation structure shall be decided at the time of implementation.

0.21.3 Legal and Institutional Framework for Implementing Project

0.21.3.1 **Legal Framework**

The legislation for construction of Phase -1 may also provide legal cover for construction of Nagpur Metro Phase 2. Implementation of proposed Extension of Nagpur Metro can be done under “The Metro Railways (Amendment) Act 2009”.

0.21.3.2 **Institutional Arrangements**

Effective institutional arrangement is needed to enable the Metro project to be implemented without any loss of time and cost over-run. The details of possible arrangements are discussed in following sections. Experience of implementing Delhi, Mumbai and Nagpur Phase 1 metro projects has shown that a Special Purpose Vehicle (SPV), vested with adequate powers, is an effective organizational arrangement to implement and subsequently operate and maintain a metro rail project.

It is suggested to have a two tier organization with well-defined responsibilities for getting this project executed. At the apex will be the Maha Metro - the organization with full mandate and total power. The second level will be a project management team called “General Consultants”, engaged by the Maha Metro on contract basis and fully responsible for planning, design and project management. In fact they will be the “Engineers” for the Maha Metro, who is the “Client”. The detailed design consultants may be engaged by General Consultants as their Sub-Consultants within their own contract responsibilities. Since the alignment length is elevated, it is recommended that the contracts be made on “design and build” basis, based on broad technical specifications and performance requirements drawn up by the General Consultants.

0.21.4 Role, Responsibility and Involvement of City Government

0.21.4.1 **Unified Metropolitan Transport Authority (UMTA)**

For integrated approach in planning and management of urban transport in the city, State Government shall constitute Unified Metropolitan Transport Authority (UMTA) as a statutory body. This Authority would implement various proposals as per CMP for the city, organize investments in urban transport infrastructure, establish effective coordination among various urban transport agencies, manage the Urban Transport Fund (UTF) etc. UMTA will have to play active role in the implementation of Nagpur Metro being a city government authority.

0.21.4.2 **Steering Committee**

Apart from a High Power Committee under the chairmanship of Chief Secretary, Maharashtra, a 'Steering Committee' may be set up under the chairmanship of Commissioner of Nagpur Municipal Corporation. Other members of this Committee may be District Collector, Municipal Commissioner, and other heads of civic bodies who will be connected in one way or the other with the implementation of the project.

Chapter – 1
PROFILE OF THE CITY

1. PROFILE OF THE CITY

1.1 GENERAL BACKGROUND

Nagpur, the Orange city of India, is third largest city in the state of Maharashtra and second capital of the state. It is the seat of annual winter session of the Maharashtra State Vidhan Sabha. Nagpur lies precisely at center of the country with Zero Mile Marker indicating the geographical center of India. It is a major commercial and political centre of the Vidarbha region of Maharashtra. The city is also considered as the second greenest city in India along with title 'Tiger Capital of India' as it connects to many tiger reserves in the country. Due to its proximity from various parts of country, the city is also emerging as one of economical hubs in recent times.

The city of Nagpur acts as the headquarter for the Nagpur district with a population of about 46 Lakh of which about 24 Lakh population accounts to Nagpur Municipal Corporation as per 2011 Census data.

Nagpur has large number of technical institutes which can cater to the rising needs of the IT-ITES industry in the region by generating enough manpower resources. Nagpur, also considered as a low living cost city, has become a prime destination for Information Technology Enabled Services (ITES) and Business Process Outsourcing (BPO) units. In addition to establishment of Multi-modal International Cargo Hub & Airport (MIHAN), Nagpur is also expected to be established as one of the major IT sectors in the country.

As Indian economy is moving towards more outward oriented fashion, rising per capita income and changes in economy structure are generating greater mobility demand to meet business and personal needs. There is an increase in demand for physical infrastructure in general and transportation in particular. Rapid urbanization and intense commercial developments in recent past have resulted in steep rise in travel demand putting Nagpur's transport infrastructure to stress. To relieve this stress MRTs system i.e. Nagpur Metro Phase-1 is already under construction. There are two corridors, North-South Corridor from Automotive Square to MIHAN (19.7 kms & 18 stations) and East-West Corridor from Prajapati Nagar to Lokmanya Nagar (18.6 km & 20 stations).

In order to alleviate the transport related problems in the City, Comprehensive Mobility Plan (CMP) has been prepared in 2013. It identifies various short, medium and long-term measures of transport infrastructure in the City. CMP recommends mass transport systems along major travel corridors.

Based on the proposals from CMP, an Alternatives Analysis has been carried out to find the most viable mass transit system along identified corridors. Alternatives Analysis Report recommends extension of mass transit corridors of Phase 1 in order to meet the future traffic demand. Nationally and globally it is seen that the metro network expands progressively to cover entire city. Hence, it is essential that in Nagpur also, such expansion of Metrorail network is taken up in time, so that before fully commissioning of Phase 1, Phase 2 construction can be commenced. Maha Metro has engaged RITES Ltd. to prepare a 'Detailed Project Report (DPR) for Extension of Nagpur Metro Rail System Phase 2'.

1.2 LOCATION, CLIMATE, PHYSICAL SETTING AND REGIONAL LINKAGES

1.2.1. Location, Climate and Physical Setting

Nagpur is located at the exact centre of the Indian peninsula. The city has the Zero Mile Stone locating the geographical centre of India, which was used by the British to measure all distances within the Indian subcontinent. The city lies on the Deccan plateau of the Indian Peninsula and has a mean altitude of 310.5 meters above sea level. The geographical location of Nagpur city i.e. latitude and longitude is 21.1458° N, 79.0882° E.

Nagpur has tropical savannah climate with dry conditions prevailing for most of the year. It receives about 163 mm of rainfall in June. The amount of rainfall is increased in July to 294 mm. Gradual decrease of rainfall has been observed from July to August (278 mm) and September (160 mm). The highest recorded daily rainfall was 304 mm. Summers are extremely hot, lasting from March to June, with May being the hottest month. Winter lasts from November to January, during which temperatures drop below 10 °C (50 °F). The highest recorded temperature in the city was 48 °C, while the lowest was 3.9 °C.

Geographically, Nagpur city lies at the origin Nag River Basin with its vertex at the edge of the Deccan trap plateau and arms spread eastward in the alluvial plain up to Wainganga River. The areas to the west of the city are low elevation located into the valleys. The corridor in which Nagpur city lies roughly coincides with the Satpura and Vindhya ranges and connects the Western Ghats and Aravali Range. The city stands on the eastern edge of the undulating trap.

1.2.2. Regional Linkages

Two important highways NH-7 (Varanasi - Kanyakumari) and NH-6 (Mumbai - Sambalpur – Kolkata) pass through Nagpur. The city is developed with radial and circumferential network pattern, of which outer ring is partly constructed, while inner ring road is completely operational. Nagpur Municipal Corporation (NMC) has executed an Integrated Road Development Project (IRDP) to improve the transportation system within the city limits.

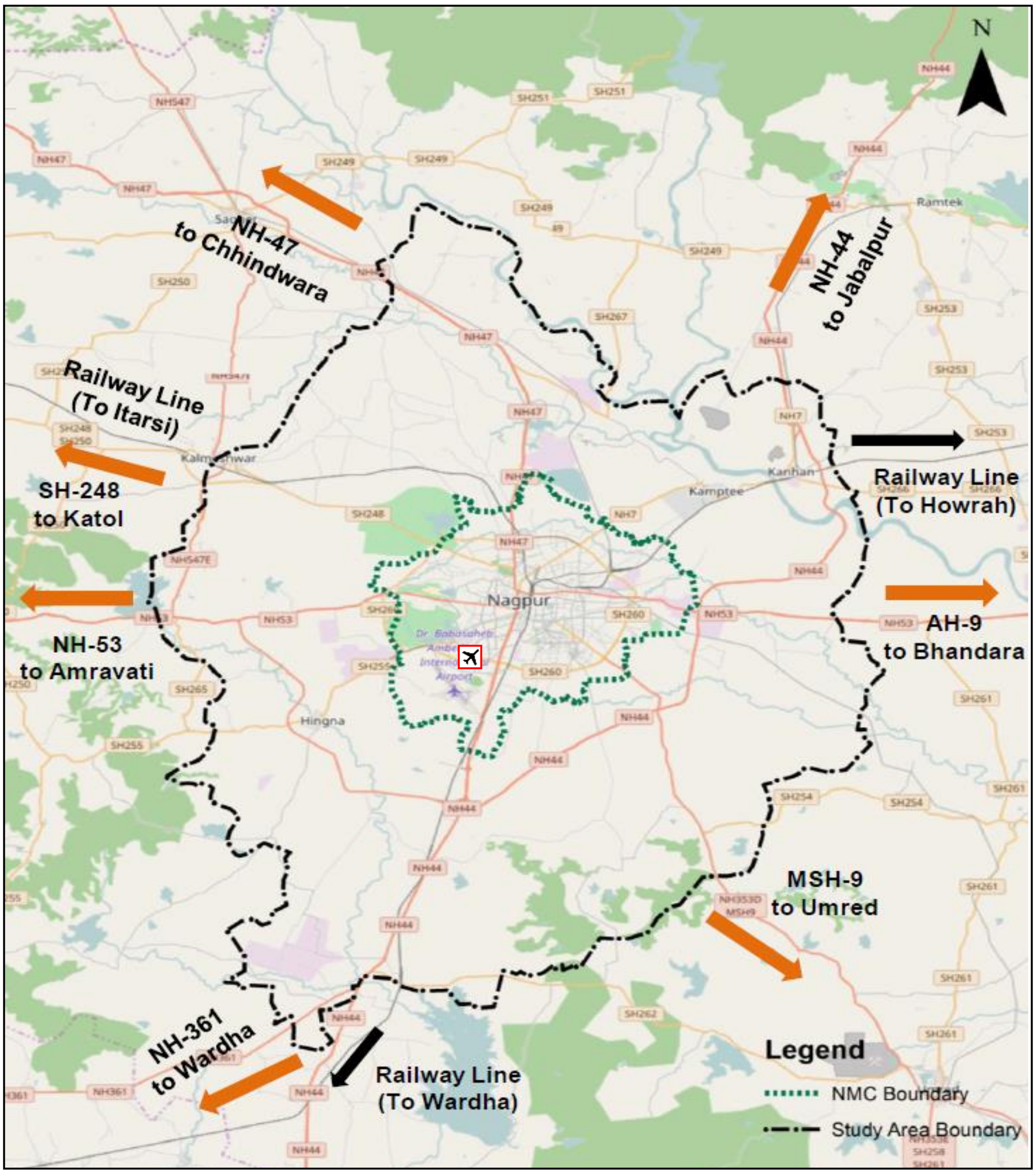
Ghat Road, Ajni Road, Railway Station Road, Manewada Road, Subhash Road, and Ambazari Road are some of the major sub-arterial roads within the city. The old part of Nagpur has network of narrow roads. The road infrastructure facilities such as signages, traffic signals, etc. have not expanded in accordance with the increase of population and vehicles. The Regional Transport Connectivity of Nagpur map has been shown in **Figure 1.1.**

Nagpur is the divisional headquarters of the Maharashtra State Road Transport Corporation (MSRTC) and also holds one of the three bus workshops in the state. MSRTC runs cheaper transport service for intercity and interstate travel. It has two major bus terminals in Nagpur viz. Nagpur Bus Sthanak (CBS-1) at Ganeshpeth and Mor Bhawan (CBS-2) at Jhansi Rani Square, Sitabuldi.

Nagpur Railway Station is an important railway junction for all the trains that connect the four major metropolises Mumbai, Delhi, Chennai, and Kolkata. Within the city, there are small railway stations located at Ajni, Itwari, Kalamna, Kamptee, and Khapri. Around 160 trains from various destinations pass through the city. Further, about 65 trains pass through the city on a daily basis and approx 26 trains start or end at Nagpur.

Nagpur has an airport located in the MIHAN area, and the domestic airlines connect with major cities such as Mumbai, Delhi, Ahmedabad, Pune, Bengaluru, Hyderabad, Indore, and Kolkata. Nagpur is also connected to international destinations namely Doha and Sharjah.

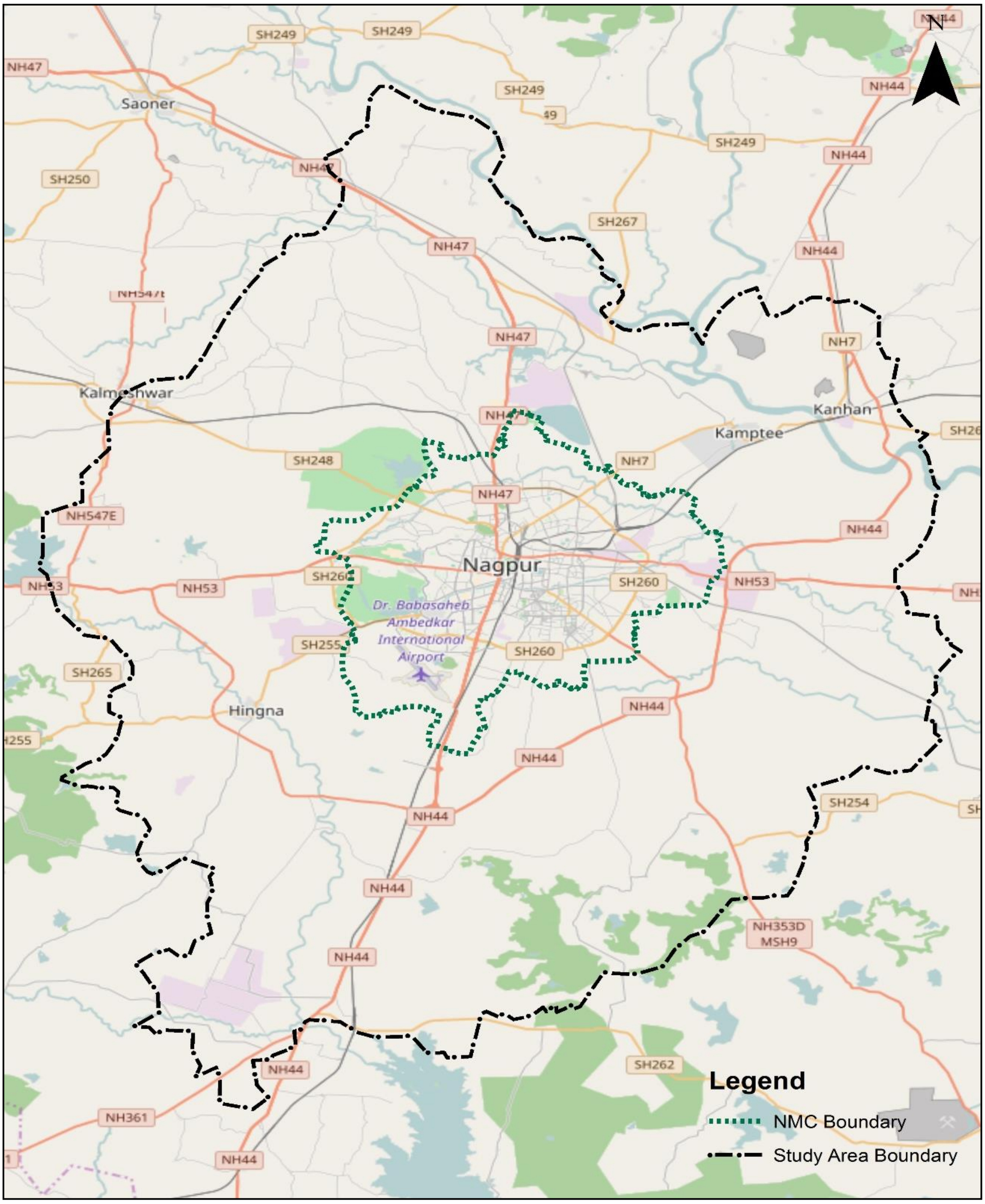
FIGURE 1.1: REGIONAL TRANSPORT CONNECTIVITY OF NAGPUR



1.3 DEMOGRAPHIC AND SOCIO ECONOMIC PROFILE

The geographic area within the jurisdiction of Nagpur Municipal Corporation (NMC) along with other areas including Municipal Councils of Kamptee, Kalmeshwar, Hingna and surrounding villages is taken as the study area (**Figure 1.2)**. The study area comprise of about 1550 sq. km out of total 3567sq km of NMA area. The majority of population of the study area resides within NMC area. As per Census 2011, the population of NMC area is about 24 Lakh.

FIGURE 1.2: STUDY AREA MAP



1.3.1. Population Growth

The average overall decadal growth for the past 5 decades stands at 32.5%. The population growth shows not so steep trend in the last decade with annual growth being only about 1.6%. The decadal population growth during the last six decades is shown in **Table 1.1** & **Figure 1.3.**

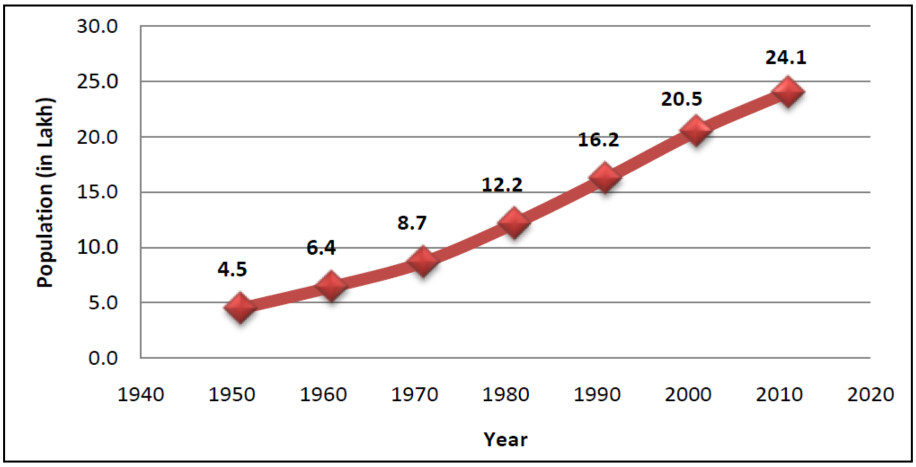
TABLE 1.1: DECADAL POPULATION GROWTH RATES 1951-2011

S. No	Year	Population	Growth Rate
1	1951	449000	-
2	1961	644000	43.4%
3	1971	866000	34.5%
4	1981	1217000	40.5%
5	1991	1622820	33.3%
6	2001	2051320	26.4%
7	2011	2405665	17.3%

Source: Census of India, 1951-2011

The study area population for the year 2011 has been taken from Census 2011 data. The population of NMC area is 24.1 Lakh and other areas including Kamptee, Kalmeshwar, Hingna and surrounding villages is 6.6 Lakh. The total population of study area is 30.7 Lakh in 2011.

FIGURE 1.3: DECADAL POPULATION GROWTH IN NMC



1.3.2. Population Density, Migration and Spatial Pattern

As per 2011 census data, the average density of 11,000 persons/sq km is observed in Nagpur. During the decade 2001-2011, NMC has witnessed only the natural growth, and the migration population accounts for only nominal growth.

RITES has also forecasted the population based on the growth trends taken separately for municipal corporation and outer areas collectively forming the study area in addition to existing growth pattern from Census Data. The population in the study area for base year is 34.3 lakh.

Based on discussions with concerned officials and population projections for Revised Draft Development Plan of Nagpur City, 2011, Nagpur Metropolitan Area Development Plan 2012 - 2032 and Nagpur Metro Ph-I DPR, projected study area population for various horizon years is estimated. The average annual growth rates of 1.4%, 1.2% & 1.1% have been considered for the years 2021, 2031 and 2041 respectively for the NMC area. Areas other than NMC are expected to grow at higher growth rates as per NMA Development Plans. The same annual growth rates of about 3% up to 2031 and about 2% for 2041 have been considered for projecting the population of other than NMC areas.

The overall study area population annual growth rates is 1.8% up to the year 2031 and 1.5% up to 2041. The projected study area population for various horizon years is given in **Table 1.2.**

TABLE 1.2: FORECASTED POPULATION OF STUDY AREA FOR HORIZON YEARS

S. No.	Area	Population (Lakh)			
		2018	**2021**	**2031**	**2041**
1	Nagpur Municipal Corporation	26.5	27.6	31.1	34.8
2	Other than NMC Areas Including Kamptee, Kalmeshwar, Hingna and surrounding villages	7.8	8.6	12.3	15.5
	Total	**34.3**	**36.2**	**43.4**	**50.3**

Spatial distribution of population across the wards is uneven in Nagpur. The population by traffic zones in various horizon years has been distributed considering the future growth of traffic zones and residential density for study area. Traffic zones have been assumed to grow according to the residential density pattern and the land-use distribution as given in Revised Draft Development Plan of Nagpur City, 2011 and Nagpur Metropolitan Area Development Plan 2012 - 2032.

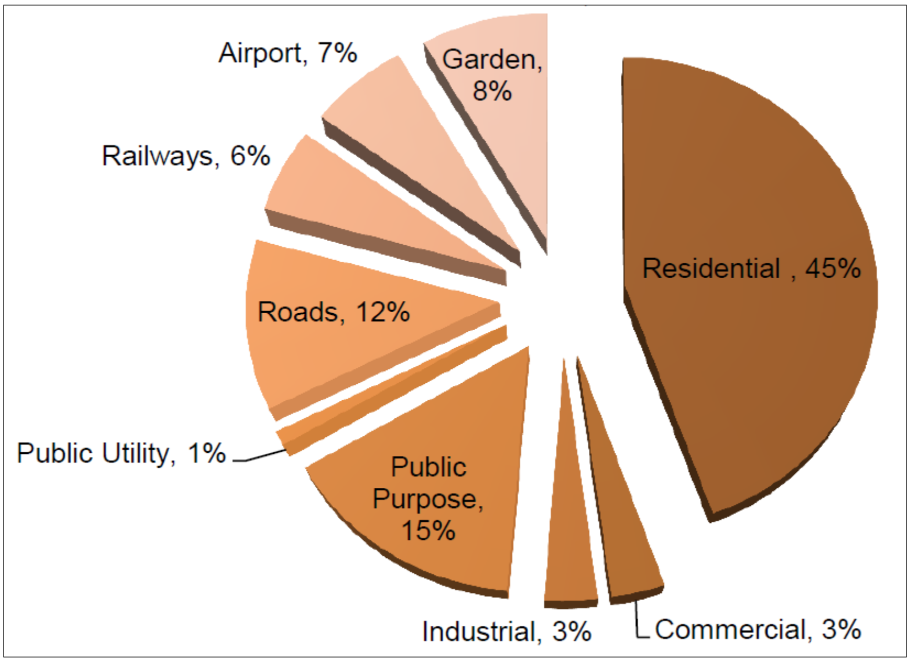
As per Development Plan, the traffic zones inside the CBD area will experience lesser growth as compared to the fast developing outer areas towards South-West & North -East would experiences moderate to high population growth. Accordingly growth rates for the various zones have been considered for population distribution. Traffic zone wise population for various horizon years is presented in **Table 1.5**.

1.4 URBAN LAND USE STRUCTURE

1.4.1. Existing Land-use Plans/Distribution

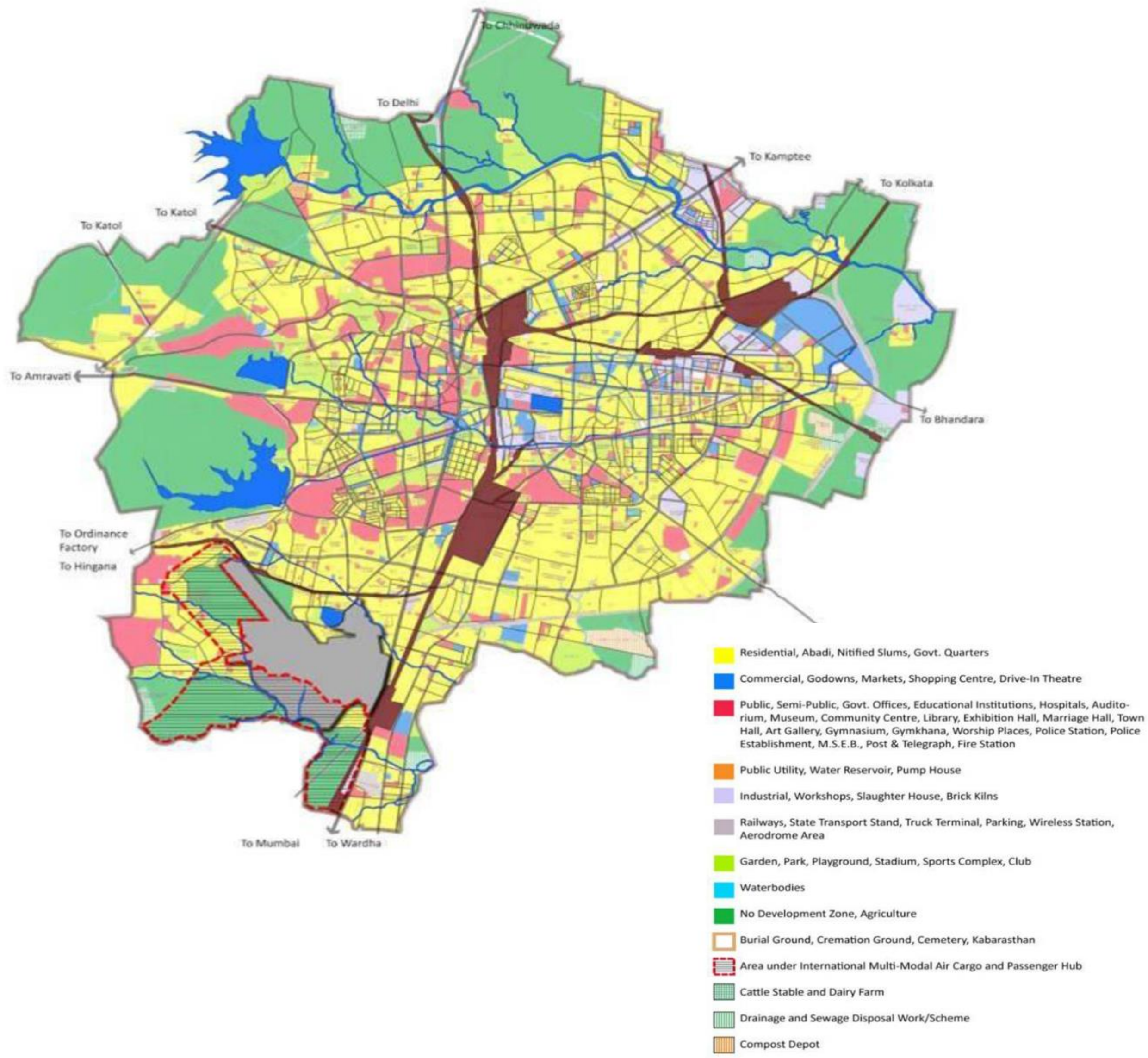
As per Revised Draft Development Plan 1986-2011 the existing land use, majority of the land portion is developed as residential, 45%; commercial and industrial land use is 6%; land under public use is approximately 41%; and 8% is under parks and gardens **(Figure 1.4)**.

FIGURE 1.4: EXISTING LANDUSE BREAKUP OF NAGPUR, 2011



Revised Draft Development Plan 1986- 2011 was prepared by NIT and sanctioned by the Government of Maharashtra (GoM) in 2000. This development plan as given in **Figure 1.5** is currently in force and is due for revision. The land-use distribution indicates the cosmopolitan nature of the city with a fair distribution of land uses. A comparatively higher percentage of land allocated to public purpose indicates the administrative importance of the city. At present, Nagpur is spread over an area of 21,756 ha. As per 1984 land use, only 80% of the land was developable, which has increased in 2011 to 100%. Also, 15033 hectares of area is developed, which is 69% of the total area and developed area in last three decades (since 1984) has doubled.

FIGURE 1.5: REVISED DRAFT DEVELOPMENT PLAN 1986-2011



1.4.2. Proposed Land-use

In order to improve the land use the Town Planning department has prepared the revised development plan for Nagpur. The proposed land use for horizon years 2021 and 2031 is given in **Table 1.3.**

TABLE 1.3: PROPOSED LANDUSE PLAN

Sr. No.	Land use	2021			2031		
		Area in Ha.	% of Developed Area	% of Total Area	Area in ha.	% of Developed Area	% of Total Area
1	Residential	6,706	44.6	30.8	7000	46.6	32.2
2	Commercial	501	3.3	2.3	700	4.7	3.2

Sr. No.	Land use	2021			2031		
		Area in Ha.	% of Developed Area	% of Total Area	Area in ha.	% of Developed Area	% of Total Area
3	Industrial	495	3.3	2.3	800	5.3	3.7
4	Public Purpose	2,312	15.4	10.6	2312	15.4	10.6
5	Public Utility	149	1.0	0.7	150	1.0	0.7
6	Roads	1,754	11.7	8.1	1800	12.0	8.3
7	Railways	873	5.8	4.0	900	6.0	4.1
8	Airport	993	6.6	4.6	1000	6.7	4.6
9	Garden	1,251	8.3	5.8	1300	8.6	6.0
10	Developable Vacant Land	0	0.0	0.0	0	0.0	0.0
	Total	**15,033**	**100.0**	**69.1**	**15,962**	**100**	**73.4**
11	Agriculture Land	5,774		26.5	4,846		22.3
12	Water Bodies &Nallahs	463		2.1	463		2.1
13	Non-Developable Land	0		0.0	0		0.0
14	Drainage & Sewage Disposal	141		0.6	141		0.6
15	Cattle Stable & Dairy Farm	212		1.0	212		1.0
16	Compost Depot	131		0.6	131		0.6
	Total	**6,723**		**30.9**	**5793**		**26.6**
	Grand Total	**21,756**		**100.0**	**21,756**		**100.0**

Source: Nagpur Environment Assessment Report 2008, CDP for Nagpur 2041, NMC

1.4.3. Zoning and Floor Space Index (FSI) Pattern

Further zoning regulations, planning norms and redevelopment of building falling within Transit Oriented Development Corridor classification for transit oriented development and mixed land use have been notified in Development Control and Promotion Regulations for Nagpur Metropolitan Regional Development Authority (Nagpur Metropolitan Area Development Plan) as published by Urban Development Department, Government of Maharashtra (sanctioned under section 31 (1) of MRTP Act, 1966 vide Government Notification No. TPS-2416/CR-122(A)/2016/DCPR-NMA/UD-9 dated 5th January 2018.

Basic FSI permitted by Government of Maharashtra in for buildings in Nagpur is 1 for residential area and 2.5 for industrial and commercial area. Land owners may utilize FSI of common spaces like passages upto an extent of 30% of built-up area on payment of premium. Accordingly, the maximum potential will vary from 1.3 to 2.8. At present there is no limitation on utilization of TDR loading but the owner has to fulfill parking norms and therefore parking requirement is the governing criteria for utilization of FSI in plot/land. Utilization of TDR is not allowed in NMRC corridor.

1.4.4. Employment – Forecast and Distribution by Traffic Zones

WFPR as observed in the base year is 37.0%. The employment of 10.8 lakh for year 2011 has been worked out from the census data figures and has been extrapolated to obtain base year employment figures. Keeping in view the economic profile of the study area, development prospects and transport intervention policies, WFPR of 38%, 40% and 41% for respectively 2021, 2031 and 2041 for NMC area and WFPR of 37%, 38% and 39% for 2021, 2031 and 2041 for outer areas have been assumed as per NMA Development Plan 2032 for the Horizon years. Thus, it has been estimated that 20.4 lakh workers would comprise the workforce in the study area by 2041. **Table 1.4** shows the growth trend in employment in the study area. **Table 1.5** gives the zone-wise forecasted employment for the horizon years.

TABLE 1.4: WORK FORCE PARTICIPATION FOR HORIZON YEARS

SN	Area	No. of Workers (Lakh)			
		2018	2021	2031	2041
1	Nagpur Municipal Corporation	9.8	10.5	12.4	14.3
2	Other than NMC Areas Including Kamptee, Kalmeshwar, Hingna and surrounding villages	2.9	3.2	4.7	6.1
Total		**12.7**	**13.7**	**17.1**	**20.4**

** Estimated Figures based on NMA Development Plan 2032, Economic & Landuse Profiles*

TABLE 1.5: ZONEWISE FORECASTED POPULATION AND EMPLOYMENT FOR HORIZON YEARS

Zone No.	2021		2031		2041	
	Population	Employment	Population	Employment	Population	Employment
1	41440	3683	49533	4470	58054	5244
2	38662	4057	46212	4925	55238	5778
3	32680	3868	39063	4694	46692	5508
4	74296	5835	88807	7082	106151	8309
5	22910	2202	25307	2673	27679	3136
6	19831	2754	21906	3343	23959	3922
7	20759	4101	22931	4978	25081	5840
8	22554	9056	24913	10992	27249	12897
9	23763	3704	26250	4496	28710	5274
10	20556	2747	22706	3334	24835	3912
11	18765	2114	20728	2566	22671	3011
12	29192	2912	34894	3535	41709	4147

Zone No.	2021		2031		2041	
	Population	Employment	Population	Employment	Population	Employment
13	44814	3754	53566	4556	64028	5346
14	35029	1370	41870	1662	50048	1950
15	23375	7185	27941	8721	33398	10231
16	24729	6404	29558	7772	35331	9119
17	18228	6443	20135	7820	22022	9175
18	16735	5556	18486	6743	20218	7912
19	17417	4776	19240	5797	21043	6801
20	18979	3739	20964	4538	22929	5324
21	18240	2876	20148	3490	22037	4095
22	20656	4937	22817	5992	24956	7030
23	17430	3748	19254	4549	21058	5337
24	17755	3402	19613	4129	21451	4845
25	21278	4502	23504	5464	25708	6411
26	20399	2763	22533	3354	24645	3935
27	26882	4706	32133	5712	38408	6702
28	39984	978	47793	1187	57127	1393
29	33994	1571	40633	1907	48569	2238
30	24317	5372	29066	6521	34742	7650
31	17875	4341	19745	5269	21596	6182
32	19609	3241	21661	3934	23691	4616
33	23057	7142	25469	8669	27856	10171
34	17557	6341	18455	7697	19016	9030
35	13763	7379	14466	8956	14906	10508
36	16546	11906	17392	14451	17921	16955
37	16319	6046	17154	7338	17675	8609
38	14764	6614	15519	8028	15991	9419
39	16109	5835	16933	7082	17447	8309
40	16637	10534	17488	12785	18020	15000
41	15598	5903	16396	7165	16894	8406
42	15246	11568	16025	14041	16513	16473
43	17044	25862	18827	31391	20592	36830
44	15398	3405	17009	4133	18603	4849
45	24179	25990	28901	31546	34545	37011
46	21786	10188	26041	12366	31127	14508
47	16674	30543	18419	37072	20145	43495
48	13928	44866	15385	49457	16827	58025
49	13895	38652	15348	43915	16787	51523
50	15647	13389	16447	16252	16948	19068
51	16157	4461	16983	5414	17500	6352
52	19484	6033	20480	7323	21103	8592
53	15008	4587	15776	5567	16255	6532
54	13478	5908	14167	7170	14598	8413
55	14577	8460	15323	10269	15789	12048

Zone No.	2021		2031		2041	
	Population	Employment	Population	Employment	Population	Employment
56	15794	8668	16602	10521	17107	12344
57	15774	14161	17425	17189	19058	20167
58	17949	27320	19827	33161	21685	38906
59	18303	3981	20218	4832	22113	5670
60	15227	3918	16820	4755	18397	5579
61	15066	10515	15836	12763	16318	14975
62	15675	18872	16476	22907	16977	26876
63	12263	16916	12890	20532	13282	24089
64	14121	4718	14843	5727	15295	6719
65	13168	11618	13841	14102	14262	16545
66	15662	9363	16463	11364	16964	13333
67	17389	4809	18278	5838	18834	6849
68	15541	20876	16336	25339	16833	29729
69	14544	19335	15287	23468	15752	27534
70	15239	10694	16019	12980	16506	15229
71	14223	16925	14950	20543	15405	24102
72	13064	21478	13732	26070	14149	30586
73	13795	9413	14501	11425	14942	13404
74	14516	5768	15259	7001	15723	8214
75	14534	5873	15277	7128	15742	8363
76	15633	7791	16432	9457	16932	11095
77	13343	7584	14026	9205	14452	10799
78	14329	25547	15062	31008	15520	36380
79	15038	24441	15807	29666	16287	34805
80	10845	35235	11399	40768	11746	47831
81	13620	36061	14316	43770	14751	51353
82	14460	18496	15973	22450	17470	26340
83	14045	15577	15514	18906	16968	22182
84	18182	4354	20084	5285	21967	6201
85	19263	4587	23025	5567	27521	6532
86	14972	9878	17896	11990	21391	14067
87	13534	19407	14950	23556	16351	27637
88	16264	17417	17965	21140	19649	24803
89	15348	13525	16133	16416	16623	19260
90	14093	11927	14813	14476	15264	16984
91	17486	14471	18380	17564	18939	20608
92	12504	11650	13144	14140	13544	16590
93	14549	5944	15293	7215	15758	8465
94	14088	5509	14809	6686	15259	7845
95	22656	4856	25027	5895	27372	6916
96	21137	6569	23349	7973	25537	9354
97	39679	5770	47429	7003	56692	8216
98	22850	3102	25240	3765	27606	4417

Zone No.	2021		2031		2041	
	Population	Employment	Population	Employment	Population	Employment
99	18513	3504	20450	4253	22367	4989
100	16065	7204	17745	8744	19409	10259
101	17379	5372	19197	6521	20996	7650
102	13227	3918	14610	4755	15980	5579
103	16727	3481	18477	4225	20209	4957
104	18106	5903	20000	7165	21875	8406
105	18092	4543	19985	5514	21858	6469
106	18777	2180	20742	2645	22686	3104
107	13418	4496	14822	5457	16211	6402
108	16605	6558	18342	7960	20062	9339
109	14665	8193	16199	9945	17718	11668
110	16331	11638	19520	14126	23333	16573
111	18596	12687	22228	15399	26569	18067
112	21150	12264	25280	14886	30217	17465
113	24180	5606	28902	6804	34547	7983
114	25912	8806	30973	10688	37022	12540
115	31321	2856	37438	3466	44750	4067
116	24642	3526	29455	4280	35207	5022
117	20798	8043	24860	9763	29716	11454
118	18187	10579	21739	12841	25985	15065
119	18898	9172	22589	11132	27001	13061
120	21356	8873	25526	10769	30512	12635
121	41324	2339	49395	2839	59041	3331
122	29604	2773	35386	3365	42297	3948
123	19944	2231	22030	2708	24095	3177
124	20214	2648	22329	3214	24422	3771
125	21406	3258	23645	3954	25862	4639
126	15079	3319	16657	4028	18218	4726
127	18739	3805	20699	4619	22639	5419
128	19235	3950	21247	4794	23239	5624
129	22233	2198	24559	2668	26861	3130
130	40664	3223	48606	3912	58099	4590
131	33257	4071	39752	4941	47515	5797
132	24040	2195	28735	2664	34347	3125
133	20137	4568	22244	5545	24329	6506
134	20574	3783	22726	4591	24857	5387
135	32592	6854	38958	8319	46566	9761
136	37812	4970	45197	6033	54024	7078
137	30896	2130	68437	2586	85039	3034
138	37644	1981	62735	2405	79667	2822
139	4167	2840	5406	2962	6775	3475
140	3226	1460	3449	1772	4320	2079
141	5285	1673	8267	2030	10451	2382

Zone No.	2021		2031		2041	
	Population	Employment	Population	Employment	Population	Employment
142	8512	1481	14723	1798	18441	2109
143	5251	80100	6861	150725	8513	205000
144	42414	6324	53044	12676	66577	14872
145	49693	6271	57290	12611	71814	14796
146	14843	679	20202	824	25247	967
147	48960	674	68509	818	84181	959
148	15565	1225	19426	1487	24334	1745
149	6524	1193	7338	1448	9115	1699
150	32080	1140	36328	1384	45239	1623
151	17522	1065	21043	1293	31985	1517
152	71262	3840	81882	4661	99813	5468
153	70615	2254	88403	2736	111126	3210
154	15614	2260	18457	2743	22697	3218
155	15807	685	26792	831	33563	975
156	6642	701	7448	850	9334	998
157	20719	2206	23357	2678	27604	3142
158	7526	1887	9153	2290	11466	2687
159	3309	1949	4175	2366	5231	2776
160	2446	790	2770	958	3470	1124
161	5358	1266	5767	1536	7222	1802
162	4840	2120	5117	2574	5943	3020
163	9540	2131	10701	2587	13372	3035
164	1910	2184	2045	2651	2560	3110
165	1189	1560	1070	1894	1339	2222
166	5751	1401	8852	1700	11091	1995
167	7548	1294	8902	1571	11058	1843
168	5674	2625	19496	3186	33690	3738
169	43008	4144	61194	5030	82057	5901
170	11140	2760	13649	3350	16848	3931
171	1711	1590	2934	1929	3672	2264
172	3651	1483	3332	1800	4176	2112
173	24026	913	34396	1109	43205	1301
174	9806	3457	21592	4196	27049	4923
175	12287	4860	73509	5899	93441	6921
176	23102	807	69590	979	87224	1149
177	3519	2754	3776	3342	4734	3921
178	2299	1957	2755	2375	3449	2786
179	26463	1134	30707	1377	38052	1616
180	34487	1081	39862	1312	48989	1540
181	24666	2686	27700	3260	34702	3825
182	59262	2654	65413	3222	81825	3780
Total	**3613301**	**1364477**	**4334352**	**1709184**	**5035369**	**2033467**

1.4.5. Major Activity Centers in Nagpur

1.4.5.1. MIDC Estates

a. Butibori MIDC

At around 30 km from Nagpur, towards Hyderabad, an industrial estate has been established at Butibori within the area of 2,500 hectares (ha). Currently, 1,757 ha have been developed and approximately 722 units are operational. If the MIHAN project is completed in the near future, it would support the growth of export-related industries within the MIDC premises. This would further boost the economy of Nagpur city and would create huge employment opportunities within the region.

b. Wardha MIDC

MIDC has acquired 312.19 Hectares of land for Industrial Development. At present, only demarcation of road network is done but plot boundaries are not allotted. The area has all the necessary infrastructure. It has a CFC Bldg., Post & Telegraph office, Telephone Exchange, Telex, Fax, ISD/STD facility, City Transport, Fire Station, Hotels, Canteen, Banks and Hospitals etc. The land rates for industrial area, commercial area and residential area are 200/ sq m, 400/ sq m and 300/ sq m respectively. The area is classified as a major Industrial Area and would contribute to growth of Nagpur city.

c. Hingna MIDC

Hingna MIDC estate was developed in 1962 and is located 7 km from Nagpur city. Several engineering industries, electrical-based industries, food-based industries, etc., are located in this Industrial area. The Maharashtra State Electricity Board (MSEB) has established its two sub-stations in the estate area. To facilitate the industrialists and workers, amenities like a post office, banks, a police station, petrol pumps, canteens, and bus services are available in this area. No land is available in this area for further planning. In Hingna MIDC, 1,266 units are operational.

1.4.5.2. Medium, Small, and Micro Enterprises/Industries (MSME)

Nagpur district has a number of small- and medium-scale industries. Most of the small-scale industries in the region are engaged in engineering and agro-based production. Majority of them are fabrication workshops; re-rolling mills; foundries; and manufacturing of steel furniture, auto parts, and machinery and machine parts.

These small-scale industries provide employment opportunities and contribute towards the economic development of the region.

As per the MSME Report on Nagpur, around 3.5 lakh people are engaged in the MSMEs. Approximately 41% of these workers are employed in the public sector enterprises, while 59% are employed in the private sector.

1.4.5.3. MIHAN

MIHAN is a state government initiative to support the economic development in and around Nagpur region. MIHAN is a composite project consisting of international airport and an SEZ. The project will be developed over an area of 4354 ha and will be developed by Maharashtra Airport Development Company Ltd. (MADC).

MIHAN comprises an international passenger and a cargo hub airport, a road terminal, a rail terminal, a health city, international schools, an SEZ, and various facilities. The MIHAN project is under implementation and is estimated to cost around Rs. 2,580 crores (as per 2002 rates). Few companies have started their operations at MIHAN. The MIHAN SEZ is proposed to attract various industries like IT, gems and jeweler, pharmaceuticals, processed food, health, garments, electronic goods, and other types of industries.

1.4.5.4. Tertiary markets

Along with formal economic activities there are markets (both formal and informal), which are part of Nagpur's economic profile and provide employment to many people. There are various types of markets like retail and wholesale and further it can be classified based on the goods that are sold in these markets. Some markets are held on daily basis, and some markets are held on specific days only. These markets are regularized by NMC and is maintained by the Market department with a dedicated team.

The list of various NMC authorized markets held in the city are Gokulpeth Bazar, Somewaripeth Bazar (Budhwari Bazar), Netaji Market, Supermarket Sitabuldi, Mahatma Phuley Bazar, Mahal Bazar, Itwari Bazar etc.

1.5 SCOPE OF WORK

DPR for of Nagpur Metro has been prepared as per Metro Policy 2017 of MoHUA, Government of India. The scope covers the following:

1.5.1. Assessment of Existing City Profile with Existing Transport Characteristics

Task 1: A brief overview of the city in terms of its growth, economy, spatial structure and trends, perspectives on the future growth. Overview of study areas and existing plans with land use distribution, review of zoning Regulations, employment distribution by Traffic Zones, land use plan proposals should be done.

Task 2: Brief review of previous transport studies like City Master Plan, Comprehensive Mobility Plan and other urban transport proposals. A brief showing interconnection among City Master Plan, Comprehensive Mobility Plan and proposed metro rail plan should be given.

1.5.2. Existing Travel Characteristics and Demand Estimates

Task 3: Describes the components of urban transport system in terms of status, trends and gaps based on primary survey data, present travel patterns and forecast for the future travel demand.

Task 4: Based on primary survey data and various traffic and transportation studies undertaken for the city, the present travel patterns and forecast for future travel demand should be done.

Task 5: Travel demand analysis, model framework, model calibration, summary of travel demand patterns and ridership assessment for horizon year should be done.

1.5.3. System and Technology Selection

Task 6: Identification of suitable transit technology and the system specification to be adopted for the corridor including the rationale for choosing a particular technology as per the prescribed specification as issued by MoHUA from time to time. The technology chosen should not be a proprietary technology of any vendor.

1.5.4. Corridor Alignment Description

Task 7: Alignment description of approved alignment, with detail about site conditions specifying road geometrics, utilities available along the corridor

Task 8: Detailed analysis of corridor options with grade selection for construction shall be carried out. Design norms for track geometry, fixed structure clearance, geotechnical details with new innovative techniques to be used for implementation in civil works, track system etc.

Task 9: Identification of existing services/utilities, if any

Task 10: Detailed estimation regarding land requirement for the corridor, depots, stations, parking, multi modal stations etc. with land ownership

1.5.5. Station Planning

Task 11: Station planning with preparation of general layouts based on type of station and site specific conditions focusing on:

- StationAreaplanningfornon-motorizedvehiclesandpedestriansfacilities,multi modal integration with existing modes, feeder service planning.
- Accessibility for differently abled persons including specifying parking at stations for private and para transit facilities.
- Platform widths based on Station loadings and the minimum width to be provided.

1.5.6. Intermodal Integration

Task 12: Prepare an Intermodal Integration Plan focusing on how the Metro Rail will integrate with the existing transportation systems/proposed transit system and introduction of a feeder system, integrated with the proposed Metro Rail project for improving last mile connectivity. This will include not only preparation of an operational plan for feeder system but also infrastructure that need to be upgraded/ improved or introduced for improving the intermodal integration with other modes of public transport to improve the viability of the project. Recommendations for institutional integration, physical integration, fare integration, operational integration and technology integration would also need to be elaborated in the report.

1.5.7. Train Operation Plan

Task 13: System operation approach, station yard planning, trains operation plan including system frequency, timetabling, rolling stock requirement, stabling details.

1.5.8. Signaling and Telecommunication

Task 14: Identification of Signaling and System control, Operation Control Centre (OCC), maintenance requirement, technology selection and choice of automation.

Task15: Identification of Telecommunication System, System Traffic Control, maintenance and emergency communication, Passenger Information System (PIS)

1.5.9. Fare Collection System

Task 16: Detailing the specifications for Automatic fare collection system, Ticketing and pass system, Fare System integrated with other transport Systems including integration of fares of all available modes with the Metro system planned (such as National Common Mobility Card).

1.5.10. Rolling Stock

Task 17: Technology selection, identification of rolling stock adopted as per Guidelines laid by MoHUA. Rationale for deviations, if any in choice of rolling stock parameters from the prescribed specifications and standards prevailing and rolling stock requirement for various horizon years should be specified.

1.5.11. Power Supply and Traction System

Task 18: Choice of electric traction system, Projected power demand, Source of power supply, Traction and Auxiliary Supply and supervisory control and data acquisition system. Number of tractions and their locations are also to be detailed out.

1.5.12. Ventilation and Air Conditioning System

Task 19: Need for Ventilation and Air Conditioning, design parameters and design concepts for VAC System with details on tunnel ventilation, station ventilation and air conditioning of ancillary spaces including specifications for control and monitoring facilities.

1.5.13. Depots

Task 20: Identification of Depot locations, approach to maintenance of depot facilities and workshop along with detailed designs and layout plans.

1.5.14. Environmental and Social Impact Assessment

Task 21: Existing scenario, with analysis on water quality, noise level, land environment, biological environment etc.

Task 22: Environmental norms and regulations, detailed Environment Impact Assessment (EIA), Environment Management Plan (EMP), formation of an Environmental Management System (EMS) and costs estimates for Environment

Impact mitigation measures.

Task 23: Detailed Social Impact Assessment (SIA) including R&R assessment, Resettlement Impacts, Resettlement Assistance Plan (RAP) and Monitoring and Evaluation Framework.

1.5.15. Disaster Management and Security Measures

Task 24: Disaster Management, Disaster Management imperatives, Objectives of Disaster Management Plan, Systems to cater for disasters and Security Systems recommended for MRTS and Safety and Security Measures.

1.5.16. Cost Estimation

Task 25: Detailed project cost estimates shall include

- Capital cost estimates including taxes and duties
- Innovations proposed to reduce the cost of system
- Estimation of Operations and Maintenance Cost and the assumptions made thereof

1.5.17. Transit Oriented Development Plan

Task 26: The potential for Transit Oriented Development along the metro corridors to be developed including densification of corridor by increasing FSI and land value capture. Detail of lands/areas amenable for change in near future e.g. vacant land, low rise development relocation etc.

1.5.18. Financial Analysis and Non Fare Box Revenue Assessment

Task 27: Estimations and inputs for the corridor, estimation for O & M, overheads, phasing of construction and lease of Built up Area (BUA), Operational viability of the project

Task 28: Means of finance, revenue from different sources, fare box revenue, non-fare box revenue, like advertisement, taxes and property development etc., possible ways of funding the project using different approaches. Alternative means of funding the project using different approaches Like PPP, BOT, DBFOT, DFBOT, Developer Finance Model Etc. and need to identify the proposed funding /implementation model in line with the Metro Policy 2017.

Task 29: FIRR with 30 year time horizon, Sensitivity analysis should be done based on scenario building with variation in ridership estimates scenarios, costs estimates and Time overrun. Alternative scenarios based on the different options for funding /implementation of the project should be evaluated. A project should be able to meet its financial requirement for cost recovery and under a set of plausible assumptions be able to self-finance its activities. The State Governments will have to ensure the financial sustainability of the project through financial assistance.

1.5.19. Economic Analysis

Task 30: The Economic analysis should include economic cost and benefit analysis of the project and estimation of the EIRR for a period of 30 years.

1.5.20. Implementation Plan

Task 31: Project implementation structure, if proposed to be implemented under various alternatives such as public or PPP model, role, responsibility and involvement (including financial stake) of the city government along with other government agencies in metro rail project, needs to be elaborated in the report.

1.5.21. Institutional Arrangement and Stakeholders Consultation

Task 32: Legal and Institutional Framework for implementation of the project based on the identified implementation plan should be included in the report. Stakeholders' consultation should be held at each major stage of the project such as the Draft DPR stage.

1.6 COMPOSITION OF THE REPORT

This Report consists of following 21 chapters covering:

Chapter 1: Profile of the City covers background, demographic characteristics and urban land-use structure of the study area.

Chapter 2: The chapter gives existing transport system covering existing road network, traffic characteristics status of IPT and PT systems.

Chapter 3: Existing traffic and travel characteristics, development of base year transport demand model and future travel demand estimates have been covered in the Chapter.

Chapter 4: System and Technology Selection covering traction system etc. are part of the Chapter.

Chapter 5: This chapter gives the details about civil engineering components covering alignment planning, geometric design parameters, geotechnical investigations, utilities and land requirements.

Chapter 6: Station Planning Chapter gives the typical stations, facilities for differently-abled, parking planned for metro corridors

Chapter 7: Intermodal integration - the interchange possibilities of existing and proposed modes of transport are summarised in this Chapter.

Chapter 8: Train operation plan gives operation plan for trains and frequency of operation for the proposed corridors

Chapter 9: Signalling and Telecommunication Chapter covers the types of signaling and telecommunication systems and standards

Chapter 10: The Chapter on Fare Collection System covers the proposed ticketing system for passenger fare collection

Chapter 11: The chapter gives the requirement of rolling stock for operation

Chapter 12: This Chapter gives power supply requirements, sources of power supply, substations and related infrastructure facilities

Chapter 13: Ventilation and Air Conditioning Systems Chapter covers the need for ventilation and standards adopted

Chapter 14: Maintenance depot facilities, rolling stock maintenance and depot layouts are covered in this Chapter

Chapter 15: This Chapter details the Environmental& Social Impact Assessment characteristics covering environmental and social components

Chapter 16: Disaster Management and Security Measures Chapter covers types of disaster, preparedness and security measures

Chapter 17: Detailed Cost Estimates chapter includes details on capital and O&M cost

Chapter 18: This chapter covers the revenue potential along the corridors from Transit Oriented Development

Chapter 19: Financial Analysis and Non-Fare Box Revenue chapter covers revenue estimates and estimation financial internal rate of return

Chapter 20: Economic Analysis chapter gives economic benefits and estimation of Economic Internal Rate of Return

Chapter 21: Implementation Plan chapter provides the project implementation options.

Chapter – 2
EXISTING TRANSPORTATION SYSTEM IN THE CITY

2. EXISTING TRANSPORTATION SYSTEM IN THE CITY

2.1 INTRODUCTION

Urbanization and rapid growth of vehicles population has laid severe stress on the urban transport system in Nagpur. Increase in vehicular traffic and limited augmentation road infrastructure facilities have been observed in the City. Private modes have gained more usage due to limited public transport facilities with poor level of service. This necessitates the assessment of existing transportation infrastructure in the City.

2.2 VEHICULAR GROWTH AND COMPOSITION

The registered vehicles in Nagpur have increased significantly over the years. The number of vehicles registered in the last four years is given in **Table 2.1** & **Figure 2.1**. The high density and rapid growth of vehicles have worsened the transport situation to a significant extent. The sharp increase of two-wheelers and cars could be attributed to the improved economic status of people and deficient public transport supply. The phenomenal increase of cars - demand more road space and has resulted in dense concentration of traffic on roads.

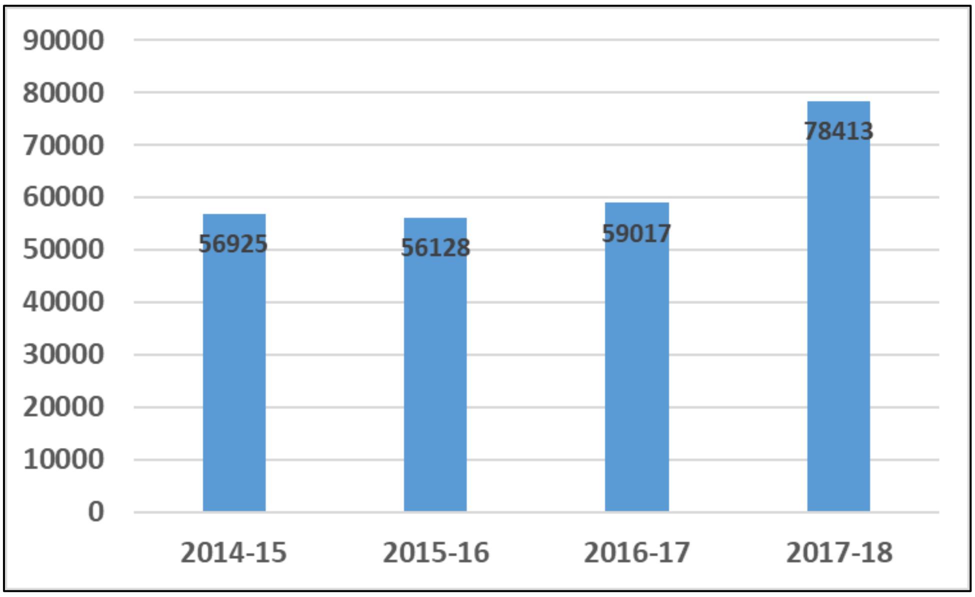
TABLE 2.1: REGISTERED MOTOR VEHICLES IN NAGPUR

S.No.	Vehicle Category	Registered Vehicle in Nagpur City			
		2014-15	2015-16	2016-17	2017-18
1	Total Two Wheelers	42958	42617	42280	61412
2	Moter Cars	6524	7498	8094	11157
3	Jeeps	1789	1851	2187	734
4	Stn. Wagons	0	0	0	4
5	Taxies a) Meter Fitted	3	0	0	0
	b) Luxury & Tourist Cabs	413	576	1752	866
6	Autorickshaws	2746	1079	1884	1920
7	Stage Carriage	0	0	40	53
8	Contract Carriage	35	43	58	45
9	School Buses	254	303	224	137
10	Pvt. Ser. Vehicle	4	1	2	0
11	Ambulance	27	43	40	30
12	Multi & articulated Veh.	22	41	63	151
13	Trucks	144	166	187	200
14	Tanker	11	15	309	0

S.No.	Vehicle Category	Registered Vehicle in Nagpur City			
		2014-15	2015-16	2016-17	2017-18
15	Del. Van. (4 Wheelers)	911	833	846	860
16	Del. Van. (3 Wheelers)	1041	985	808	719
17	Tractors	30	68	213	88
18	Trailers	8	16	10	3
19	Other Tippers	0	2	20	34
	Total	**56920**	**56137**	**59017**	**78413**

Source: RTO, Nagpur

FIGURE 2.1: YEARWISE TOTAL VEHICLE REGISTRATION IN NAGPUR



2.3 ROAD NETWORK CHARACTERITICS

2.3.1 Network Inventory

The road network inventory was carried out along all arterial and major roads in the study area. The data collected as part of this survey include the right of way, carriageway details, footpath, median, street lighting and abutting land use. The survey has been conducted for a total length of about 767 km.

The distribution of the road network as per right of way (ROW) is presented in **Table 2.2.** It can be observed from the table that about 22% of the road network has less than 20 m ROW, 32% has 20-30 m ROW and only 19% has ROW above 40 m.

It was observed from the field surveys that only 20% of the surveyed road network has footpath available along the sides of the road as presented in **Table 2.3.** Majority of footpath availability is along the major roads in NMC areas.

TABLE 2.2: DISTRIBUTION OF ROAD NETWORK AS PER RIGHT OF WAY

S. No.	Right of Way (m)	Length (km)	Percentage (%)
1	< 10	5.0	0.7
2	10 – 20	161.8	21.1
3	20 – 30	247.5	32.3
4	30 – 40	204.7	26.7
5	>40	148.0	19.3
Total		**767.08**	**100.0**

TABLE 2.3: AVAILABILITY OF FOOTPATH

S. No.	Footpath	Road Length (km)	Percentage (%)
1	Present	152.7	19.9
1a	*One-side*	*9.1*	*1.2*
1b	*Both-sides*	*143.6*	*18.7*
2	Absent	614.4	80.1
Total		**767.1**	**100.0**

2.4 MAJOR TRANSPORT NODES

There are 8 major bus terminals in the City, namely, Mor Bhawan Bus Terminal, Sitabuldi Bus Terminal, Ganesh Peth Bus Terminal, Chatterpati Bus Terminal, Ravi Nagar Bus Stop, Indora Bus Stop, M. P. Bus Terminal and Aashirwad Talkies Bus Terminal. The daily boarding and alighting figures are observed to be 42994 (Mor Bhawan Bus Terminal), 37144 (Ganesh Peth Bus Terminal), 24074 (Sitabuldi Bus Terminal).

The study area is served majorly by 5 railway stations, namely, Nagpur Railway Station, Ajni Railway Station, Buti Bori Railway Station, Itwari Railway Station and Kamptee Railway Station which provide connectivity to major cities. The daily boarding and alighting figures are observed to be 91356 (Nagpur Railway Station), 15699 (Itwari Railway Station) and 13654 (Kamptee Railway Station).

Dr. Baba Sahab Ambedkar Airport is used to serve the domestic as well as international air traffic. The daily boarding and alighting figure at airport comes out to be 4907.

2.5 PEDESTRIAN AND NMV FACILITIES

The pedestrian volume counts were carried out at major junctions/locations mostly along the study corridor. The survey was carried out continuously for a period of 12 hours (800 a.m. to 800 p.m.) for along and across movements of pedestrians. The daily and peak hour pedestrian flows at various survey locations are presented in **Table 2.4**. The maximum daily pedestrian volume in across and along direction are observed as 10,089 and 22,778 pedestrians at Amravati Road.

Similarly, maximum morning peak hour pedestrian across volume of 687 pedestrians is observed at CRPF Gate and maximum morning peak hour pedestrian along volume of 2203 pedestrians observed at Ambazari Road. Maximum evening peak hour pedestrians with across and along volumes 1528 and 2992 pedestrians observed at Amravati Road.

TABLE 2.4: DAILY & PEAK HOUR TRAFFIC AT PEDESTRIAN SURVEY LOCATIONS

S. No.	Name of Location	Approach	Daily Pedestrian Vol. – Both Side (12 Hours)		Peak Hour Pedestrian Vol.			
					Morning Peak		Evening Peak	
			Along	Across	Along	Across	Along	Across
1	Govt Hospital Kamptee	Dragon Palace	2700	1045	323	57	263	104
2	Main Road Kamptee	Sanjay Nagar	4567	2719	435	246	563	311
3	Kamptee Road (Kamptee)	Pili Haveli Chowk	12033	1405	978	81	1585	227
4	Kamptee Road (Kamptee)	Sharda Chowk	9416	3271	437	267	899	451
5	Kalamna Road (Kamptee)	Kalamna	5682	1831	325	108	868	193
6	Bhandara Rd. (HB Town)	Sudarshan Chowk	2734	610	327	69	362	43
7	Sharda Chowk	Kamptee	3216	912	239	86	388	60
8	Sharda Chowk	Ring Road	4719	1230	435	118	412	84
9	Tekanaka Chowk	Kamptee Road	7032	3148	519	202	1136	663
10	Kalamna Market Road HB Town	Kalamna Road	5053	1528	505	131	495	142
11	HB Town	Bhandara Road	3508	8018	426	100	487	71
12	Indora Chowk	Cement Road	7624	1784	693	92	653	136
13	Kadbi Chowk	Gondwana Chowk	1615	268	201	10	136	30
14	Ring Road HB Town	Vaishno Devi Chowk	5282	1191	596	182	356	160
15	Kadbi Chowk	Nagpur Rly. stn.	2239	693	429	191	125	42
16	HB Chowk Near Royal Tower	HB Chowk Near Royal Tower	4322	2342	323	172	460	266
17	Santra Market Rly Station	Chitnis Park Chowk	10023	3796	916	345	844	405
18	Tekadi Road	Sudarshan Chowk	4323	1784	365	194	360	178
19	Abhyankar Marg	Munje Chowk	5555	4255	593	476	495	292
20	Amravati Road	Star Bus Stop	22778	10089	1700	557	2992	1528
21	Wardha Road	Rani Jhansi Chowk	17122	6727	1452	616	1485	603
22	Ambazari Road	Munje Chowk	10259	2555	956	221	1017	145

S. No.	Name of Location	Approach	Daily Pedestrian Vol. – Both Side (12 Hours)		Peak Hour Pedestrian Vol.			
					Morning Peak		Evening Peak	
			Along	Across	Along	Across	Along	Across
23	Ambazari Road	Senapati Bapat Chowk	21189	3729	2203	364	2185	247
24	Alankar Chowk (Ambazari Road)	Sitabuldi	14771	2579	1541	253	1525	171
25	Shankar Chowk	Shankar Chowk	6452	2452	555	205	834	386
26	Gandhi Nagar Chowk (Ambazari Road)	Ambazari Lake	3196	1209	276	101	415	192
27	Hingna Road (Towards Bansi Nagar)	Bansi Nagar	7440	2611	904	374	831	308
28	Electronic Zone Chowk (Towards Nildhoh)	Nildhoh	5479	2350	507	266	604	322
29	Electronic Zone Chowk	Bansi Chowk	7786	3943	820	381	776	479
30	YCCE College	Hingna	4219	1524	470	115	482	132
31	Hingna Road	YCCE College	8503	1228	900	68	915	147
32	Wanadongri Chowk	Waddhamna	4691	2083	373	131	481	202
33	Hingna Road	Raipur	9534	4177	964	471	953	402
34	MIDC Hingna Village	Wadi Chowk	2481	573	304	88	185	73
35	Ring Road (Wadi T Point)	Hingna Road	4229	1203	467	145	285	91
36	Wadi T Point (Amravati Road)	Futala Lake	4246	1301	347	127	402	112
37	Wadi T Point (Amravati Road)	Wadi	6159	1529	566	96	913	272
38	Dhatali	Neelgagan Apartment	6994	2410	827	271	1018	349
39	Ajni Square	Chhatrapati Shivaji Square	496	727	43	96	46	69
40	Dongargaon Near Wainganga College	Wardha	8319	2131	1101	224	757	208
41	Butibori Chowk	Airport	3191	1970	221	139	337	195
42	Butibori Chowk	Butibori MIDC	5853	3735	408	328	521	400
43	Butibori Chowk	Wardha	6959	1877	553	167	621	161
44	Shyam Talikes Road (Agarsen Chowk)	Chitnis Park Chowk	5878	2910	872	523	511	200
45	Agrasen Chowk	Mayo Hospital	3296	1285	357	114	273	92
46	Agrasen Chowk	Golibar Chowk	5701	1928	510	178	389	181
47	Chandra Shekhar Azad Chowk	Telephone Exchange	7547	4409	545	457	789	441
48	Telephone Exchange	Ambedkar Chowk	2753	1835	300	192	300	218
49	Pardi Bazar Chowk	Bhandara Road (Near Pooja School)	7173	3039	620	257	773	400
50	Vaishno Devi Chowk	Central Avenue Road	3839	1728	286	128	424	268
51	Jamtha Village	Jamtha Village	239	133	34	19	26	15
52	Buti Bori MIDC Chowk	Nagpur	4839	2710	396	166	483	286
		Railway Station Side	6673	2883	1189	566	499	213
		Hinganghat	2366	2257	245	234	212	224
		Tembhari	9133	1530	609	96	1314	171

S. No.	Name of Location	Approach	Daily Pedestrian Vol. – Both Side (12 Hours)		Peak Hour Pedestrian Vol.			
					Morning Peak		Evening Peak	
			Along	Across	Along	Across	Along	Across
53	KEC Chowk Butibori	Butibori	238	90	23	25	46	3
		KEC	379	109	46	29	33	2
		Tembhari	569	249	122	61	56	3
54	Indorama Company Gate No. 3	MIDC	820	488	111	56	87	22
		TakalGhat	621	160	248	160	74	11
55	Junction near MIDC Garden Chowk	Butibori	1845	679	180	69	193	78
56	Dhangar Chowk	Dhangar	806	596	117	72	126	118
57	Shivaji Chowk	Wanadogri	1443	209	235	25	253	12
		Panjari	2330	1063	226	111	259	164
		Dhanoli	2073	957	313	114	289	103
58	Ambhore Nagar Chowk	Wanadogri	2464	820	253	95	308	65
		Gumgaon	1363	683	170	66	141	63
		Hingna	3619	1206	668	175	479	124
59	Wanadongri Chowk	Nagalwadi	4898	1827	439	215	623	200
		Nagpur	3190	1469	367	114	348	217
		Hingna	7338	2284	1128	298	903	184
60	Electronic Zone	Electronic Zone	3557	898	299	61	447	86
		Nagpur	1251	1105	195	131	143	112
		Hingna	1547	606	150	32	137	56
61	Wadi Chowk	Defence Road	259	48	39	4	20	1
		Nagpur	833	457	105	55	142	45
		Hingna	495	306	38	38	39	31
62	Automotive Square	Mankapur	1977	769	170	49	176	59
		Kamptee	8878	2466	1141	361	1179	275
		HB Nagar	3826	1245	309	102	341	99
		Nagpur	3004	438	278	15	387	112
63	Khasala Chowk	Kwatha	2730	532	259	71	502	66
		Garud Chowk	2183	1261	123	72	347	190
		Nagpur	1957	1200	249	149	266	200
64	Garud Chowk	Mahadev Ghat	665	223	49	9	123	52
		Kamptee	485	391	43	39	77	36
		Nagpur	405	96	28	12	52	20
65	Old Kamptee	Khanhan	3495	1607	322	123	418	211
		Kalamana	3414	926	331	38	306	98
		Garud Chowk	4934	652	389	51	662	78
66	Babu Hardas LN Chowk	Mahadev Ghat	12168	3257	1466	665	1050	381
		Khanhan	7239	3257	540	277	1103	416
		Railway Station Side	8618	2175	792	260	1232	237
		Nagpur	2754	1183	198	103	303	105
67	Kanhan Chowk	Khandala (DU)	3050	1059	454	142	367	94
		Pardi	2213	1070	272	83	172	110
		Kamptee	4296	1121	464	134	553	195
68	H. B. Town Chowk	Kalamana	1015	697	146	51	113	77
		Pardi	1980	1779	271	233	246	236
		Wardha	1632	1017	240	107	176	134
		Itwari	1739	1014	252	38	160	89
69	Pardi Chowk Near Hanuman Temple	Bhawani Nagar	1497	1069	210	83	201	147
		Kapsipul	5097	4229	606	492	684	460

S. No.	Name of Location	Approach	Daily Pedestrian Vol. – Both Side (12 Hours)		Peak Hour Pedestrian Vol.			
					Morning Peak		Evening Peak	
			Along	Across	Along	Across	Along	Across
		Bhandewadi	2951	1443	505	200	324	188
		Nagpur	3079	1361	402	77	295	125
70	Kapsi Flyover	Tarodi	513	179	90	20	56	21
		Pardi	473	40	82	7	67	9
71	Donger Goan	Nagpur - Butibori Highway	8758	3924	895	390	1236	527
72	Dutta Chowk Near Butibori	College Road	1339	458	160	43	132	65
73	Hingna Bus Stop Near Hingna PS	Hingna Road	4883	3018	371	257	641	425
74	Ambedkar Chowk	Hingna Road	874	731	134	87	119	148
75	YCC Collage	Hingna Road	6478	3471	622	291	699	518
76	Rajiv Nagar Chowk	Hingna Road	5344	1953	751	201	469	224
77	IC Chowk	Hingna Road	2885	2175	388	288	309	219
78	CRPF Gate	Hingna Road	7714	6498	732	687	967	791
79	Infront of CRPF Gate-8	Hingna Road	2015	1300	179	86	372	263
80	8th Mile Ambajari	Nagpur-Aurangabad Highway	0	1824	0	217	0	137
81	Uppalwadi Road	Kamptee Road	1359	515	140	52	134	59
82	Pilee Nadi Chowk	Kamptee Road	2110	820	217	84	218	99
83	Tara Nagar Chowk	Kamptee Road	1556	592	160	59	158	63
84	Ismilpura Road Kamptee	Kamptee Road	1845	680	191	65	187	53
85	Near Police Station Kamptee	Kamptee Road	1698	726	163	69	214	57
86	Near Jay Stambh Kamptee Market	Kamptee Road	1828	668	201	65	196	53
87	Near Jay Stambh Kamptee Railway Station	Kamptee Road	2479	891	236	85	256	103
88	Infront of Astha Hospital Pardi	Pardi Road	2086	845	197	83	259	65
89	On Bhandewadi Railway Station Pardi	Pardi Road	3366	887	195	88	282	98
90	On Bidgaon Road Pardi (Bharat Petrol Pump)	Pardi Road	1527	616	168	51	174	69

The CMP has also recommended some proposed measures to develop facilities for pedestrians and bicyclists on the streets as mentioned below:

- Construction of Footpaths and Pavement Improvement: Nearly 87.2 km stretch comprising of national and state highways is proposed for pavement improvement and footpath construction in short term.
- Construction of Cycle Tracks: Cycle track is proposed on both sides of the identified primary roads i.e. Wardha Road, Hingna Road, Kamptee Road, Amravati Road, Katol Road etc. (approx. 87.2 km in phase-1 & 58.7 km in phase-2). It is also proposed on various secondary and tertiary roads covering overall length of 340 running km.

- Majority of the mobility corridors are recommended for dedicated cycle tracks and the major docking stations are proposed at each Traffic and Transport Management Centre such as Koradi Road, Katol Road, Hingna Road etc.
- Two Foot Over Bridges and Walkways are proposed between MSRTC Bus Terminal to Nagpur Railway Station and MSRTC Bus Terminal to Proposed Transport Hub at Patvardhan Ground. The approximate length is 1.9 km and 1.6Km respectively.
- Provision of the Pedestrian Zones: Considering heavy pedestrian movement in core areas namely Sitabuldi, Mahal, Itwari and Sardar are proposed as a vehicle free zones.

2.6 TRAFFIC MANAGEMENT INCLUDING PARKING MANAGEMENT

Traffic Management proposals in CMP consists of development of a parking strategy, junction improvement, planning of ITS systems, removal of encroachment at various locations etc. in order to shape the framework for the future provision, management and maintenance of traffic.

Traffic Management proposals in CMP includes:

- Removal of encroachments on major roads like CA Road, Santra Market Road, Old Bhandara Road etc.
- Substantial improvements in junctions by providing proper signages and markings.
- Installation of ITS systems at major junctions for easy flow of traffic.
- Other Traffic Management Measures
  - Bus stops should be at least 60 m away from the junctions
  - Bus bays should be considered at all possible bus stop locations
  - Auto parking should be banned near all junctions and moved at least 50m away from junctions.
  - On street parking should be banned at critical locations on all major roads. To curb the menace of haphazard and illegal parking on main roads-measures like restricted parking, time limit parking and metered parking should be thought.

The development of Parking Strategy has been based on understanding of the parking supply and demand position in Nagpur City. The parking strategies that would be considered for Nagpur include:

- Off Street parking facilities
- Parking Pricing
- Restriction of on street parking on mobility corridors

The central city area of Nagpur is developed with commercial as a predominant activity. Lack of land availability for off street parking is forcing vehicles to park on streets.

As per CMP, to encourage the use of off street parking facility, the on street parking charges should be kept higher than off street parking fees. The pricing should be based on three aspects viz type of parking, location and demand management. At introductory level, fees can be kept at Rs 10 for first two hours for on street parking and Rs 5 for off street parking.

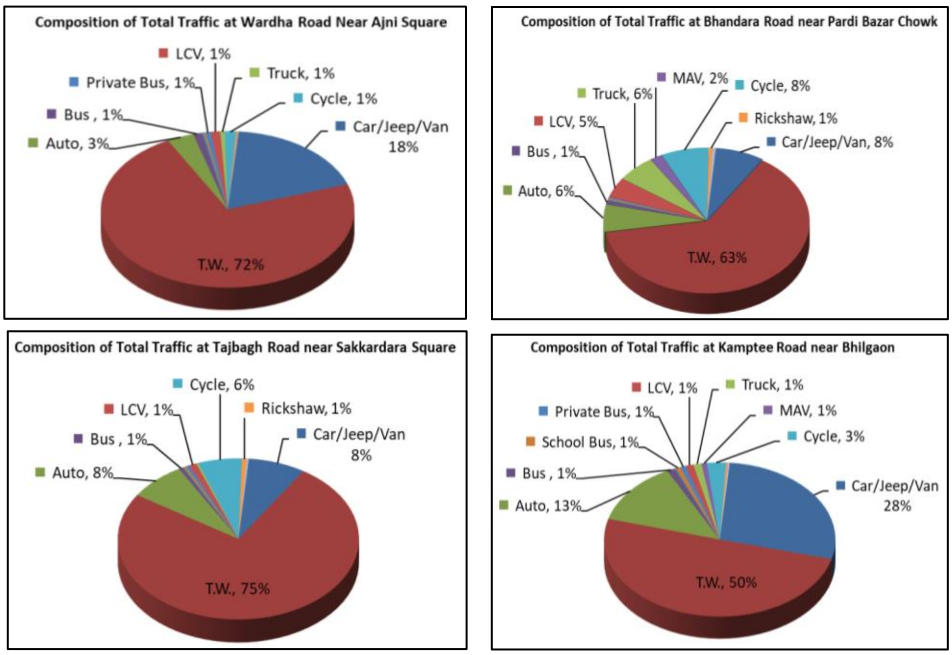
2.7 TRAFFIC CHARACTERISTICS

2.7.1 Traffic Volumes and Composition

The daily traffic volumes total vehicles in terms of numbers of vehicles and Passenger Car Units (PCUs) have been computed at various mid-block locations. The counts observed at different locations varies from 877 PCUs (1098 vehicle) at Kapsi BK to 72079 PCUs at Bhandara Road near Pardi Bazar Chowk throughout a normal working day.

The daily traffic composition along these midblock locations is presented in **Figure 2.2.**

FIGURE 2.2: DAILY TRAFFIC COMPOSITION ON MAJOR MIDBLOCK LOCATIONS



2.7.2 Speed and Delay Characteristics

It is observed that about 54% of the total road network has journey speed upto 30 kmph and 28% of network has journey speed more than 40 kmph during peak hours. About 40% of surveyed network has journey speed upto 30 kmph and 32% of network has journey speed more than 40 kmph during off-peak hours. Average Journey Speed during peak and off-peak period for city as a whole is observed to be 23.4 kmph and 27.1 kmph respectively. It is also observed that journey speed in core area is about 19 kmph and 34 kmph in outer area during peak hours.

2.8 TRAFFIC SAFETY

The increase in number of private vehicles and inter mixing of slow and fast moving vehicles on road has led to increase in number of accidents on roads in Nagpur, which is a cause of concern. Considering the urban expanse, population growth and increased trends of vehicles on city roads; the safety of commuters is equally vital.

There are many reasons for the growth in the number of accidents in Nagpur such as increase in population and rise in vehicle ownership. They are also caused due to the casual approach of road users in observing driving rules, adhering to safety precautions and regulations. Over-speeding and negligent driving have proved to be a frequent cause of serious and fatal accidents. Similarly, poor road geometry has also increased the incidence of accidents on urban roads. One of major causes of pedestrian safety is endangered by extended trading activities of shops and commercial activity on footpaths and sidewalks. This compels the pedestrians to clog the road space, hence give a chance to accidents.

Table 2.5 shows the number of accidents in recent years along-with the number of fatalities and series/ minor injuries occurred.

TABLE 2.5: ROAD ACCIDENT STATISTICS

Type of Accidents	2016			2017			January, 2018		
	Accidents	Fatalities	Injured	Accidents	Fatalities	Injured	Accidents	Fatalities	Injured
Fatal	222	232	66	291	310	116	18	21	8
Serious	473	0	604	553	0	774	49	0	68
Minor	547	0	615	529	0	620	35	0	40
Total	**1242**	**232**	**1285**	**1373**	**310**	**1510**	**102**	**21**	**116**

2.9 INTERMEDIATE PUBLIC TRANSPORT SYSTEM

Intermediate Public Transit (IPT) is also known as Para Transit. IPT plays an important and unique role in the urban transportation system of city like Nagpur. It plays an intermediary role between a private vehicle and a public transit. It also provides substantial source of employment.

The Auto / Share Auto is popular Intermediate public transport in Nagpur. The base fare of auto is Rs. 14 for the first km and thereafter increases in the same trend of Rs. 14 for every additional km. Similarly the city also has many share autos operating from prime locations such as Nagpur Railway Station, Medical Chowk, Ajini Railway Station, Ganesh Peth, Sitabuldi & Mayo Hospital. The average fare of share auto is observed at Rs. 3 to Rs. 4 per Km.

2.10 PUBLIC TRANSPORT SYSTEM

Public transport offers economies of scale with minimised road congestion and low per capita road usage. Cheaper and affordable public transport systems world over have proved to promote mobility – move people more efficiently and safely with increased opportunities for education, employment, social development etc.

At present the public transport services are rather limited and city bus is the only mass transport system in the Nagpur in addition to planned Phase-1 Metro system. Nagpur Mahanagar Parivahan Limited (NMPL) operates the city bus services consisting of normal buses, low floor buses and mini buses. Details of city bus routes and fare structure are presented in **Table 2.6** and **Table 2.7**. The present supply of buses per lakh populations works out to only ten buses, which cannot be compared with any standards. The benchmark for assessing the supply of buses should be about 60 to 70 buses per lakh population for city like size of Nagpur. Private auto, shared auto, cycle rickshaw and e-rickshaws supplement these transportation services. With the rise in population, the number of commuters has increased manifold. However, the transport system has been unable to cope up with increasing demand.

The present intra city bus fleet (about 350 buses) in Nagpur city is insufficient for current travel demand. With increase in population and dependence on personalized modes of transport, increase in road accidents, the existing traffic congestion on major roads the city transport system requires an expansion of metro system for safe, efficient and convenient travel.

TABLE 2.6: EXISTING CITY BUS ROUTES IN NAGPUR

Sr. No.	Name of Route	No. of Buses
1	Pardi-Jaitala & Pardi-Bardi	16
2	Sitabuldi-Brahmanwada	1
3	Piplafata-Hazaripahad/Sitabuldi	20
4	Piplafata-Gandhibagh	1
5	Sitabuldi-Suradevi	1
6	Sitabuldi- New Narsala	2
7	Sitabuldi Via Indora Square -Kamptee	5
8	Sitabuldo-Sonegaon Via Laxmi Nagar	2
9	Sitabuldi-Nagsenvan/Yashodhara Nagar	6
10	Sitabuldi-Godhani	10
11	Sitabuldi-Khaparkheda	15
12	Sitabuldi-Gandhibagh-Pardi	12
13	Sitabuldi-Isasani	4
14	Pardi-Ycce	12
15	Hingna Gramin Hospital-Pardi	3
16	Sitabuldi- Jn Hospital	8
17	Sitabuldi-Defence	12
18	Sitabuldi-Mangrulgondkhari	1
19	Sitabuldi Via Shanti Nagar -Kamptee	9
20	Sitabuldi-Gondkhairi	1
21	Sitabuldi-Crpf	4
22	Sitabuldi-Nari	4
23	Sitabuldi- Nara	4
24	Sitabuldi-Dabha	1
25	Sitabuldi-Brahmni Fata-Sawali Fata	10
26	Siatbuldi-Khadgaon-Sawali-Mawali	1
27	Bardi -Banwadi-Wadad	2
28	Sitabuldi-Wadad/Banwadi	
29	Sitabuldi-Alesar	1
30	Sitabuldi-Pawangaon	1
31	Besa-Gorewada	10
32	Sitabuldi-Belatrodi	4
33	Sitabuldi- Vaishali Nagar	4
34	Sitabuldi-Shesh Nagar	2
35	Sitabuldi-Waddhamna	1
36	Gorewada-Gandhibagh	1
37	Sitabuldi-Bahadura Fata/Narsala	13
38	Sitabuldi- Indorama Gate No. 6	24
39	Dikshabhumi- Dragon Palace	1
40	Sitabuldi-Hingna Gramin Hospital	21
41	Sitabuldi-Ycce	2
42	Hkharbi-Jaitala/Pannasey & Bardi	14
43	Sitabuldi-Uppalwadi Fata	2

Sr. No.	Name of Route	No. of Buses
44	Sitabuldi- Om Nagar T Point	2
45	Sitabuldi-Bhandewadi Bidgaon Fata	2
46	Sitabuldi-Shrikrishna Nagar	3
47	Panchsheel Square - New Manish Nagar	2
48	Sitabuldi-Giddoba Nagar	4
49	Sitabuldi-Bhilgaon T Point	1
50	Ramana Maroti-Bardi Via Medical	2
51	Bardi -Wardha Road -Jaitala	2
52	Sitabuldi-Muldiyar Square	2
53	Bardi-Punapur-Bharatwada	2
54	Bardi-Bidgaon -Bhandewadi Fata	2
55	Bardi-Shivni Via Bidgaon Fata	1
56	Dixa Bhoomi -Samta Nagar	2
57	Bardi - Ghogali	2
58	Bardi -Prajapati Nagar -Pardi	2
59	Pipla Fata - Bardi	1
60	Piplafata - Gandhi Bagh	1
61	Sonegaon Via Deonagar-Pardi	4
62	Sonegaon - Medical	4
63	Bardi Godhani Bokhara, Bailwada	1
64	Bardi - Swaminarayan Mandir	2
65	Koradi -Swaminarayan Mandir	1
66	Shanti Nagar - Medical -Bardi	1
67	Bharatwada- Medical - Bardi	1
68	Sangarsh Nagar - Medical - Bardi	1
69	Bardi-Chikrapani Nagar	2
70	Hingna-Defence	1
71	Bardi-Wanjari Leyout	1
72	Ambed Chowk Garoba Maidan -Ycc	1
73	Atharva Nagari -Gandhibagh	1
74	Godhani -- Pardi	1
75	Godhani-Gandhibagh	3
76	Godhani-Bahadura Fata	1
77	Mireleyout-Bardi	1
78	Katol Naka -Gandhibagh	2
79	Bardi-Frinnds Colony - Tv Tower	2
80	Bardi - Koradi Colony	2
81	Sonegaon - Jaipatka	4
82	Bardi- Atharva Nagari	1
83	Bardi - Takalghat	3
84	Bahadura Fata -Ycc	1
85	Gorewada Dharampeth-Bardi	1
86	Bardi – Gorkhede Leyout	1
87	Bardi - Ganga Nagar	1

Sr. No.	Name of Route	No. of Buses
88	Bardi- Dindayal Nagar Bhende - Leyout	1
89	Bardi-Gargoti -Sudama Nagari	1
90	Hingna - Gumgaon- Butibori	1
Other Routes		
1	Narendra Nagar - Central School	
2	CGO -Bahadura Fata	
3	Pannase Layout - GPO	
4	Kharbi- CGO	
5	CGO -Vishuarma Nagar	
6	Pipla Fata - CGO Complex Near TV Tower	
7	Uday Nagar - CGO Complex	

TABLE 2.7: FARE STRUCTURE FOR CITY BUSES IN NAGPUR

Kms	Non AC
	Existing Fare for Adults
0 -4	8
4-6	9
6-8	11
8-10	13
10-12	16
12-14	19
14-16	23
16-18	26
18-22	30
22-26	34
26-30	38
30-34	42
34-38	46
38-42	50
42-46	54
46-50	58

Kms	AC
	Existing Fare for Adults
0 -4	14
4-8	16
8-10	23
10-12	28
12-14	33
14-16	40
16-18	46
18-22	53
22-26	60
26-30	67
30-34	74
34-38	81
38-42	88
42-46	95
46-50	102

2.11 REVIEW OF PAST STUDIES

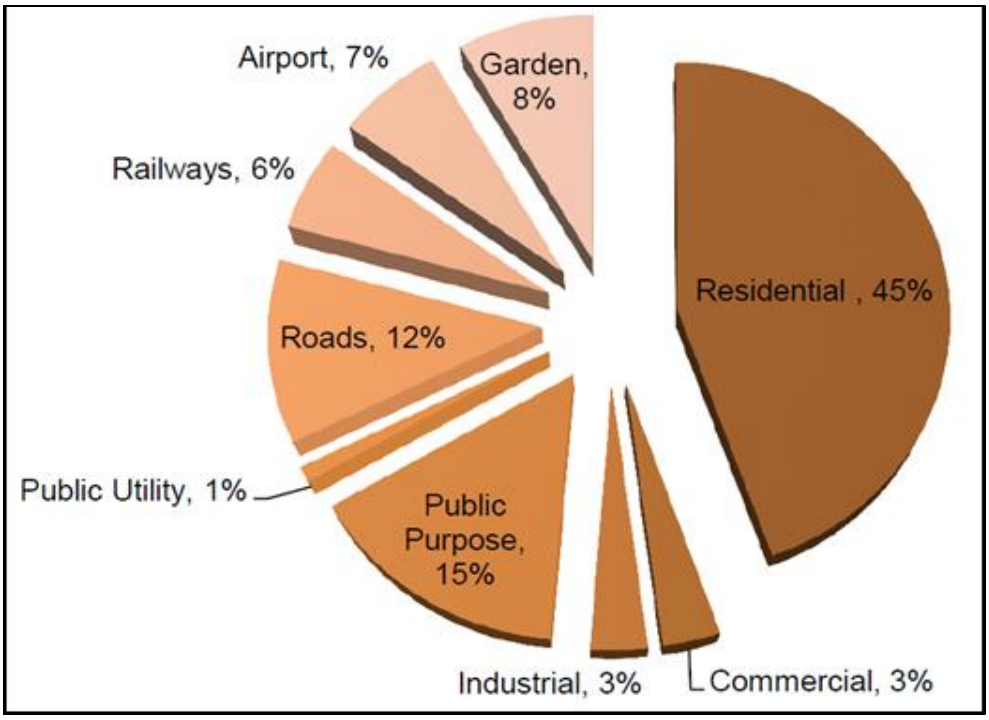
2.11.1 Revised Draft Development Plan 1986-2011

Revised Draft Development Plan 1986- 2011 was prepared by NIT and sanctioned by the Government of Maharashtra (GoM) in 2000. This development plan as given in **Figure 2.4** is currently in force and is due for revision. Recently, the GoM has passed a resolution empowering the NMC as a planning authority for areas under its jurisdiction – this includes the municipal limits of Nagpur City except certain areas that come under the purview of NIT. Consequently the task of preparation of revised development plan has been transferred from NIT to NMC.

The land use distribution indicates the cosmopolitan nature of the city with a fair distribution of land uses. A comparatively higher percentage of land allocated to public purpose indicates the administrative importance of the city. At present, Nagpur is spread over an area of 21,756 ha. As per 1984 land use, only 80% of the land was developable, which has increased in 2011 to 100%.

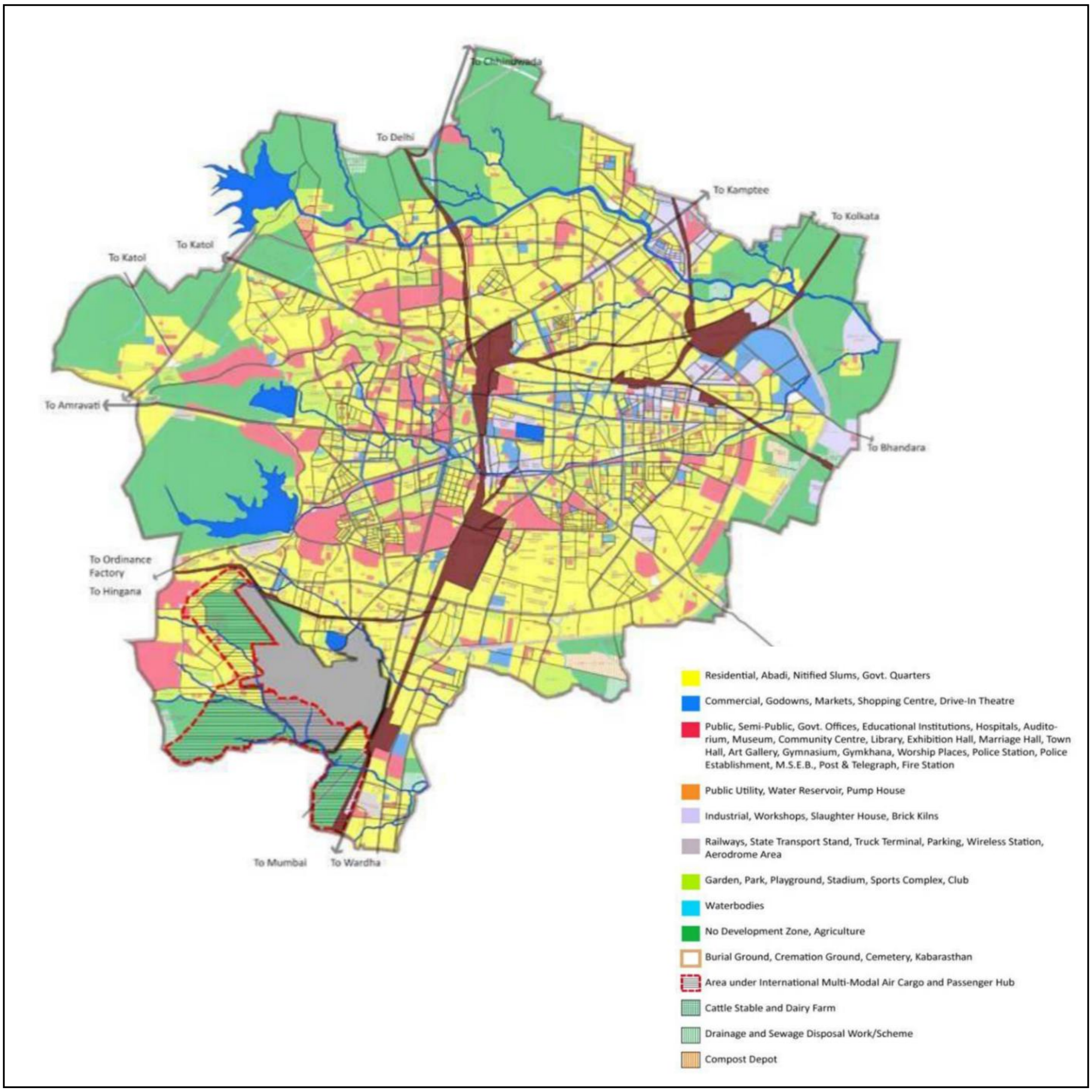
Also, 15033 hectares of area is developed, which is 69% of the total area and developed area in last three decades (since 1984) has doubled. As per the existing land use, majority of the land portion is developed as residential, 45%; commercial and industrial land use is 6%; land under public use is approximately 41%; and 8% is under parks and gardens (**Figure 2.3**).

FIGURE 2.3: EXISTING LANDUSE BREAKUP OF NAGPUR, 2011



Source: Revised Draft Development Plan of Nagpur City, 2011

FIGURE 2.4: REVISED DRAFT DEVELOPMENT PLAN 1986-2011



Source: Revised Draft Development Plan of Nagpur City, 2011

Total area considered under the revised development plan being prepared by NMC is 235 sq. km. Of this, 217.6sq km is under NMC jurisdiction, and rest 7.3sq km is located outside NMC limits. An area of 17.7sq km is earmarked for sewerage and drainage disposal schemes. NMC has divided the entire area into 10 planning units for preparing the development plan. Area of newly merged census town is 7.3sq km will also be added to the NMC area for future development under revised development plan. In order to improve the land use and conform to the required norms as per URDPFI guidelines, the Town Planning department has prepared the revised development plan for Nagpur. The proposed land use for horizon years 2021 and 2031 is given in **Table 2.8.**

TABLE 2.8: PROPOSED LANDUSE PLAN FOR NAGPUR CITY

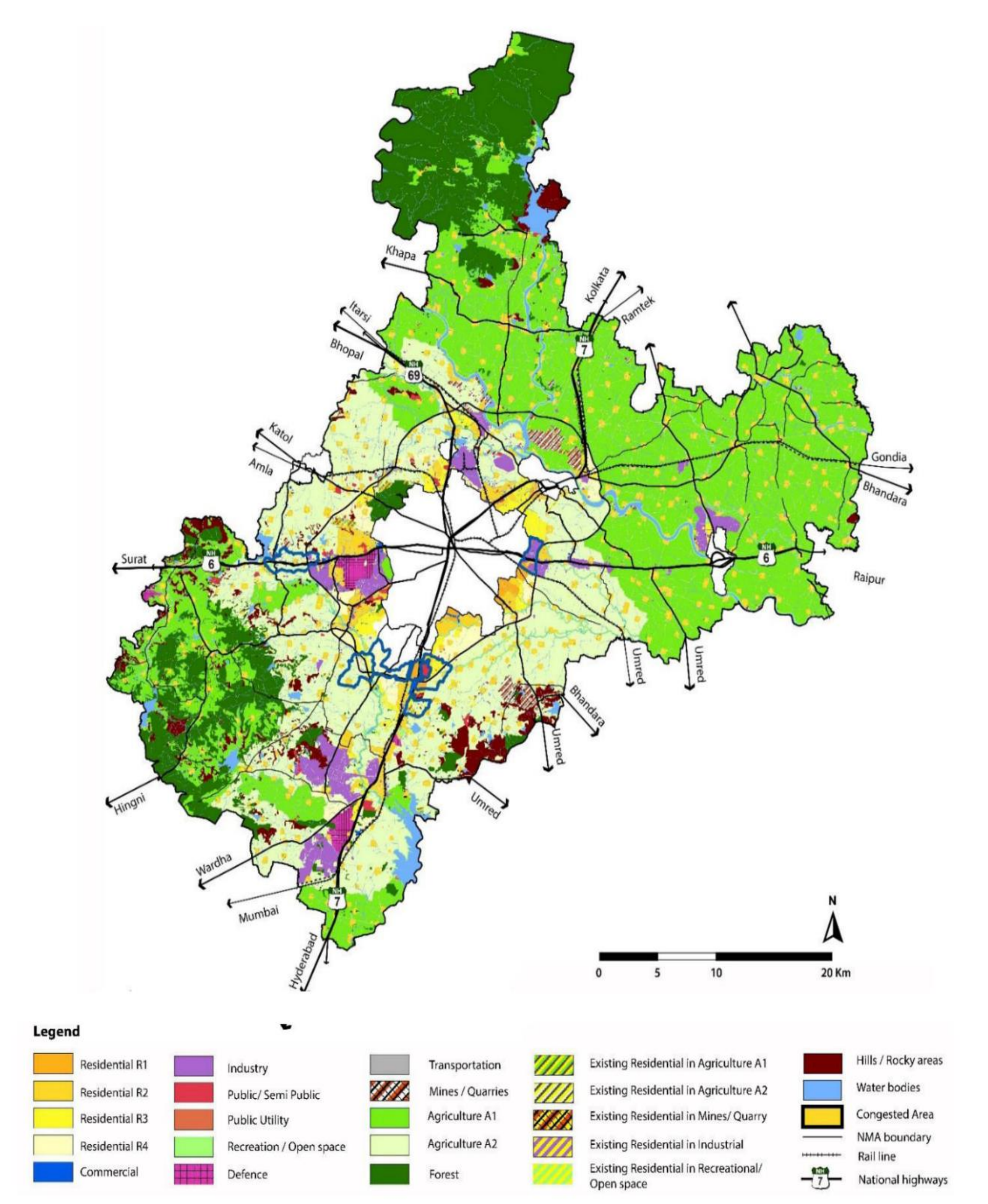
S. No.	Land use	2021			2031		
		Area in Ha.	% of Developed Area	% of Total Area	Area in ha.	% of Developed Area	% of Total Area
1	Residential	6,706	44.6	30.8	7000	46.6	32.2
2	Commercial	501	3.3	2.3	700	4.7	3.2
3	Industrial	495	3.3	2.3	800	5.3	3.7
4	Public Purpose	2,312	15.4	10.6	2312	15.4	10.6
5	Public Utility	149	1.0	0.7	150	1.0	0.7
6	Roads	1,754	11.7	8.1	1800	12.0	8.3
7	Railways	873	5.8	4.0	900	6.0	4.1
8	Airport	993	6.6	4.6	1000	6.7	4.6
9	Garden	1,251	8.3	5.8	1300	8.6	6.0
10	Developable Vacant Land	0	0.0	0.0	0	0.0	0.0
	Total	**15,033**	**100.0**	**69.1**	**15,962**	**100**	**73.4**
11	Agriculture Land	5,774		26.5	4,846		22.3
12	Water Bodies & Nallahs	463		2.1	463		2.1
13	Non-Developable Land	0		0.0	0		0.0
14	Drainage & Sewage Disposal	141		0.6	141		0.6
15	Cattle Stable & Dairy Farm	212		1.0	212		1.0
16	Compost Depot	131		0.6	131		0.6
	Total	**6,723**		**30.9**	**5793**		**26.6**
	Grand Total	**21,756**		**100.0**	**21,756**		**100.0**

Source: Nagpur Environment Assessment Report 2008, CDP for Nagpur 2041, NMC

2.11.2 Nagpur Metropolitan Area Development Plan 2012 - 2032

The State Government formed Nagpur Metropolitan Area (NMA) in 1999. The metropolitan region includes Nagpur city, Nagpur Gramin (rural), Hingna, Parshivni, Mauda, and Kamptee tehsils and parts of Savner, Kalmeshwar, Umred, and Kuhi tehsils. The total metropolitan area considered for carrying out planning and preparing the land use plan is 3,780 sq km, excluding the Nagpur city area under NMC jurisdiction. Preparation of the land use plan for NMR was carried out in two phases. In Phase – 1, the land use plan for an area of 1,520 sq km has been prepared by NIT. The areas earmarked under Phase – I and II are shown in the **Figure 2.5**

FIGURE 2.5 : PROPOSED LANDUSE PLAN FOR NMA



Source: Nagpur Metropolitan Area Development Plan,2032

2.11.3 Comprehensive Mobility Plan For Nagpur, 2018

Comprehensive Mobility Plan has been prepared for long term with a vision for transport in Nagpur to ensure that the city has a planned, best performing transport system to address the needs and concerns of the city. The objectives of CMP is to develop specific actions in the form of short, medium and long term transportation improvement proposals that will achieve the transportation vision for the area.

Important CMP Strategy and Proposals were as follows:

Public transport Proposals

One of the goals defined as part of the vision is to increase the public transport share. For this purpose, augmentation of Buses and Route Rationalization, before embarking on other capital intensive system(s) is considered in CMP.

Based on the PPHPD (Passengers per Hour per Direction) values estimated from the transport model developed for CMP, corridors mentioned in **Table 2.9** and shown in **Figure 2.6** are proposed as High Capacity Mass Transit Corridors and Medium Capacity Transit corridors.

Improvement of City Bus System is also proposed in CMP. Location of proposed depots and terminals are listed in **Table 2.10**. At each proposed location, land required for a Depot would be approximately 5 acres for 100 buses and some additional area would be required for terminal facility.

Important Multi Modal Hub locations proposed in CMP are represented in **Figure 2.7.** Apart from physical integration fare integration and information integration is also proposed. Intelligent Transport System is also proposed for Nagpur city including AFCs, Validators, Electronic Ticket Machines, Security Access Modules etc.

Non-Motorize Transport Strategy and Proposal

To promote NMT in the city, a Public Bike-Sharing scheme is also suggested. All the mobility corridors are recommended for dedicated cycle tracks on both side of the roads. As part of their infrastructure requirement and bike sharing scheme, the major docking stations are proposed at each Transit station (MRTS station, major bus station and Interchanges etc. Cycle Tracks are also proposed for total road length of 146 kms, 87 km is proposed to be constructed in Phase-I and the remaining in Phase-2. Footpath construction is also proposed for new roads as well as existing road network. Also some zones namely Sitabuldi, Mahal, Itwari and Sadar are proposed as a vehicle free zones considering the heavy pedestrian movement

TABLE 2.9: PROPOSED TRANSIT CORRIDORS IN CMP

Sr. No.	Mass Transit Corridors	Length (km)
	High Capacity Mass Rapid Transit Corridors	
1	Automotive Square to Khapri Station	19.7
2	Pardi to Mount View (Hingna)	20.1
3	Automotive Square to Kanhan River	13
4	Prajapati Nagar to Transport Nagar	5.6
5	MIHAN to MIDC ESR	18.5
6	Lokmanya Nagar to Hingna	6.7
7	Vasudev Nagar to Dattawadi	4.5
	Medium Capacity Transit System Corridors	
8	Katol Road	5.8
9	Koradi Road	2.6
10	Umred Road	5.5
11	Amaravathi Road	8.2

FIGURE 2.6: PROPOSED MASS TRANSIT SYSTEMS AS PER CMP

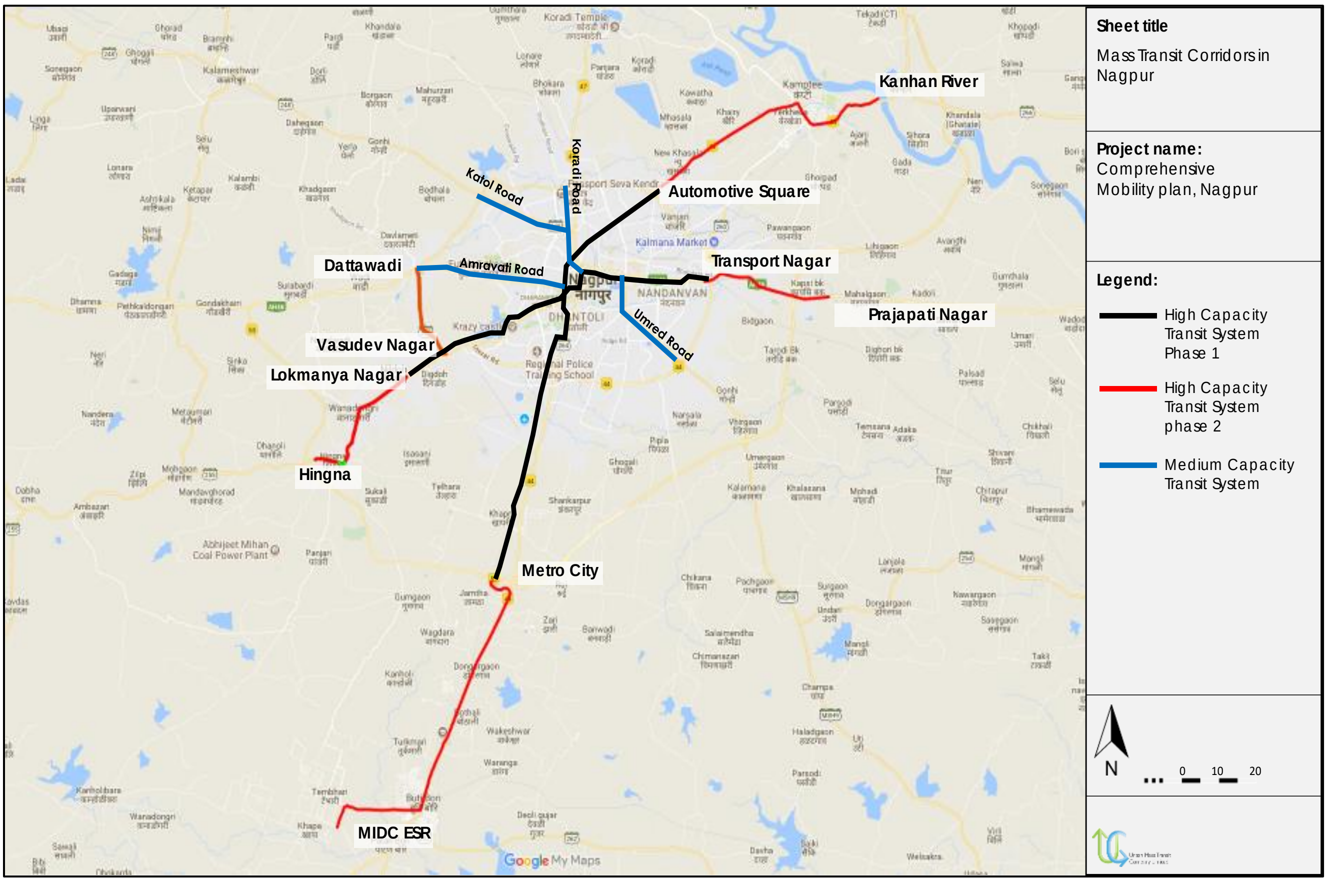
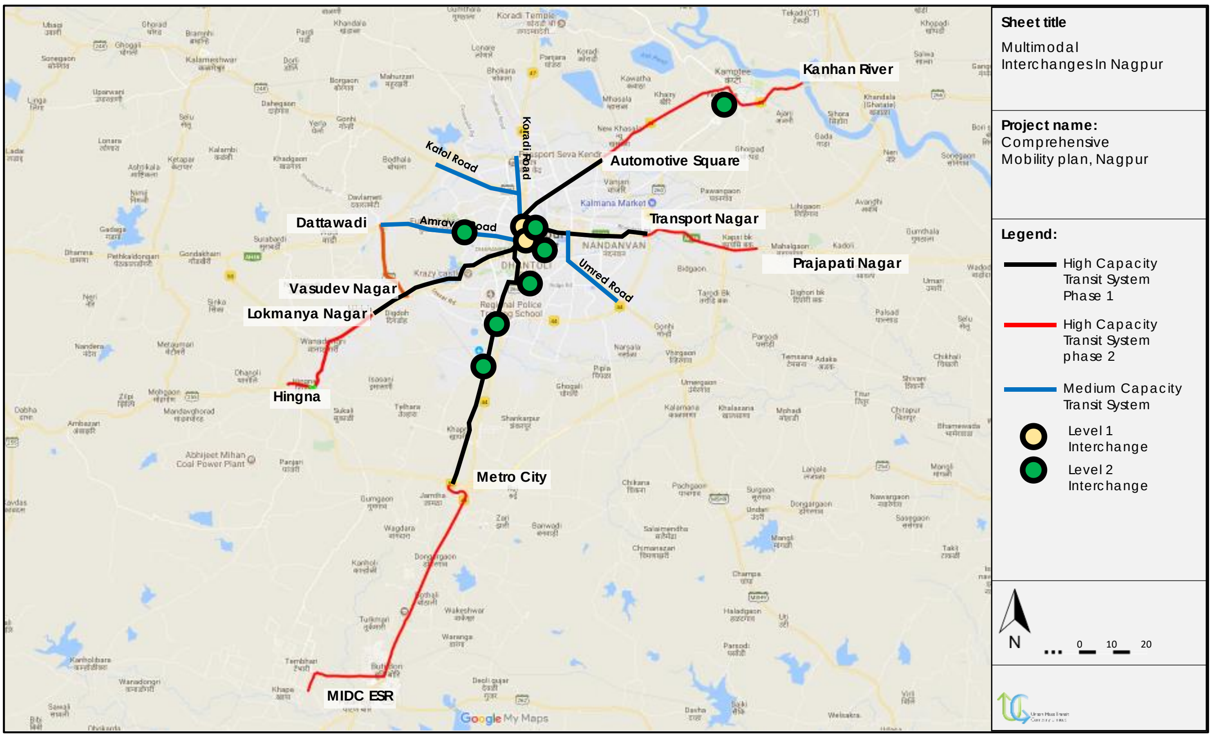


TABLE 2.10: PROPOSED NEW BUS DEPOT AND TERMINAL LOCATIONS IN CMP

Sr. No.	Proposed Location	Facility
1	Adarsh Nagar (Near Manka Pur Square)	New Terminal cum depot
2	Venuka Vaseem Colony	New Terminal cum depot
3	Maulli Nagar	New Terminal cum depot
4	Dighori	New Terminal cum depot
5	Jhakarkati	Up gradation of Terminal
6	Fazalganj	
7	Chunniganj	
8	Rawatpur	
9	Juhi	

FIGURE 2.7: PROPOSED MULTIMODAL HUBS IN CMP



Freight Management Strategy and Proposal

The proposals for freight management are given in phases. Phase 1 includes Improvement of existing Transport Nagar, Movement Restrictions of heavy vehicles in the city Movement restrictions for animal carts on all Orbital and Radial roads etc. the corridors proposed as freight corridors are mentioned in **Table 2.11.**

Proposals for phase 2 & 3 includes setting up of truck terminals at various locations like Koradi, Kamptee, Kapsi etc. and segregated high speed goods vehicle lane on Ring Road.

TABLE 2.11: PROPOSED FREIGHT CORRIDORS IN CMP

S. No.	Freight Corridors	Length	Lanes
1	Inner ring road	40	6
2	Outer New ring* (Existing part ring = Gondakkhairi – Hingna – Gavsi Manapur – Umergaon – Kapsi BK, Proposed part ring = Gondakkhairi – Dahegaon – Mahadula - Kamptee)	110	6

Parking Strategy and Proposal

Parking in Nagpur, especially in the core area, has become a serious concern and needs immediate attention. NMC decided to develop the "Parking Policy and Parking Master Plan for the city" with an aim of closing down the demand-supply gap and manage the future parking demand. Concept of paid parking mechanism is used and applied along the mobility zone- metro corridors and major corridors in the city Central Business District (Commercial areas*) and Mixed zone. Pay and Parking is proposed at following locations:

1. Gaurakshan Rahate colony
2. Indian Gymkhanna ground
3. Panchsheel chowk to lokmat chowk (Area above and below tha fly over)
4. Area in front of Yashvant stadium
5. Kachipura chowk to Creams Hospital (south)

Project Phasing: Short, Medium and Long Term Improvements

All the proposals are broadly grouped under three categories based on their usefulness. The three phases are as under;

- Long Term Improvements: the usefulness of these improvements will last for more than 10-15 years
- Medium Term Improvements: the usefulness of these improvements will last for about 5-10 years
- Short Term Improvements: these are short term proposals that need to be reviewed and revised within 5 years as per the requirement

Short Term Projects : Traffic and Pedestrian Management measures, Junction Improvements and Management Measures, Construction of Footpaths, Provision of cycle track and Provision of Pedestrian Zones and Pedestrian Infrastructure.

Medium Term Projects : Bus Augmentation, Bus shelters, Off Street Parking, ITS, Rail Over Bridges, Freight Terminal, Transport Hub, Bus Depot and Workshop, Bike Sharing

Plan : Docking Station, Rail Over Bridges etc.

Long Term Projects: High/Medium Capacity Mass Transit System, Road network improvement plans, Freight terminals and Multimodal Hubs.

2.11.4 Detailed Project Report For Nagpur Metro Rail Project, 2013

Detailed Project Report for Phase 1 corridors was prepared by DMRC in year 2013. The salient features of the recommended metro rail system and engineering are summarized below:

- Standard Gauge (1435 mm)
- Maximum permissible speed 80 kmph, Scheduled speed for North-South & East-West Corridors are 32-34 kmph and 30 kmph respectively.
- 3 Car rake with 25 KV AC, Overhead Current Collection System
- Signalling System - Cab signaling and continuous automatic train control with Automatic Train Protection (ATP)
- Automatic Fare collection system with POM and Smart card etc.
- Depot- cum- workshop near Khapri Station (MADC Land) and near Lokmanya Nagar Station (SRP Land)

TABLE 2.12: SUMMARY OF DPR PHASE 1

Description	Length (km)	Max. PHPDT						Stations (Elevated, At Grade)
		2016	2021	2026	2031	2036	2041	
Line 1 (North-South Corridor): Automotive Square to MIHAN	19.66	10089	10936	11915	12934	14286	15729	18 (15, 3)
Line 2 (East-West Corridor): Prajapati Nagar to Lokmanya Nagar	18.56	7746	8460	9154	9906	10748	11882	20 (20, 0)

Nagpur Metro Rail Corporation Limited (NMRCL) has already begun the construction of following Phase 1 Corridors of length 38.2 Km. Details presented in **Table 2.12**.

- North-South Corridor - Automotive Square to MIHAN (19.7 km)
- East-West Corridor - Prajapati Nagar to Lokmanya Nagar (18.6 km)

2.11.5 Alternative Analysis Report for Nagpur MRTS Phase-II

Alternatives Analysis has been carried out to find the most feasible alternative transport system for Nagpur Phase-II corridors.

- Qualitative evaluation of the available alternatives namely Normal Bus System, Bus Rapid Transit, Metro Rail and Light Rail Transit have been carried out. Normal Bus and Bus Rapid Transit have been ruled out in view of limited RoW, inability to meet the passenger demand in future and significant greenhouse gas emissions.
- In preliminary screening, Metro Rail and Light Rail Transit emerged as prospective mass transport system for Nagpur for further quantitative evaluations.
- In view of several operational metro rail systems in India and under construction Nagpur Metro Phase-I, its technology as well as various components like track gauge, civil structures and rolling stock components have been standardized and now available within the country. Efforts have also been made by the Government and Implementing Agencies towards indigenizing the various components of metro rail systems. Technical expertise has also been developed in the country over the period of time.
- Based on both qualitative and quantitative screening carried out, Metro System has emerged as the most viable alternative mass transport system for Phase-II corridors to meet the transport needs of Nagpur city.

2.12 INTERCONNECTIONS AMONG VARIOUS STUDIES

The past studies carried out earlier has analysed the existing conditions in detail and have come up with possible improvement proposals in Nagpur. The City requires extension of existing mass transport system that would cater to the increased demand and provide a safe and convenient travel and alleviate the existing traffic woes. Various Non-motorised transport facilities and road improvements have also been part of proposals from CMP.

2.13 ISSUES AND PROSPECTS

2.13.1 Existing Traffic Characteristic and Related Issues

Existing traffic related issues and concerns are listed as follows and presented in **Figure 2.8.**

- Encroachment of footpaths / Unorganized On-street parking causing reduction in efficient roadway width
- Lack of pedestrians facilities like footpath along major roads resulting in pedestrian spill over on right of way
- Chaotic operations of shared auto services
- Absence of necessary infrastructure such as bus stop, lighting etc.

The said issues and concerns are widespread in the City which reduces the efficiency of road carriageway leading to congestion and causes vulnerability to road users. Other reasons for congestion include encroachment of road space by street vendors, unauthorized movement of auto-rickshaws and tempos which have not been regularized. With increase in population and dependence on personalized modes of transport, increase in road accidents the transport system requires expansion and augmentation for safe, efficient and convenient travel.

FIGURE 2.8: EXISTING ISSUES AND CONCERNS

Encroachment of Footpath

Pedestrian & Vehicular Interference

Passenger Traffic

Median without maintenance

Absence of Footpath

Roadside Encroachment and Cyclists in Wrong Side

2.13.2 Air Pollution Levels

Air pollution levels are determined by existing Ambient Air Quality Index (AQI). The AQI considers eight pollutants (PM10, PM2.5, NO2, SO2, CO, O3, NH3, and Pb) in which one of PM10 or PM2.5 parameter is mandatory. There are six AQI categories namely Good, Satisfactory, Moderately polluted, Poor, Very Poor, and Severe. The AQI values for identified pollutants are provided in **Figure 2.9**.From AQI values, it is observed that Nagpur has moderate pollution levels from 101-200.

FIGURE 2.9: AIR QUALITY INDEX PARAMETERS

AQI Category, Pollutants and Health Breakpoints								
AQI Category (Range)	PM_{10} 24-hr	$PM_{2.5}$ 24-hr	NO_2 24-hr	O_3 8-hr	CO 8-hr (mg/m^3)	SO_2 24-hr	NH_3 24-hr	Pb 24-hr
Good (0-50)	0-50	0-30	0-40	0-50	0-1.0	0-40	0-200	0-0.5
Satisfactory (51-100)	51-100	31-60	41-80	51-100	1.1-2.0	41-80	201-400	0.5 –1.0
Moderately polluted (101-200)	101-250	61-90	81-180	101-168	2.1- 10	81-380	401-800	1.1-2.0
Poor (201-300)	251-350	91-120	181-280	169-208	10-17	381-800	801-1200	2.1-3.0
Very poor (301-400)	351-430	121-250	281-400	209-748*	17-34	801-1600	1200-1800	3.1-3.5
Severe (401-500)	430 +	250+	400+	748+*	34+	1600+	1800+	3.5+

Source: NAQI Status of Indian Cities 2015-16, Central Pollution Control Board

2.13.3 Prospects

With view of developing effective and efficient mass transit system to address traffic woes and pollution levels in the City, the Government of Maharashtra has decided to implement Metro Rail system in Nagpur. Phase-I of Nagpur Metro Rail is under implementation. Further extension of Phase-I corridors have been proposed in order to compliment with other sustainable transport initiatives and transport infrastructure improvement measures.

Chapter – 3
TRAVEL CHARACTERISTICS AND DEMAND ESTIMATES

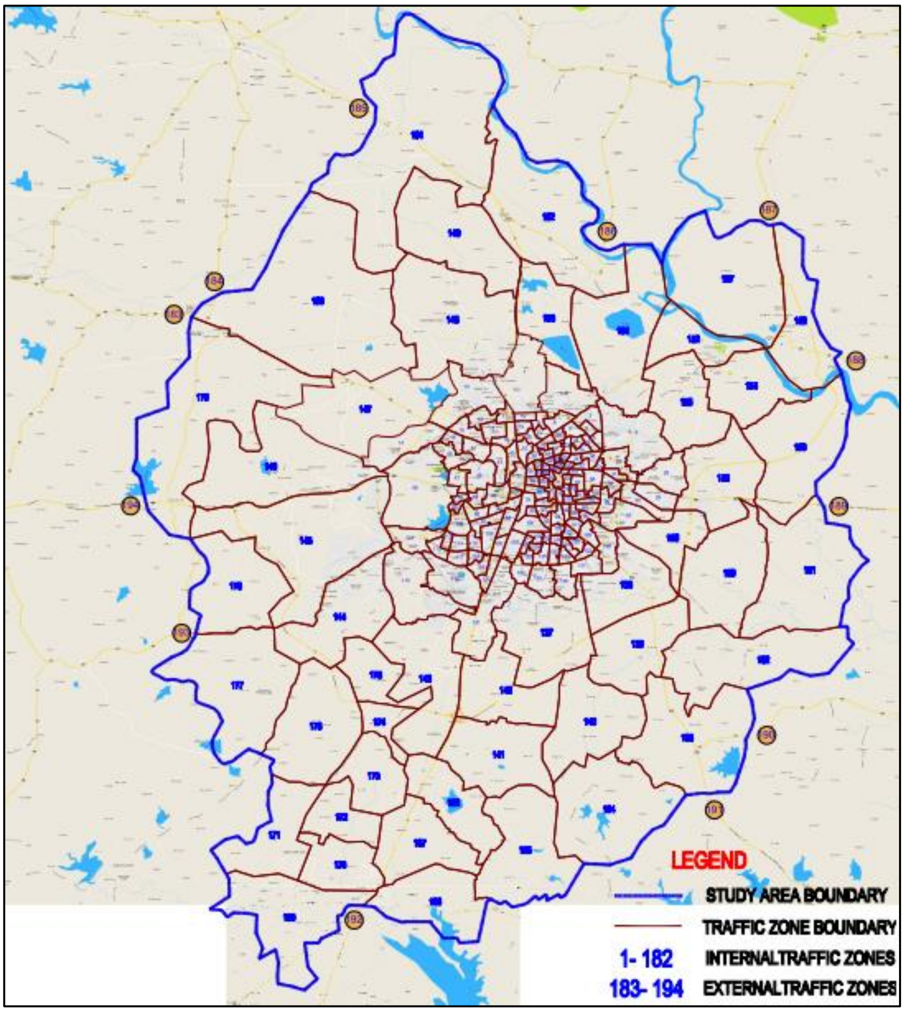
3. TRAVEL CHARACTERISTICS AND DEMAND ESTIMATES

3.1. VARIOUS TRAFFIC AND TRANSPORTATION STUDIES UNDERTAKEN

3.1.1 Study Area and Zoning

The geographic area within the jurisdiction of Nagpur Municipal Corporation (NMC) along with other areas including Municipal Councils of Kamptee, Kalameshwar, Hingna and surrounding villages is taken as the study area. The study area comprise of about 1550 sq km out of total 3567sq km of NMA area. The study area has been divided into 182 internal and 12 external traffic zones. The traffic zone map has been shown in **Figure 3.1.**

FIGURE 3.1: TRAFFIC ZONE SYSTEM



3.1.2 Landuse Surveys

The distribution of the road network with respect to abutting land use is presented in **Table 3.1**. It is seen that the road network is abutted by residential land use upto an extent of about 7% in left and 13% right side of the road, commercial 52% left and 54% right side of the road, residential + commercial 8% left and 9% right side. About 4% left side and 2% right side network has vacant land.

TABLE 3.1: DISTRIBUTION OF ROAD NETWORK AS PER ABUTTING LANDUSE

S. No.	Type	Left		Right	
		Road Length (km)	Percentage (%)	Road Length (km)	Percentage (%)
1	Residential	52.5	6.8	97.5	12.7
2	Commercial	398.8	52.0	416.6	54.3
3	Residential + Commercial	61.4	8.0	66.4	8.7
4	Educational	3.5	0.5	0.7	0.1
5	Industrial	25.1	3.3	15.6	2.0
6	Agriculture	197.1	25.7	156.9	20.5
7	Vacant	28.7	3.7	13.4	1.7
Total		**767.1**	**100.0**	**767.1**	**100.0**

3.1.3 Traffic and Transportation Surveys

A number of traffic & travel surveys were conducted to appreciate and quantify the characteristics of commuter travel within the Study Area. This data analysis has helped us in developing the Travel Demand Model.

3.1.3.1 Classified Traffic Volume Counts

Classified traffic volume surveys were carried on average weekday to quantify the volume of traffic moving along various road sections in the study area. The counts were carried out for 16-hour at mid block/screen line and Intersection locations and for 24 hour at outer cordon locations. The survey locations were selected in a manner that would cover the entire study area and assist in understanding the traffic pattern within the study area as well as with adjacent urban settlements. These surveys help in assessing the existing traffic problems in the study area as well as to validate the transport demand models.

i. Mid-Block/Screen Line Count Survey

Locations of Midblock/Screen Line Counts are shown in **Figure 3.2**. The quantum and temporal variation of total and daily vehicles and trips moving in the study area has been carried out in the following sections.

Average Daily and Peak Hour Traffic Characteristics

The traffic counts both in terms of numbers of vehicles and Passenger Car Units (PCUs) have been computed at various screen line/mid-block locations as presented in **Table 3.2.** It is observed that the traffic at different locations varies from 877 PCUs (1098 vehicle) at Kapsi BK to 72079 PCUs at Bhandara Road near Pardi Bazar Chowk throughout a normal working day.

The peak hour traffic at screen line/mid-block locations is presented in **Table 3.2** The morning peak hour volume varies from 93 PCUs (98 Vehicles) at Jamtha Village to 5708 PCUs along Bhandara Road near Pardi Bazar Chowk & evening peak hour volume varies from 105 PCUs (135 Vehicle) on Jamtha Village to 6977 PCUs at Wardha Road near Ajni Square throughout a normal working day.

ii. Turning Movement Counts at Intersections

Direction-wise classified traffic volume surveys were carried out at 20 intersections on an average weekday in the study area to quantify the mode-wise volume of traffic moving along various road sections and intensity of traffic flow throughout the day. Locations of intersection survey are presented in **Table 3.3** and **Figure 3.3.**

Traffic Volume (Average Daily Traffic – 16 hours)

The traffic counts both in terms of numbers of vehicles and passenger car units (PCUs) have been computed for the total daily (16 hour) traffic at various intersection locations and presented in **Table 3.3.** It is observed that the traffic at different locations varies from 16401 PCU's (16325 Vehicle) at No. 1 Water Tank Chowk to 95045 PCU's (101791 Vehicle) at Automotive Square Intersection which is followed by 75393 PCU's at Butibori Chowk.

iii. Classified Traffic Volume Counts at Outer Cordon Locations

The classified traffic volume counts were carried out at 12 outer cordon locations to assess the intensity of the traffic entering and leaving the study area.

Average Daily (24 hours) and Peak Hour Traffic Characteristics

Outer Cordon survey locations are shown in **Figure 3.2**. Daily and peak hour traffic composition of vehicles at Outer Cordon locations are given in **Table 3.4**. It is observed that most of the locations exhibit predominance of fast moving passenger traffic. The morning peak hour volume varies from 485 vehicles (357 PCUs) at Hingna Road near Ujjayani Buddha Vihar to 1781 vehicles (2853 PCUs) at Bhandara Road near Sawaliand evening peak hour volume varies from 619 vehicles (446 PCUs) at Hingna Road near Ujjayani Buddha Vihar to 2113 vehicles (3395 PCUs) at Bhandara Road near Sawali.

FIGURE 3.2: SCREEN LINE/MID-BLOCK AND SURVEY LOCATIONS

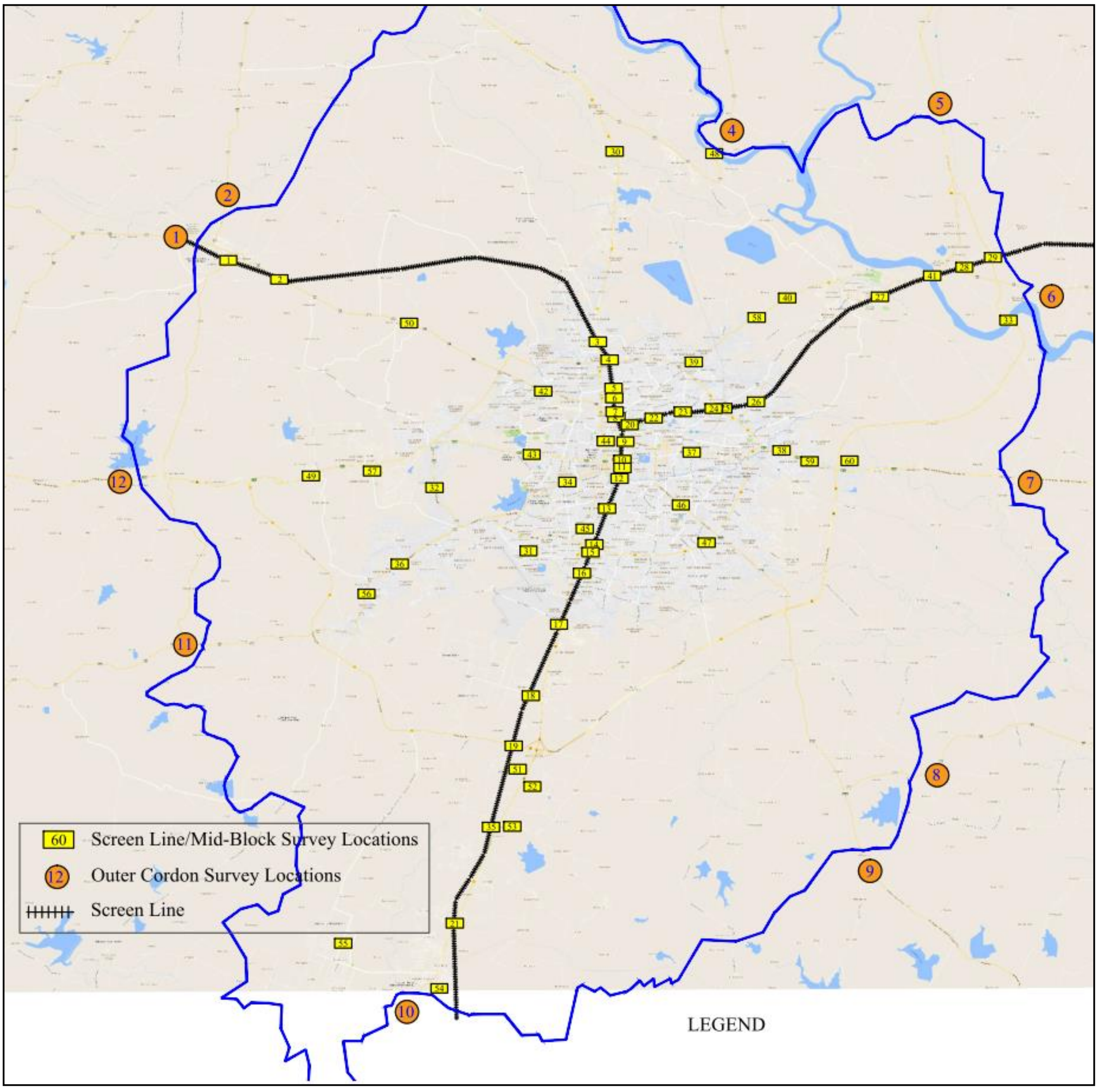


TABLE 3.2: INTENSITY AND DIRECTIONAL DISTRIBUTION OF TRAFFIC AT SCREEN LINE/MID-BLOCK LOCATIONS

Loc No.	Location's Name	Total Traffic		Morning Peak				Evening Peak		Directional Distribution					
										Peak Dir				Off Peak Dir	
		Veh.	PCU	Veh.	% of Tot Traffic	PCU	% of Tot Traffic	Veh.	% of Tot Traffic	PCU	% of Tot Traffic	PCU	%	PCU	%
Screen Line Locations															
SL-1	Ispat Nagar Railway Phatak	9846	7696	918	9.3	659	8.6	1012	10.3	771	10.0	420	63.8	232	35.2
SL-2	Kalmeshwar Railway Crossing	10734	8142	887	8.3	675	8.3	1150	10.7	834	10.2	354	52.5	321	47.6
SL-3	ROB on Chhindwara Raod near Zingabai Takli	28349	25526	2437	8.6	2181	8.5	2702	9.5	2115	8.3	1211	55.5	970	44.5
SL-4	Ring Road Rly. Crossing near Mankapur Chowk	18960	20833	1448	7.6	1573	7.5	1406	7.4	1614	7.7	936	59.5	637	40.5
SL-5	Jaripatka Cement Road Railway Crossing	31084	21842	3297	10.6	2070	9.5	2988	9.6	2223	10.2	1184	57.2	886	42.8
SL-6	Mecosabagh Road ROB near Mayo Hospital	30530	22065	2579	8.4	1787	8.1	3102	10.2	2173	9.8	1100	61.6	688	38.5
SL-7	Manglawari Bazar Road ROB	21912	14176	1709	7.8	1138	8.0	1966	9.0	1316	9.3	588	51.7	550	48.4
SL-8	Kamptee Road RUB near Gurudwara Singh Sabha	76944	47204	6872	8.9	4070	8.6	7901	10.3	4644	9.8	2799	68.8	1271	31.2
SL-9	Ramjhoola ROB	63369	45292	5284	8.3	3673	8.1	6077	9.6	4288	9.5	1910	52.0	1763	48.0
SL-10	Subhash Road RUB near Cotton Market Chowk	81912	60666	6261	7.6	4713	7.8	7598	9.3	5343	8.8	2365	50.2	2348	49.8
SL-11	Ghat Road RUB near Vijay Cinema	57063	39880	4759	8.3	3223	8.1	5845	10.2	3606	9.0	1965	61.0	1259	39.1
SL-12	Humpyard Road RUB near Dhantoli Police Stn.	51697	42296	4484	8.7	3729	8.8	5125	9.9	3806	9.0	2028	54.4	1701	45.6
SL-13	Ajni Road ROB	78686	51719	7265	9.2	4326	8.4	8074	10.3	5290	10.2	3160	73.0	1166	27.0
SL-14	Ring Road RUB near Narendra Nagar	74494	48617	6061	8.1	4054	8.3	9280	12.5	5481	11.3	2618	64.6	1436	35.4

Loc No.	Location's Name	Total Traffic		Morning Peak				Evening Peak		Directional Distribution					
										Peak Dir				Off Peak Dir	
		Veh.	PCU	Veh.	% of Tot Traffic	PCU	% of Tot Traffic	Veh.	% of Tot Traffic	PCU	% of Tot Traffic	PCU	%	PCU	%
SL-15	Narendra Nagar ROB	25936	21458	2470	9.5	1977	9.2	1979	7.6	1762	8.2	1153	58.3	825	41.7
SL-16	Somalwada Rly Crossing near Sheetla Mata Mandir	46535	30896	3835	8.2	2450	7.9	4523	9.7	2838	9.2	1496	61.1	954	38.9
SL-17	Aurangabad Road ROB near Shivangaon	25036	28790	2140	8.5	2645	9.2	2106	8.4	2565	8.9	1656	62.6	989	37.4
SL-18	Khapri Road ROB near TCS	7639	6803	876	11.5	708	10.4	775	10.1	637	9.4	454	64.1	254	35.9
SL-19	Outer Ring Road ROB near Gavsi Mandir	3630	7370	240	6.6	611	8.3	263	7.2	678	9.2	475	77.7	137	22.4
SL-20	Kidwai Road RUB near Nagpur Motibagh Rly Stn.	20001	12820	1829	9.1	1247	9.7	1816	9.1	1143	8.9	677	54.3	570	45.7
SL-21	Wardha Road ROB near Butibori	28500	49614	2465	8.6	3951	8.0	2177	7.6	4220	8.5	2103	53.2	1849	46.8
SL-22	Panchpaoli ROB near Sindhi Hindi College	45227	35458	3198	7.1	2823	8.0	3678	8.1	2862	8.1	1706	60.4	1117	39.6
SL-23	Itwari Railway Station Road ROB	27597	17315	2802	10.2	1772	10.2	2224	8.1	1415	8.2	1072	60.5	701	39.6
SL-24	Old Kamptee Road ROB near Kawadapeth	26504	17751	2101	7.9	1381	7.8	2559	9.7	1682	9.5	719	52.1	662	48.0
SL-25	Ring Road ROB near Namdeo Nagar	38539	46487	2527	6.6	3153	6.8	3222	8.4	4071	8.8	1996	63.3	1158	36.7
SL-26	Kalamna Railway Crossing	12535	11147	819	6.5	832	7.5	1481	11.8	1350	12.1	433	52.0	399	48.0
SL-27	Kamptee Rly Crossing near Dragon Palace Temple	14793	8633	1212	8.2	728	8.4	1268	8.6	717	8.3	450	61.8	279	38.3
SL-28	Shankar Nagar Railway Crossing near Kamptee	8757	7412	957	10.9	794	10.7	861	9.8	790	10.7	508	64.0	286	36.0
SL-29	Jabalpur Road ROB Near Khandala Ghatate	3002	5695	245	8.2	520	9.1	289	9.6	515	9.0	298	57.3	223	42.9
SL-35	Dongargaon Rly xing	3874	2578	283	7.3	247	9.6	320	8.3	198	7.7	185	75.1	62	25.2

Loc No.	Location's Name	Total Traffic		Morning Peak				Evening Peak				Directional Distribution			
												Peak Dir		Off Peak Dir	
		Veh.	PCU	Veh.	% of Tot Traffic	PCU	% of Tot Traffic	Veh.	% of Tot Traffic	PCU	% of Tot Traffic	PCU	%	PCU	%
Mid-Block Locations															
MB-30	Chhindwara Road NH-47, near Nanda	14880	15401	977	6.6	1053	6.8	1307	8.8	1490	9.7	563	53.5	490	46.5
MB-31	Shanivar Bazar Road near Shahakar Nagar	24572	17604	2365	9.6	1575	8.9	2634	10.7	1784	10.1	1147	72.8	428	27.2
MB-32	Ring Road near MIDC Hingna	26204	22857	1741	6.6	1669	7.3	2367	9.0	1950	8.5	892	53.4	777	46.6
MB-33	River Bridge on Kamptee-Kapsi Road near Sihora	6561	11581	432	6.6	853	7.4	586	8.9	1090	9.4	440	51.6	414	48.5
MB-34	Ambazari Road near Shankar Chowk	42441	29838	3670	8.6	2507	8.4	4378	10.3	3128	10.5	1700	67.8	808	32.2
MB-36	Hingna Road near YCCE	26063	24082	1710	6.6	1688	7.0	2530	9.7	2201	9.1	860	50.9	828	49.1
MB-37	Central Avenue Road near Telephone Exchange	51969	39836	4533	8.7	3258	8.2	4789	9.2	3555	8.9	1767	54.2	1491	45.8
MB-38	Bhandara Road near Pardi Bazar Chowk	79564	72079	6586	8.3	5708	7.9	7911	9.9	6636	9.2	3016	52.8	2692	47.2
MB-39	Kamptee Road near Automotive Sqr.	44732	33697	3738	8.4	2788	8.3	3499	7.8	2858	8.5	1636	58.7	1152	41.3
MB-40	Kamptee Road near Bhilgaon	44692	38013	3560	8.0	2988	7.9	4084	9.1	3428	9.0	1601	53.6	1387	46.4
MB-41	Kanhan River Bridge on Kamptee Road	20694	16749	2111	10.2	1633	9.7	1570	7.6	1234	7.4	998	61.1	635	38.9
MB-42	Katol Road near Buddha Vihar	41117	30979	3847	9.4	2769	8.9	6085	14.8	4017	13.0	1734	62.6	1036	37.4
MB-43	Amravati Road near Hindustan Colony	31582	27251	2725	8.6	2205	8.1	2496	7.9	2205	8.1	1474	66.8	731	33.2
MB-44	Wardha Road near Zero Mile Chowk	73484	55866	7406	10.1	5410	9.7	6348	8.6	4476	8.0	3058	56.5	2353	43.5
MB-45	Wardha Road near Ajni Square	94706	65689	7768	8.2	5321	8.1	9835	10.4	6977	10.6	2716	51.0	2605	49.0

Loc No.	Location's Name	Total Traffic		Morning Peak				Evening Peak		Directional Distribution					
										Peak Dir				Off Peak Dir	
		Veh.	PCU	Veh.	% of Tot Traffic	PCU	% of Tot Traffic	Veh.	% of Tot Traffic	PCU	% of Tot Traffic	PCU	%	PCU	%
MB-46	Taj bagh Road near Sakkardara Sqaure	72936	46995	4814	6.6	3156	6.7	9896	13.6	5722	12.2	2047	64.9	1109	35.1
MB-47	Ring Road near Dighori chowk	29558	23683	3082	10.4	2171	9.2	3568	12.1	2223	9.4	1563	72.0	608	28.0
MB-48	Kanhan River Bridge near Bhanegaon	4577	3788	425	9.3	392	10.3	340	7.4	281	7.4	212	54.2	180	46.0
MB-49	Amravati Road near Surabardi	15197	19176	1506	9.9	2219	11.6	1069	7.0	1352	7.1	1560	70.3	659	29.7
MB-50	Katol Road near Fetri Godown	21130	18697	1805	8.5	1571	8.4	1893	9.0	1566	8.4	1031	65.6	541	34.4
MB-51	Jamtha Village Road	1265	960	98	7.7	93	9.6	135	10.7	105	10.9	56	60.0	37	40.0
MB-52	Zari Banwadi Road	1939	1965	259	13.4	308	15.7	131	6.8	251	12.8	254	82.3	55	17.7
MB-53	Ghuti Road	2429	1968	193	7.9	166	8.4	225	9.3	190	9.6	110	57.8	80	42.2
MB-54	Buti Bori Railway Station Road	1919	2317	201	10.5	249	10.7	184	9.6	219	9.5	150	60.2	99	39.8
MB-55	Timbhari Police Station	2390	3041	163	6.8	188	6.2	222	9.3	304	10.0	152	50.1	152	49.9
MB-56	Hingna Road (near Prince Lawn)	43936	31888	4139	9.4	2791	8.8	4116	9.4	2879	9.0	1488	51.7	1391	48.3
MB-57	Ordinance Factory Road near 8th Mile Bus Stop	9378	5771	903	9.6	559	9.7	1010	10.8	587	10.2	354	60.2	234	39.8
MB-58	Kamptee Road near Khairy Buddha Vihar	35088	29192	2401	6.8	2065	7.1	3417	9.7	2691	9.2	1513	56.2	1178	43.8
MB-59	Bhandara Road near Ambe Nagar	40202	43543	3791	9.4	4027	9.2	3124	0.4	3223	7.4	2231	55.4	1796	44.6
MB-60	Near Kapsi BK	1098	877	168	15.3	117	13.3	159	14.5	116	13.2	59	50.6	58	49.4

FIGURE 3.3: INTERSECTION AND TERMINAL SURVEY LOCATIONS

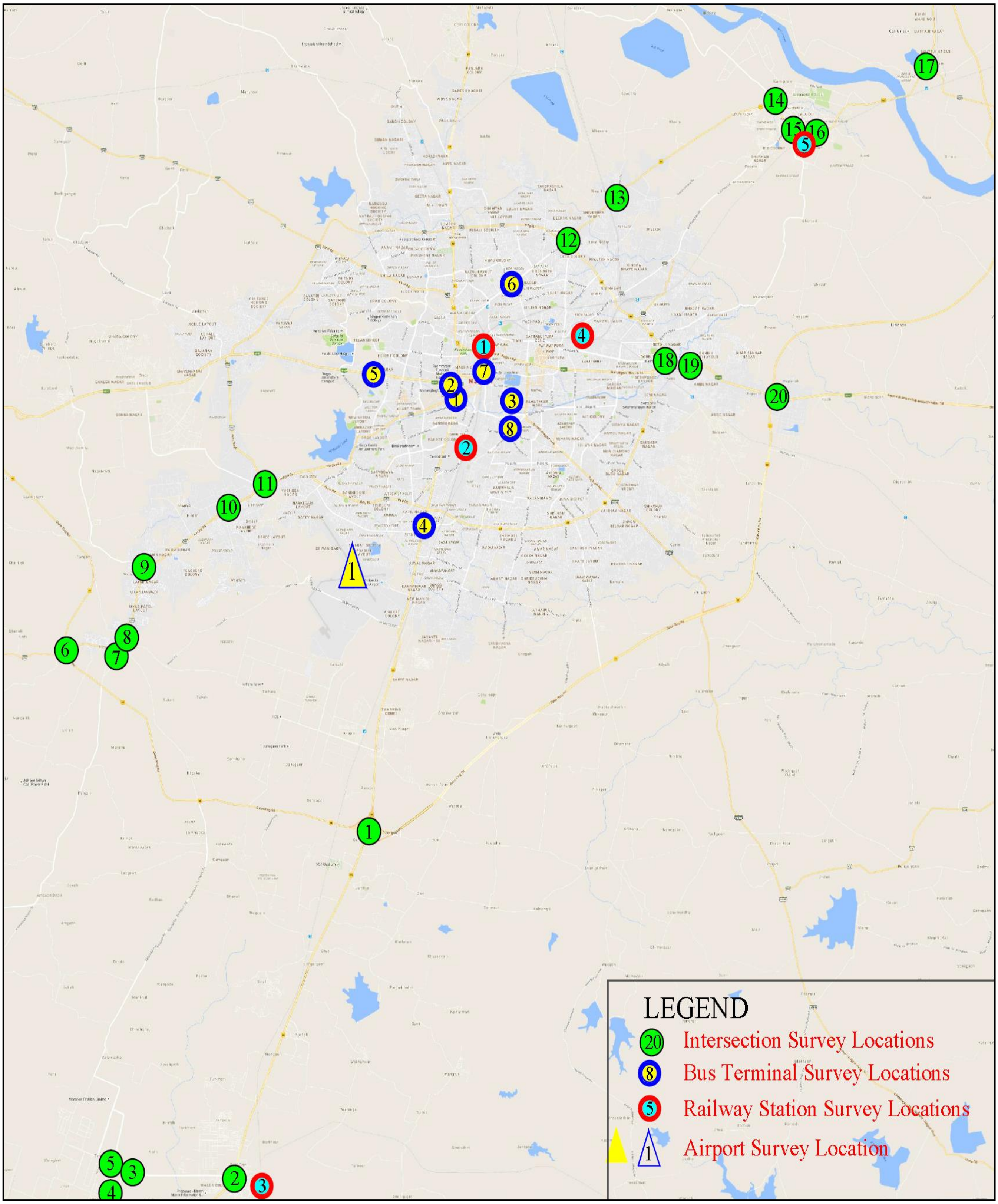


TABLE 3.3: INTENSITY OF TRAFFIC AT INTERSECTION LOCATIONS

S. No.	Name of Location	Total Traffic		Morning Peak				Evening Peak			
		(Veh.)	(PCU'S)	(Veh.)	% of Total Traffic	(PCU'S)	% of Total Traffic	(Veh.)	% of Total Traffic	(PCU'S)	% of Total Traffic
1	Jamtha Chowk	44724	71536	3642	8.1	5655	7.9	3775	8.4	5655	7.9
2	Butibori Chowk	62035	75393	5609	9.0	6301	8.4	6019	9.7	7392	9.8
3	KEC Chowk (Buti Bori)	32016	28931	3370	10.5	2876	9.9	3474	10.9	3008	10.4
4	No.-1 Water Tank Chowk.	16325	16401	1738	10.6	1739	10.6	1546	9.5	1523	9.3
5	Junction near MIDC Garden	24321	22065	2358	9.7	2129	9.6	2328	9.6	2138	9.7
6	Gamaji Chowk	15701	19786	1425	9.1	1624	8.2	1557	9.9	1827	9.2
7	Shivaji Chowk	25103	19088	2500	10.0	1819	9.5	2705	10.8	1958	10.3
8	Ambhore Nagar Chowk	35846	27479	3230	9.0	2458	8.9	3552	9.9	2596	9.4
9	Wanadongri Chowk	55964	38706	4775	8.5	3215	8.3	5024	9.0	3421	8.8
10	Electronic Zone MIDC	51597	36163	4187	8.1	2776	7.7	5154	10.0	3552	9.8
11	Wadi Chowk	50985	35642	4574	9.0	3087	8.7	4869	9.5	3144	8.8
12	Automotive Square	101791	95045	9327	9.2	8307	8.7	9558	9.4	8601	9.0
13	Khasala Chowk	43642	35846	3984	9.1	3072	8.6	4451	10.2	3482	9.7
14	Garud Chowk	46204	37255	4282	9.3	3477	9.3	4895	10.6	3883	10.4
15	Old Kamptee Road Chowk	59907	45967	4923	8.2	3628	7.9	5499	9.2	4091	8.9
16	Babu Hardas L.N Chowk	51686	37621	4192	8.1	2963	7.9	4524	8.8	3246	8.6
17	Kanhan Chowk	33790	25896	2922	8.6	2148	8.3	3214	9.5	2475	9.6
18	H. B. Town	76771	71865	6857	8.9	5684	7.9	7694	10.0	6430	8.9
19	Pardi Chowk Nr. Hanuman Temple	76327	69164	7477	9.8	5890	8.5	6547	8.6	5480	7.9
20	Kapsi Flyover	45523	67230	3866	8.5	4881	7.3	4216	9.3	6049	9.0

TABLE 3.4: INTENSITY AND DIRECTIONAL DISTRIBUTION OF TRAFFIC AT OUTER CORDON LOCATIONS

S.No.	Name of Locations	Total Traffic		Morning Peak				Evening Peak				Directional Distribution			
		(Veh.)	(PCU'S)	(Veh.)	% of Total Traffic	(PCU'S)	% of Total Traffic	(Veh.)	% of Total Traffic	(PCU'S)	% of Total Traffic	Peak Direction (PCUS)	%	Off Peak Direction (PCUS)	%
1	Katol Road near Sun City Restaurant	9002	8922	685	7.61	755	8.46	758	8.42	857	9.60	438	58.01	317	41.99
2	Savner - Kalameshwar Road near Waroda	13398	15528	1045	7.80	1256	8.09	1255	9.37	1425	9.17	639	50.88	618	49.20
3	Chhindwara Road near Patansaongi	15256	13412	1141	7.48	990	7.38	1151	7.54	1013	7.55	531	53.66	459	46.39
4	Parshivni Road (Near Dhruv Motors)	5924	3916	586	9.89	381	9.72	827	13.96	509	13.00	194	50.99	187	49.15
5	Jabalpur Road Near Oriental Toll Plaza	13395	22508	1019	7.61	1660	7.38	1246	9.30	2071	9.20	761	45.84	643	38.73
6	Tarsa Road Near Nilaj	6812	6273	535	7.85	516	8.23	646	9.48	560	8.92	336	65.12	181	35.08
7	Bhandara Road near Sawali	22068	39039	1781	8.07	2853	7.31	2113	9.57	3395	8.70	1858	65.14	995	34.88
8	Kuhi Road near Dongar Gaon	5892	7665	490	8.32	555	7.24	443	7.52	673	8.78	302	54.41	254	45.77
9	Umred Road near Champa	10234	14156	825	8.06	1139	8.04	780	7.62	1068	7.54	608	53.40	531	46.64
10	Chandrapur Road Near Wardha Crossing	20829	35252	1681	8.07	2837	8.05	1695	8.14	2977	8.44	1430	50.41	1407	49.60
11	Hingna Road near Ujjayani Buddha Vihar	6175	4914	485	7.85	357	7.26	619	10.02	446	9.08	185	51.82	173	48.46
12	Amravati Road near Pethkaldongari	17198	23505	1320	7.68	2195	9.34	1682	9.78	2354	10.01	1460	66.51	735	33.49

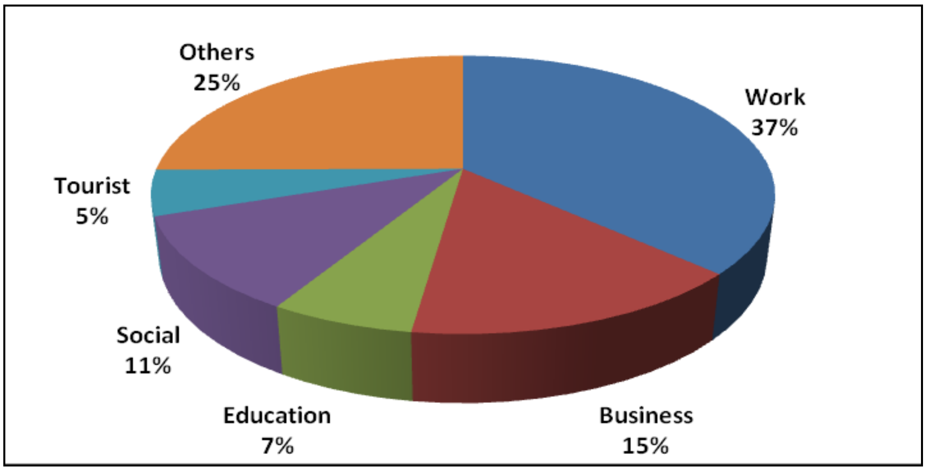
3.1.3.2 Road Side Origin and Destination Interviews at Outer Cordon Locations

It is observed from **Table 3.5** and **Figure 3.4** that the share of work and business purpose trips are 37% and 15.2% respectively at outer cordon locations. The educational trips contribute about 6.3%.

TABLE 3.5: DISTRIBUTION OF OUTER CORDON PASSENGERS BY TRIP PURPOSE

S. No.	Trip Purpose	Percentage (%)
1	Work	37
2	Business	15.2
3	Education	6.3
4	Social	11.1
5	Tourist	5.3
6	Others	25.1
Total		**100**

FIGURE 3.4: DISTRIBUTION OF OUTER CORDON PASSENGERS BY TRIP PURPOSE

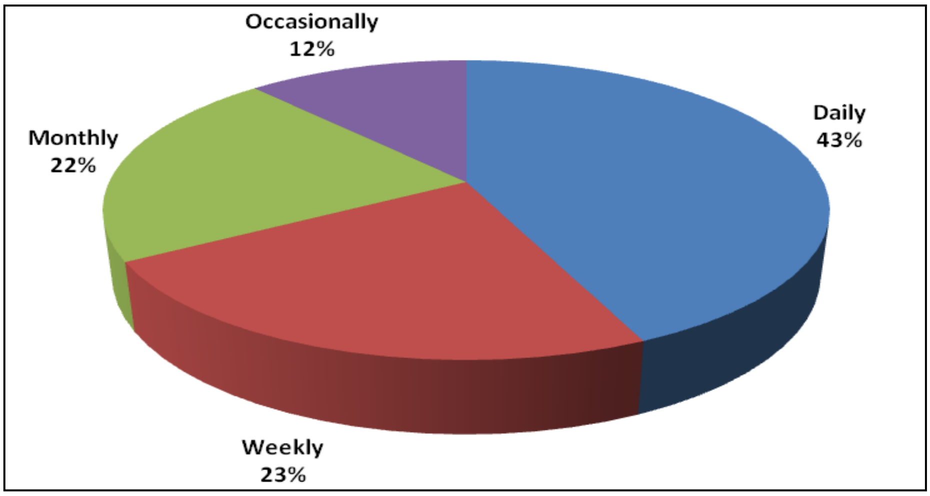


It is observed from **Table 3.6** and **Figure 3.5** that about 43.4% of passengers travel on daily basis, 23.4% Weekly, 21.6 % Monthly and 11.8% Occasionally at outer cordons.

TABLE 3.6: DISTRIBUTION OF OUTER CORDON PASSENGERS BY TRAVEL FREQUENCY

S. No.	Frequency	Percentage (%)
1	Daily	43.3
2	Weekly	23.4
3	Monthly	21.6
4	Occasionally	11.8
Total		**100**

FIGURE 3.5: DISTRIBUTION OF OUTER CORDON PASSENGERS BY TRAVEL FREQUENCY

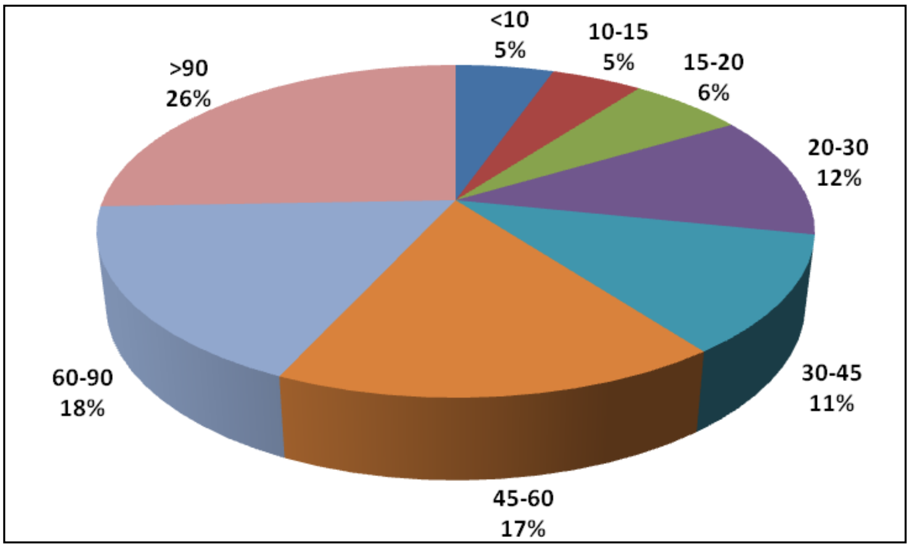


It is observed from **Table 3.7** and **Figure 3.6** that about 23% of total passengers travel time is 20-45 minutes and about 17% of passengers travel for 45-60 minutes and nearly 26% travel time is more than 90 minutes.

TABLE 3.7: DISTRIBUTION OF OUTER CORDON PASSENGERS BY TRAVEL TIME

S. No.	Travel Time	Percentage (%)
1	<10	5.3
2	10-15	4.9
3	15-20	6.2
4	20-30	11.9
5	30-45	11.5
6	45-60	17
7	60-90	17.6
8	>90	25.6
Total		**100**

FIGURE 3.6: DISTRIBUTION OF OUTER CORDON PASSENGERS BY TRAVEL TIME

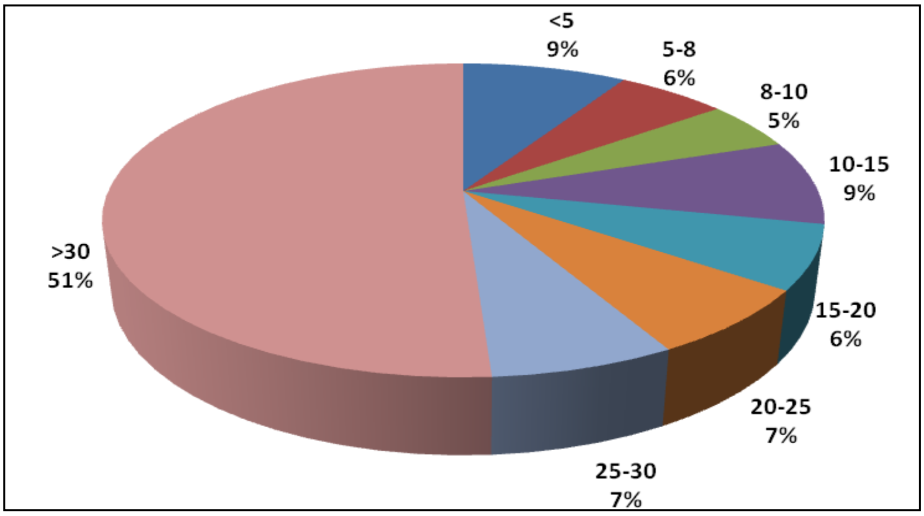


Distribution of Passengers by trip length is presented in **Table 3.8** and **Figure 3.7.** It is observed that 8.8% of Passengers Trip length is less than 5 km. About 11% trip length is 5-10 kms & 51% trip length more than 30 km.

TABLE 3.8: DISTRIBUTION OF OUTER CORDON PASSENGERS BY TRIP LENGTH

S. No.	Trip Length (km)	Percentage (%)
1	<5	8.8
2	5-8	5.9
3	8-10	5
4	10-15	8.7
5	15-20	6.6
6	20-25	7
7	25-30	7
8	>30	51.1
Total		**100**

FIGURE 3.7: DISTRIBUTION OF OUTER CORDON PASSENGERS BY TRIP LENGTH



3.1.3.3 Willingness to Pay/Use Surveys

This section focused on the opinion of users with respect to various characteristics of a new mass transit system in Nagpur. The respondents at various bus terminals, rail terminals and airport were queried with regard to preference for the quantum of extra fare they are willing to pay.

i. Willingness to Pay Survey at Bus Terminals

It is observed that about 6438 (98.3%) bus passengers have willingness to shift to MRTS which gives them comparatively superior travelling experience. The willingness to pay extra fare for reaching bus terminal is presented in **Table 3.9.** The result indicates that about 47% respondents want the same existing fare for new public transport, 47% are willing to pay up-to Rs.5 as extra fare.

About 6% are willing to pay more than Rs.10 as extra fare for MRTS in comparison to existing fare.

TABLE 3.9: WILLINGNESS TO PAY FOR REACHING BUS TERMINAL BY METRO

Parameters	Same as Existing Mode Fare	Extra as Compared to Existing Mode Fare (Rs.)					Total
		2	5	10	12	>=15	
Bus Passengers	3027	2136	883	316	58	18	6438
Composition (%)	47.0	33.2	13.7	4.9	0.9	0.3	100.0

ii. Willingness to Pay Survey at Rail Terminals

It is observed that about 6482 (92%) of rail passengers have willingness to shift to MRTS. The result indicated in **Table 3.10** shows that about 21% respondents want the same existing fare for new public transport, 70% are willing to pay up-to Rs.5 as extra fare.

TABLE 3.10: WILLINGNESS TO PAY FOR REACHING RAIL TERMINAL BY METRO

Parameters	Same as Existing Mode Fare	Extra as Compared to Existing Mode Fare (Rs.)					Total
		2	5	10	12	>=15	
Rail Passengers	1350	3376	1148	504	78	26	6482
Composition (%)	20.8	52.1	17.7	7.8	1.2	0.4	100.0

iii. Willingness to Pay Survey at Airport

It is observed that 1131 (99%) of surveyed passengers have willingness to shift to MRTS. The willingness to pay extra fare to reach Airport by MRTS is presented in **Table 3.11.** The result indicates that about 4% respondents want the existing fare for new public transport as same as existing fare, 67% are willing to pay up-to Rs.5 as extra fare. About 29% are willing to pay in the range of Rs.10Rs 15 as extra fare. And, only about 3% of respondents are showing their willingness to pay more than Rs.15 as extra fare for good MRTS system in comparison to existing fare.

TABLE 3.11: WILLINGNESS TO PAY FOR REACHING AIR TERMINAL BY METRO

Parameters	Same as Existing Mode Fare	Extra as Compared to Existing Mode Fare (Rs.)					Total
		2	5	10	12	15	
Air Passengers	44	318	438	247	71	13	1131
Composition (%)	3.9	28.1	38.7	21.8	6.3	1.1	100.0

3.1.3.4 Speed and Delay Survey

The speed and delay survey was conducted along the network using the running car method during peak and off-peak periods. The results of the survey with respect to the journey and running speed and delays are presented in the following paragraphs.

i. Journey Speed

The journey speed characteristics during peak and off-peak period are presented in **Table 3.12**. It is observed that about 54% of the total road network has journey speed upto 30 kmph and 28% of network has journey speed more than 40 kmph during peak hours. About 40% of surveyed network has journey speed upto 30 kmph and 32% of network has journey speed more than 40 kmph during off-peak hours. Average Journey Speed during peak and off-peak period for city as a whole is observed to be 23.4 kmph and 27.1 kmph respectively.

TABLE 3.12: DISTRIBUTION OF ROAD LENGTH BY PEAK HOUR JOURNEY SPEED

S. No.	Journey Speed (km/hr)	Peak Hour		Off-Peak Hour	
		Road Length (km)	Percentage (%)	Road Length (km)	Percentage (%)
1	<=20	163.6	21.3	94.6	12.3
2	21-30	250.6	32.7	213.6	27.8
3	31-40	139.2	18.1	213.4	27.8
4	41-50	148.8	19.4	153.7	20.0
5	>50	64.9	8.5	91.8	12.0
Total		**767.1**	**100.0**	**767.1**	**100.0**

ii. Running Speed

The distribution of road length by peak and off-peak hour running speed is given in **Table 3.13.** It can be observed that about 45% of the road network has running speed less than 30 kmph during peak hours. Average running speed for peak and off-peak period for city as a whole is found as 28.3 Kmph and 30.9 Kmph respectively.

iii. Delays

The distribution of causes of delays during peak hours and off-peak hours is presented in **Table 3.14**. The analysis of causes of delays reveal that the delays are caused mostly by traffic signal which account for about 60% in the peak hour, while traffic Jam with traffic signal account for about 22%. Whereas delay in the off peak period, due to traffic congestion accounts for 73%.

TABLE 3.13: DISTRIBUTION OF ROAD LENGTH BY PEAK HOUR RUNNING SPEED

S. No.	Running Speed (km/hr)	Peak Hour		Off-Peak Hour	
		Road Length(km)	Percentage (%)	Road Length(km)	Percentage(%)
1	<=20	53.8	7.0	26.6	3.5
2	21-30	289.4	37.7	206.4	26.9
3	31-40	202.5	26.4	274.8	35.8
4	41-50	145.8	19.0	166.7	21.7
5	>50	75.6	9.9	92.6	12.1
Total		**767.1**	**100.0**	**767.1**	**100.0**

TABLE 3.14: DISTRIBUTION OF CAUSES AND DELAYS IN PEAK & OFF PEAK HOURS

S. No.	Causes and Delays	Peak Hour		Off-Peak Hour	
		No. of Points	Percentage	No. of Points	Percentage
1	Traffic Jam	34	13.5	17	9.3
2	Traffic Signal	152	60.3	134	73.2
3	Traffic Jam + Traffic Signal	55	21.8	26	14.2
4	Railway Crossing	11	4.4	6	3.3
Total		**252**	**100.0**	**183**	**100.0**

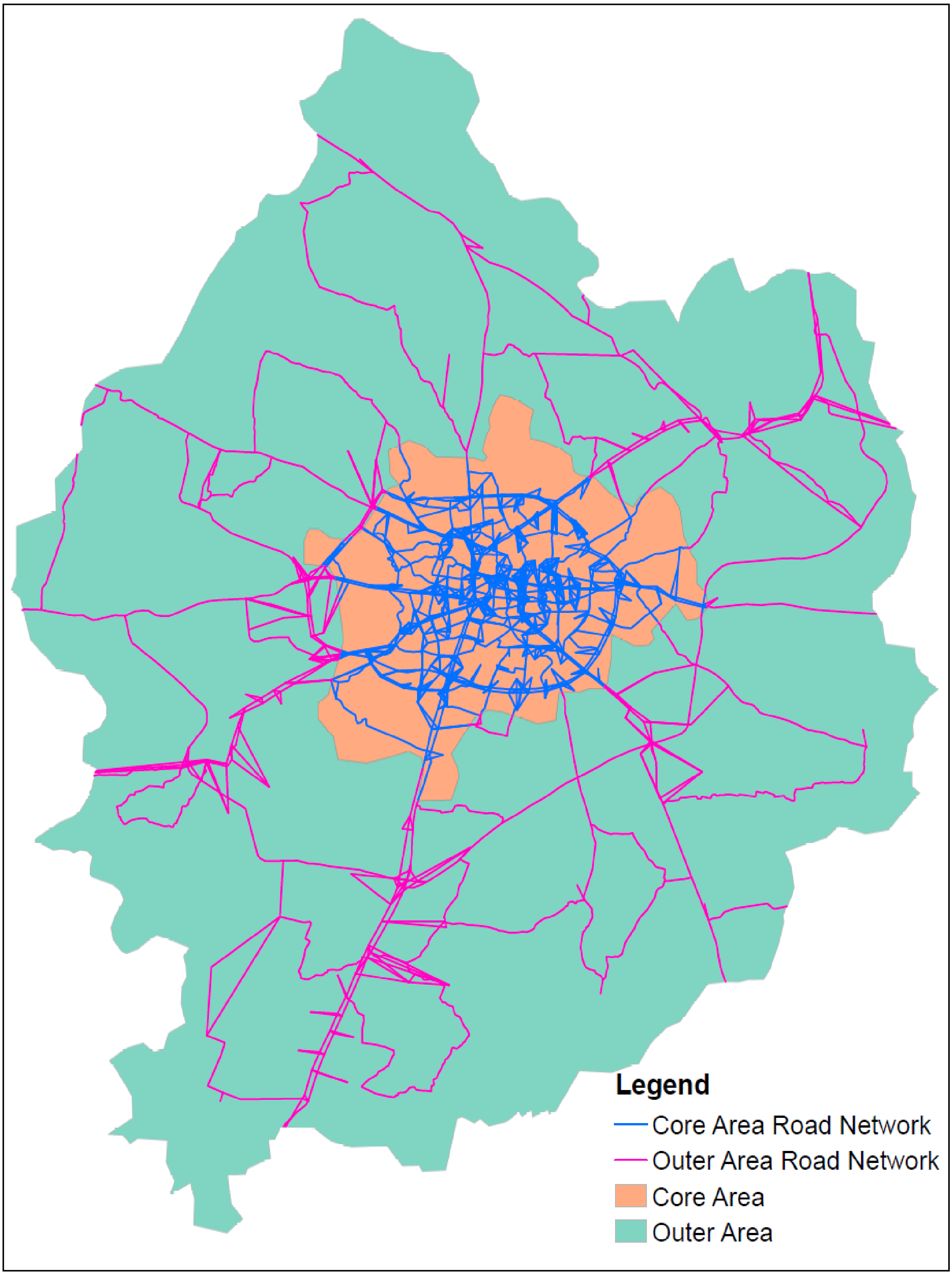
iv. Area wise Journey Speed Characteristics

The Journey Speed in core area and outer area is given in **Table 3.15**. It can be observed that journey speed is about 19 kmph in core area, 34 kmph in outer area during peak hours. The road network considered for core and outer areas are given in **Figure 3.8.**

TABLE 3.15: DISTRIBUTION OF CAUSES AND DELAYS IN PEAK & OFF PEAK HOURS

S. No.	Area	Journey Speed (kmph)
1	Core Area	19.03
2	Outer Area	34.13

FIGURE 3.8: ROAD NETWORK IN CORE AND OUTER AREA



3.1.3.5 Parking Characteristics

The Parking surveys data for 40 locations at identified on-street parking stretches on major arterial and sub-arterial roads and at major existing off-street parking lots in the study area for 12 hours (8 a.m. to 8 p.m.) on fair weather working day is given in the following sections. Parking survey locations presented in **Figure 3.9.**

i. Parking Accumulation

The observed peak parking accumulation along the surveyed locations is presented in **Table 3.16**. The total peak parking accumulation at the surveyed locations with maximum concentration is observed at Central Avenue Road (Meo Hospital to Satguru Machine Tools) (150 E.C.S.)

ii. Parking Demand

The total parking demand at the surveyed locations is presented in **Table 3.17.** The total parking demand over the day at the main parking stretches was observed to be about 17,054 E.C.S. with maximum demand being observed at Central Avenue Road (Meo Hospital to Satguru Machine Tools).

iii. Parking Duration

The composition of parking demand by parking duration is presented in **Table 3.18**. It indicates that 97.5% of cars are parked on short-term duration basis. It is also observed that max. number of 2Ws are also parked for short term basis.

FIGURE 3.9: PARKING SURVEY LOCATIONS

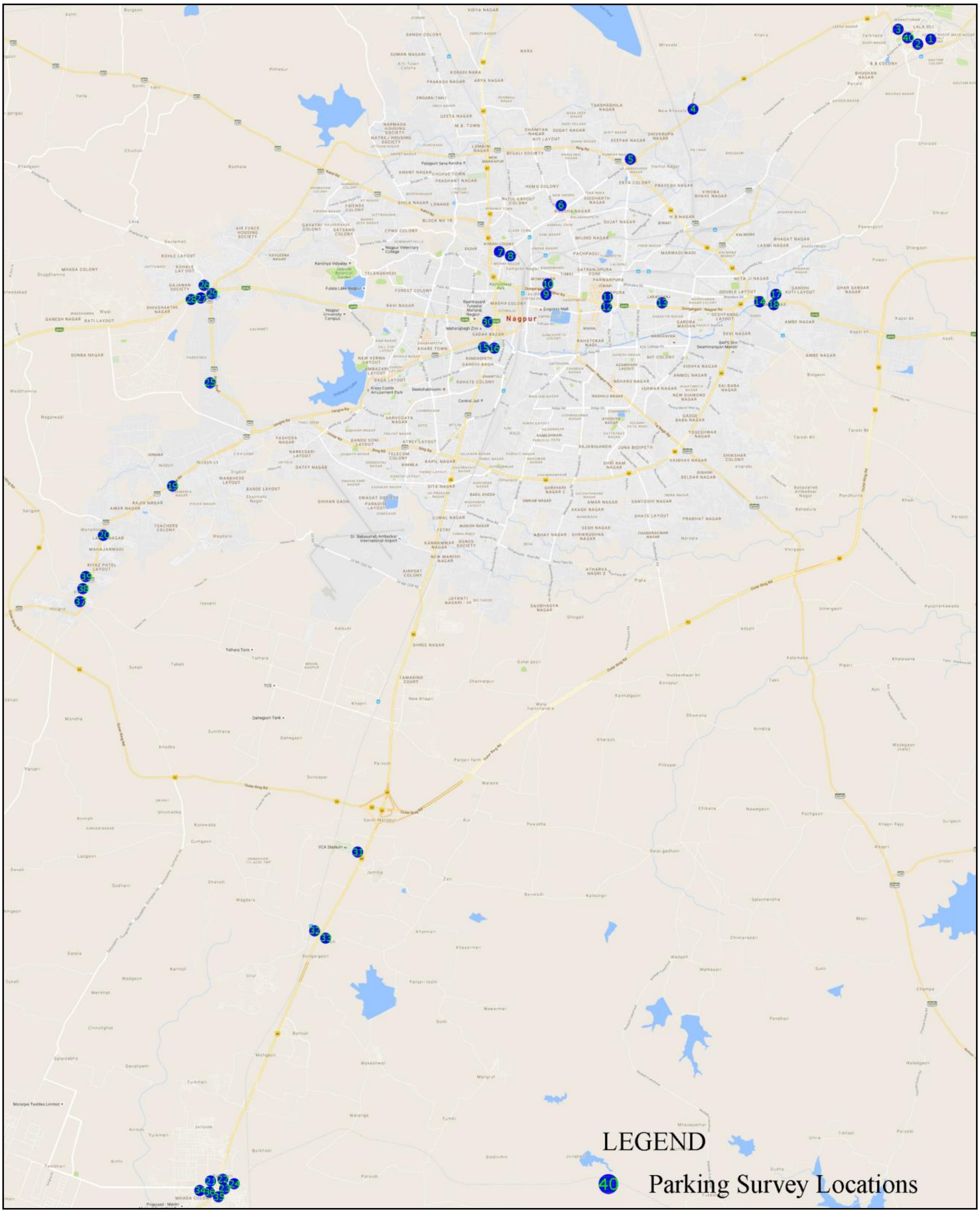


TABLE 3.16: PEAK HOUR PARKING ACCUMULATION

S. No.	Location Name	Peak Accumulation					Peak Accumulation Equivalent Car Spaces (ECS)
		Peak Time	Car	T.w.	Auto	Bus	
1	Kamptee Bus Stop (Govt. Hospital to Choudhary Hospital)	1700-1800	12	45	26	3	58
2	Kamptee Bus Stop (Shanti Niwas Lounge to Narayan Singh Dwar)	1800-1900	14	65	11	5	56
3	Kamptee Road (Mato Shri Motor to Near Dargah Road)	1100-1200	10	57	12	6	54
4	Kamptee Rd. Naka No-2 Bhilgaon (Abha Travel to Aamir Khan Travels)	1900-2000	19	23	18	8	67
5	Sharda Chowk Automotive (Masjid Nagin Nuri to Shri Sai Mandir)	1800-1900	7	26	3	1	20
6	Indora Chowk Kamptee Road (Opp. Yashwantpuri Mall)	1900-2000	34	43	10	2	61
7	Gaddi Godam (Rail Bridge to Gaddi Godam Chowk)	1500-1600	31	76	38	3	97
8	Gaddi Godam (Rail Crossing Bridge to Gaddi Godam Chowk)	1400-1500	71	140	7	0	113
9	Central Avenue Road (Meo Hospital to Satguru Machine Tools)	1400-1500	84	105	22	6	150
10	Chander Lok Building (Krishnum Restaurant to Vikas Travels)	1700-1800	39	91	0	0	62
11	Gandhi Bagh Chowk (HDB Financial to Geetanjali Jewellers)	1800-1900	32	64	3	2	57
12	Gandhi Bagh Chowk to Chander Shekhar Azad Chowk	1800-1900	36	75	4	2	65
13	Central Avenue Road (Dr. Ambedkar Chowk to Chappru Nagar Chowk)	1200-1300	33	44	9	0	53
14	HB Chowk Bhandara Rd. (HB Town Chowk to Shikhar Wine Shop)	1400-1500	26	17	3	0	33
15	Wardha Road Right (Panchshil Talkies to Lokmat Square)	1900-2000	94	40	6	0	110
16	Wardha Road Left (Panchshil Talkies to Lokmat Square)	1600-1700	84	29	7	0	98
17	Pardi Bazar Chowk Bhandara Rd. (Pallavi Online Lotary to Girnar Computer)	0800-0900	23	41	3	1	39
18	Pardi Bazar Chowk (Lucky Chicken to Shri Shubh Laxmi Credit Socaity Ltd.)	1400-1500	9	40	4	1	26
19	Electronic Zone Chowk(Electronic Zone Chowk to Sachine Medical	1600-1700	6	78	2	0	28
20	WanaDongri (WanaDongri Chowk to Prince Lawn)	1500-1600	6	33	7	3	30

S. No.	Location Name	Peak Accumulation					Peak Accumulation Equivalent Car Spaces (ECS)
		Peak Time	Car	T.w.	Auto	Bus	
21	Wardha Road Right (Usha Family Resturant to Parnav Juice Parlour)	1500-1600	6	94	1	0	31
22	Wardha Road Left (Towards Wardha)	1100-1200	1	64	4	2	27
23	AmchiButibori Chowk (RHS)	1100-1200	7	32	10	0	25
24	Behind of Acharya Bhawan	1000-1100	6	53	1	0	20
25	Maruti Showroom (Infront of Maruti Showroom Gate)	1300-1400	8	32	0	0	16
26	Dutta Wadi (JK Tyre to Raison Family Resturant)	1600-1700	20	97	0	2	50
27	Wadi Square (Hotel Rahul Palace Under Hotel)	1900-2000	3	53	0	0	16
28	Wadi Square (Rahul Hotel to Toll Gate)	1700-1800	16	11	0	0	19
29	Wadi Squre Left (Pan Corner to PNB ATM)	1300-1400	7	33	4	0	19
30	Amravati Road (Eternity Mall to Shri Niketan Xerox)	1900-2000	18	104	18	0	62
31	Wardha Road near Jamtha Village	1630-1700	4	24	0	0	10.0
32	Wardha Road near Dongar Gaon (Left)	1130-1200	6	44	0	0	17.0
33	Wardha Road near Dongar Gaon (Right)	1730-1800	5	41	1	0	16.3
34	MIDC road near Butibori Chowk	1030-1100	17	22	14	0	36.5
35	Butibori Chowk near Patanjali Store	1130-1200	2	166	0	0	43.5
36	Wardha Road near Butibori Chowk (Right)	1830-1900	7	54	0	0	20.5
37	Lallu Sai Chowk	1200-1230	12	45	4	0	27.3
38	SDM Office Hingna	1400-1430	3	11	2	0	7.8
39	Hingna Road near Hanuman Temple	930-1000	7	35	16	0	31.8
40	Old Kamptee	930-1000	7	20	9	0	21.0

TABLE 3.17: PARKING DEMAND

S. No.	Location Name	Car	TW	Auto	Bus	Parking Demand (ECS)
1	Kamptee Bus Stop (Govt. Hospital to Choudhary Hospital)	150	716	196	19	582
2	Kamptee Bus Stop (Shanti Niwas Lounge to Narayan Singh Dwar)	112	1103	156	22	610
3	Kamptee Road (Mato Shri Motor to Near Dargah Road)	99	711	136	29	500
4	Kamptee Rd. Naka No-2 Bhilgaon (Abha Travel to Aamir Khan Travels)	128	419	188	30	511
5	Sharda Chowk Automotive (Masjid Nagin Nuri to Shri Sai Mandir)	20	358	63	17	224
6	Indora Chowk Kamptee Road (Opp. Yashwantpuri Mall)	111	622	152	12	455
7	Gaddi Godam (Rail Bridge to Gaddi Godam Chowk)	430	802	285	14	958
8	Gaddi Godam (Rail Crossing Bridge to Gaddi Godam Chowk)	507	933	113	13	892
9	Central Avenue Road (Meo Hospital to Satguru Machine Tools)	590	936	236	67	1261
10	Chander Lok Building (Krishnum Restorant to Vikas Travels)	195	382	15	4	318
11	Gandhi Bagh Chowk (HDB Financial to Geetanjali Jewellers)	296	680	37	25	578
12	Gandhi Bagh Chowk to Chander Shekhar Azad Chowk	321	773	48	28	646
13	Central Avenue Road (Dr. Ambedkar Chowk to Chappru Nagar Chowk)	276	331	22	3	390
14	HB Chowk Bhandara Rd. (HB Town Chowk to Shikar Wine Shop)	182	288	35	2	295
15	Wardha Road Right (Panchshil Talkies to Lokmat Square)	646	449	86	0	844
16	Wardha Road Left (Panchshil Talkies to Lokmat Square)	663	505	76	3	874
17	Pardi Bazar Chowk Bhandara Rd. (Pallavi Online Lotary to Girnar Computer)	198	321	65	7	364
18	Pardi Bazar Chowk (Lucky Chicken Shop to Shri Shubh Laxmi Credit Socaity Ltd.)	111	357	47	6	265
19	Electronic Zone Chowk(Electronic Zone Chowk to Sachine Medical	36	594	4	1	192
20	WanaDongri (WanaDongri Chowk to Prince Lawn)	61	597	72	21	345
21	Wardha Road Right (Usha Family Garden Resturant to Parnav Juice Parlour)	51	733	4	0	238

S. No.	Location Name	Car	TW	Auto	Bus	Parking Demand (ECS)
22	Wardha Road Left (Towards Wardha)	18	631	16	10	222
23	AmchiButibori Chowk (RHS)	80	481	50	2	256
24	Behind of Acharya Bhawan	47	454	8	0	169
25	Maruti Showroom (Infront of Maruti Showroom Gate)	25	125	0	0	56
26	Dutta Wadi (JK Tyre to Raison Family Resturant)	127	482	12	25	335
27	Wadi Square (Hotel Rahul Palace Under Hotel)	12	223	0	0	68
28	Wadi Square (Rahul Hotel to Toll Gate)	68	54	1	0	83
29	Wadi Squre Left (Pan Corner to PNB ATM)	54	454	46	0	214
30	Amravati Road (Eternity Mall to Shri Niketan Xerox)	179	714	444	0	802
31	Wardha Road near Jamtha Village	27	509	1	0	155
32	Wardha Road near Dongar Gaon (Left)	109	692	3	0	285
33	Wardha Road near Dongar Gaon (Right)	50	738	20	0	255
34	MIDC road near Butibori Chowk	232	594	249	0	630
35	Butibori Chowk near Patanjali Store	25	1850	0	0	488
36	Wardha Road near Butibori Chowk (Right)	76	973	1	0	320
37	Lallu Sai Chowk	205	724	35	0	421
38	SDM Office Hingna	19	267	10	0	96
39	Hingna Road near Hanuman Temple	130	935	162	0	526
40	Old Kamptee	95	554	97	0	331
Total		**6761**	**24064**	**3191**	**360**	**17054**

TABLE 3.18: PARKING DURATION

S. No.	Location Name	Mode	Duration (hours)					Total
			0--2	2--4	4--8	8--12	>12	
			Short Term		Medium Term	Long Term		
1	Kamptee Bus Stop (Govt. Hospital to Choudhary Hospital)	Car	135	8	1	3	3	150
		%	90.0	5.3	0.7	2.0	2.0	100.0
		TW	612	26	0	50	28	716
		%	85.5	3.6	0.0	7.0	3.9	100.0
		Auto	194	2	0	0	0	196
		%	99.0	1.0	0.0	0.0	0.0	100.0
		Bus	19	0	0	0	0	19
		%	100.0	0.0	0.0	0.0	0.0	100.0
2	Kamptee Bus Stop (Shanti Niwas Lounge to Narayan Singh Dwar)	Car	92	2	1	12	5	112
		%	82.1	1.8	0.9	10.7	4.5	100.0
		TW	1101	2	0	0	0	1103
		%	99.8	0.2	0.0	0.0	0.0	100.0
		Auto	155	1	0	0	0	156
		%	99.4	0.6	0.0	0.0	0.0	100.0
		Bus	22	0	0	0	0	22
		%	100.0	0.0	0.0	0.0	0.0	100.0
3	Kamptee Road (Mato Shri Motor to Near Dargah Road)	Car	90	1	1	6	1	99
		%	90.9	1.0	1.0	6.1	1.0	100.0
		TW	650	4	0	47	10	711
		%	91.4	0.6	0.0	6.6	1.4	100.0
		Auto	135	1	0	0	0	136
		%	99.3	0.7	0.0	0.0	0.0	100.0
		Bus	28	1	0	0	0	29
		%	96.6	3.4	0.0	0.0	0.0	100.0
4	Kamptee Rd. Naka No-2 Bhilgaon (Abha Travel to Aamir Khan Travels)	Car	120	5	0	2	1	128
		%	93.8	3.9	0.0	1.6	0.8	100.0
		TW	401	10	0	5	3	419
		%	95.7	2.4	0.0	1.2	0.7	100.0
		Auto	188	0	0	0	0	188
		%	100.0	0.0	0.0	0.0	0.0	100.0
		Bus	30	0	0	0	0	30
		%	100.0	0.0	0.0	0.0	0.0	100.0
5	Sharda Chowk Automotive (Masjid Nagin Nuri to Shri Sai Mandir)	Car	14	5	0	0	1	20
		%	70.0	25.0	0.0	0.0	5.0	100.0
		TW	275	60	4	13	6	358
		%	76.8	16.8	1.1	3.6	1.7	100.0
		Auto	63	0	0	0	0	63
		%	100.0	0.0	0.0	0.0	0.0	100.0
		Bus	17	0	0	0	0	17
		%	100.0	0.0	0.0	0.0	0.0	100.0
6	Indora Chowk Kamptee Road (Opp. Yashwantpuri Mall)	Car	80	9	2	18	2	111
		%	72.1	8.1	1.8	16.2	1.8	100.0
		TW	550	22	8	35	7	622

S. No.	Location Name	Mode	Duration (hours) 0--2	2--4	4--8	8--12	>12	Total
			Short Term		Medium Term	Long Term		
		%	88.4	3.5	1.3	5.6	1.1	100.0
		Auto	152	0	0	0	0	152
		%	100.0	0.0	0.0	0.0	0.0	100.0
		Bus	12	0	0	0	0	12
		%	100.0	0.0	0.0	0.0	0.0	100.0
7	Gaddi Godam (Rail Bridge to Gaddi Godam Chowk)	Car	350	35	0	40	5	430
		%	81.4	8.1	0.0	9.3	1.2	100.0
		TW	700	35	0	65	2	802
		%	87.3	4.4	0.0	8.1	0.2	100.0
		Auto	285	0	0	0	0	285
		%	100.0	0.0	0.0	0.0	0.0	100.0
		Bus	14	0	0	0	0	14
		%	100.0	0.0	0.0	0.0	0.0	100.0
8	Gaddi Godam (Rail Crossing Bridge to Gaddi Godam Chowk)	Car	452	36	0	18	1	507
		%	89.2	7.1	0.0	3.6	0.2	100.0
		TW	847	23	11	37	15	933
		%	90.8	2.5	1.2	4.0	1.6	100.0
		Auto	109	2	0	1	1	113
		%	96.5	1.8	0.0	0.9	0.9	100.0
		Bus	13	0	0	0	0	13
		%	100.0	0.0	0.0	0.0	0.0	100.0
9	Central Avenue Road (Meo Hospital to Satguru Machine Tools)	Car	487	38	21	36	8	590
		%	82.5	6.4	3.6	6.1	1.4	100.0
		TW	780	11	32	98	15	936
		%	83.3	1.2	3.4	10.5	1.6	100.0
		Auto	224	7	5	0	0	236
		%	94.9	3.0	2.1	0.0	0.0	100.0
		Bus	67	0	0	0	0	67
		%	100.0	0.0	0.0	0.0	0.0	100.0
10	Chander Lok Building (Krishnum Restorant to Vikas Travels)	Car	167	14	12	1	1	195
		%	85.6	7.2	6.2	0.5	0.5	100.0
		TW	354	10	15	2	1	382
		%	92.7	2.6	3.9	0.5	0.3	100.0
		Auto	15	0	0	0	0	15
		%	100.0	0.0	0.0	0.0	0.0	100.0
		Bus	4	0	0	0	0	4.00
		%	100.0	0.0	0.0	0.0	0.0	100.0
11	Gandhi Bagh Chowk (HDB Financial to Geetanjali Jewellers)	Car	285	4	1	4	2	296
		%	96.3	1.4	0.3	1.4	0.7	100.0
		TW	650	6	0	18	6	680
		%	95.6	0.9	0.0	2.6	0.9	100.0
		Auto	32	5	0	0	0	37
		%	86.5	13.5	0.0	0.0	0.0	100.0
		Bus	25	0	0	0	0	25
		%	100.0	0.0	0.0	0.0	0.0	100.0

S. No.	Location Name	Mode	Duration (hours)					Total
			0--2	2--4	4--8	8--12	>12	
			Short Term		Medium Term	Long Term		
12	Gandhi Bagh Chowk to Chander Shekhar Azad Chowk	**Car**	270	12	4	28	7	321
		%	84.1	3.7	1.2	8.7	2.2	100.0
		TW	704	11	0	46	12	773
		%	91.1	1.4	0.0	6.0	1.6	100.0
		Auto	44	4	0	0	0	48
		%	91.7	8.3	0.0	0.0	0.0	100.0
		Bus	28	0	0	0	0	28
		%	100.0	0.0	0.0	0.0	0.0	100.0
13	Central Avenue Road (Dr. Ambedkar Chowk to Chappru Nagar Chowk)	**Car**	241	24	4	5	2	276
		%	87.3	8.7	1.4	1.8	0.7	100.0
		TW	295	25	0	7	4	331
		%	89.1	7.6	0.0	2.1	1.2	100.0
		Auto	21	1	0	0	0	22
		%	95.5	4.5	0.0	0.0	0.0	100.0
		Bus	3	0	0	0	0	3
		%	100.0	0.0	0.0	0.0	0.0	100.0
14	HB Chowk Bhandara Rd. (HB Town Chowk to Shikar Wine Shop)	**Car**	155	4	0	18	5	182
		%	85.2	2.2	0.0	9.9	2.7	100.0
		TW	248	13	0	24	3	288
		%	86.1	4.5	0.0	8.3	1.0	100.0
		Auto	35	0	0	0	0	35
		%	100.0	0.0	0.0	0.0	0.0	100.0
		Bus	2	0	0	0	0	2
		%	100.0	0.0	0.0	0.0	0.0	100.0
15	Wardha Road Right (Panchshil Talkies to Lokmat Square)	**Car**	556	27	8	44	11	646
		%	86.1	4.2	1.2	6.8	1.7	100.0
		TW	412	4	0	31	2	449
		%	91.8	0.9	0.0	6.9	0.4	100.0
		Auto	81	4	0	0	1	86
		%	94.2	4.7	0.0	0.0	1.2	100.0
16	Wardha Road Left (Panchshil Talkies to Lokmat Square)	**Car**	601	15	0	42	5	663
		%	90.6	2.3	0.0	6.3	0.8	100.0
		TW	478	6	0	19	2	505
		%	94.7	1.2	0.0	3.8	0.4	100.0
		Auto	68	8	0	0	0	76
		%	89.5	10.5	0.0	0.0	0.0	100.0
		Bus	3	0	0	0	0	3
		%	100.0	0.0	0.0	0.0	0.0	100.0
17	Pardi Bazar Chowk Bhandara Rd. (Pallavi Online Lotary to Girnar Computer)	**Car**	178	8	0	10	2	198
		%	89.9	4.0	0.0	5.1	1.0	100.0
		TW	259	26	4	27	5	321
		%	80.7	8.1	1.2	8.4	1.6	100.0
		Auto	65	0	0	0	0	65
		%	100.0	0.0	0.0	0.0	0.0	100.0
		Bus	7	0	0	0	0	7
		%	100.0	0.0	0.0	0.0	0.0	100.0

S. No.	Location Name	Mode	Duration (hours)					Total
			0--2	2--4	4--8	8--12	>12	
			Short Term		Medium Term	Long Term		
18	Pardi Bazar Chowk (Lucky Chicken Shop to Shri Shubh Laxmi Credit Socaity Ltd.)	**Car**	95	12	0	3	1	111
		%	85.6	10.8	0.0	2.7	0.9	100.0
		TW	319	22	0	14	2	357
		%	89.4	6.2	0.0	3.9	0.6	100.0
		Auto	45	2	0	0	0	47
		%	95.7	4.3	0.0	0.0	0.0	100.0
		Bus	6	0	0	0	0	6
		%	100.0	0.0	0.0	0.0	0.0	100.0
19	Electronic Zone Chowk(Electronic Zone Chowk to Sachine Medical	**Car**	31	1	1	2	1	36
		%	86.1	2.8	2.8	5.6	2.8	100.0
		TW	529	31	6	23	5	594
		%	89.1	5.2	1.0	3.9	0.8	100.0
		Auto	4	0	0	0	0	4
		%	100.0	0.0	0.0	0.0	0.0	100.0
		Bus	1	0	0	0	0	1
		%	100.0	0.0	0.0	0.0	0.0	100.0
20	Wana Dongri (Wana Dongri Chowk to Prince Lawn)	**Car**	51	2	0	8	0	61
		%	83.6	3.3	0.0	13.1	0.0	100.0
		TW	537	50	0	10	0	597
		%	89.9	8.4	0.0	1.7	0.0	100.0
		Auto	68	4	0	0	0	72
		%	94.4	5.6	0.0	0.0	0.0	100.0
		Bus	21	0	0	0	0	21
		%	100.0	0.0	0.0	0.0	0.0	100.0
21	Wardha Road Right (Usha Family Garden Resturant to Parnav Juice Parlour)	**Car**	41	4	1	5	0	51
		%	80.4	7.8	2.0	9.8	0.0	100.0
		TW	680	36	11	3	3	733
		%	92.8	4.9	1.5	0.4	0.4	100.0
		Auto	4	0	0	0	0	4
		%	100.0	0.0	0.0	0.0	0.0	100.0
22	Wardha Road Left (Towards Wardha)	**Car**	15	3	0	0	0	18
		%	83.3	16.7	0.0	0.0	0.0	100.0
		TW	586	30	7	7	1	631
		%	92.9	4.8	1.1	1.1	0.2	100.0
		Auto	13	1	2	0	0	16
		%	81.3	6.3	12.5	0.0	0.0	100.0
		Bus	10	0	0	0	0	10
		%	100.0	0.0	0.0	0.0	0.0	100.0
23	Amchi Butibori Chowk (RHS)	**Car**	72	2	1	5	0	80
		%	90.0	2.5	1.3	6.3	0.0	100.0
		TW	461	6	3	9	2	481
		%	95.8	1.2	0.6	1.9	0.4	100.0
		Auto	43	7	0	0	0	50
		%	86.0	14.0	0.0	0.0	0.0	100.0
		Bus	2	0	0	0	0	2
		%	100.0	0.0	0.0	0.0	0.0	100.0

S. No.	Location Name	Mode	Duration (hours) 0--2	2--4	4--8	8--12	>12	Total
			Short Term		Medium Term	Long Term		
24	Behind Acharya Bhawan	**Car**	42	3	0	1	1	47
		%	89.4	6.4	0.0	2.1	2.1	100.0
		TW	388	44	5	15	2	454
		%	85.5	9.7	1.1	3.3	0.4	100.0
		Auto	8	0	0	0	0	8
		%	100.0	0.0	0.0	0.0	0.0	100.0
25	Maruti Showroom (Infront of Maruti Showroom Gate)	**Car**	20	3	0	1	1	25
		%	80.0	12.0	0.0	4.0	4.0	100.0
		TW	88	15	5	5	12	125
		%	70.4	12.0	4.0	4.0	9.6	100.0
26	Dutta Wadi (JK Tyre to Raison Family Resturant)	**Car**	116	5	0	5	1	127
		%	91.3	3.9	0.0	3.9	0.8	100.0
		TW	428	37	0	15	2	482
		%	88.8	7.7	0.0	3.1	0.4	100.0
		Auto	12	0	0	0	0	12
		%	100.0	0.0	0.0	0.0	0.0	100.0
		Bus	25	0	0	0	0	25
		%	100.0	0.0	0.0	0.0	0.0	100.0
27	Wadi Square (Hotel Rahul Palace Under Hotel)	**Car**	9	2	0	0	1	12
		%	75.0	16.7	0.0	0.0	8.3	100.0
		TW	177	19	6	11	10	223
		%	79.4	8.5	2.7	4.9	4.5	100.0
28	Wadi Square (Rahul Hotel to Toll Gate)	**Car**	56	3	5	3	1	68
		%	82.4	4.4	7.4	4.4	1.5	100.0
		TW	45	8	1	0	0	54
		%	83.3	14.8	1.9	0.0	0.0	100.0
		Auto	1	0	0	0	0	1
		%	100.0	0.0	0.0	0.0	0.0	100.0
29	Wadi Squre Left (Pan Corner to PNB ATM)	**Car**	49	2	0	2	1	54
		%	90.7	3.7	0.0	3.7	1.9	100.0
		TW	403	28	2	19	2	454
		%	88.8	6.2	0.4	4.2	0.4	100.0
		Auto	46	0	0	0	0	46
		%	100.0	0.0	0.0	0.0	0.0	100.0
30	Amravati Road (Eternity Mall to Shri Niketan Xerox)	**Car**	123	25	0	28	3	179
		%	68.7	14.0	0.0	15.6	1.7	100.0
		TW	609	54	3	46	2	714
		%	85.3	7.6	0.4	6.4	0.3	100.0
		Auto	443	1	0	0	0	444
		%	99.8	0.2	0.0	0.0	0.0	100.0

S. No.	Location Name	Mode	Duration (hours) 0--2	2--4	4--8	8--12	>12	Total
			Short Term		Medium Term	Long Term		
31	Wardha Road near Jamtha Village	Car	18	0	0	0	0	18
		%	100.0	0.0	0.0	0.0	0.0	100.0
		TW	144	11	7	9	1	172
		%	83.7	6.4	4.1	5.2	0.6	100.0
		Auto	1	0	0	0	0	1
		%	100.0	0.0	0.0	0.0	0.0	100.0
32	Wardha Road near Dongar Gaon (Left)	Car	13	11	0	0	0	24
		%	54.2	45.8	0.0	0.0	0.0	100.0
		TW	275	13	6	5	5	304
		%	90.5	4.3	2.0	1.6	1.6	100.0
		Auto	3	0	0	0	0	3
		%	100.0	0.0	0.0	0.0	0.0	100.0
33	Wardha Road near Dongar Gaon (Right)	Car	22	2	0	0	0	24
		%	91.7	8.3	0.0	0.0	0.0	100.0
		TW	294	17	10	9	1	331
		%	88.8	5.1	3.0	2.7	0.3	100.0
		Auto	14	0	0	0	0	14
		%	100.0	0.0	0.0	0.0	0.0	100.0
34	MIDC Road near Butibori Chowk	Car	158	3	1	0	0	162
		%	97.5	1.9	0.6	0.0	0.0	100.0
		TW	377	8	2	0	1	388
		%	97.16	2.06	0.52	0.00	0.26	100.0
		Auto	59	12	6	1	0	78
		%	75.6	15.4	7.7	1.3	0.0	100.0
35	Butibori Chowk near Patanjali Store	Car	4	0	0	1	0	5
		%	80.0	0.0	0.0	20.0	0.0	100.0
		TW	383	63	44	16	2	508
		%	75.4	12.4	8.7	3.1	0.4	100.0
36	Wardha Road near Butibori Chowk (Right)	Car	39	3	0	0	0	42
		%	92.9	7.1	0.0	0.0	0.0	100.0
		TW	457	20	13	2	0	492
		%	92.9	4.1	2.6	0.4	0.0	100.0
		Auto	1	0	0	0	0	1
		%	100.0	0.0	0.0	0.0	0.0	100.0
37	Lallu Sai Chowk	Car	58	3	4	2	2	69
		%	84.1	4.3	5.8	2.9	2.9	100
		TW	493	3	2	3	3	504
		%	97.8	0.6	0.4	0.6	0.6	100
		Auto	12	1	1	0	0	14
		%	85.7	7.1	7.1	0.0	0.0	100.0
38	SDM Office Hingna	Car	18	0	0	0	0	18
		%	100.0	0.0	0.0	0.0	0.0	100.0
		TW	181	7	0	0	0	188
		%	96.3	3.7	0.0	0.0	0.0	100.0
		Auto	9	0	0	0	0	9
		%	100.0	0.0	0.0	0.0	0.0	100.0

S. No.	Location Name	Mode	Duration (hours)					Total
			0--2	2--4	4--8	8--12	>12	
			Short Term		Medium Term	Long Term		
39	Hingna Road near Hanuman Temple	Car	50	1	3	0	1	55
		%	90.9	1.8	5.5	0.0	1.8	100.0
		TW	422	17	10	5	4	458
		%	92.14	3.71	2.18	1.09	0.87	100.00
		Auto	106	2	0	0	0	108
		%	98.1	1.9	0.0	0.0	0.0	100.0
40	Old Kamptee	Car	52	1	0	0	1	54
		%	96.3	1.9	0.0	0.0	1.9	100.0
		TW	190	20	5	5	0	220
		%	86.4	9.1	2.3	2.3	0.0	100.0
		Auto	56	1	0	1	0	58
		%	96.6	1.7	0.0	1.7	0.0	100.0

3.1.3.6 Public Transport Surveys

The following public transport surveys were conducted as part of the study:

- Bus Terminal Surveys
- Rail Terminal Surveys
- Airport Surveys

The data collected through the field surveys have been analyzed to assess the various public transport characteristics of commuters for different modes. The surveys location maps are presented in **Figure 3.3**.

i. Bus Terminal Survey

A total of 8 Bus terminals were selected to conduct in and out, Origin-Destination and willingness to shift to metro within the study area. It is observed from **Table 3.19** Mor Bhawan Bus Terminal caters to the maximum number of passengers i.e. about 42,994 passengers. The table further indicates that about 1,36,132 commuters use the intercity bus terminals daily (for 24hrs).

It is observed from **Table 3.20** that 33% of passengers use buses for their work purpose, about 14% of passengers use bus for their business purpose and about 34% of passengers uses it for Social, Recreation, Religious and other purposes while 19% are educational Trips.

TABLE 3.19: DAILY ARRIVAL / DEPARTURE AT MAJOR BUS TERMINALS

S. No.	Name of Location	Total Boarding	Total Alighting	Total B+A	Peak Time	Peak Hour Boarding	Peak Hour Alighting	Peak Hour B+A
1	Mor Bhawan Bus Terminal	21777	21217	**42994**	0815 - 0915	2288	1879	**4167**
2	Sitabardi Bus Terminal	12737	11337	**24074**	1700 - 1800	1153	1022	**2175**
3	Ganesh Peth Bus Terminal	18630	18514	**37144**	1745 - 1845	3386	1648	**5034**
4	Chatterpati Bus Terminal	4345	4248	**8593**	0915 - 1015	387	396	**783**
5	Ravi Nagar Bus Stop	1006	937	**1943**	1730 - 1830	54	184	**238**
6	Indora Bus Stop	2030	1851	**3881**	0800 - 0900	234	198	**432**
7	M. P. Bus Terminal near Nagpur Bus Terminal	3005	317	**3322**	1815 - 1915	372	3	**375**
8	Aashirwad Talkies Bus Terminal	7990	6191	**14181**	1700 - 1800	941	767	**1708**
Total		**71520**	**64612**	**136132**		**8815**	**6097**	**14912**

TABLE 3.20: DISTRIBUTION OF BUS PASSENGER BY TRIP PURPOSE AT BUS TERMINALS

S. No.	Trip Purpose	Percentage (%)
1	Work	32.8
2	Business	14.2
3	Education	19.0
4	Social	13.6
5	Recreation	6.4
6	Religious	4.4
7	Others	9.6
Total		**100.0**

ii. Rail Terminal Surveys

The Rail Passenger Surveys were conducted to ascertain travel characteristics of railway passengers. The survey was administered by counting the number of passengers boarding and alighting the trains along with origin–destination (O-D) survey on random sampling basis by interviewing passengers waiting to board the train at railway stations. This survey was conducted at 5 railway stations within the study area for a period of 24 hours. The information included:

- Boarding/Alighting passenger volume count
- O-D survey of passengers at railway stations
- Trip purpose, travel time, travel cost etc.
- Travel frequency of passengers

It is observed from the analysis of rail terminal survey that Nagpur Railway Station caters to the maximum number of passengers (91,356) followed by Itwari Railway Station (15,699). The daily and peak loadings at rail terminal are shown in **Table 3.21.**

It is observed from **Table 3.22** that the share of work & business purpose trips is about 53% followed by educational trips of about 13%.

TABLE 3.21: DISTRIBUTION OF DAILY PASSENGERS AT MAJOR RAILWAY STATIONS IN NAGPUR

S. No.	Name of Location	Total Boarding	Total Alighting	Total B+A	Peak Time	Peak Hour Boarding	Peak Hour Alighting	Peak Hour B+A
1	Nagpur Railway Station	47,530	43,826	**91,356**	0915 - 1015	3,880	4,768	**8,648**
2	Ajni Railway Station	4,048	3,950	**7,998**	1745 - 1845	1,028	404	**1,432**
3	Buti Bori Railway Station	327	279	**606**	1900 - 2000	199	120	**319**
4	Itwari Railway Station	7,886	7,813	**15,699**	0945 - 1045	956	1,718	**2,674**
5	Kamptee Railway Station	6,838	6,816	**13,654**	1030 - 1130	668	1,013	**1,681**

TABLE 3.22: DISTRIBUTION OF RAIL PASSENGERS BY TRIP PURPOSE AT RAIL TERMINALS

S. No.	Trip purpose	Percentage (%)
1	Work	34.3
2	Business	18.3
3	Education	13.4
4	Social	11.3
5	Recreation	8.8
6	Religious	5.8
7	Others	8.0
Total		**100.0**

iii. Air Terminal Survey

The air passenger survey is conducted to ascertain travel characteristics of air passengers. The survey was administered by counting the number of passengers boarding and alighting along with O-D survey on random sampling basis by interviewing passengers. This survey was conducted at Dr. Baba Shahab Ambedkar Airport within the study area for a period of 24 hours. The information included:

- Boarding/Alighting passenger volume count
- O-D survey of passengers at Airport Terminal
- Trip purpose, travel time, travel cost etc.
- Travel frequency of passengers

It is observed from the **Table 3.23** that Nagpur airport caters to about 4907 passengers per day and 1,556 passenger in peak hour.

Table 3.24 shows that 73% of trips are contributed by work and business purpose and only 3% of trips are educational, while about 24% of trips are Social, Recreation, Religious and other purposes.

TABLE 3.23: DISTRIBUTION OF PASSENGERS AT AIRPORT

S. No.	Name of Location	Total Boarding	Total Alighting	Total B+A	Peak Time	Peak Hour Boarding	Peak Hour Alighting	Peak Hour B+A
1	Dr. Baba Sahab Ambedkar Airport (Nagpur)	2,499	2,408	**4,907**	1915 - 2015	1,021	535	**1,556**

TABLE 3.24: DISTRIBUTION OF PASSENGERS BY TRIP PURPOSE AT AIRPORT

S. No.	Trip Purpose	Total Passengers	Percentage (%)
1	Work	399	35.0
2	Business	432	37.9
3	Education	38	3.3
4	Social	218	19.1
5	Recreation	22	1.9
6	Religious	14	1.2
7	Others	16	1.4
Total		**1139**	**100.0**

3.2. SOCIO-ECONOMIC & TRAVEL CHARACTERISTICS

The household travel survey has been conducted to bring out socio-economic and travel characteristics of the study area like household size, income, and vehicle ownership, per capita trip rates for various purposes viz. Work, education and other trips, expenditure on transport, modal split and origin-destination characteristics. To ensure that the sample was representative, the households interviewed during the survey were distributed throughout the study area in the same proportion as the distribution of population.

A total of 8,123 households (i.e. about 1% sample size) were interviewed in the study area representing 182 internal traffic zones. A random sampling technique was used to identify the sample. Further, care was taken that the representative households of all socio-economic strata i.e. High Income Groups (HIG), Middle Income Groups (MIG) and Lower Income Groups (LIG) were covered in the sample.

3.2.1 Socio Economic Characteristics

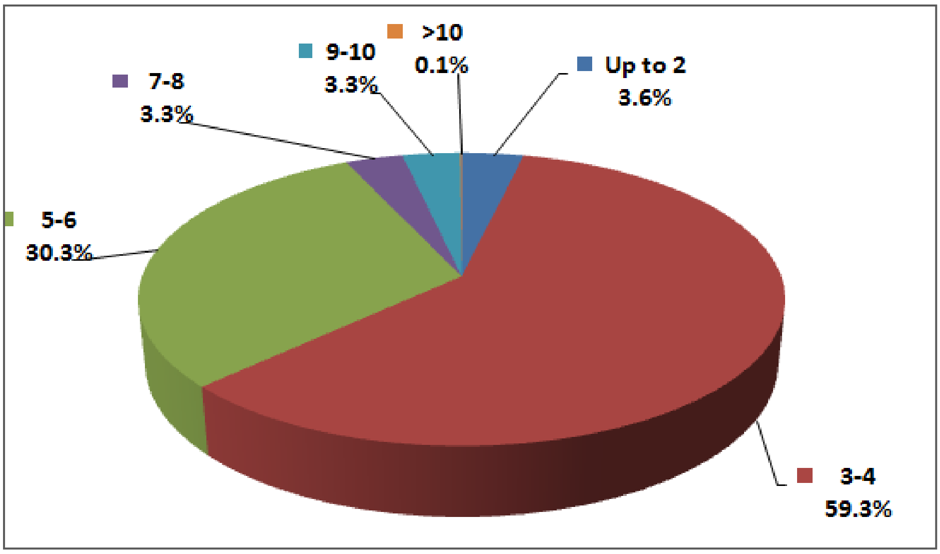
i. Household Size

The average household size in the study area is 4.3 persons per household. The distribution of households by size is presented in **Table 3.25** and **Figure 3.10.** It can be observed that 61% of the households fall under the category of four to 3-4 persons per household and 31% of households fall under category of 5-6 persons group.

TABLE 3.25: DISTRIBUTION OF HOUSEHOLDS BY SIZE

S. No.	Household by Size	Number of Households	Percentage
1	Upto 2	299	3.7
2	3-4	4928	60.7
3	5-6	2523	31.1
4	7-8	276	3.4
5	9-10	89	3.4
6	>10	8	0.1
	Total	**8123**	**100.0**

FIGURE 3.10: DISTRIBUTION OF HOUSEHOLDS BY SIZE



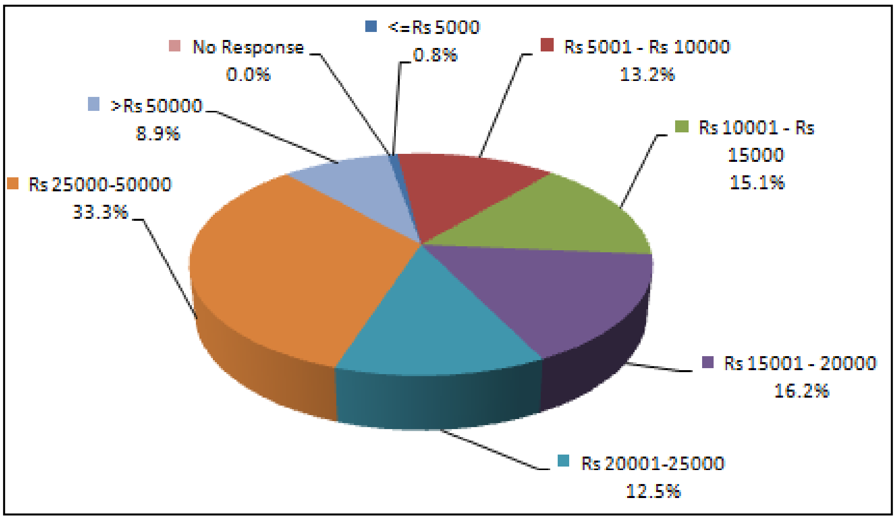
ii. Monthly Household Income

The average monthly household income in the study area is Rs.26,945 **Table 3.26** presents the distribution of surveyed population by monthly income. **Figure 3.11** indicates that 13% of the households earn Rs.5,000 to Rs.10,000. About 15% between Rs.10,001 to Rs.15,000. A considerable percentage of 1% households are earning even less than or equal to Rs.5000 per month. Only, about 9% of the households has monthly income more than Rs.50,000.

TABLE 3.26: DISTRIBUTION OF HOUSEHOLDS BY MONTHLY INCOME

S. No.	Income Group (Rs.)	No. of Households	Percentage
1	<5000	69	0.8
2	5000-10000	1075	13.2
3	10000-15000	1223	15.1
4	15000-20000	1319	16.2
5	20000-25000	1012	12.5
6	25000-50000	2702	33.3
7	>50000	723	8.9
8	No Response	0	0.0
	Total	**8123**	**100.0**

FIGURE 3.11: DISTRIBUTION OF HOUSEHOLDS BY MONTHLY INCOME



3.2.2 Travel Characteristics

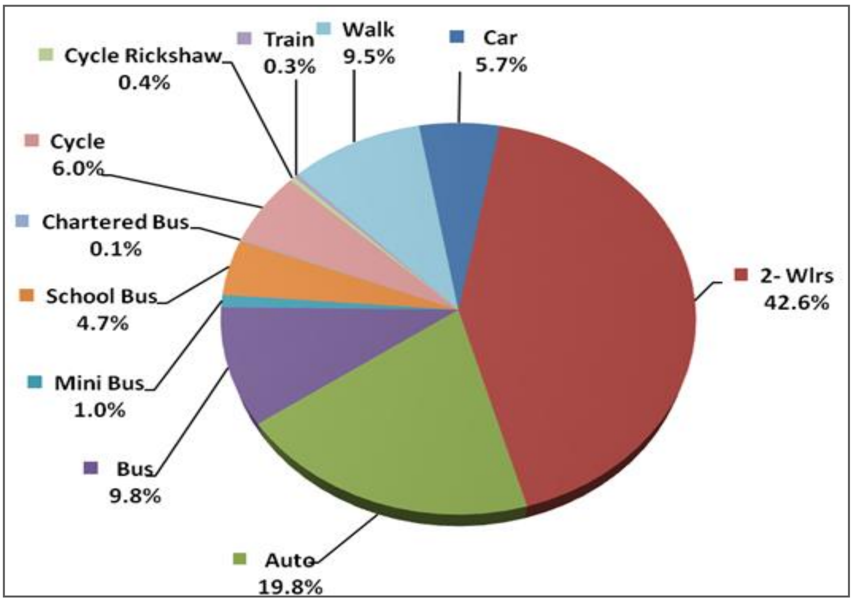
i. Per Capita Trip Rate

The total daily trips are estimated at 51,20,650 as derived from the household survey. Distribution of daily trips by modes is presented in **Table 3.27.** About 90% of these are vehicular trips while 10% are walk trips. The per capita trip rate for motorized trip in the study area is 1.3. The details are presented in **Figure 3.12**.

TABLE 3.27: DISTRIBUTION OF DAILY PASSENGER TRIPS BY MODE

Mode	No. of Trips	Percentage	
Car	2,92,557	5.7	84.1
2- Wheeler	21,81,173	42.6	
Auto	10,15,885	19.8	
Bus	5,03,656	9.8	
Mini Bus	51,838	1.0	
School Bus	2,38,904	4.7	
Chartered Bus	4,688	0.1	
Train	17,152	0.3	
Cycle	3,07,865	6.0	15.9
Rickshaw	18,731	0.4	
Walk	4,88,202	9.5	
Total Trips	**51,20,650**	**100.0**	**100.0**
Total Motorized Trips	**43,05,853**		
PCTR for Motorized Trips	**1.3**		

FIGURE 3.12: DISTRIBUTION OF DAILY PASSENGER TRIPS BY MODE



ii. Trip Purpose

Distribution of daily vehicular and walk trips is presented in **Table 3.28**. It is observed that about 35% and about 13% of daily vehicular and walk trips have been performed for work purpose. The detailed distribution is presented in **Table 3.29**. Among the total trips, government and private work trips account for about 35%, education about 32%, business trips for about 11%, shopping trips about 17% and others account for about 9%. Among the work trips, 96% are vehicular trips and 4% are walk trips while this distribution is 92% and 8% for education trips and 80% and 20% for other trips respectively. The ratio of work to return trip is 50.9% to 49.1% respectively.

TABLE 3.28: DISTRIBUTION OF VEHICULAR & WALK TRIPS BY PURPOSE

S. No.	Trip Purpose	Vehicle Trips		Walk Trips		Total Trips by Purpose
		Trips	%	Trips	%	
1	Work	16,18,762	34.9	61,614	12.6	16,80,376
2	Business	5,05,969	10.9	31,323	6.4	5,37,292
2	Education	14,71,271	31.8	1,31,286	26.9	16,02,557
3	Others	10,36,447	22.4	2,63,978	54.1	13,00,425
	Total Trips	**46,32,449**	**100.0**	**4,88,202**	**100.0**	**51,20,650**

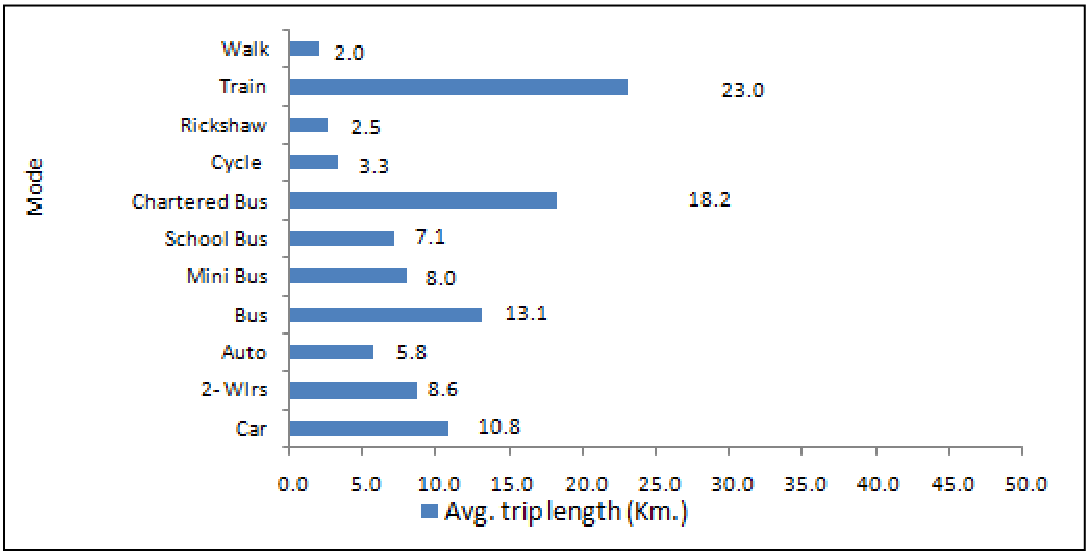
TABLE 3.29: DISTRIBUTION OF PASSENGER TRIPS BY PURPOSE

S. No.	Trip Purpose	Total Trips	%
1	Govt. Service	264873	5.2
2	Pvt. Service	1415503	27.6
3	Business	537292	10.5
4	Education	1602557	31.3
5	Shopping	857985	16.8
6	Medical	162954	3.2
7	Social/Other	279486	5.5
Total		**5120650**	**100.0**

iii. Trip Length

Average trip length of 7.6 km (including walk) and 8.2 km (excluding walk) is observed in the study area. The analysis of trips lengths by different modes reveals that long distance trips of average trip length 23 km are being covered by trains. **Figure 3.13** indicates that an average trip length of 2.0 km is being covered up by walk. Cars travel an average trip length of 10.8 km, two wheelers 8.6 km while cycles and cycle rickshaws covers average trip distance of 3.3 km and 2.5 km respectively.

FIGURE 3.13: DISTRIBUTION OF AVERAGE TRIP LENGTH (KM) BY MODE



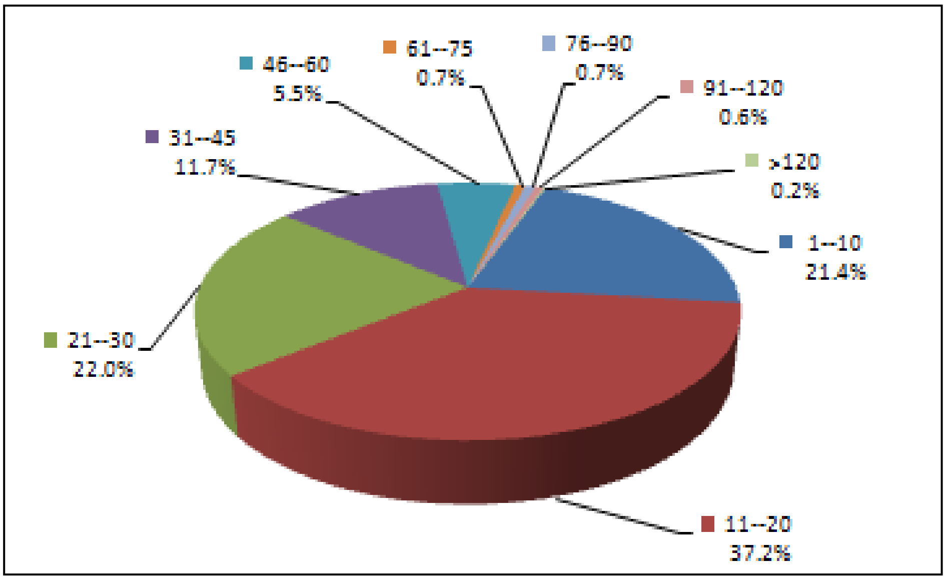
iv. Travel Time

Distribution of trips by travel time and mode is presented in **Table 3.30** and **Figure 3.14**. The analysis of trips by all modes reveals that maximum trips i.e. 37% are made in 11-20 minutes and about 21% in 1-10 minutes.

TABLE 3.30: DISTRIBUTION OF PASSENGER TRIPS BY TRAVEL TIME

Travel Time (minutes)	1-10	11-20	21-30	31-45	46-60	61-75	76-90	91-120	>120	Total
Number of Trips	10,91,911	19,07,897	11,27,180	5,98,173	2,83,855	36,407	36,916	30,605	7,706	**51,20,650**
Percentage	**21.4**	**37.2**	**22.0**	**11.7**	**5.5**	**0.7**	**0.7**	**0.6**	**0.2**	**100.0**

FIGURE 3.14: DISTRIBUTION OF PASSENGER TRIPS BY TRAVEL TIME



v. Travel Cost

The distribution of passenger trips (excluding walk and cycle) by travel cost in the study area is presented in **Table 3.31**. It is seen that 6% of the trips cost upto Rs.5 for travelling and about 32% of the trips cost between Rs 6 to 10. About 15% of the trips have travel cost between Rs.21 to Rs.30.

TABLE 3.31: TRIP DISTRIBUTION BY TRAVEL COST (EXCLUDING WALK & CYCLE)

Travel Cost (Rs)	1-5	6-10	11-15	16-20	21-30	31-45	46-70	71-100	>100	Total
Number of Trips	2,47,547	13,82,134	7,59,378	7,07,740	6,34,018	2,95,226	2,05,972	66,940	25,628	**43,24,583**
Percentage	**5.7**	**32.0**	**17.6**	**16.4**	**14.7**	**6.8**	**4.8**	**1.6**	**0.6**	**100.0**

3.3. TRAVEL DEMAND ANALYSIS

3.3.1 Approach For Travel Demand Modeling

The travel demand assessment in urban environment is a complex exercise involving a large number of parameters and warrants the development of a transport model at the City level.

The transportation modeling process consists of development of formulae (or models), enabling forecast of travel demand, and development of alternative strategies for handling this demand. It is not just one model, but a series of inter-linked and inter-related models of varying levels of complexity, dealing with different facets of travel demand. Through these models, the transportation study process as a whole is checked and calibrated before it is used for future travel predictions.

Whilst a large number of commercially acceptable softwares are available for the purpose of modelling travel demand, due heed was paid to the observed traffic heterogeneity in the study area. After analyzing the specific requirements of the model and the software, RITES has used CUBE software developed by Citilabs for the modelling exercise.

The software can address the impact of new landuse developments as envisaged by master plan control policies. Cube is fully capable of modeling typical mixed traffic flow conditions such as private transport (car and 2wheeler) and public transport (shared auto rickshaw, bus and rail based mass transit systems).

An operational travel demand model is required to enable estimation of future travel demand that will help towards identifying transport requirements for the study area. The said model is also a pre-requisite to the fact that the consultants are able to validate the actual travel patterns (as observed) within an acceptable error range (+-15%).

The standard 4 stage Urban Transport Planning System model has been adopted that inter-alia consists of:

- Trip Generation and Attraction Sub Model
- Trip Distribution Sub Model
- Modal Split Sub Model
- Assignment Sub Model

The parameters involved in the model development are population, employment, school enrolments and transport systems (with their accessibility, speed & capacity) of the study area. A commuter decides on his/ her selection of travel mode considering a number of parameters including accessibility of travel mode from the house, total travel time, total cost of travel, convenience/ comfort of travel and cost/ convenience for reaching the destination at the other end of the main journey. The commuter evaluates the merits and demerits of all possible alternative modes and their combinations before deciding on the final selection of travel mode(s).

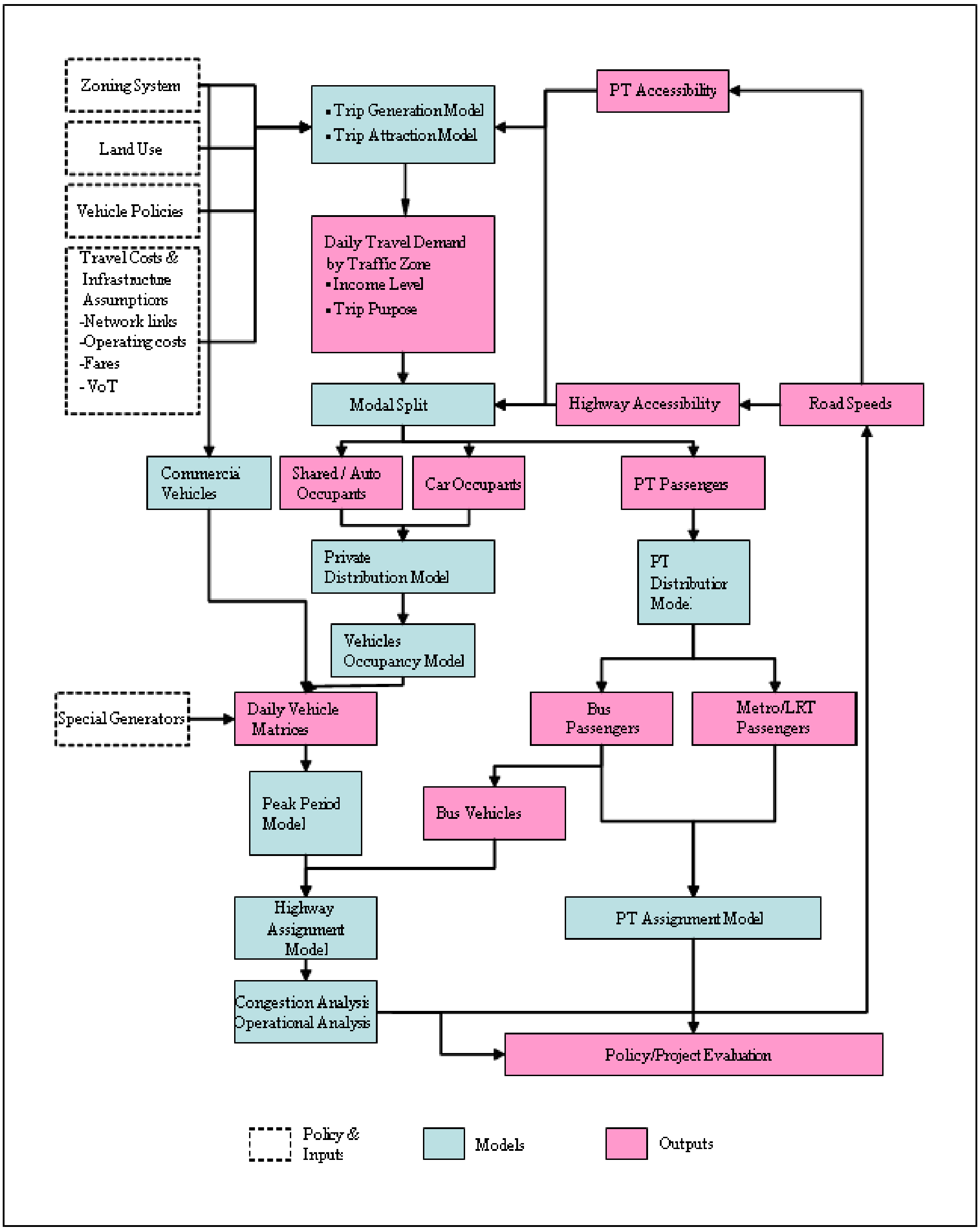
Transport demand is a function of landuse and the growth of demand in various years vary depending upon the interrelationship of various landuse and traffic intensity in future years. Some of the major inputs to an urban transport demand model are:

- Delineation of study area into smaller traffic zones
- Population (existing and proposed at traffic zone level)
- Employment (existing and proposed at traffic zone level)
- School enrolment data
- Transport network and system (along with their respective carrying capacity and speed of each type of network/ system)
- Speed and frequency of operation of the proposed System.
- Intermodal integration facilities available and time required for passengers to interchange from one mode to another. This will also include the walking time required to access a particular System.

To understand the travel pattern of the City, a total of 194 zones called traffic analysis zones have been identified inside the study area. Considering the ease of getting required zonal information, administrative wards were combined as zones within the Municipal Area. The areas that fall within Nagpur Municipal Area but outside the Municipal Boundary have been divided into zones based on homogenous land use and traffic generation points. A total of 182 internal zones and 12 external zones have been considered for the Study.

Zone connectors are included in the model to allow the trip matrices to be assigned to the highway network. All zones have been provided with at least one zone connector. The location and definition of connector is intended to assimilate, as far as possible, the actual connectivity of trip generation centers to the road network. The zoning system of the Study Area is presented in **Figure 3.1.** The sequence of activities involved in the model is depicted in **Figure 3.15.**

FIGURE 3.15: FOUR STAGE TRAVEL DEMAND MODELMODEL STRUCTURE



3.3.2 Model Structure

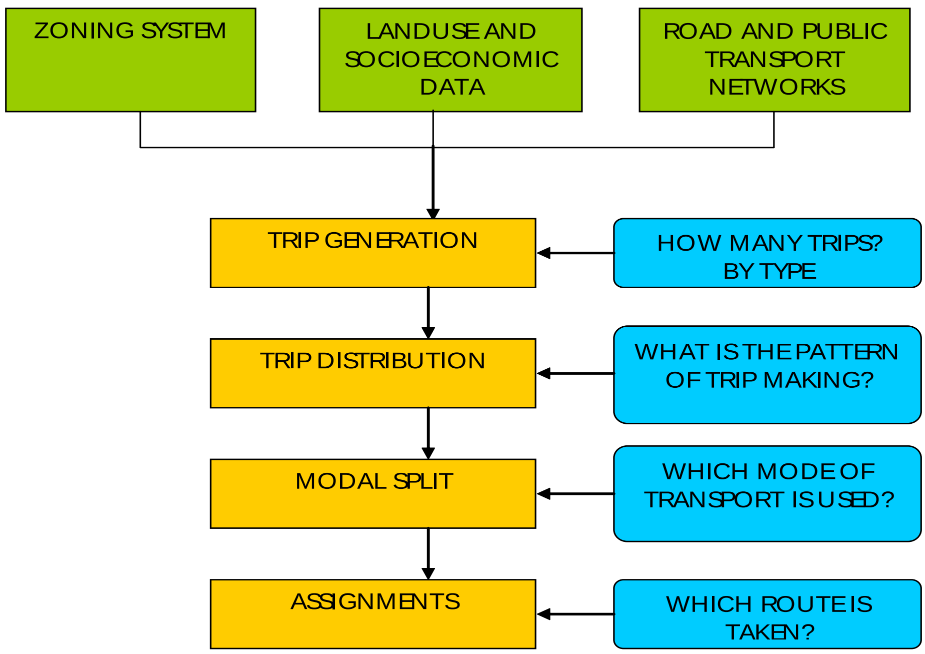
The model developed is a traditional four-stage transportation model, as illustrated in **Figure 3.16,** with the following characteristics:

The model is based on motorised trip productions / attractions and internal trips of Study Area residents for base year comprises of about total 42.6 Lakh daily motorised trips.

Four sub models are developed viz. Generation, Attraction, Distribution, Modal Choice and Assignment models

- Generation and Attraction models calculate trips generated and attracted by each zone
- Distribution models distribute trips generated into the possible destinations and provide matrix of total trips
- Modal choice models split total trip matrix by mode
- Assignment models represent the last stage of the model, build paths, assign origin / destination (OD) matrices, and finally provide loaded networks (average hour - for daily calculations and peak hour)
- 4 modes i.e. car, two wheelers (2w), auto-rickshaw (auto) and public transport (PT) have been considered
- The purpose of the trip can be broadly categorized in home based trips & non-home based trips. Home based trips are those in which one of the either trip ends is at the home while the non-home based are those in which neither end is at home. The trip generation model has been developed for home based trips in aggregation while the trip attraction model incorporates the 4 trip purposes of home base work (HBW), home base business (HBB), home base education (HBE) and home base other (HBO) trips for the study.

FIGURE 3.16: FOUR STAGE MODEL STRUCTURE



The model development is largely based on the Households Interview Survey (HIS) and other traffic surveys after expansion from survey sample to total population. This is calculated at a zonal level.

The next step is to build the base year road matrices necessary to obtain costs for the model development (distribution and modal choice). The base year HIS person matrices converted to vehicles using occupancy factors, trip matrices of external zones matrices from road side interview at Outer Cordon locations and special generators (bus and railway station) trip matrices to get total trip matrix by modes across the Study Area.

3.3.3 Trip Generation & Attraction

Trip generation is the first stage of the travel demand estimation process. Trip Generation modeling aims at predicting the total number of trips generated by and attracted to each zone of the study area from the estimated future land use activities. Thus, the two components of trip generation modeling are:

Trip Production: This is defined as the home end of a home based trip or as the origin of a non-home based trip. It thus gives the total trips produced by a zone.

Trip Attraction: This is defined as the non-home end of a home-based trip or as the destination of a non-home based trip. It thus, gives the total trips attracted to a zone.

3.3.3.1 Factors Affecting Trip Generation

The factors that affect Trip Generation include:

- Land Use Factors: Population, Indicators of Intensity of Residential Activity, Intensity of Employment Opportunities, Land Values etc.
- Household Factors: Household Income, Vehicle Ownership, Family Size, Family Structure etc.
- Urbanization Factors: Degree of Urbanization, Distance from CBD, Accessibility etc.

3.3.3.2 Trip Generation Sub Model

The linear regression analysis was used to develop the trip production and trip attraction equations. A zonal regression model was used in which each traffic zone is treated as one observation. The aggregated analysis has been applied for developing the model which is based on the assumption that contiguous households exhibit a certain amount of similarity in travel characteristics. This assumption allows the data in a zone to be grouped and the mean value of the independent variable used in further calculations. The trip production and attraction output in terms of the correlation coefficients are given in **Table 3.32.**

TABLE 3.32: TRIP GENERATION SUBMODELS - 2018

Dependent Variable	Independent Variable	Regression Coefficient (Household Trip Rate)	(R^2) Co-efficient of Determination
(Y)	(X)	(b)	
Trip Production			
All Modes	Population	1.911142	0.72

- **Independent Variable: Zonal Population**

Figure 3.17 shows the scatter plotting between population and production. **Table 3.33** details the summary of the output for Trip Production Model. The trip production model developed is shown below:

Trips Produced = 1.911142 * (Population), **R^2 = 0.72**

Where,

P = Population, R^2 = Coefficient of Determination

FIGURE 3.17: SCATTER PLOT: POPULATION VS TRIP PRODUCTION

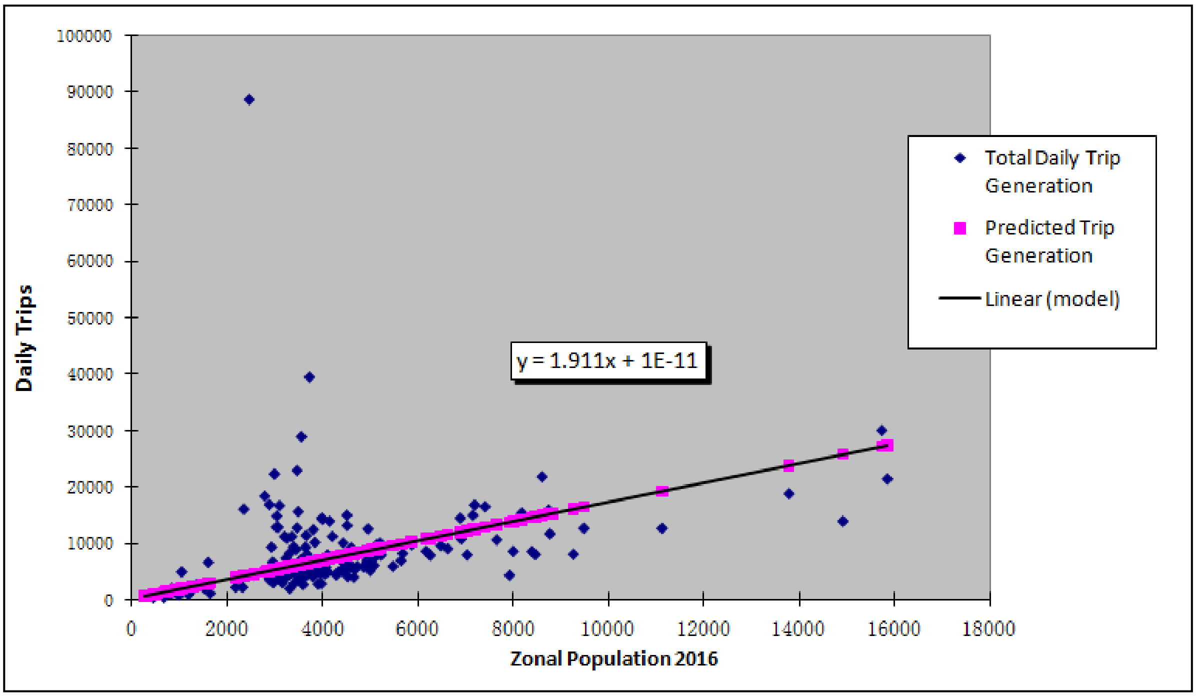


TABLE 3.33: SUMMARY OF OUTPUT OF TRIP PRODUCTION MODEL

SUMMARY OUTPUT								
Regression Statistics								
Multiple R	0.718769							
R Square	0.51663							
Adjusted R Square	0.511105							
Standard Error	8268.283							
Observations	182							
ANOVA								
	df	***SS***	***MS***	***F***	***Significance F***			
Regression	1			193.4539828	2.44E-30			
Residual	181							
Total	182							
	Coefficients	***Standard Error***	***t Stat***	***P-value***	***Lower 95%***	***Upper 95%***	***Lower 95.0%***	***Upper 95.0%***
Intercept	0	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
X Variable 1	1.911142	0.123753	13.908773	2.19315E-30	1.477077	1.965448	1.477077	1.965448

Generation model calculates daily person trips generated by purpose (Home Base Work, Home Based Education, Home Based Business, and Home Based Other) from Daily household level trip rates which is estimated from per capita trips segmented by respective purpose from HIS database and are presented in **Table 3.34.**

The generation is for home based trips and therefore based on Productions / Attractions (PA), not Origins / Destinations. At the end of the generation sub model application, the trips are aggregated by purpose. **Table 3.35** shows the numbers of daily person trips by purpose in the HIS database.

TABLE 3.34: HIS DATABASE DAILY HOUSEHOLD TRIP RATES BY PURPOSE

Trip Purpose	Per Capita Trip Rates	Avg. Household Size	Daily Houeshold Trip Rates
HBW	0.45	4.27	1.91
HBE	0.36	4.27	1.55
HBB	0.14	4.27	0.60
HBO	0.29	4.27	1.23

Note: external, walk, cycle, cycle rickshaw not included.

TABLE 3.35: HIS DATABASE DAILY PERSON TRIPS BY PURPOSE

Purpose	Daily Person Trips	Model	Difference
HBW	15,36,637	15,35,859	0.05%
HBE	12,49,523	12,51,748	-0.18%
HBB	4,84,929	4,84,287	0.13%
HBO	9,88,522	9,88,122	0.04%
Total	**42,59,611**	**42,60,015**	**-0.01%**

3.3.3.3 Trip Attraction Sub Model

The Generation model produces daily person trips (all purpose combined) generated by zone, whilst the attraction model estimates daily person trips attracted by zone. For each of the 4 purpose groups, a linear regression was estimated, explaining the number of trips attracted by the socio-economic data, total employment for HBW, HBB, and HBO, and school enrolments for HBE. To be consistent with the generation model, the attraction model is based on PA.

The coefficient of Determination R2 is the deciding factor for linear regression analysis. The more R2 is near to 1, more the linear regression is reliable. For instance, **Figure 3.18** represents the linear regression of HBW trips with R-square value equal to 0.91 showing a good match between the data from HIS and the estimated values from the linear regression. **Table 3.36** details the summary of the output for Trip Production Model.

The Attraction Model calibration is summarized in **Table 3.37**, by purpose, HIS and model figures are very similar, showing a very close correspondence between modeled and observed values.

FIGURE 3.18: ATTRACTION MODEL (HBW – LINEAR REGRESSION)

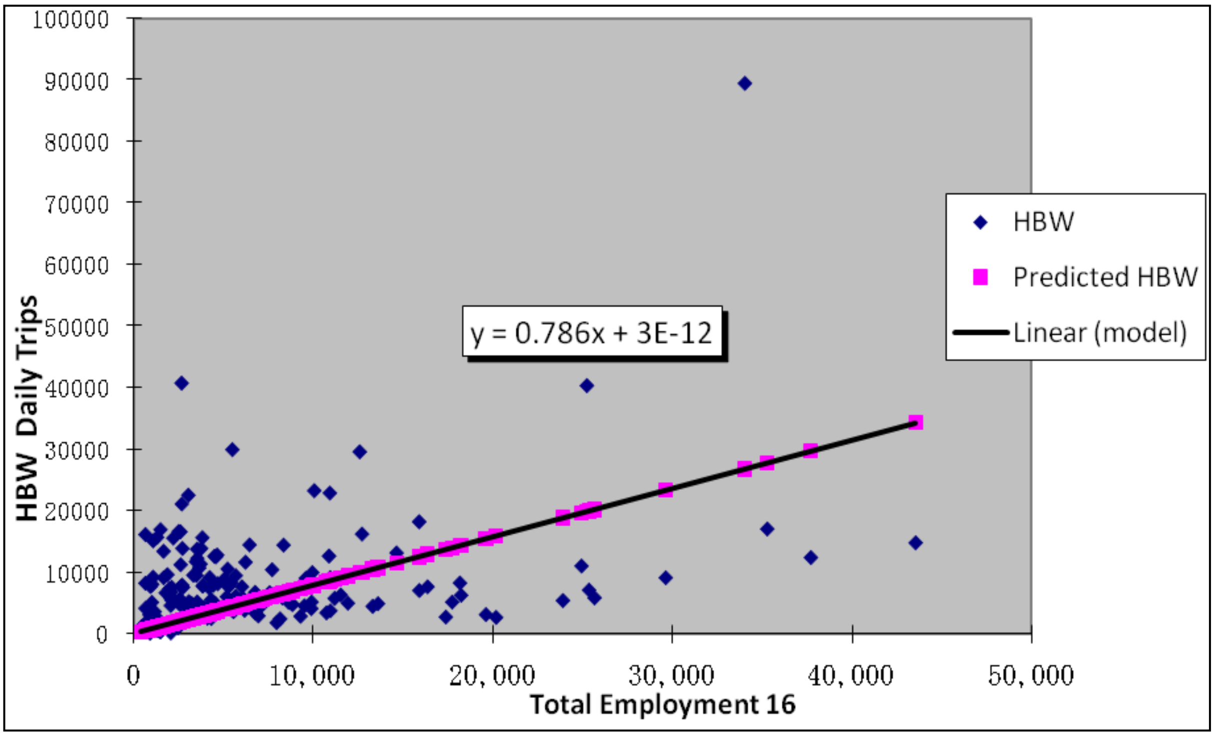


TABLE 3.36: SUMMARY OF OUTPUT OF TRIP ATTRACTION SUB MODEL FOR HBW TRIPS

SUMMARY OUTPUT								
Regression Statistics								
Multiple R	0.8473							
R Square	0.6191							
Adjusted R Square	0.6135							
Standard Error	9147.525							
Observations	182							
ANOVA								
	df	*SS*	*MS*	*F*	*Significance F*			
Regression	1	10927790056	10927790056	130.5945696	4.32199E-23			
Residual	181	15145576165	83677216.38					
Total	182	26073366221						
	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	0	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
X Variable 1	0.786565	0.068829055	11.42779811	4.0563E-23	0.650754008	0.922375	0.650754	0.922375

TABLE 3.37: ATTRACTION MODEL CALIBRATION RESULTS

Group	HIS	Model	Difference
HBW	15,36,637	15,35,868	0.05%
HBB	12,49,523	12,51,784	-0.18%
HBE	4,84,929	4,84,280	0.13%
HBO	9,88,522	9,88,115	0.04%
Total	**42,59,611**	**42,60,047**	**-0.01%**

3.3.3.4 Trip Distribution Sub Model

After determining the trip productions (Ti) and trip attraction (Tj), the next stage is to link the productions with attractions in order to quantify how the trips are produced in a zone and are distributed among or attracted to all other zones (Tij).

A number of methods are available which explains and predicts the distribution of trips. These are:

- Growth Factor Models
- Gravity Models
- Opportunity Models
- Stochastic Behavioral Models

3.3.4 Model Method and Description

Of the above four types of models available for trip distribution stage of travel demand modeling, Gravity Model has been most widely used in previous studies and suits the present study most due to data availability and its better applicability in the future.

The more recent trip models have the least resemblance with this original version, but the generic name still continues. The basic philosophy is to relate productions and attractions of different zones with quantum of trip modeling between individual zone pairs.

$$T_{ij} = R_i C_j P_i A_j f(W_{ij})$$

Where,

Tij= Trips between zonal pairs i and j

Pi=Trip Production at zone i = ΣiTij

j= Trip Attractions at zone j = Σj Tij

f (Wij) = Function separating zonal pairs i& j typically known as Friction Factor

Ri and Cj = Constants of proportionality

3.3.4.1 Gravity Model Types

Gravity models can be run in Cube with/ without constraints. The types of Gravity Models are:

- **i.** Unconstrained
- **ii.** Production Constrained (Singly Constrained)
- **iii.** Attraction Constrained (Singly Constrained)
- **iv.** Fully Constrained (Doubly Constrained)

The variations in the Gravity Models mentioned above are the result of variations in satisfying these productions and attractions conditions.

i. Unconstrained Gravity Model

This takes the following shape

$$T_{ij} = K P_i A_j f(W_{ij})$$

Where,

K =Constant of proportionality which ensures that the total number of trips from the model output equals to the total number of trips in the survey matrix. But there is no guarantee that the sums of the rows and columns of the matrix will balance individually with the survey total.

ii. Production Constrained Gravity Model

This model is of the form

$$T_{ij} = \frac{P_i A_j f(W_{ij})}{\Sigma A_j f(W_{ij})}$$

This ensures that when summed across the rows of the model Tij matrix, the individual zone trip origin totals equal the corresponding observed trip totals.

iii. Attraction Constrained Gravity Model

This model is of the form

$$T_{ij} = \frac{A_i p_j f(W_{ij})}{\Sigma P_j f(W_{ij})}$$

Here the constant of proportionality guarantees that when summed down the columns of the model Tij matrix the zonal trip destinations equal the corresponding observed trip destination total.

iv. Fully constrained Gravity Models

This model is of the form

$$T_{ij} = R_i C_j P_i A_j f(W_{ij})$$

$$R_i = \frac{1}{\Sigma R_i P_i f(W_{ij})}$$

The constant of proportionality now becomes the joint product of Ri and Cj. It is known as balancing or normalizing factor. The purpose is to ensure that the model Tij Attractions and Productions match the observed Tij Attractions and Productions.

3.3.4.2 Gravity Model Development and Calibration

For the practical purpose of gravity model application in the study area and distribution of the observed Tij for other zone pairs where zero trips were observed in sample matrix, fully constrained gravity model has been chosen for the base year of 2018. The models were developed based on the HIS database and the generalized costs (GC) produced from the highway and public transport cost models implemented in Cube Voyager software. The main features of the models are as follows:

- **Unit:** person (productions / attractions – PA);
- **Period:** daily;
- **Model formulation:** gravity model, based on composite GC presented in **Figure 3.19.**

FIGURE 3.19: GRAVITY MODEL FORMULATION

$$T_{ij} = a_i b_j P_i A_j F(C_{ij})$$

Where

T_{ij} = trips estimated from zone i to zone j

P_i = productions from zone i

A_j = attractions to zone j

a_i, b_j = row/column balancing factors

$F(C_{ij})$ = cost deterrence from zone i to zone j

$$F(C_{ij}) = C_{ij}^{X_1} \exp(X_2 C_{ij})$$

Where

$F(C_{ij})$ = cost deterrence for zone i to zone j

C_{ij} = generalised cost for zone i to zone

X_1, X_2 = coefficients to be calibrated.

The composite GC is the average of the GC for individual modes weighted by modal split proportions (produced by modal split models) by origin / destination movements. The measure of deterrence is the perceived inter-zonal generalised cost (this is what the traveller unconsciously thinks it costs him to travel from one place to another). For each pair of zones, generalised cost by different modes is determined. For any inter-zonal trip, the cost between each of the two zone centroids and between them and the appropriate actual network nodes is added to establish the least cost journey through the whole network between the zones. For example, for a trip including one or more public transport links and walk links thereto, the public transport generalised cost is made up of:

- Walking time to bus stop (from notional centroid link)
- Waiting time at bus stop
- Travelling time on bus
- Interchange waiting time – where appropriate
- Walking time from bus stop to destination (to notional centroid link)

For individual modes, the GC represents perceived costs, where the unit is minute equivalent, implying the use of values of time (VOT, 2018 prices, Rupees / hour) by mode to convert monetary costs (fare, vehicle operating cost - VOC) into minutes. Occupancy factors (OCC) are also used for car, 2w, and auto to obtain person based GC. The GC by mode is described below:

- **Car GC** = Time + [((VOC) / OCC) / VOT] x 60;
- **2W GC** = Time + [((VOC) / OCC) / VOT] x 60;

- **Auto GC** = Time + 1.5 x Wait Time + [(Fare / OCC) / VOT] x 60;
- **PT GC** = IVT + 1.5 x Walk Time + 2 x Wait Time + (Fare / VOT) x 60 + Transfer Time;

3.3.4.3 Gravity Model – Calibration Results

The sequence of activities involved in the calibration of Gravity Model is shown in **Figure 3.20**. This section provides the distribution models calibration results by the segments: X1 and X2 parameters, average GC (in minutes), and trip GC distribution. As illustrated by **Table 3.38** the overall models results are almost similar to the HIS database.

TABLE 3.38: DISTRIBUTION SUB MODEL CALIBRATION RESULTS

Group	HIS		MODEL				DIFFERENCE	
	Daily Trips	Observed GC	X1	X2	Daily Trips	GC	TRIPS	GC
Total Trips	4259611	21.74	-1.78531	0.01424	4260047	22.75	-0.01%	-4.6%

Calibration process included comparison of observed and simulated mean trip time (minutes) as well as shapes of the trip time frequency distribution. The observed trip time frequency distributions were obtained from the Household Travel Survey data. A comparison of observed and modeled trip length frequency for total trips is presented in **Figure 3.21.**

For developing speed flow relationship, data from Road User Cost Study was adopted and used to calculate calibration factors of Curve. The form of equation (power curve) used for the study is as under;

t(v) = t0 + (tc – t0) (v/c)n

Where tc = t0 + acn is the travel time at capacity. This form is sometimes easier for user manipulation since it uses only basic variables and removes the necessity to calculate the value of the coefficient ‘a’.

FIGURE 3.20: SEQUENCES OF ACTIVITIES FOR CALIBRATING GRAVITY MODEL

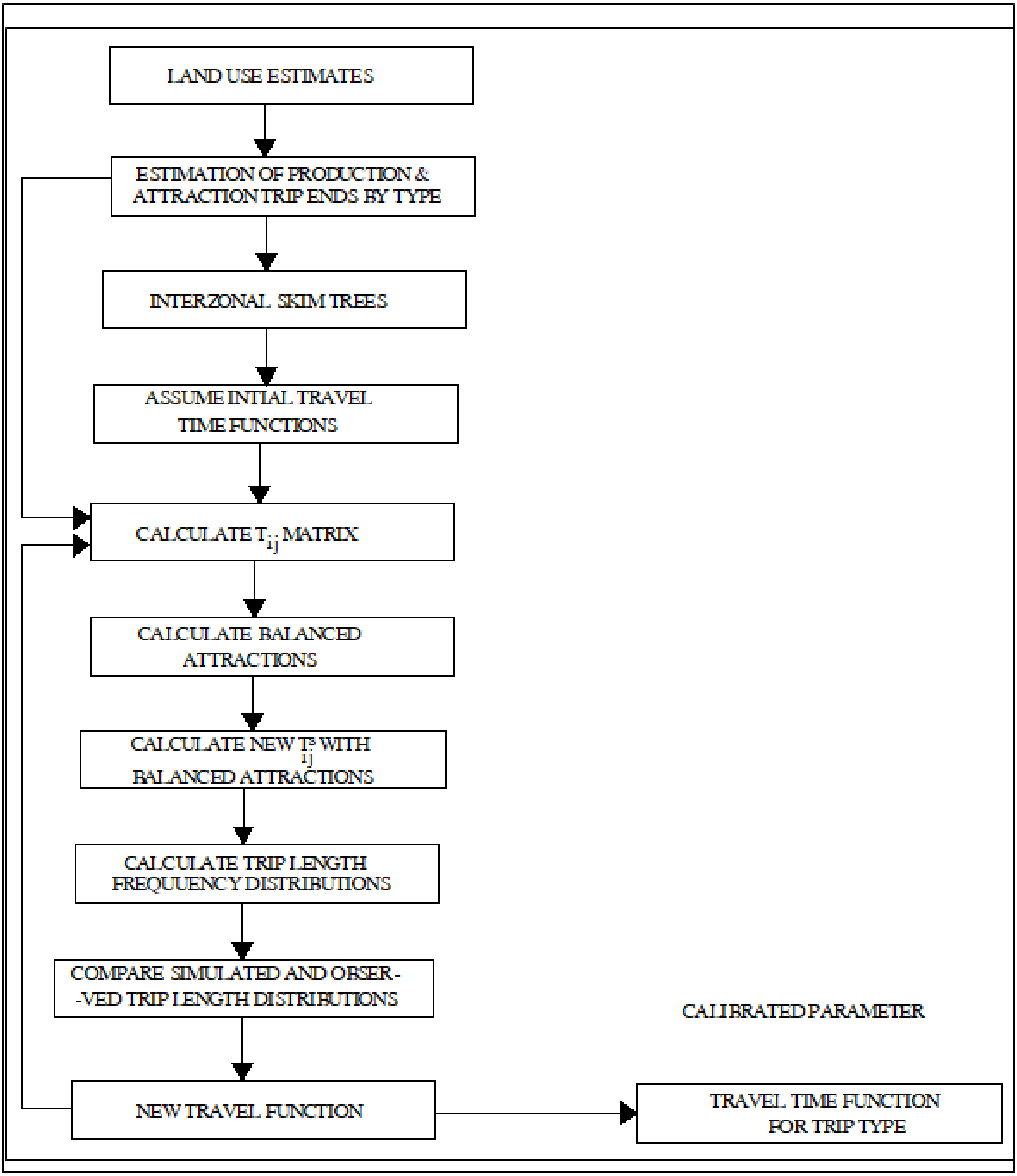
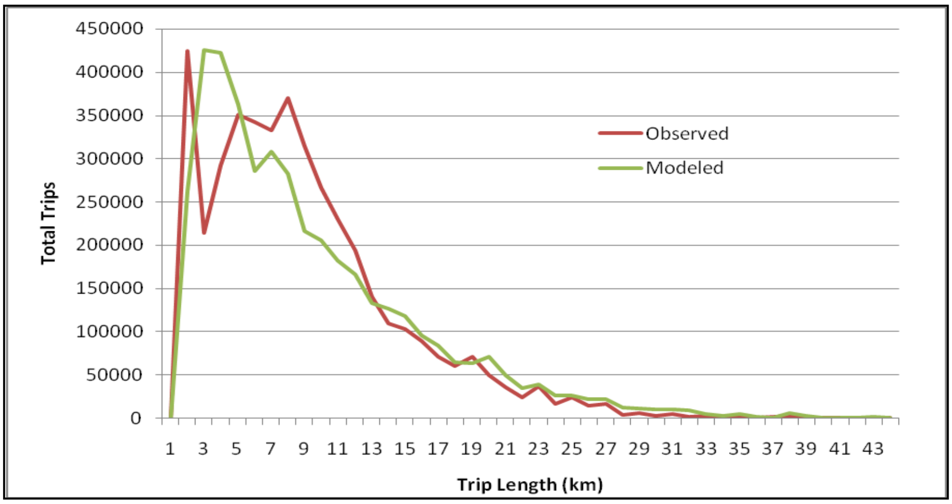


FIGURE 3.21: OBSERVED & MODELED TRIP LENGTH FREQUENCY DISTRIBUTION



3.3.5 Modal Split Model

The modal split model is developed based on the HIS database and the Generalised Costs (GC) produced from the highway and public transport cost models implemented in Cube Voyager software.

The total trips are split into two major group of private and public mode of travel. Then private modes are further divided into Car, 2W, and Auto. PT trips are separated between bus, shared auto and metro services during the assignment stage. It should be noted that the PT matrix produced by the modal split model contains trips using school, chartered, and public buses, but only the last category is retained for the PT assignment, the other two groups (school and chartered buses) not using the public network. However, these are taken into account in the highway assignment.

The main features of the modal split model are as follows:

- **4 modes:** Car, two wheelers, auto, and PT (including shared auto);
- **Unit:** person (productions / attractions – PA);
- **Period:** daily;

Model formulation: Combined Split, Multi-Logit Formulas (equations provided in **Figure 3.22**, where P means Probability and C is the Generalised Cost);

Logit Parameters Estimation: The mode choice sensitivity revealed by the model is mainly determined by the parameter λ. This model parameter was developed based on statistical regression analysis, which also provided some initial estimates on the mode biases between private and public modes of travel. **Figure 3.23** shows logit model sensitivity for illustrative purpose (example with Private versus Public Travel modes), when λ increases, the model becomes more responsive to the difference in cost.

FIGURE 3.22: MULTI-LOGIT FORMULAS (COMBINED SPLIT)

$$P_{Car} = \frac{e^{(-\lambda C_{Car})}}{e^{(-\lambda C_{Car})} + e^{(-\lambda C_{2W})} + e^{(-\lambda C_{Auto})} + e^{(-\lambda C_{PT})}}$$

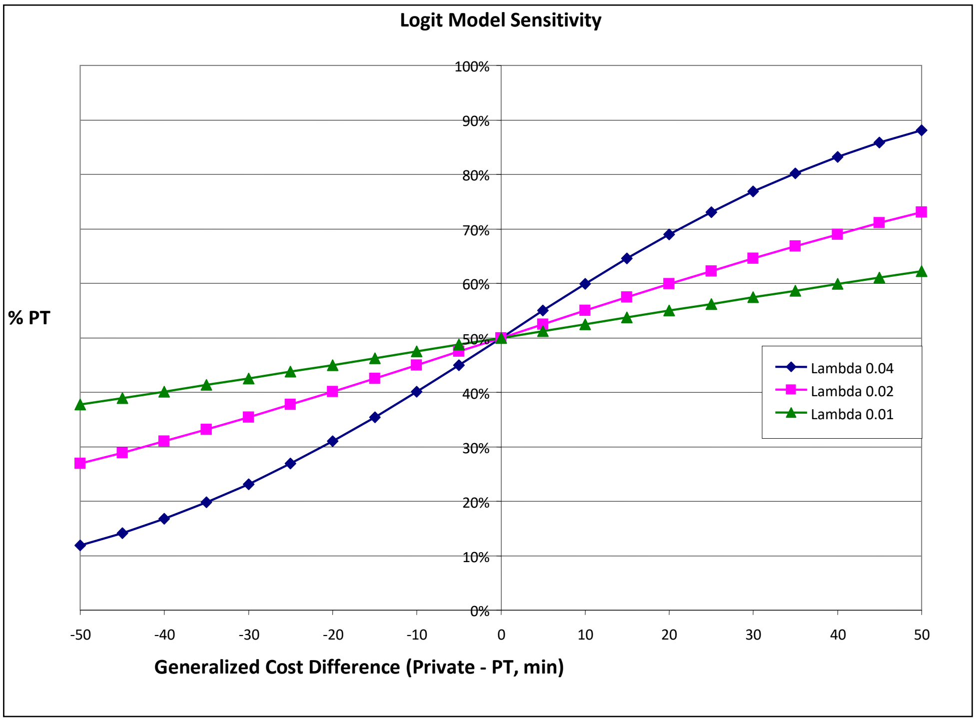
$$P_{2W} = \frac{e^{(-\lambda C_{2W})}}{e^{(-\lambda C_{Car})} + e^{(-\lambda C_{2W})} + e^{(-\lambda C_{Auto})} + e^{(-\lambda C_{PT})}}$$

$$P_{Auto} = \frac{e^{(-\lambda C_{Auto})}}{e^{(-\lambda C_{Car})} + e^{(-\lambda C_{2W})} + e^{(-\lambda C_{Auto})} + e^{(-\lambda C_{PT})}}$$

$$P_{PT} = \frac{e^{(-\lambda C_{PT})}}{e^{(-\lambda C_{Car})} + e^{(-\lambda C_{2W})} + e^{(-\lambda C_{Auto})} + e^{(-\lambda C_{PT})}}$$

The GC represents perceived costs, where the unit is minute equivalent, implying the use of Values of Time (VOT, 2018 prices, Rupees / hour) by mode to convert monetary costs (fare and vehicle operating cost - VOC) into minutes.

FIGURE 3.23: LOGIT MODEL SENSITIVITY



Occupancy factors (OCC) are also used for car, 2w, and auto to obtain person based GC. Below are described the GC by mode:

- **Car GC** = Time + [(VOC/OCC) / VOT] x 60;
- **2W GC** = Time + [(VOC/OCC) / VOT] x 60;
- **Auto GC** = Time + 1.5 x Wait Time (4) + [(Fare / OCC) / VOT] x 60;
- **PT GC** = IVT + 1.5 x Walk Time + 2 x Wait Time + (Fare / VOT) x 60 + Transfer Time

Table 3.39 gives the mode wise VOC to estimate benefits accruing to the society from the project.

TABLE 3.39: MODE WISE VOC FOR NAGPUR

Mode	VOC* Rs /Km
Bus	17.84
Car	7.35
2Wheelers	2.75
Auto	5.51
Shared Auto	6.89

**Source IRC SP 30 (2009) Values brought to 2018 level using factor of 5%*

Table 3.40 gives the mode wise VOT to estimate benefits accruing to the society from the project.

TABLE 3.40: MODE WISE VOT FOR NAGPUR METRO

Mode	Value of Travel Time**Passenger/ Hour
Bus	67.48
Car	89.20
2Wheelers	41.89
Auto	41.89
Shared Auto	41.89

**Source IRC SP 30 (2009) Values brought to 2018 level using factor of 5%*

3.3.5.1 Modal Split Calibration Results

Table 3.41 demonstrates that there is close correspondence between the synthesized and observed values from the HIS. The following observations can be made:

In theory, for any multi-logit model with two possible choices, there is one bias factor available. Calibrated Modal Choice Model has been developed with the

Lambda parameters between private & public as 0.19197.

TABLE 3.41: MODAL SPLIT MODEL CALIBRATION RESULTS

Mode	HIS	Model
Car	282950	285189
2W	2218950	2258771
Auto	651478	650423
PT including Shared Auto	1106233	1065664
Total	**4259611**	**4260047**

3.3.6 Trip Assignment Model

The trip assignment procedure determines the route choice of trip maker to whole or a part of a network and is the last part of travel demand modeling process where the inter-zonal modal trips are assigned to the various links of the network. There are at least four factors that lead people to choose one route over another. They are travel time, generalized travel cost, Travel distance and level of service. Taking a single parameter to determine the shortest path between each zone pair assumes that there is only one preferred path between each origin and destination. The traffic assignment itself can be of various type like All or Nothing Assignment, Capacity Restrain Assignment and Multipath Assignments.

The highway assignment is a multiple user class assignment using equilibrium algorithm and capacity constraint. In this method of assignment, trip matrices are loaded onto the network, using an incremental assignment method. The trip matrices are assigned to the shortest paths generated successively after assignment of small lots each of 15-20% increment of the trips matrices. The incremental assignment proceeds by updating the transport networks using the speed flow relationships of the links. The assignment is largely controlled by alternative paths, which are built by the shortest path algorithm through the network. The output of the assignment is a loaded highway network with volumes (PCU unit) by link and vehicle type, and network speeds.

For the public transport assignment, the person trips unit is retained. The public transport network is developed from the highway network following the highway assignment, a process which produces a loaded road network representing congested travel times on the road network.

The public transport assignment considers multiple routes at an origin / destination level, and includes the modeling of fares for different modes. The selection of public transport route choice is based on the travel costs, including walk access time to bus or metro stops, wait time, in vehicle time and fare, transfer or interchange walk times and subsequent wait times, and the time to reach the final destination. The output of the assignment is a loaded public transport network with patronage by service.

The PT assignment is based on the PT lines file built in Cube Voyager software, which contains a total of existing 101 “real” lines of buses and shared auto (considering the directionality) in the study area.

The 4-stage model produces daily matrices therefore a standard average hour factor of 8% is applied to the matrices for both the daily road and public transport assignments. Peak hour model assignment is done separately to exhibit the constrained level of services during the peak hour.

3.3.7 Peak Hour Model Validation

The 4-stage model finally provides Daily & Peak Hour person matrices by mode at the end of the process including the peak hour external and special generators matrices.

3.3.7.1 Peak Hour Assignments Validation Result

The travel demand model needs to be validated to determine whether it is reproducing existing traffic conditions. Model validation has been undertaken by comparing the observed data collected from the traffic volume count surveys with their equivalent synthesized results as produced by model. The discrepancies observed at most of the survey locations are within 0-15% of the actual counts.

The validation results are quantified thorough GEH Statistics using the ‘Validation’ option in Cube. The GEH Statistic is a formula used in traffic modelling to compare two sets of traffic volumes. Although its mathematical form is similar to a chi-square test, is not a true statistical test. Rather, it is an empirical formula that has proven useful for a variety of traffic analysis purposes.

The formula for the "GEH Statistic" is:

$$GEH = \sqrt{\frac{2(M-C)^2}{M+C}}$$

Where, M is the hourly traffic volume from the traffic model (or new count) and C is the real-world hourly traffic count (or the old count).

Using the GEH Statistic avoids some pitfalls that occur when using simple percentages to compare two sets of volumes. This is because the traffic volumes in real-world transportation systems vary over a wide range. For traffic modelling work in the "baseline" scenario, a GEH of less than 7.0 is considered a good match between the modelled and observed GEHs in the range of 7.0 to 10.0 may warrant investigation. GEH greater than 10.0 is not acceptable.

Itarsi - Wardha Railway Line and Nagpur - Howrah Railway Line which are major railway lines in the city constitute Screenline 1 and Screenline 2 respectively in the study area. Kanhan River constitutes another Screenline. For the present study the traffic flows at identified midblock locations are within the acceptable error range. **Table 3.42** shows comparison of observed and assigned flows at identified Midblock/Screenline locations.

TABLE 3.42: COMPARISON OF OBSERVED AND MODELED FLOWS AT SCREENLINES

SN	Screenline /Mid-Block Locations	Observed Peak Hour PCU	Modelled Peak Hour PCU	% Diff	GEH Value
	Screenline 1: Itarsi – Wardha Railway Line				
1	Kalmeshwar Railway Crossing	811	922	12.0%	3.8
2	Ring Road Railway Crossing near Mankapur Chowk	1504	1227	-22.5%	7.5
3	Jaripatka Cement Road Railway Crossing	1870	1655	-13.0%	5.1
4	Mecosabagh Road ROB near Mayo Hospital	2112	1806	-16.9%	6.9
5	Manglawari Bazar Road ROB	1292	1425	9.3%	3.6
6	Ramjhoola ROB	4212	4020	-4.8%	3.0
7	Humpyard Road RUB near Dhantoli Police Station	3602	3186	-13.1%	7.1
8	Narendra Nagar ROB	1701	1895	10.2%	4.6
9	Somalwada Rly Crossing near Sheetla Mata Mandir	2672	2999	10.9%	6.1
10	Aurangabad Road ROB near Shivangaon	2466	1997	-23.5%	9.9
11	Outer Ring Road ROB near Gavsi Mandir	677	727	6.9%	1.9
12	Wardha Road ROB near Butibori	2109	1885	-11.8%	5.0
	Screenline 2: Nagpur – Howrah Railway Line				
13	Kidwai Road RUB near Nagpur Motibagh Rly Stn.	989	992	0.4%	0.1
14	Old Kamptee Road ROB near Kawadapeth	1322	1617	18.2%	7.7

SN	Screenline /Mid-Block Locations	Observed Peak Hour PCU	Modelled Peak Hour PCU	% Diff	GEH Value
15	Ring Road ROB near Namdeo Nagar	3832	3732	-2.7%	1.6
16	Kamptee Rly Crossing near Dragon Palace Temple	594	482	-23.1%	4.8
17	Shankar Nagar Railway Crossing near Kamptee	673	495	-36.0%	7.4
18	Jabalpur Road ROB Near Khandala Ghatate	499	493	-1.1%	0.2
	Screenline 3: Kanhan River				
19	River Bridge on Kamptee-Kapsi Road near Sihora	1076	933	-15.3%	4.5
20	Kanhan River Bridge near Bhanegaon	271	308	12.0%	2.2
	Outer Cordon Locations				
21	Chhindwara Road near Patansaongi	972	705	-37.8%	9.2
22	Parshivni Road (Near Dhruv Motors)	499	308	-62.0%	9.5
23	Tarsa Road Near Nilaj	507	448	-13.1%	2.7
24	Bhandara Road near Sawali	3220	2822	-14.1%	7.2
25	Kuhi Road near Dongar Gaon	533	456	-16.9%	3.5
26	Hingna Road near Ujjayani Buddha Vihar	412	362	-13.8%	2.5

Screenline-wise difference (in total peak hour PCUs for all locations combined) between the observed and modeled figures is -9.9%, 6.3% and -8.5% for Screenlines 1, 2 and 3 respectively. Total peak hour PCUs of 40463, 12734, 1347 are observed at Screelines 1, 2 and 3 against modelled PCUs of 36806, 13585 and 1241 respectively.

The model validation results as presented above show that the model replicates the existing travel situation within permissible norms of transport planning in the study area since the model figures are close to the observed data, HIS database and field traffic counts. Therefore, the step following the model development, calibration, and validation, is to provide travel demand forecasts for the future years.

3.4. FUTURE TRAVEL DEMAND SCENARIOS

3.4.1 Forecast of Planning Parameters

The horizon year planning parameters were finalized in consultation with Client and a technical note on 'Land-use Parameters and Distribution by Traffic Zones' was submitted on 23rd September, 2016.

3.4.1.1 Population – Trends and Forecast

RITES has also forecasted the population based on the growth trends taken separately for municipal corporation and outer areas collectively forming the study area in addition to existing growth pattern from Census Data. The population in the study area for 2011 and for base year is 30.7 lakhs and 34.3 lakh respectively.

Based on discussions with concerned officials and population projections for Revised Draft Development Plan of Nagpur City, 2011, Nagpur Metropolitan Area Development Plan 2012 - 2032 and Nagpur Metro Ph-I DPR, projected study area population for various horizon years is estimated. The average annual growth rates of 1.4%, 1.2% & 1.1% have been considered for the years 2021, 2031 and 2041 respectively for the NMC area. Areas other than NMC are expected to grow at higher growth rates as per NMA Development Plans. The same annual growth rates of about 3% up to 2031 and about 2% for 2041 have been considered for projecting the population of Other than NMC areas.

The overall study area population annual growth rates is 1.8% up to the year 2031 and 1.5% up to 2041. The projected study area population for various horizon years is given in **Table 3.43**

TABLE 3.43: STUDY AREA POPULATION FORECAST FOR BASE AND HORIZON YEARS

SN	Area	Population (Lakh)			
		2018	2021	2031	2041
1	Nagpur Municipal Corporation	26.5	27.6	31.1	34.8
2	Other than NMC Areas Including Kamptee, Kalmeshwar, Hingna and surrounding villages	7.8	8.6	12.3	15.5
Total		**34.3**	**36.2**	**43.4**	**50.3**

3.4.1.3 Employment – Trends and Forecast

WFPR as observed in the base year is 37.0%. The employment of 10.8 lakh for year 2011 has been worked out from the census data figures and has been extrapolated to obtain base year employment figures. Keeping in view the economic profile of the study area, development prospects and transport intervention policies, WFPR of 38%, 40% and 41% for respectively 2021, 2031 and 2041 for NMC area and WFPR of 37%, 38% and 39% for 2021, 2031 and 2041 for outer areas have been assumed as per NMA Development Plan 2032 for the Horizon years. Thus, it has been estimated that 20.4 lakh workers would comprise the workforce in the study area by 2041 (**Table 3.44**).

TABLE 3.44: NUMBER OF WORKERS FOR BASE AND HORIZON YEARS

SN	Area	No. of Workers (Lakh)			
		2018	**2021**	**2031**	**2041**
1	Nagpur Municipal Corporation	9.8	10.5	12.4	14.3
2	Other than NMC Areas Including Kamptee, Kalmeshwar, Hingna and surrounding villages	2.9	3.2	4.7	6.1
	Total	**12.7**	**13.7**	**17.1**	**20.4**

** Estimated Figures based on NMA Development Plan 2032, Economic & Landuse Profiles*

3.4.2 Assumptions for Transport Demand Forecasting

Following assumptions have been made for forecasting transport demand on proposed metro corridors for the years 2024, 2031 and 2041. On the basis of growth rate calculated between 2021 and 2031, demand forecasting for year 2024 is estimated.

(i) Calibrated and validated travel demand model has been used.

(ii) Land use parameters (population, employment and student enrolment) have been distributed in various traffic zones for 2024, 2031 and 2041.

(iii) Inter-city passenger to/from the study area will grow at the growth rate of 3% per annum in various adjoining towns.

(iv) The special generator passenger traffic of bus terminals and railway stations in Nagpur is expected to grow at 6% per annum respectively.

(v) Inter and Intra-city goods traffic is expected to grow at 5% per annum up to 2041.

(vi) Fare levels of buses and vehicle operating costs of different vehicles have been taken same as in the year 2018. The fare levels of metro have been considered same as that of Nagpur Metro Phase-1. **Table 3.45** gives the year wise fare structure as assumed for Nagpur metro.

TABLE 3.45: MRTS FARE STRUCTURE ASSUMED FOR PHASE 2 METRO

Distance Slabs	Fare in 2017-18
0-2	10
2-5	20
5-12	30
12-21	40
21-32	50
>32	60

3.4.3 Transport Demand Forecast For Business As Usual (BAU) Scenario, 2041

Considering the above assumptions and calibrated / validated traffic demand model, forecasting of transport demand has been carried out for 'Business as Usual' (BAU) scenario in the year 2041. Overall modal split for various modes in this scenario for the year 2041 is given in **Table 3.46.** The intra and inter city motorized trips modal split (% of trips by public transport to total motorized trips) in favor of public transport (i.e. Bus, Minibus, Shared Auto and Phase 1 of Nagpur Metro) in 2041 is expected to be 19.2% even less than existing modal share of 23.4% in 2018. The total no. of PT trips will increase from 10.8 Lakh to about 14 Lakh indicating augmentation of high capacity mass transport network to address the travel demand requirements in the study area in the horizon years.

TABLE 3.46: DAILY INTRA + INTER CITY TRIPS IN BASE AND 2041 BAU SCENARIO

SN	Mode	2018		2041 BAU	
		Trips	Modal Share	Trips	Modal Share
1	Car	398151	8.7%	689726	9.4%
2	Two Wheeler	2465743	53.6%	4305065	59.0%
3	Auto	661448	14.4%	904415	12.4%
4	PT + Shared Auto	1075664	23.4%	1402667	19.2%
	Total	**4601006**	**100.0%**	**7301873**	**100.0%**

Traffic assignment for peak hour traffic (in PCUs) in BAU and Recommended Scenario 2041 are given in **Figure 3.23** and **Figure 3.24** respectively. The figure indicates the traffic flows on the overloaded roads in 2041 in both the scenarios.

FIGURE 3.24: PEAK HOUR TRAFFIC ASSIGNMENT (IN PCU'S) IN 2041BAUSCENARIO

FIGURE 3.25:

PEAK HOUR TRAFFIC ASSIGNMENT (IN PCU'S) IN RECOMMENDED 2041

3.4.4 Transport Demand Forecast for Nagpur Metro Corridors

The trips made between two adjacent stations of proposed mass transit corridors have been worked out for the years 2024, 2031 and 2041.

The transport demand forecast has been assessed considering the full system of Nagpur Metro i.e., Phase 1 & 2 corridors. The proposed mass transport network will be most efficient in catering the future passenger transport demand in the horizon years. The maximum peak hour peak direction trips (PHPDT) for proposed metro corridors of Nagpur Metro Phase 1 & 2 are given in **Table 3.47.**

TABLE 3.47: MAXIMUM PHPDT ON PHASE 1 & 2 NAGPUR METRO CORRIDORS

Phase	Corridor Details	Maximum PHPDT		
		2024	2031	2041
1	Automotive Square to MIHAN	12,952	13,407	15,743
	Prajapati Nagar to Lokmanya Nagar	10,195	11,411	16,889
2	1A - MIHAN to MIDC ESR	3,501	4,387	5,695
	2A - Automotive Square to Kanhan River	9,012	9,546	11,445
	3A - Lokmanya Nagar to Hingna	3,462	3,887	5,137
	4A - Prajapati Nagar to Transport Nagar	3,511	3,858	5,213
	5 - Vasudev Nagar to Dattawadi	3,806	4,862	5,835

3.5. RIDERSHIP ASSESSMENT FOR HORIZON YEARS

3.5.1 Ridership on Nagpur Metro Corridors for 2023, 2031 & 2041

Daily ridership on the Phase 1 &2 metro corridors for the years 2024, 2031 and 2041 is expected to be 5.5 Lakh, 6.3 Lakh and 7.8 Lakh passengers respectively. Line wise daily trips and boarding (including the interchanges between metro stations) for 2024, 2031 and 2041 are shown in **Table 3.48**. The sectional loads of the proposed Phase-I metro corridors for 2021 is presented in **Figure 3.25**.

TABLE 3.48: DAILY RIDERSHIP IN NAGPURPHASE 1 & 2 METRO CORRIDORS

S.No.	Corridor	Daily Ridership (Lakh)		
		2024	2031	2041
1	Kanhan River - Automotive Square – MIHAN - MIDC ESR	2.61	3.00	3.73
2	Transport Nagar - Prajapati Nagar - Lokmanya Nagar – Hingna	2.58	2.98	3.62
3	Vasudev Nagar - Dattawadi	0.30	0.35	0.39
	Total Trips	**5.49**	**6.33**	**7.75**
	Daily Total Interchange Trips	1.31	1.54	1.83
	Total Boarding	**6.80**	**7.87**	**9.58**

3.5.1.1 Peak Hour Section Loads and Station Boarding & Alighting on Phase-2 Metro Corridors

The trips made between two adjacent stations of proposed metro corridors have been worked out for the horizon years of 2024, 2031 and 2041. The section loads for the horizon years are presented in **Table 3.49.**

TABLE 3.49: PEAK HOUR SECTION LOADS ON PHASE-II METRO CORRIDORS

From	To	2024		2031		2041	
		DIR1	DIR2	DIR1	DIR2	DIR1	DIR2
Kanhan River to Automotive Square							
Kanhan River	Golf Club	112	117	121	133	173	176
Golf Club	Dragon Palace	137	146	149	165	208	216
Dragon Palace	Kamptee Municipal Council	261	397	275	426	346	490
Kamptee Municipal Council	Kamptee Police Station	405	371	421	404	529	464
Kamptee Police Station	Cantonement	1136	541	1165	590	1366	697
Cantonement	Lekha Nagar	4331	843	4690	904	5653	1059
Lekha Nagar	Lok Vihar	5798	957	6204	1061	7471	1297
Lok Vihar	Khairi Fata	6232	914	6669	1016	8193	1234
Khairi Fata	All India Radio	7279	1143	7733	1271	9447	1539
All India Radio	Khasara Fata	8370	1680	8891	1861	10746	2279
Khasara Fata	Pili Nadi	8721	1701	9261	1884	11162	2305
Pili Nadi	Automotive Square	9012	1791	9546	1983	11445	2420
Automotive Square to MIHAN							
Automotive Square	Nari Road	9825	2274	10345	2509	12246	3035
Nari Road	Indora Square	10330	2535	10817	2804	12676	3394
Indora Square	Kadvi Square	11517	2994	11956	3340	13769	4116
Kadvi Square	Gaddigodam Square	11585	3797	11982	4244	13722	5272
Gaddigodam Square	Kasturchand Park	12952	4066	13407	4560	15418	5686
Kasturchand Park	Zero Mile	12601	6835	13095	7633	15141	9624
Zero Mile	Sitaburdi (interchange)	12065	7081	12566	7898	14554	10052
Sitaburdi (interchange)	Congress Nagar	10563	6200	12216	6861	15743	11098
Congress Nagar	Rahate Colony	9534	6759	11107	7493	14333	12240
Rahate Colony	Ajni Square	7231	7091	8638	7883	11225	13394
Ajni Square	Chhatrapati Square	6499	6175	7846	7007	10341	11852
Chhatrapati Square	Jaiprakash Nagar	5882	5377	7222	6193	9466	10583
Jaiprakash Nagar	Ujjwal Nagar	5243	3272	6593	3961	8689	6595
Ujjwal Nagar	Airport	4954	2099	6336	2690	8732	3899
Airport	South Airport	4815	1374	6202	1930	8587	2400
South Airport	New Airport	4672	916	6165	1171	8524	1523
New Airport	Khapri	4751	874	6247	1143	8560	1503
MIHAN to MIDC ESR							
Khapri	Eco Park	1048	3501	1118	4387	1607	5695
Eco Park	Metro City	991	3389	1062	4206	1532	5473
Metro City	Ashokvan	901	3236	979	3909	1437	5114

From	To	2024		2031		2041	
		DIR1	DIR2	DIR1	DIR2	DIR1	DIR2
Ashokvan	Dongragaon	768	3246	837	3921	1245	5126
Dongragaon	Mohgaon	652	1086	712	1552	1090	2211
Mohgaon	Meghdoot CIDCO	622	955	679	1414	1056	2041
Meghdoot CIDCO	Butibori Police Station	193	825	201	1054	338	1386
Butibori Police Station	MHADA Colony	121	750	121	969	239	1282
MHADA Colony	MIDC KEC	249	168	317	230	435	252
MIDC KEC	MIDC ESR	116	128	146	174	155	185
Transport Nagar to Prajapati Nagar							
Transport Nagar	Kapsi Khurd	977	210	1248	245	1460	334
Kapsi Khurd	Pardi	1610	509	1916	564	2211	559
Pardi	Prajapati Nagar	3511	964	3858	1042	5213	1133
Prajapati Nagar to Lokmanya Nagar							
Prajapati Nagar	Vaishnodevi Square	4381	1468	4914	1592	5634	1809
Vaishnodevi Square	Ambedkar Square	5521	2454	6057	2670	6830	3101
Ambedkar Square	Telephone Exchange	5521	4116	5993	4462	6692	5205
Telephone Exchange	Chittrauli Square	5636	6122	6060	6666	6747	7879
Chittrauli Square	Agrasen Square	6120	7079	6421	7825	6970	9501
Agrasen Square	Dosar Vaisya Square	6015	9037	6206	10090	6616	12571
Dosar Vaisya Square	Nagpur Railway Station	8609	8917	9067	9973	10077	12469
Nagpur Railway Station	Cotton Market	8211	9757	8645	10936	9622	13721
Cotton Market	Sitaburdi (interchange)	10195	10118	10869	11411	12276	14606
Sitaburdi (interchange)	Jhansi Rani Square	7755	6832	8011	8747	10348	12588
Jhansi Rani Square	Institute of Engineers	7360	7556	7601	9565	9896	13776
Institute of Engineers	Shankar Nagar Square	5805	7986	6069	10047	8071	14484
Shankar Nagar Square	LAD Square	3792	9095	3974	11314	5326	16659
LAD Square	Dharampeth College	3797	9125	3966	11354	5259	16745
Dharampeth College	Subhash Nagar	3140	9048	3279	11285	4412	16889
Subhash Nagar	Rachana Ring Road Junction	2862	8767	2999	10981	4100	16132
Rachana Ring Road Junction	Vasudev Nagar	1963	7404	2072	9534	2612	13087
Vasudev Nagar	Bansi Nagar	1294	3825	1369	5627	1745	8125
Bansi Nagar	Lokmanya Nagar	1209	2968	1212	4871	1557	7159
Lokmanya Nagar to Hingna							
Lokmanya Nagar	Hingna Mount View	1237	3462	1232	3887	1673	5137
Hingna Mount View	Rajiv Nagar	255	1063	238	3032	308	3571
Rajiv Nagar	Wanadongri	178	975	192	2966	251	3485
Wanadongri	APMC	168	862	189	2819	248	3303
APMC	Raipur	140	305	179	739	235	788
Raipur	Hingna Bus Station	135	62	174	91	230	256
Hingna Bus Station	Hingna	136	12	171	13	240	116
Vasudev Nagar to Dattawadi							
Vasudev Nagar (interchange)	Police Station MIDC	1071	3806	1142	4862	1408	5835
Police Station MIDC	MIDC Post Office	646	3087	705	3470	846	4072
MIDC Post Office	DattaWadi	684	2722	743	3075	880	3614

Peak hour station loads (two way boarding & alighting) on Phase-II metro corridors for various horizon years of 2024, 2031 and 2041 are given in **Table 3.50**.

TABLE 3.50: PEAK HOUR STATION LOADS ON PHASE-I & II METRO CORRIDORS

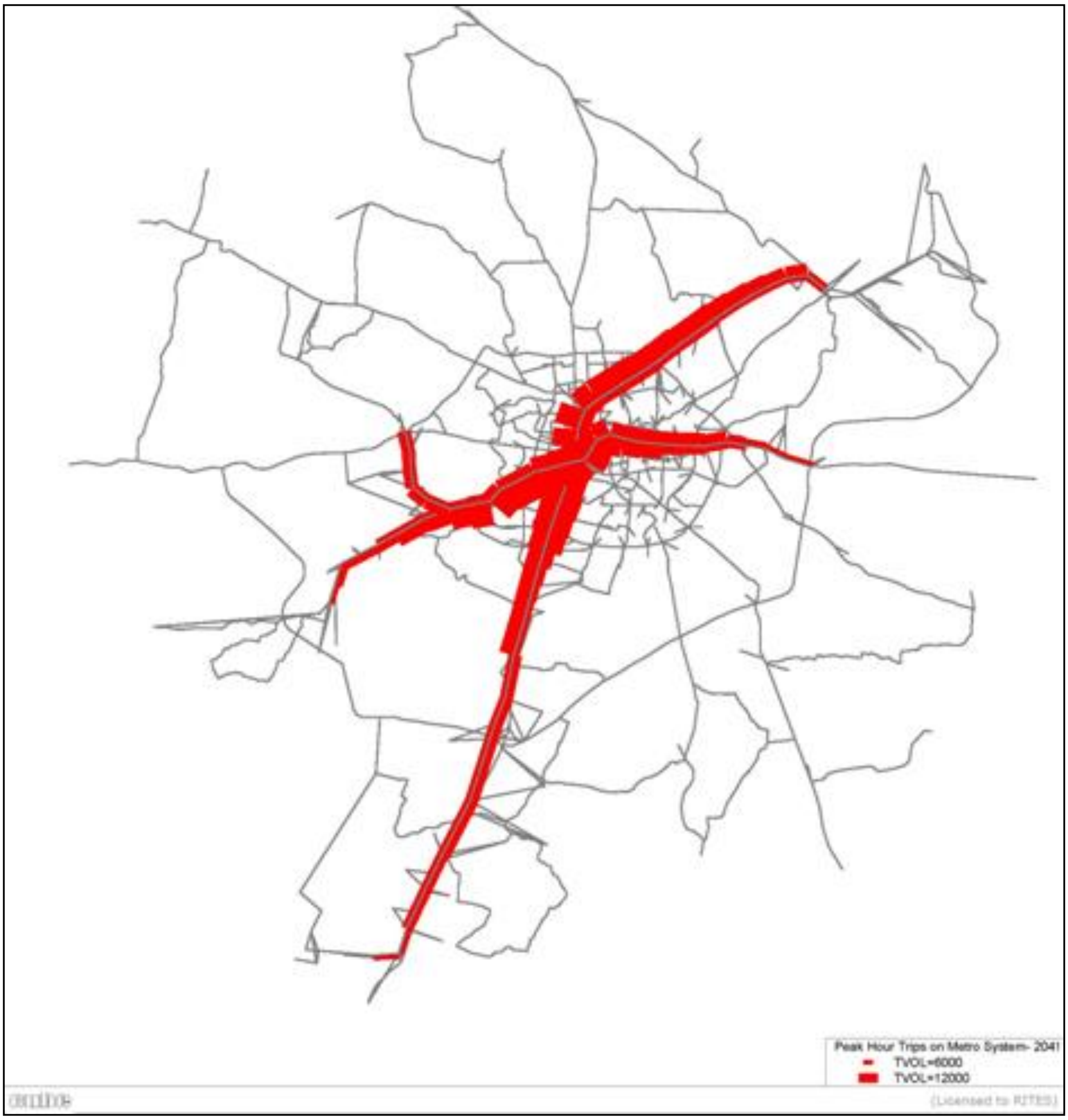
Station	Peak Station Loads 2024		Peak Station Loads 2031		Peak Station Loads 2041	
	On	Off	On	Off	On	Off
Kanhan River to Automotive Square						
Kanhan River	112	117	121	133	173	176
Golf Club	96	100	179	182	215	220
Dragon Palace	145	273	151	286	169	304
Kamptee Municipal Council	214	43	225	57	314	106
Kamptee Police Station	800	240	815	257	912	307
Cantonement	3503	610	3848	637	4637	713
Lekha Nagar	1880	527	1941	584	2274	694
Lok Vihar	546	67	619	110	970	185
Khairi Fata	1121	304	1143	335	1346	397
All India Radio	1466	911	1556	987	1757	1198
Khasara Fata	471	141	489	142	581	191
Pili Nadi	381	179	420	234	438	270
Automotive Square to MIHAN						
Automotive Square	1294	964	1316	1044	1402	1216
Nari Road	968	719	1109	932	1134	1062
Indora Square	2104	1376	2117	1513	2213	1842
Kadvi Square	601	1334	637	1516	718	1921
Gaddigodam Square	2093	996	2178	1069	2530	1249
Kasturchand Park	1641	4763	1694	5078	1924	6138
Zero Mile	117	899	145	940	163	1179
Sitaburdi (interchange)	13464	14094	15713	15025	20119	19977
Congress Nagar	404	1992	505	2246	652	3204
Rahate Colony	887	3518	917	3777	1000	5262
Ajni Square	1571	1389	1578	1493	2688	2030
Chhatrapati Square	1556	1373	1655	1467	2504	2110
Jaiprakash Nagar	2654	1187	2854	1249	4983	1772
Ujjwal Nagar	1670	786	1851	839	3832	1093
Airport	837	257	909	282	1773	419
South Airport	650	342	1095	373	1289	475
New Airport	606	487	655	545	739	684
Khapri	129	6451	205	8577	280	11426
MIHAN to MIDC ESR						
Eco Park	141	90	236	111	282	134
Metro City	202	150	394	180	563	298
Ashokvan	142	285	194	348	250	455
Dongragaon	2198	166	2425	182	2985	225

Station	Peak Station Loads 2024		Peak Station Loads 2031		Peak Station Loads 2041	
	On	Off	On	Off	On	Off
Mohgaon	156	57	172	67	213	78
Meghdoot CIDCO	397	693	621	739	1027	1089
Butibori Police Station	301	297	384	380	454	449
MHADA Colony	842	134	1112	177	1458	232
MIDC KEC	164	257	256	371	317	530
MIDC ESR	128	116	174	146	185	155
Transport Nagar to Prajapati Nagar						
Transport Nagar	977	210	1248	245	1460	334
Kapsi Khurd	653	321	695	346	924	397
Pardi	2115	673	2183	720	3267	839
Prajapati Nagar to Lokmanya Nagar						
Prajapati Nagar	2224	1856	2435	1928	2751	3006
Vaishnodevi Square	1505	1353	1537	1472	1629	1726
Ambedkar Square	691	2352	759	2616	775	3017
Telephone Exchange	1590	3482	1629	3766	1760	4378
Chittrauli Square	1868	2338	1931	2730	1969	3367
Agrasen Square	1051	3112	1104	3583	1154	4578
Dosar Vaisya Square	3268	555	3592	615	4311	748
Nagpur Railway Station	369	1607	430	1815	523	2229
Cotton Market	4193	2573	4563	2814	5273	3505
Sitaburdi (interchange)	13991	13167	15072	15267	19686	19596
Jhansi Rani Square	127	1245	164	1392	221	1859
Institute of Engineers	131	2115	135	2149	140	2673
Shankar Nagar Square	650	3771	685	4048	768	5689
LAD Square	250	274	287	335	295	449
Dharampeth College	510	1092	541	1158	608	1598
Subhash Nagar	811	809	865	842	1705	1260
Rachana Ring Road Junction	1791	1335	1912	1392	3764	2207
Vasudev Nagar	4007	1130	4423	1218	5589	1495
Bansi Nagar	958	213	963	364	1147	368
Lokmanya Nagar	2072	2515	3529	2526	4698	2560
Lokmanya Nagar to Hingna						
Hingna Mount View	2896	1637	2898	3036	3245	3044
Rajiv Nagar	179	186	216	197	241	212
Wanadongri	197	106	275	130	354	175
APMC	686	154	2280	210	2816	312
Raipur	356	111	768	124	782	255
Hingna Bus Station	99	101	110	112	185	181
Hingna	135	258	213	371	416	540
Vasudev Nagar to Dattawadi						
Vasudev Nagar (interchange)	1071	3619	1142	4110	1408	5835

Station	Peak Station Loads 2024		Peak Station Loads 2031		Peak Station Loads 2041	
	On	Off	On	Off	On	Off
Police Station MIDC	920	813	1054	852	2226	1025
MIDC Hingna	632	230	678	245	768	275
Dattawadi	2722	684	3075	743	3614	880

*Two way boardings/alightings on platforms

FIGURE 3.26: PEAK HOUR SECTION LOADS IN METRO PHASE 1 & 2 CORRIDORS - 2041



The implementation of Phase 2 Metro will enhance the ridership on Phase 1 corridors as well. The train operation plan, rake requirement and O&M will have to be planned considering this incremental travel demand on Phase 1 along with Phase 2 extension i.e. for full network.

DMRC has projected some ridership on the two corridors of Phase 1 in the DPR prepared by them in 2013.

The incremental daily passenger trips for Phase 1 and Phase 2 have been estimated considering the difference of estimated daily trips on full network (Phase 1 & 2) to that of Phase 1 (taken from DPR, 2013) as shown in **Table 3.51.**

TABLE 3.51: INCREMENTAL DAILY TRIPS DUE TO PHASE 2 CORRIDORS

Horizon Year	Daily Passenger Trips		
	Phase 1 as per DPR prepared by DMRC, 2013	Full Network (Ph 1 & Ph 2) as per RITES Model	Incremental ridership due to Ph 2 Extensions
2024	2,59,892	5,49,389	2,89,497
2031	2,94,241	6,32,894	3,38,653
2041	3,66,121	7,74,614	4,08,493

3.6. DESIGN RIDERSHIP

The maximum PHPDT and daily ridership figures will rely on the proposed developments as envisaged in Revised Draft Development Plan for NMC Area 1986-2011, Development Plan of Nagpur Metropolitan Area 2032 and realization of other planned transport infrastructure projects.

Ridership realization however depends on a number of factors including the type/ intensity/ direction of development, various policies of the government and a number of unforeseen issues that could appear during next 20-40 years. The system will start operating with initial ridership estimated and the capacity will be increased depending on the ridership growth.

Chapter – 4
SYSTEM AND TECHNOLOGY SELECTION

4. SYSTEM &TECHNOLOGY SELECTION

4.1 INTRODUCTION

Selection of a particular mass transit system largely depends on the characteristics of the city and its metropolitan area, the projection of traffic demand for transit travel and the availability of suitable right-of-way (ROW). Mass Transit System is selected and planned to provide comfortable, safe, reliable and fast/ high frequency connectivity across the cityscapes.

The projected traffic demand for the proposed corridors i.e. Kanhan River to MIDC ESR corridor is 15743 PHPDT, for Transport Nagar to Hingna corridor is 16889 PHPDT and for spur from Vasudev Nagar to Dattawadi is 5835 PHPDT. The urban transport requirements of Nagpur City have been evaluated based on projected traffic demand. The Nagpur metro Phase-1 is planned with medium capacity metro rail system. System parameters and technology for Nagpur metro Phase II extensions are proposed similar to phase-1 to ensure continuity and compatibility of systems and avoid complexity in train operation & maintenance of systems adopted for different route sections. Hence, for Nagpur metro extensions, similar type medium capacity metro system is proposed.

Metro Rail system is most prevalent mass transit system adopted worldwide. In India, MRTS is operational in various cities viz. Delhi, Chennai, Kolkata, Mumbai, Bangalore, Kochi, Jaipur etc. Metro rail technology offers the advantage of latest technology being available off the shelf with standardization, indigenization and has already stabilized for reliability, acceptance and availability of manufacturing infrastructure (for spare parts etc.) around the world and also in India. It is a grade separated system with exclusive right of way characterized by short distances of stations spaced at about 1 km and modern state of the art rolling stock having high acceleration and deceleration with maximum speed of 80-120 kmph. Sharpest curve of 120m radius is permitted for MRTS. The system can be designed to meet the peak hour peak direction traffic (PHPDT) carrying capacity from 10,000 to up to 80,000 depending upon the type of systems and infrastructure adopted such as rolling stock, train set configurations, signaling system, stations platform length etc. The capacities indicated above have been calculated considering 6 car trains operating at 1.5 minutes (90 seconds) headway which is achievable with advanced signalling system i.e. Communication Based Train Control (CBTC) technology. However, because of the track geometry, radius of curvatures and gradients etc. along the track alignment, headway of 90 seconds may not be practically achievable for metro systems.

However, considering the city specific characteristics, traffic demand, availability of right of way, Medium capacity Metro rail system with 3 car train composition is proposed to be adopted for the corridors of Nagpur Phase 2. The operation with 3 car train configuration can cater to a maximum traffic demand of 39000 PHPDT (with train operation at 1.5 min headway).

4.2 SYSTEM SPECIFICATIONS ADOPTED FOR THE CORRIDOR

Following system specification parameters are considered for the Nagpur Metro corridors. The rationale for choosing the particular technological parameter has been discussed in detail in the respective chapters.

TABLE 4.1: SYSTEM SPECIFICATION PARAMETERS

Parameters		System Specification
Traffic Handling capacity (PHPDT)		30000 with 3 coach trains at 2 min headway
Gauge		Standard gauge (1435 mm)
Traction System		25 kV AC OHE System
Signaling System		Communication Based Train Control (CBTC) System as per IEEE 1474.1
Telecommunication System		IP GE based
Rolling Stock	**Coach Width**	2.9 m wide coaches
	Basic Unit	3 car basic unit DMC-TC-DMC
	Train Composition	3 car – DMC-TC-DMC Capable of GoA4 operation Every coach should be fully interchangeable with any other coach of same type.
	Coach construction	Light weight stainless steel/Aluminum body
	Axle load	≤16 T
	Braking System	Regenerative Braking
	Propulsion system	3 phase drive system with VVVF control

Parameters		System Specification
	Performance Characteristics	Max. Design speed : 90 kmph Max. Operating speed : 80 kmph Max. Acceleration : 1.0 m/s^2 Max. Deceleration : 1.1 m/s^2 (Normal brake) More than 1.3 m/s^2 (Emergency brake)

Chapter – 5
CIVIL ENGINEERING

5. CIVIL ENGINEERING

5.1. ALIGNMENT DESCRIPTION OF APPROVED ALIGNMENT, AVAILABILITY OF ROAD

5.1.1. Engineering Survey

5.1.1.1. Objective of the Study

The main objective of the study is to map the existing land features available on the ground in the proposed extension of the proposed alignment of Extension of Phase II. The map will be used for study and planning for the proposed project. The study will give the present Land use of the area and horizontal as well as vertical dimensions of the area. The map will serve as base map for all the future development to be undertaken in the area.

Maharashtra Metro Rail Corporation (also known as Maha Metro) is constructing Phase-1 corridors of Nagpur Metro. There are two routes in Phase-1, one of them start from Automotive Square to MIHAN Area known as North-South Route and second from Prajapati Nagar to Lokmanya Nagar i.e. the East-West Route. There are two locations of Depot Area Known as MIHAN Depot Area Located in MIHAN Area near Khapri & second is located at Hingna Road. The corridors are divided in four reaches. Reach-1 start from Sitaburdi to khapri depot via Wardha road, Reach-2 start from Sitaburdi to Automotive square along Kamptee road, Reach-3 starts from Sitaburdi to Lokmanya Nagar via south Ambazari - Hingna road and Rech-4 start from Sitaburdi to Pardi naka via CA road.

FIGURE 5.1: PHOTOS TO OF THE CONSTRUCTION ACTIVITY ON PHASE-1

5.1.1.2. Corridor Details:

The DPR work for Nagpur Phase-2 has been entrusted to RITES Limited which are generally, extension of Phase -1 corridors in four directions which are as follows:

- MIHAN to MIDC ESR
- Automotive Square - Kampthee (Buddh Vihar) - Kanhan river
- Lokmanya Nagar - Wanadongri- Hingna
- Prajapati Nagar - Pardi -Transport Nagar
- Vasudev Nagar – Dattawadi

MIHAN to MIDC ESR

In this route, the required survey in Phase-II extension starts from **MIHAN to MIDC ESR.** The proposed survey length of route is 18452m. Following image shows the extension of route.

FIGURE 5.2: MIHAN TO MIDC ESR

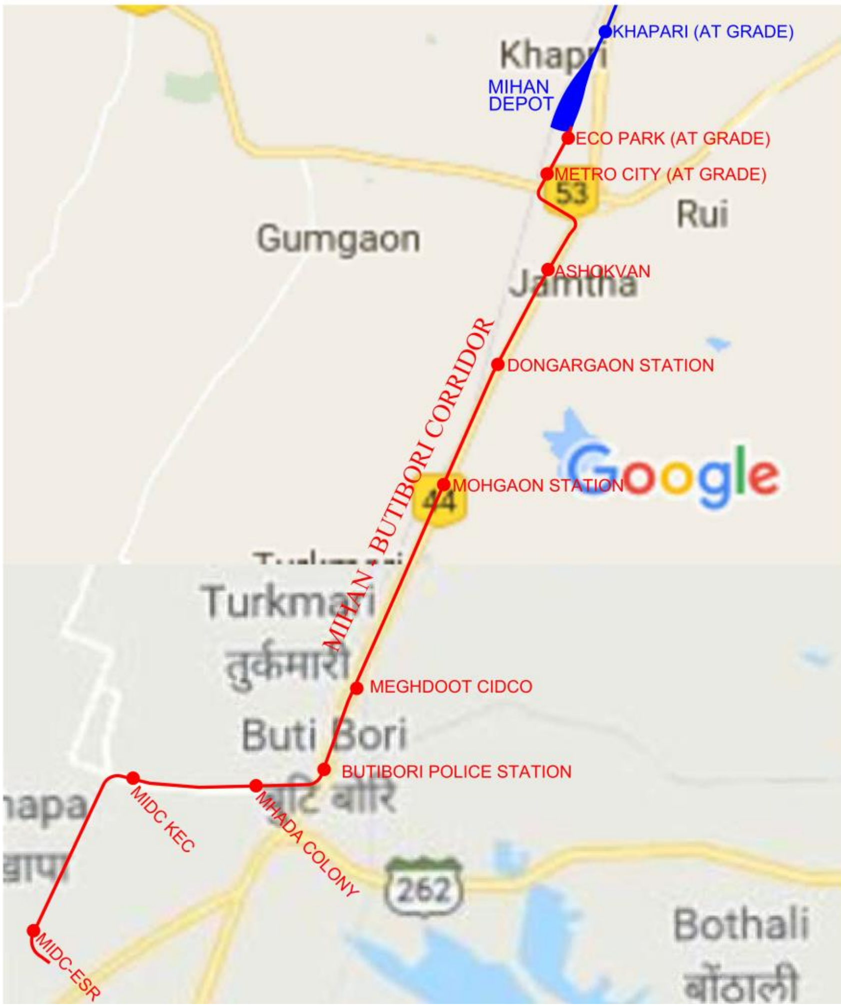
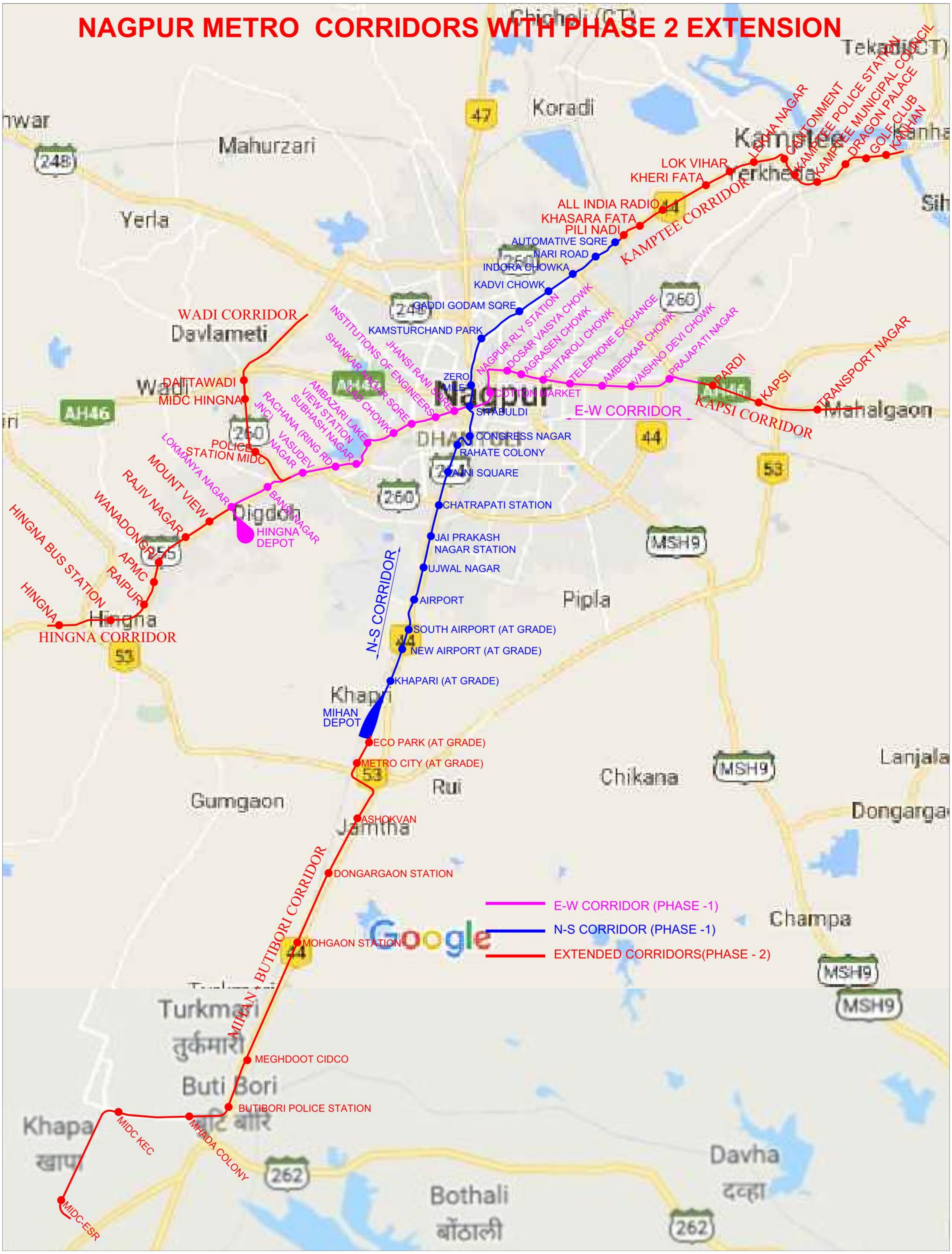


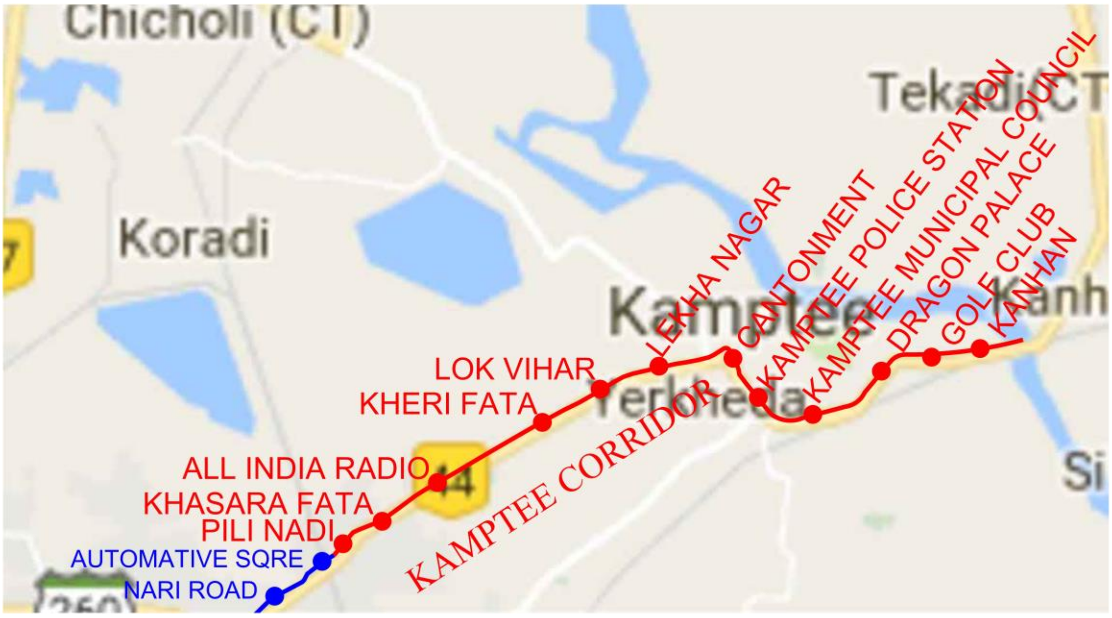
FIGURE 5.3: ROUTES OF PHASE II



Automotive Square to Kanhan River

In this route, the required survey in Phase-II extension starts from Automotive Square to Kanhan River along road NH-7. The proposed Extension length of route is 12925m. Following image shows the extension of route.

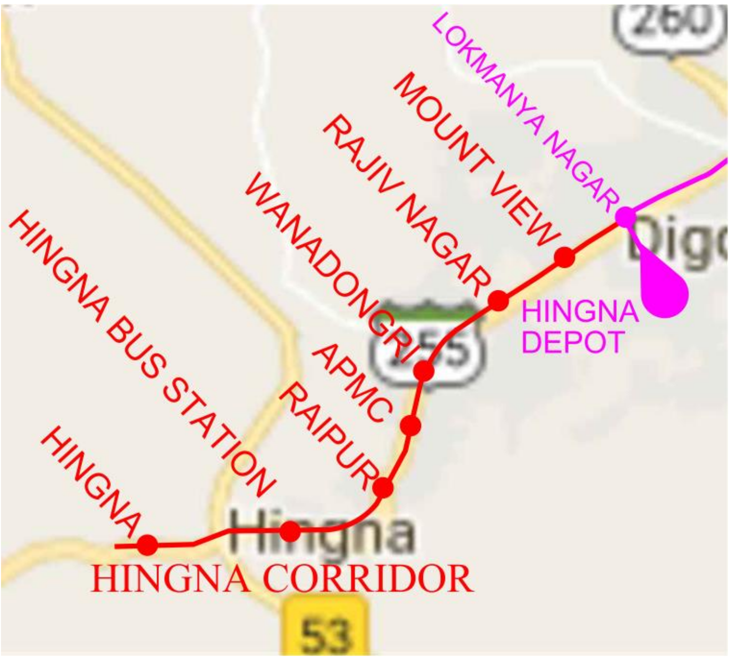
FIGURE 5.4: AUTOMOTIVE SQUARE TO KANHAN RIVER



Lokmanya Nagar to Hingna

In this route, the required survey in Phase-II extension starts from Lokmanya Nagar to Hingna village. The proposed extension length of route is 6657m. Following image shows the extension of route.

FIGURE 5.5: LOKMANYA NAGAR TO HINGNA



Prajapati Nagar to Transport Nagar

In this route, the required survey in Phase-II extension starts from **Prajapati Nagar to Transport Nagar.** The proposed extension length of route is 5441m. Following image shows the extension of route.

FIGURE 5.6: PRAJAPATI NAGAR TO TRANSPORT NAGAR

Vasudev Nagar to Dattawadi

In this route, the required survey in Phase-II extension starts from **Vasudev Nagar to Dattawadi**. The proposed extension length of route is 4489m. Following image shows the extension of route.

FIGURE 5.7: VASUDEV NAGAR TO DATTAWADI

TABLE 5.1: LENGTH OF PHASE-II EXTENSION FOR TOPOGRAPHICAL SURVEY

S.no	Phase-II Corridor		Length (in m).
1	CORRIDOR-1A	MIHAN TO MIDC ESR	18652
2	CORRIDOR-2A	AUTOMOTIVE SQUARE TO KANHAN RIVER	12925
3	CORRIDOR-3A	LOKMANYA NAGAR TO HINGNA	6657
4	CORRIDOR-4A	PRAJAPATI NAGAR TO TRANSPORT NAGAR	5441
5	CORRIDOR-5	VASUDEV NAGAR TO DATTAWADI	4489
TOTAL LENGTH			48164

5.1.1.3. Survey References

The reference for this extension lines were taken in continuation of the reference of the extension in Phase-I DPR of NMRCL which was in December 2016.

For Elevation: The reference for elevation for old DPR was taken from GTS BENCH MARK at Zero Mile, Sitabuldi Nagpur. The elevation of reference point is 310.948 M above MSL. This Elevation was transferred to proposed site area to carry out the detailed survey work. The Figure shows the GTS BENCH MARK.

FIGURE 5.8: GTS BENCH MARK

For Horizontal Control: The reference for horizontal control was in Phase-I extension DPR established with the help of DGPS. These points served as the control points for carrying out Phase-II extension survey work. See the Detail of GPS Points common between Phase-I survey extensions and Phase-II survey extension. Photograph of Base DGPS GPS-4 is shown below:

FIGURE 5.9: BASE DGPS GPS-4

TABLE 5.2: BASE POINT FOR PHASE-II SURVEY

S.no.	GPS ID	Easting	Northing	MSL	Remark
1	GPS 4	299855.758	2336651.569	303.673	ON TOP OF NAIL AT AJNI BASE SQUARE

TABLE 5.3: PHASE-II SURVEY REFERENCE COORDINATES FOR CORRIDOR-1A

SN	GPS ID	Easting	Northing	MSL	Remark
1	N-60	296816.863	2327943.101	302.018	Phase-I NCC PILLAR
2	N-61	296793.612	2327888.905	301.528	Phase-I NCC PILLAR

TABLE 5.4: PHASE-II SURVEY REFERENCE COORDINATES FOR CORRIDOR-2A

SN	GPS ID	Easting	Northing	MSL	Remark
1	GPS-EX-30	312636.033	2346791.080	287.396	Phase-I GPS
2	GPS-EX-30A	312716.249	2346793.800	287.216	Phase-I GPS

TABLE 5.5: PHASE-II SURVEY REFERENCE COORDINATES FOR CORRIDOR-3A

SN	GPS ID	Easting	Northing	MSL	Remark
1	GPS-EX-19	289768.551	2334100.309	313.381	Phase-I GPS
2	GPS-EX-19A	289653.039	2334035.963	314.624	Phase-I GPS

TABLE 5.6: PHASE-II SURVEY REFERENCE COORDINATES FOR CORRIDOR-4A

SN	GPS ID	Easting	Northing	MSL	Remark
1	GPS_EX_25	311518.726	2338924.220	287.368	Phase-I GPS
2	GPS-EX-25A	311676.117	2338898.711	285.278	Phase-I GPS

TABLE 5.7: PHASE-II SURVEY REFERENCE COORDINATES FOR CORRIDOR-5

SN	GPS ID	Easting	Northing	MSL	Remark
1	GPS 4	299855.758	2336651.569	303.673	ON TOP OF NAIL AT AJNI BASE SQUARE

5.1.1.4. Survey Methodology

- Before starting the detailed topographical survey work, a team of expert in the field of alignment design and survey has conducted reconnaissance survey to familiarize with the area and selection of control points along the proposed Metro Route. This includes site visit, Plot boundary observations, assessment of probable difficulties and bottle necks that may be affect the field survey, planning and arrangement of resources, finalizing survey methodology, old reference details, client's requirements, transfer old bench mark, verify the old reference point as old DPR etc

- Topographical survey of the Corridors 1A, 2A, 3A, 4A & 5 have been carried out to collect all manmade and natural features like roads, building, drain, railway line telephone/electric pole etc., falling in the proposed metro corridor for better and accurate planning of the metro alignment.

- Topographical survey was carried out in detail covering all the activities which are mentioned in Terms of Reference of the Contract using modern surveying instrument like GPS, Total Station and Auto/Digital Level. Survey Drawings were prepared in AutoCAD format.

- Topographical survey has been carried out in following six steps:

1. Establishment of Horizontal Control Points using DGPS
2. Densification of Horizontal Control Points using Total station
3. Establishment of Vertical Control Points
4. Detailed survey of corridor
5. Preparation of drawings.
6. Site verification of features.

5.1.1.5. Establishment of Horizontal Control Points using DGPS

- DGPS is a satellite-based system developed and maintained by US Department of Defense. In this system, 28 satellites are orbiting round the globe in six different planes which gives the coordinates of any point on the globe. The technology gives high accuracy coordinates when observed in differential mode. In the survey, differential GPS technology was used for maintaining the overall control and accuracy of the survey exercise. The distance between the control stations was 2 km to achieve better accuracy. The observation time for each control station was about 2 hrs. Sokkia GRX 2 DGPS receivers were used for this survey. The observed data was post processed using the Magnet Tools software. The DGPS survey results were used for the detailed survey using the Total Station. The DGPS data was collected in UTM map projection system with 44 North zone parameters and WGS 84 datum. In old DPR, the reference elevation of the control stations was taken from GTS Bench Mark at Zero Mile at Nagpur. The elevation of reference point is 310.948 m above MSL.

- After completing the DGPS control station work, close traverse survey was carried out using the DGPS coordinates. This was carried out using Total Stations with 1" accuracy. The traverse was closed on the pre-established DGPS control stations and the closing error was recorded. The closing error was distributed along the traverse length using Bowditch rule. Final coordinates derived after doing traverse adjustment were used for carrying out detailed topographic survey. All the accuracy parameters as per Tender Documents in section 5, Technical Specifications were strictly followed.

- Details of GPS Control points of Corridor-1 established are provided is given in
- Detailed Topographic Survey

  This activity was carried out with the help of Electronic Total Station instrument which works on Infra Red Ray technique. The control stations as established with the DGPS and inter-visible GPC pillars (traversing pillars) were fixed at site at interval of 200m.

  After adjustment of the traverse data the GPC pillars were used as starting and closing reference stations for topographic survey. The detailed survey includes observations for all the surface features within the corridor of 50m either side from road center of the proposed project. The surface features like road edges, shoulders, toe, central divider, electric poles, telephone poles, trees with species details and having girth more than 0.3 m, building lines, no of storey's of every structure, type of use of existing structures within ROW, manholes, electric junction boxes etc. were observed and recorded in the memory of the Total Station.

5.1.1.6. Data down load and interpretation:

The survey data was down loaded on daily basis to PC and the correctness of the same was analyzed. Further, this survey data was imported in AutoCAD and processed for generating the drawings.

5.1.1.7. Quality check of survey drawings:

The draft prints of topographic drawings as prepared above were taken to field for quality checking. The omissions / corrections, if any, were identified and noted. The AutoCAD drawings were modified for the corrections as noted in the field and final drawings were generated.

5.1.1.8. Report Preparation and submission:

The report is prepared on the basis of drawings generated and the data collected and is presented here for the submission.

5.1.2. Details of Phase-II Extension Survey

5.1.2.1. Reference Point Demarcations

The DGPS survey reference stations were established on concrete pillars as instructed in the tender document. M-15 grade concrete pillars of size 300mm x 300mm x 450mm with 20mm dia steel rod at centre were cast in situ with a surrounding concrete of 15 cms. @ 2km interval. The top of the pillar is kept 15 cms above the adjoining ground level. Following photographs shows the DGPS pillars.

5.1.2.2. Traverse Station Reference Point Demarcations

The traverse survey reference stations were established on concrete pillars as instructed in the tender document. M-15 grade concrete precast pillars of size 150mm x 150mm x 400mm with 10mm dia steel rod at centre with a surrounding concrete of 15 cms. @ 200m interval. The top of the pillar is kept 15 cms above the adjoining ground level.

Following photographs shows the traverse pillars.

TABLE 5.8: LIST OF GPS CONTROL POINTS FOR CORRIDOR 1A – MIHAN TO MIDC ESR

S.No.	DGPS ID	Ground Coordinate		MSL	Remark
		Easting	Northing		
• Reach-1 extension survey done by using N-60 and N-61 as reference coordinate from Phase-I survey station. There are 16 points of DGPS control stations established for phase-II extension. Following table shows the DGPS coordinate statement					
1	N-60	296816.863	2327943.101	302.018	NCC PILLAR

S.No.	DGPS ID	Ground Coordinate		MSL	Remark
		Easting	Northing		
2	N-61	296793.612	2327888.905	301.528	NCC PILLAR
3	GPS_EX–II_B1	296673.266	2324415.313	292.614	Phase-II GPS, L.H.S,in open field after sure tech hospital
4	GPS_EX–II_B2	296607.835	2324424.611	291.237	Phase-II GPS, R.H.S on top of pillar, opp. to B1
5	GPS_EX–II_B3	295731.559	2322803.763	297.989	Phase-II GPS, L.H.S on top of pillar, 38m ahead of my asset infra mai group
6	GPS_EX–II–B4	295696.898	2322726.578	295.588	Phase-II GPS, L.H.S in open field near meter stone 18/200
7	GP_EX–II_B5	294981.616	2321278.879	293.496	Phase-II GPS, LHS near weight bridge.
8	GPS_EX_II_B6	294933.956	2321193.022	294.804	Phase-II GPS, LHS 40m before wakeshwar bus stop.
9	GPS_EX_II_B7	294127.043	2319461.621	287.477	Phase-II GPS, LHS on top of pillar near meter stone 21/800
10	GPS_EX_II_B8	294045.528	2319363.899	285.570	Phase-II GPS, RHS on top of pillar in open field
11	GPS_EX_II_B9	293190.024	2317615.714	279.119	Phase-II GPS, RHS on top of pilla near well
12	GPS_EX_II_B10	293132.539	2317486.974	279.763	Phase-II GPS, RHS on top of pillar in open field near chainage 31600
13	GPS_EX–II_B11	292392.562	2315385.880	266.672	Phase-II GPS, RHS on top pillar near near MIDC road
14	GPS_EX_II_B12	292357.081	2315275.062	266.148	Phase-II GPS, LHS on top of pillar.
15	GPS_EX_II_B13	289954.582	2315512.395	262.921	Phase-II GPS, LHS on open field opp. to shada ispat limited.
16	GPS_EX_II_B14	289858.772	2315507.064	263.364	Phase-II GPS, LHS on top of pillar near chainage

S.No.	DGPS ID	Ground Coordinate		MSL	Remark
		Easting	Northing		
					36280
17	GPS_EX_II_B15	288228.712	2314867.875	276.855	Phase-II GPS, RHS near culvert
18	GPS_EX_II_B16	288245.574	2314735.111	276.867	Phase-II GPS, RHS in front of maharastra rajya Vidyut mandal.
19	GPS_EX_II_B17	296236.725	2326000.727	293.629	Phase-II GPS near Outer Ring Road
20	GPS_EX_II_B18	296374.220	2325986.353	296.026	Phase-II GPS near Outer Ring Road

TABLE 5.9: LIST OF GPS CONTROL POINTS FOR CORRIDOR 2A - AUTOMOTIVE SQUARE TO KANHAN RIVER

S.N.	GPS ID	Ground coordinate		MSL(m)	Description
		Easting	Northing		
AUTOMOTIVE SQUARE TO BUDDH VIHAR (KAMPTEE)					
1	GPS-EX-26	306258.380	2344949.334	291.067	RHS SIDE NEAR PLOT OF SHRI. MOHIL GUPTA NEAR BRIDGE AFTER RAILWAY CROSSING
2	GPS-EX-26A	306349.338	2344999.218	290.796	LHS SIDE BEFORE J.K. CONSTRUCTION & INFRASTRUCTURE (INDIA) PVT. LTD. AFTER RAILWAY CROSSING
3	GPS-EX-27	307599.761	2345893.572	299.045	RHS SIDE INFRONT OF M.H.K.S. MOHAMMED ALI BHARAT PETROLEUM PETROL PUMP
4	GPS-EX-27A	307704.880	2345951.323	298.547	RHS SIDE INFRONT OF RATANLAL DAMADULAL SHED
5	GPS-EX-28	309086.528	2346723.884	289.418	LHS INFRONT OF H.P. PETROL PUMP NEAR DELHI PUBLIC SCHOOL
6	GPS-EX-28A	309177.639	2346776.136	289.023	LHS INFRONT OF EDEN GRRENZ HOTEL
7	GPS-EX-29	311536.413	2347670.827	281.576	LHS INFRONT OF HANUMAN TEMEPLE NEAR OCTROI OFFICE
8	GPS-EX-29A	311632.232	2347683.667	283.120	RHS NEAR KHAPERKHEDA / DAHEGAON ROAD

S.N.	GPS ID	Ground coordinate		MSL(m)	Description
		Easting	Northing		
					JUNCTION
9	GPS-EX-30	312636.033	2346791.08	287.396	RHS SIDE NEAR DR. B.R. AMBEDKAR STATUE GARDEN AREA IN KAMPTEE
10	GPS-EX-30A	312716.249	2346793.8	287.216	ON CENTERAL MEDIAN INFRONT OF CORPORATION SHOPING COMPLEX
11	GPS-EX-31	314070.254	2347272.994	287.396	ON CENTERAL MEDIAN BEFORE NALLAH
12	GPS-EX-31A	314115.23	2347307.017	287.216	RHS AFTHER NALLAH CROSSING
BUDDH VIHAR (KAMPTEE) TO KANHAN RIVER					
• Reach-2 extension survey done by using GPS-EX-30 and GPS-EX-30A as reference coordinate from Phase-I survey station. There are 2 points of DGPS control stations established for phase-II extension. Following table shows the DGPS coordinate statement.					
1	GPS-EX-30	312636.033	2346791.080	287.396	Phase-I GPS, ON TOP OF PILLAR R/S NEAR FOUNTAIN
2	GPS-EX-30A	312716.249	2346793.800	287.216	Phase-I GPS, ON TOP OF PILLAR (DIVIDER CENTER) INFRONT OF NISHA BEAUTY PARLOUR
3	GPS-EX-II-32	315624.817	2347849.516	278.579	Phase-II GPS, ON TOP OF PILLAR L/S NEAR SAI BABA TEMPLE
4	GPS−EX−II−32A	315612.959	2347946.531	278.934	Phase-II GPS, ON TOP OF PILLAR L/S NEAR SAIYAD PIR SHAHAJI DARGA

Following photographs shows the DGPS Observation on Concrete Pillars.

TABLE 5.10: LIST OF GPS CONTROL POINTS FOR CORRIDOR 3A – LOKMANYA NAGAR TO HINGNA

S.No.	DGPS Point ID	Ground coordinate		MSL (m)	Description
		Easting	Northing		
LOKMANYA NAGAR TO MAHATAMA GANDHI COLLEGE					
1	GPS-EX-18	292359.584	2335690.860	316.255	RIGHT SIDE INFRONT OF ALL ENGINEERING LIMITED ON HIGNA ROAD
2	GPS-EX-18A	292264.825	2335624.678	314.940	RIGHT SIDE ON MIDC SERVICE ROAD INFRONT OF VIP INDUSTRIE'S COMPOUND WALL ON HIGNA ROAD
3	GPS-EX-19	289768.551	2334100.309	313.381	RIGHT SIDE INFRONT OF ASHISH HARDWARE ON HIGNA ROAD
4	GPS-EX-19A	289653.039	2334035.963	314.624	LEFT SIDE NEAR COMPOUND WALL OF SCHOOL OF SCHOLARS MAHATMA GANDHI HIGH SCHOOL & COLLEGE WANADONGRI AND INFRONT OF BUS STOP WANADONGARI
MAHATAMA GANDHI COLLEGE TO HINGNA • Reach-3 extension survey done by using GPS-EX-19 and GPS-EX-19A as reference coordinate from Phase-I survey station. There are 4 points of DGPS control stations established for phase-II extension. Following table shows the DGPS coordinate statement.					
1	GPS-EX-19	289768.551	2334100.309	313.381	Phase-I GPS
2	GPS-EX-19A	289653.039	2334035.963	314.624	Phase-I GPS, On top of pillar near baba taj chicken center
3	GPS-EX-II-20	289147.865	2332381.521	294.287	Phase-II GPS, On top of pillar near cow shed
4	GPS–EX–II–20A	289054.930	2332352.097	295.837	Phase-II GPS, On top of pillar near muslim kabrasthan
5	GPS-EX-II-21	287483.252	2331758.447	302.797	Phase-II GPS, On top of pillar R/S infront of goverment hospital
6	GPS–EX–II–21A	287380.683	2331734.604	303.503	Phase-II GPS, On top of pillar R/S near sanjay zile house

Following photographs shows the DGPS Observation on Concrete Pillars.

TABLE 5.11: LIST OF GPS CONTROL POINTS FOR CORRIDOR 4A – PRAJAPATI NAGAR TO TRANSPORT NAGAR

S. No.	DGPS Point ID	Ground coordinate		MSL (m)	Description
		Easting	Northing		
PRAJAPATI NAGAR TO TRANSPORT NAGAR					
1	GPS_EX_23	307759.638	2339892.115	286.463	ON LHS, NIT OPEN LAND (ACQURED BY NMRCL) NEAR SOMANI BUILDER & DEVELOPERS LAND
2	GPS_EX_23 A	307810.778	2339927.798	286.462	ON LHS IN FRONT OF CITY HOSPITAL COMERCIAL COMPLEX
3	GPS_EX_24	309650.106	2339617.711	291.603	LHS AT OLD SCRAP GODOWN NEAR SHRI PATIDAR DHARM KATA
4	GPS_EX_24_A	309711.310	2339554.268	292.530	LHS AT MEHAR CELEBRATION LAWN & KOUSHIK UDYOG LIMITED

S. No.	DGPS Point ID	Ground coordinate		MSL (m)	Description
		Easting	Northing		
5	GPS_EX_25	311518.726	2338924.22	287.368	ON CENTERAL MEDIAN, INFRONT OF NIRMAL SAI DHABA
6	GPS_EX_25_A	311676.117	2338898.711	285.278	ON ISLAND AFTER OUTER RING FLYOVER TOWARDS BHANDARA
TRANSPORT NAGAR TO ASOLI VILLAGE					
• Reach-4 extension survey done by using GPS-EX-25 and GPS-EX-25A as reference coordinate from Phase-I survey station. There are 2 points of DGPS control stations established for phase-II extension. Following table shows the DGPS coordinate statement.					
1	GPS_EX_25	311518.726	2338924.220	287.368	Phase-I GPS
2	GPS-EX-25A	311676.117	2338898.711	285.278	Phase-I GPS
3	GPS-EX2-26	313341.982	2338903.551	280.100	Phase-II GPS, ON TOP OF PILLAR L/S NEAR NALLA
4	GPS–EX–II–26A	313278.460	2338746.372	279.748	Phase-II GPS, ON TOP OF PILLAR R/S NEAR NAG TEMPLE

TABLE 5.12: LIST OF GPS CONTROL POINTS FOR CORRIDOR 5 – VASUDEV NAGAR TO DATTAWADI

S.No.	DGPS Point ID	Ground Coordinate		MSL (m)	Description
		Easting	Northing		
1	GPS EX_20	293825.112	2336602.680	331.159	RIGHT SIDE INFRONT OF MAHANAND MILK
2	GPS_EX_20 A	293731.300	2336680.230	332.545	LEFT SIDE NEAR CENTRAL WORKSHOP COMPOUND WALL
3	GPS_EX_21	292709.096	2338741.554	344.026	RIGHT SIDE INFRONT OF MIA GUEST HOUSE
4	GPS_EX_21 A	292679.398	2338774.349	344.073	LEFT SIDE NEAR A.H.R. ENGINEERING CO.PVT.LTD
5	GPS_EX_22	292625.519	2340205.680	343.901	RIGHT SIDE NEAR S. M. TRADERS
6	GPS_EX_22 A	292580.384	2340266.211	345.115	LEFT SIDE NEAR HOTEL RAHUL PALACE

Following photographs shows the DGPS Observation on Concrete Pillars.

5.1.2.3. Densification of Horizontal Control Points using Total Station

As per project requirement, five to six additional pillars of same size on traverse points have been fixed between GPS control points which is used during the detailed topographical survey of the corridors.

Densification of horizontal points involves fixing of additional pillars between GPS Pillars along the corridors. In this activity traversing has been carried out by Leica Total Station of 1"(one second) accuracy between GPS points which co-ordinates are already determined with help of GPS observation. Co-ordinates of intermediate points established with the help of total station have been determined by solving the traverse network between GPS control Points. Closing error of traverse network was calculated and errors which were within permissible limits, were adjusted by transit rule method after adjusting the angular error of the traverse. As per TOR, total linear error in traverse after angular adjustment was permitted 1 in 50,000 where as angular error of traverse was permitted 15"√n where n is the number of angle measured in the traverse network.

Details of additional control points (GCP's) of Corridor-1A established are given in **Table 5.13**

TABLE 5.13: LIST OF GCP'S CONTROL POINTS FOR CORRIDOR 1A – MIHAN TO MIDC ESR

S.No.	GCPs ID	Easting	Northing	MSL	Remarks
• The traverse stations were established on precast concrete pillars of size 150 X 150 X 400mm @200m interval. There are 75 points traverse stations established for phase-II extension. Following table shows the traverse station coordinate statement.					
TRAVERSE STATION COORDINATE (GCP'S) STATEMENT FOR LOOP-1					
1	GCP-B1/1	296644.627	2324485.932	292.210	ON TOP PILLAR L/S NEAR AMRUT DAIRY FARM
2	GCP-B1/2	296753.840	2324624.772	290.934	ON TOP PILLAR R/S NEAR SAGWAN PLANTATION
3	GCP-B1/3	296554.969	2324249.571	291.809	ON TOP PILLAR L/S NEAR CULVERT
4	GCP-B1/4	296458.810	2324077.531	292.094	ON TOP PILLAR L/S NEAR SHED
5	GCP-B1/5	296356.660	2323959.349	293.424	ON TOP PILLAR R/S NEAR OFC STONE

S.No.	GCPs ID	Easting	Northing	MSL	Remarks
6	GCP-B1/6	296282.866	2323761.063	298.350	ON TOP PILLAR L/S NEAR YADAV ESTATES
7	GCP-B1/7	296148.811	2323605.231	299.461	ON TOP PILLAR R/S NEAR INDRAYANI FURNITURE WORKS
8	GCP-B1/8	296076.856	2323422.626	298.113	ON TOP PILLAR L/S NEAR NAGARAJUN CONSTRUCTION COMPANY
9	GCP-B1/9	295952.933	2323212.119	302.491	ON TOP PILLAR L/S NEAR TENDUPATTA GODOWN
10	GCP-B1/10	295841.057	2323072.960	304.199	ON TOP PILLAR R/S NEAR ELECTRIC POLE
11	GCP-B1/11	295753.542	2322871.149	301.294	ON TOP PILLAR L/S NEAR LAND OF BAJAJ SUCHAK AND SARDA
TRAVERSE STATION COORDINATE (GCP'S) STATEMENT FOR LOOP-2					
1	GCP-B2/1	295631.716	2322665.159	296.943	ON TOP PILLAR L/S NEAR NALA
2	GCP-B2/2	295502.000	2322515.722	299.760	ON TOP PILLAR R/S NEAR HANUMAN TEMPLE
3	GCP-B2/3	295416.497	2322377.347	298.935	ON TOP PILLAR R/S NEAR BHARAT PETROL PUMP
4	GCP-B2/4	295328.522	2322146.035	298.310	ON TOP PILLAR L/S NEAR VIJAY NASHTA CENTER
5	GCP-B2/5	295209.659	2321972.627	297.859	ON TOP PILLAR R/S NEAR OPEN PLOT
6	GCP-B2/6	295180.206	2321808.907	295.342	ON TOP PILLAR L/S NEAR TAKA
7	GCP-B2/7	295068.669	2321646.098	295.204	ON TOP PILLAR R/S NEAR OLD TOLL NAKA HOUSE
8	GCP-B2/8	295034.380	2321438.372	295.911	ON TOP PILLAR L/S NEAR HOUSE
9	GCP-B2/9	294926.700	2321241.378	295.415	ON TOP PILLAR L/S NEAR TOILET BLOCK
TRAVERSE STATION COORDINATE (GCP'S) STATEMENT FOR LOOP-3					
1	GCP-B3/1	294863.732	2321100.342	295.160	ON TOP PILLAR L/S NEAR RB STONE
2	GCP-B3/2	294748.912	2320918.030	293.643	ON TOP PILLAR R/S NEAR RAILWAY PILLAR
3	GCP-B3/3	294697.771	2320734.386	293.303	ON TOP PILLAR L/S NEAR MACHINE ROOM
4	GCP-B3/4	294609.369	2320543.167	292.511	ON TOP PILLAR L/S NEAR FARM
5	GCP-B3/5	294501.843	2320383.795	291.587	ON TOP PILLAR R/S NEAR KHALSA DHABA AND RESTAURANT

S.No.	GCPs ID	Easting	Northing	MSL	Remarks
6	GCP-B3/6	294441.203	2320176.950	290.886	ON TOP PILLAR L/S NEAR SECURITY CHECK POST
7	GCP-B3/7	294334.481	2320002.109	293.073	ON TOP PILLAR R/S NEAR OFC STONE
8	GCP-B2/8	294273.090	2319798.824	291.701	ON TOP PILLAR L/S NEAR DIRECTION BOARD
9	GCP-B3/9	294173.568	2319646.488	289.582	ON TOP PILLAR R/S NEAR ELECTRIC POLE
TRAVERSE STATION COORDINATE (GCP'S) STATEMENT FOR LOOP-4					
1	GCP-B4/1	294039.891	2319271.355	285.474	ON TOP PILLAR L/S NEAR DIRECTION BOARD
2	GCP-B4/2	293917.504	2319065.824	283.850	ON TOP PILLAR R/S NEAR BUS STOP
3	GCP-B4/3	293867.750	2318898.718	283.724	ON TOP PILLAR L/S NEAR MACHINE ROOM
4	GCP-B4/4	293765.586	2318731.302	282.680	ON TOP PILLAR R/S NEAR DIRECTION BOARD
5	GCP-B4/5	293673.769	2318537.069	279.810	ON TOP PILLAR R/S NEAR DIRECTION BOARD
6	GCP-B4/6	293590.981	2318350.263	278.417	ON TOP PILLAR R/S NEAR CULVERT
7	GCP-B4/7	293503.152	2318198.640	279.833	ON TOP PILLAR R/S NEAR FENCING
8	GCP-B4/8	293420.382	2318004.347	278.502	ON TOP PILLAR R/S NEAR PIPE CULVERT
9	GCP-B4/9	293315.320	2317850.450	278.780	ON TOP PILLAR R/S NEAR RAILWAY LINE
10	GCP-B4/10	293216.963	2317647.420	279.026	ON TOP PILLAR R/S NEAR WELL
TRAVERSE STATION COORDINATE (GCP'S) STATEMENT FOR LOOP-5					
1	GCP-B5/1	293041.612	2317300.137	280.106	ON TOP PILLAR R/S NEAR HOARDING
2	GCP-B5/2	292951.432	2317105.214	281.107	ON TOP PILLAR R/S NEAR OPEN FOUNDATION
3	GCP-B5/3	292919.510	2316898.584	280.029	ON TOP PILLAR L/S NEAR BSNL OFC STONE
4	GCP-B5/4	292862.732	2316732.214	278.854	ON TOP PILLAR L/S NEAR ADITYA ENTERPRISES
5	GCP-B5/5	292774.053	2316525.590	277.851	ON TOP PILLAR R/S NEAR OFC STONE
6	GCP-B5/6	292740.079	2316331.253	276.371	ON TOP PILLAR L/S NEAR FENCING
7	GCP-B5/7	292640.415	2316160.704	275.082	ON TOP PILLAR R/S NEAR RB STONE
8	GCP-B5/8	292604.755	2315950.085	274.268	ON TOP PILLAR L/S NEAR SATYAM PLYWOOD AND HARDWARE
9	GCP-B5/9	292519.659	2315764.882	271.049	ON TOP PILLAR R/S

S.No.	GCPs ID	Easting	Northing	MSL	Remarks
					NEAR DIRECTION BOARD
10	GCP-B5/10	292490.583	2315544.031	268.553	ON TOP PILLAR L/S NEAR POLICE STATION BUTIBORI
11	GCP-B5/11	292452.677	2315442.922	267.592	ON TOP PILLAR L/S NEAR PARATE COMPLEX
TRAVERSE STATION COORDINATE (GCP'S) STATEMENT FOR LOOP-6					
1	GCP-B6/1	292363.044	2315438.006	266.543	ON TOP PILLAR L/S NEAR WATER VALVE
2	GCP-B6/2	292248.955	2315516.042	267.415	ON TOP PILLAR R/S NEAR EDP
3	GCP-B6/3	292101.943	2315475.539	267.145	ON TOP PILLAR L/S NEAR CITY CENTER BLOCK 2
4	GCP-B6/4	291874.202	2315482.575	266.646	ON TOP PILLAR L/S NEAR HP INDUSTRIAL LUBE INDUSTRIES
5	GCP-B6/5	291668.430	2315533.661	266.262	ON TOP PILLAR R/S NEAR IRA INTERNATIONAL SCHOOL
6	GCP-B6/6	291454.551	2315490.749	264.514	ON TOP PILLAR L/S NEAR TREE PLANTATION
7	GCP-B6/7	291238.620	2315507.986	266.004	ON TOP PILLAR L/S NEAR HOARDING
8	GCP-B6/8	291025.411	2315536.675	265.266	ON TOP PILLAR R/S NEAR WATER VALVE
9	GCP-B6/9	290791.515	2315521.096	264.992	ON TOP PILLAR L/S NEAR ELECTRIC POLE
10	GCP-B6/10	290577.768	2315524.388	267.584	ON TOP PILLAR L/S NEAR ELECTRIC POLE
11	GCP-B6/11	290324.520	2315529.235	269.291	ON TOP PILLAR L/S NEAR BRIDGE
12	GCP-B6/12	290079.259	2315558.654	264.549	ON TOP PILLAR R/S NEAR GUARD HOUSE
13	GCP-B6/13	289927.386	2315535.704	264.894	ON TOP PILLAR L/S NEAR OFC STONE
TRAVERSE STATION COORDINATE (GCP'S) STATEMENT FOR LOOP-7					
1	GCP-B7/1	289805.512	2315538.102	264.813	ON TOP PILLAR L/S NEAR DANDEKAR MACHINE WORKS
2	GCP-B7/2	289633.215	2315539.920	264.344	ON TOP PILLAR L/S NEAR PITAMBARA POLYMER INDUSTRIES
3	GCP-B7/3	289385.094	2315568.977	265.341	ON TOP PILLAR R/S NEAR LARSEN AND TOUBRO LTD.
4	GCP-B7/4	289207.900	2315576.282	269.445	ON TOP PILLAR R/S

S.No.	GCPs ID	Easting	Northing	MSL	Remarks
					NEAR SALASAR ALLOY AND STEEL IND.PVT.LTD
5	GCP-B7/5	289070.743	2315581.027	271.876	ON TOP PILLAR L/S NEAR SHILPA STEEL AND POWER LTD.
6	GCP-B7/6	288896.299	2315678.579	271.726	ON TOP PILLAR R/S NEAR TIMES OF INDIA
7	GCP-B7/7	288696.495	2315730.557	272.127	ON TOP PILLAR L/S NEAR KEC INTERNATIONAL LTD.
8	GCP-B7/8	288546.692	2315671.530	271.127	ON TOP PILLAR R/S NEAR GUARD ROOM
9	GCP-B7/9	288494.527	2315464.345	270.470	ON TOP PILLAR L/S NEAR KEC INTERNATIONAL LTD.
10	GCP-B7/10	288388.909	2315257.193	269.540	ON TOP PILLAR R/S NEAR SHRI.KANCHANVARNA HANUMAN TEMPLE
11	GCP-B7/11	288324.432	2315029.703	274.256	ON TOP PILLAR L/S NEAR TEXPRINT OVERSEAS LTD.

TABLE 5.14: LIST OF GPS CONTROL POINTS FOR CORRIDOR 2A – AUTOMOTIVE SQUARE TO KANHAN RIVER

S. No.	Rev Point ID	Easting	Northing	MSL (m)	Remarks
AUTOMOTIVE SQUARE TO BUDDH VIHAR					
1	GCP 12/1	304733.013	2343789.698	291.337	LHS INFRONT OF FARM LAND BELONGING TO SMT. LAXMI MEHTA
2	GCP 12/2	304853.457	2343936.718	291.723	LHS INFRONT OF FARM LAND BELONGING TO SMT. LAXMI MEHTA
3	GCP 12/3	304982.946	2344019.713	290.188	LHS INFRONT OF FARM LAND BELONGING TO SMT. LAXMI MEHTA
4	GCP 12/4	305080.162	2344129.477	289.240	LHS INFRONT OF FARM LAND BELONGING TO SMT. LAXMI MEHTA
5	GCP 12/5	305226.201	2344173.126	289.158	LHS INFRONT OF FARM LAND BELONGING TO SMT. LAXMI MEHTA
6	GCP 12/6	305419.712	2344298.846	290.033	LHS INFRONT OF

S. No.	Rev Point ID	Easting	Northing	MSL (m)	Remarks
					FARM LAND BELONGING TO SMT. LAXMI MEHTA
7	GCP 12/7	305532.252	2344342.357	291.695	LHS INFRONT OF FARM LAND BELONGING TO SMT. LAXMI MEHTA
8	GCP 12/8	305599.576	2344500.463	294.276	LHS INFRONT OF FARM LAND BELONGING TO SMT. LAXMI MEHTA
9	GCP 12/9	305708.026	2344544.523	293.399	LHS INFRONT OF FARM LAND BELONGING TO SMT. LAXMI MEHTA
10	GCP 12/10	305783.729	2344590.741	293.238	LHS INFRONT OF FARM LAND BELONGING TO SMT. LAXMI MEHTA
11	GCP 12/11	305936.519	2344719.407	291.594	LHS INFRONT OF FARM LAND BELONGING TO SMT. LAXMI MEHTA
12	GCP 12/12	306096.883	2344803.374	290.789	LHS INFRONT OF FARM LAND BELONGING TO SMT. LAXMI MEHTA
13	GCP 12/13	306187.752	2344886.928	290.427	LHS INFRONT OF FARM LAND BELONGING TO SMT. LAXMI MEHTA
14	GCP 12/14	306237.612	2344897.765	291.108	LHS INFRONT OF FARM LAND BELONGING TO SMT. LAXMI MEHTA
15	GCP 26/1	306342.9089	2345048.702	290.196	RHS, INFRONT OF GULAM TYRES
16	GCP 26/2	306365.9116	2345080.547	291.109	RHS INFRONT OF ABHA TRAVELS
17	GCP 26/3	306479.0783	2345187.455	292.881	LHS INFRONT OF MOHIT GUPTA HOUSE
18	GCP 26/4	306548.8415	2345291.879	293.474	RHS INFRONT OF ROYAL LAWN & HALL
19	GCP 26/5	306794.847	2345358.647	292.978	LHS INFRONT OF TULSI LAWN AREA
20	GCP 26/6	306963.2114	2345456.575	293.932	LHS NEAR CHAMDI

S. No.	Rev Point ID	Easting	Northing	MSL (m)	Remarks
					FACTORY ROAD JUCTION INFRONT OF LAMBA CELEBRATION
21	GCP 26/7	307158.1034	2345573.839	297.617	LHS INFRONT OF SHREE PUNJAB DHABA
22	GCP 26/8	307358.3499	2345735.218	298.489	RHS INFRONT OF GRACE TOYOTA SHOWROOM
23	GCP 26/9	307508.3709	2345813.079	298.657	LHS INFRONT OF SUMAN VIHAR BUS STOP
24	GCP 27/1	307816.5167	2345986.658	298.025	LHS INFRONT OF HARPAL SINGH PETROL PUMP
25	GCP 27/2	307984.9052	2346105.607	296.723	RHS INFRONT OF SURYALAL JAISWAL'S INDIAN OIL PETROL PUMP
26	GCP 27/3	308082.9049	2346165.292	296.064	RHS INFRONT OF UNNATI MOTORS SALES & SERVICE DEPARTMENT
27	GCP 27/4	308191.9066	2346192.179	294.284	RHS NEAR LAND OF SHRI. JIBHKATE
28	GCP 27/5	308245.3735	2346214.236	294.925	RHS INFRONT OF LAND OF SHRI. ANIL & SUNIL BUTANI
29	GCP 27/6	308348.3861	2346305.211	294.642	LHS INFRONT OF LAND OF M.K.H.S.
30	GCP 27/7	308567.6355	2346407.948	293.446	RHS NEAR FAUJI BAR & RESTAURANT
31	GCP 27/8	308784.3809	2346553.467	291.483	LHS NEAR K.K. CONSTRUCTION LAND
32	GCP 27/9	308987.3983	2346643.831	290.190	RHS NEAR NAGLOK BOUDHA VIHAR
33	GCP 28/1	309374.3881	2346855.158	288.384	RHS NEAR WCL CONTRACTOR MANKAR COMPOUND WALL
34	GCP 28/2	309638.2572	2347014.604	284.487	LHS NEAR THE RAJ

S. No.	Rev Point ID	Easting	Northing	MSL (m)	Remarks
					ROYAL LAWN
35	GCP 28/3	309859.5818	2347099.764	284.374	RHS NEAR OPEN LAND OF SANT NIRANKARI SATSANG BHAVAN
36	GCP 28/4	310085.7181	2347250.118	284.198	LHS SIDE INFRONT OF GAUTE RICE MILL LAND
37	GCP 28/5	310297.1527	2347353.511	286.622	RHS SIDE INFRONT OF OPEN LAND OF RAJENDRA GUPTA
38	GCP 28/6	310463.8745	2347453.308	286.110	LHS SIDE INFRONT OF MANAKCHAND PRABHUDAN CHARITABLE TRUST
39	GCP 28/7	310706.5043	2347491.318	287.335	RHS SIDE INFRONT OF RAKSHA MANGLYA AWAS, LEKHA NAGAR
40	GCP 28/8	310874.9888	2347544.904	287.237	LHS 82 M AHEAD OF TALATHI KARYALAY YERKHEDA TOWARDS KAMPTEE
41	GCP 28/9	311071.6407	2347570.531	282.819	RHS INFRONT OF KALPATARU COLONY
42	GCP 28/10	311357.9104	2347631.09	281.122	LHS INFRONT OF KALPATARU COLONY
43	GCP 28/11	311469.4326	2347641.802	281.081	RHS INFRONT OF KALPATARU COLONY NEAR NALLAH
44	GCP 29/1	311749.1729	2347753.02	283.040	RHS INFRONT OF CHRISTIAN CHURCH
45	GCP 29/2	311869.0979	2347816.232	281.292	RHS NEAR GARUD CHOWK
46	GCP 29/3	311918.8842	2347806.864	281.177	RHS NEAR GARUD CHOWK
47	GCP 29/4	311983.434	2347717.812	281.744	RHS NEAR CHUNGI NAKA SHED
48	GCP 29/5	312045.0771	2347563.313	282.256	LHS INFRONT OF LAHORI DHABA
49	GCP 29/6	312109.0085	2347376.417	281.993	LHS INFRONT OF VAISHNAVI KIRANA SHOP

S. No.	Rev Point ID	Easting	Northing	MSL (m)	Remarks
50	GCP 29/7	312289.6923	2347181.081	285.184	LHS INFRONT OF HOUSE OF BADULLA MOHAMMAD SALIM
51	GCP 29/8	312373.9494	2347046.409	286.048	RHS SIDE NEAR BALAJI COMPLEX
52	GCP 29/9	312503.9777	2346920.439	287.208	LHS INFRONT OF STATUE OF JAWAHARLAL NEHRU
53	GCP 29/10	312543.903	2346840.441	287.639	RHS NEAR KAMAL SCOOTERS REPAIR SHOP
54	GCP-30/1	312894.684	2346815.172	287.319	LHS INFRONT OF RAJESH PAN SHOP
55	GCP-30/2	313054.967	2346804.217	286.163	RHS INFRONT OF NAGAR PRISHAD OFFICE KAMTEE
56	GCP-30/3	313268.980	2346848.341	285.221	LHS INFRONT OF HOUSE OF BHIMRAO BABNKULE HOUSE
57	GCP-30/4	313511.869	2346852.307	284.031	RHS NEAR RAILWAY LINE OPEN LAND
58	GCP-30/5	313745.475	2346955.125	279.517	LHS INFRONT OF KRUSHNA DHUPAL HOUSE NEAR TO TRAFFIC SIGNAL POLE
59	GCP-30/6	313909.616	2347005.619	280.043	RHS NEAR RAILWAY LINE OPEN LAND
60	GCP-30/7	313986.765	2347161.291	279.282	LHS INFRONT OF RESIDENTIAL AREA OF KAMPTEE
BUDDH VIHAR TO KANHAN RIVER					
1	GCP30/6	313909.616	2347005.619	280.043	ON TOP OF PILLAR R/S NEAR SHED
2	GCP30/6A	313923.498	2347012.579	280.113	ON TOP OF PILLAR R/S INFRONT OF HOUSE
3	GCP30/7A	313988.204	2347163.575	279.366	ON TOP OF PILLAR L/S INFRONT OF SUBHAS CHAKRAVATI HOUSE
4	GCP31/1	314136.521	2347331.714	278.963	ON TOP OF PILLAR R/S NEAR SHIV TEMPLE
5	GCP31/2	314259.942	2347524.283	279.939	ON TOP OF PILLAR L/S

S. No.	Rev Point ID	Easting	Northing	MSL (m)	Remarks
					NEAR NAKA
6	GCP31/3	314419.607	2347676.847	279.490	ON TOP OF PILLAR L/S NEAR CANTONMENT AREA
7	GCP31/4	314613.190	2347638.575	278.327	ON TOP OF PILLAR R/S NEAR CULVERT
8	GCP31/5	314824.827	2347683.142	278.816	ON TOP OF PILLAR L/S NEAR SAMAJIK VANIKARAN VIBHAG
9	GCP31/6	315025.529	2347641.849	278.797	ON TOP OF PILLAR R/S NEAR 414 ASC BN MARKETING
10	GCP31/7	315197.825	2347669.328	279.037	ON TOP OF PILLAR L/S NEAR CULVERT
11	GCP31/8	315365.713	2347670.817	278.903	ON TOP OF PILLAR R/S NEAR CANTONMENT AREA
12	GCP31/9	315576.822	2347759.788	278.790	ON TOP OF PILLAR L/S NEAR CANTONMENT AREA
13	GCP-32/1	315773.305	2347847.447	278.906	ON TOP OF PILLAR R/S NEAR SAGWAN TREE PLANTATION
14	GCP-32/2	315890.900	2347925.848	276.857	ON TOP OF PILLAR R/S NEAR SAGWAN TREE PLANTATION

TABLE 5.15: LIST OF GCP'S CONTROL POINTS FOR CORRIDOR 3A – LOKMANYA NAGAR TO HINGNA

S. No.	Rev Point ID	Easting	Northing	MSL (m)	Remarks
LOKMANYA NAGAR TO MAHATAMA GANDHI COLLEGE					
1	GCP 18/1	292261.758	2335581.502	315.409	LEFT SIDE NEAR RAJ TAILORS
2	GCP 18/2	292216.344	2335577.046	315.659	RIGHT SIDE IN BETWEEN SERVICE ROAD AND HIGNA ROAD INFRONT OF V.I.P. INDUSTRIES
3	GCP 18/3	292136.654	2335503.172	316.011	LEFT SIDE IN FRONT OF SCHOOL OF MANTHAN MEDICOSE

S. No.	Rev Point ID	Easting	Northing	MSL (m)	Remarks
4	GCP 18/4	292019.711	2335453.156	316.137	RIGHT SIDE IN BETWEEN SERVICE ROAD AND HIGNA ROAD INFRONT OF MICON WIRES
5	GCP 18/5	291909.511	2335356.213	317.893	LEFT SIDE ON HIGNA ROAD INFRONT OF GAYATRI PLAZA
6	GCP 18/6	291744.956	2335277.260	315.041	RIGHT SIDE IN BETWEEN SERVICE ROAD AND HIGNA ROAD INFRONT OF INDIAN BUREAU OF MINES
7	GCP 18/7	291632.247	2335149.568	314.411	LEFT SIDE ON HIGNA ROAD INFRONT OF SHREE RAM STEEL FURNITURE
8	GCP 18/8	291469.620	2335059.837	316.674	RIGHT SIDE IN BETWEEN SERVICE ROAD AND HIGNA ROAD INFRONT OF PRIYADARSHANI J.L. COLLEGE OF PHARMACY
9	GCP 18/9	291314.226	2334962.244	318.962	RIGHT SIDE IN BETWEEN SERVICE ROAD AND HIGNA ROAD INFRONT OF SHRI UDYOG
10	GCP 18/10	291165.138	2334842.421	314.469	LEFT SIDE ON HIGNA ROAD INFRONT OF GUPTA TRADERS
11	GCP 18/11	290999.430	2334760.627	313.533	RIGHT SIDE IN BETWEEN CEMENT ROAD AND HIGNA ROAD INFRONT OF HANUMAN TEMPLE
12	GCP 18/12	290849.966	2334665.884	315.302	RIGHT SIDE ON HIGNA ROAD INFRONT OF SHRI. BALAJI AGROTECH

S. No.	Rev Point ID	Easting	Northing	MSL (m)	Remarks
13	GCP 18/13	290694.708	2334565.224	314.797	RIGHT SIDE ON HIGNA ROAD INFRONT OF SHOP OF VERMA
14	GCP 18/14	290530.938	2334438.801	313.687	LEFT SIDE INFRONT OF OPEN PLOT INDRAJIT SINGH
15	GCP 18/15	290356.917	2334358.456	312.921	RIGHT SIDE ON HIGNA ROAD INFRONT OF LAND OF ABHIJIT POWER PLANT
16	GCP 18/16	290166.853	2334213.994	312.989	LEFT SIDE INFRONT OF TOWER TESTING STATION RICHARDSON AND KUDAS LTD.
17	GCP 18/17	289947.056	2334160.179	312.283	RIGHT SIDE INFRONT OF PIONEER WOODS
18	GCP 18/18	289841.172	2334095.956	314.314	LEFT SIDE IN FRONT C/W OF SCHOOL OF SCHOLARS MAHATMA GANDHI HIGH SCHOOL & COLLEGE WANADONGRI & TOOL BOOTH
MAHATMA GANDHI COLLEGE TO HINGNA					
1	GCP-19/1	289545.554	2333919.868	313.577	On top of pillar R/S infront of patanjali store
2	GCP-19/2	289523.894	2333720.540	305.749	On top of pillar R/S infront of patanjali store
3	GCP-19/3	289452.921	2333544.384	302.522	On top of pillar R/S infront of patanjali store
4	GCP-19/4	289418.530	2333332.201	302.798	On top of pillar R/S infront of patanjali store
5	GCP-19/5	289341.619	2333121.820	300.329	On top of pillar R/S infront of patanjali store

S. No.	Rev Point ID	Easting	Northing	MSL (m)	Remarks
6	GCP-19/6	289304.500	2332906.209	299.102	On top of pillar L/S infront of shiv mandir
7	GCP-19/7	289233.053	2332734.707	298.678	On top of pillar R/S near nana godbole house
8	GCP-19/8	289213.715	2332557.559	296.430	On top of pillar L/S near culvert
9	GCP-20/1	289116.710	2332366.501	295.797	On top of pillar L/S near land of shri. bhagat
10	GCP-20/2	288986.030	2332281.465	295.762	On top of pillar R/S near bridge
11	GCP-20/3	288909.330	2332148.507	297.645	On top of pillar R/S near jilha parishad prathamik school
12	GCP-20/4	288936.614	2331978.891	296.395	On top of pillar R/S infront of laxmi anaz bhandar
13	GCP-20/5	289008.296	2331848.650	294.720	On top of pillar L/S near open land of dilip bang
14	GCP-20/6	288929.518	2331715.309	296.088	On top of pillar R/S near venna river bridge
15	GCP-20/7	288808.920	2331506.695	294.675	On top of pillar L/S infront of mukesh ambore shop
16	GCP-20/8	288694.144	2331455.045	293.856	On top of pillar L/S near statue of shivaji maharaj
17	GCP-20/9	288483.630	2331551.267	296.090	On top of pillar R/S near dahi wase house
18	GCP-20/10	288256.020	2331582.282	297.264	On top of pillar L/S infront of open land
19	GCP-20/11	288059.259	2331616.508	298.835	On top of pillar L/S near open land of chandpukar
20	GCP-20/12	287871.923	2331681.489	300.415	On top of pillar R/S near sitabai niwal house
21	GCP-20/13	287671.162	2331702.428	302.431	On top of pillar L/S infront of

S. No.	Rev Point ID	Easting	Northing	MSL (m)	Remarks
					madhukar chamate houe
22	GCP-20/14	287534.151	2331732.292	303.443	On top of pillar L/S infront of sanjay zile house

TABLE 5.16: LIST OF GCP'S CONTROL POINTS FOR CORRIDOR 3 – VASUDEV NAGAR TO DATTAWADI

S.No.	Point ID	Easting	Northing	MSL (m)	Remarks
1	GCP 20/1	293712.525	2336746.707	333.376	RIGHT SIDE INFRONT OF MAHANAND MILK
2	GCP 20/2	293609.550	2336862.003	335.084	LEFT SIDE INFRONT OF GUJARAT CO-OPRATIVE MILK
3	GCP 20/3	293527.708	2337064.394	336.092	RIGHT SIDE INFRONT OF FOREST AREA COMPOUND WALL
4	GCP 20/4	293435.861	2337223.143	336.031	RIGHT SIDE INFRONT OF COCA COLA FACTORY COMPOUND WALL
5	GCP 20/5	293285.214	2337328.256	337.007	RIGHT SIDE INFRONT OF SHIRISH PLASTIC & INDUSRIES COMPOUND WALL
6	GCP 20/6	293102.439	2337416.296	336.576	LEFT SIDE INFRONT OF MIDC BSNL TELEPHONE EXCHANGE COMPOUND WALL
7	GCP 20/7	292974.382	2337524.512	336.454	RIGHT SIDE INFRONT OF FIRTH INDIA STEEL CO.LTD.
8	GCP 20/8	292805.256	2337616.710	338.034	LEFT SIDE INFRONT OF FACOR STEEL LIMITED COMPOUND WALL
9	GCP 20/9	292793.344	2337804.803	337.978	RIGHT SIDE INFRONT OF FIRTH INDIA STEEL CO.LTD.
10	GCP 20/10	292750.623	2337991.292	338.552	LEFT SIDE INFRONT OF ANAND JCB
11	GCP 20/11	292749.500	2338184.920	342.174	RIGHT SIDE INFRONT

S.No.	Point ID	Easting	Northing	MSL (m)	Remarks
					OF MAHINDRA SHOW ROOM.
12	GCP 20/12	292701.776	2338418.161	346.986	LEFT SIDE NEAR SHREEYA CONVERSATION
13	GCP 20/13	292710.589	2338565.704	346.494	RIGHT SIDE NEAR S.K. ENGINEERING
14	GCP 20/14	292687.189	2338680.807	344.711	LEFT SIDE NEAR OPEN PLOT
15	GCP 21/1	292701.207	2338920.705	344.645	RIGHT SIDE NEAR NAGPUR CEMENT PRODUCT LTD.
16	GCP 21/2	292674.318	2339136.963	343.159	LEFT SIDE NEAR MAHINDRA PROVINCIAL AUTOMOBIES
17	GCP 21/3	292691.490	2339302.918	343.236	RIGHT SIDE NEAR RMC. REDIMIX INDIA LTD.
18	GCP 21/4	292665.888	2339486.351	345.617	LEFT SIDE NEAR FORCE MOTORS.
19	GCP 21/5	292681.547	2339651.699	344.962	RIGHT SIDE NEAR DOZCO LTD.
20	GCP 21/6	292654.591	2339857.588	341.768	LEFT SIDE NEAR R.C. PLASTO TANKS PIPES PVT.LTD.
21	GCP 21/7	292674.803	2340036.933	342.533	RIGHT SIDE NEAR RUMEN EMUSIFERS

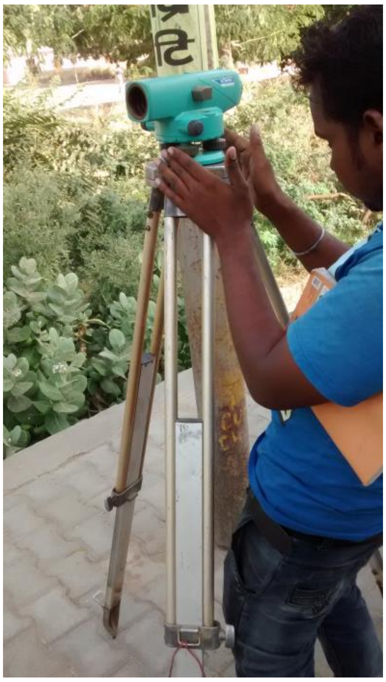
TABLE 5.17: LIST OF GCP'S CONTROL POINTS FOR CORRIDOR 4A – PRAJAPATI NAGAR TO TRANSPORT NAGAR

S. No.	Point ID	Easting	Northing	MSL (m)	
PRAJAPATI NAGAR TO TRANSPORT NAGAR					
1	GCP 23/1	307953.180	2340004.087	286.760	ON LHS, IN FRONT OF SHIV KRUPA APPARTMENT
2	GCP 23/2	308126.701	2339948.167	286.312	ON RHS, IN FRONT OF ASHTA HOSPITAL
3	GCP 23/3	308341.318	2339912.743	287.401	ON LHS, IN FRONT OF MAA GANESH TRADERS NEAR BRIDGE
4	GCP 23/4	308528.303	2339844.961	286.817	ON RHS, IN FRONT OF

S. No.	Point ID	Easting	Northing	MSL (m)	
					LAND OF BABA KALANDARDARSHI AFTER THE BRIDGE
5	GCP 23/5	308676.377	2339812.585	286.192	ON RHS, IN FRONT OF CHOICE CHICKEN CENTER
6	GCP 23/6	308831.020	2339829.462	288.290	ON LHS, NEAR UMESH DIGITAL PHOTO STUDIO
7	GCP 23/7	308941.933	2339798.446	290.013	ON RHS, IN FRONT OF JANAVI MOBILE SHOP
8	GCP 23/8	309179.165	2339811.237	291.387	ON LHS, IN FRONT OF VIPUL EICHER, MAZDA REPAIRING SHOP
9	GCP 23/9	309427.174	2339782.044	292.186	ON LHS, NEAR BHAGWATI ROAD LINES
10	GCP 23/10	309586.570	2339637.925	291.124	ON RHS, IN FRONT OF MR. RAJESH MENANI
11	GCP 24/1	309778.588	2339443.259	293.413	ON RHS NEAR MSETCL PARDI SUB STATION
12	GCP 24/2	309937.646	2339336.289	291.398	ON RHS NEAR N.M.C CHUNGI NAKA NO.5
13	GCP 24/3	310184.470	2339289.460	288.331	ON LHS IN FRONT OF PARMATMA MOBILE SHOPEE
14	GCP 24/4	310437.730	2339184.090	286.481	ON RHS NEAR MAHINDRA FIRST CHOICE
15	GCP 24/5	310758.773	2339100.070	287.076	ON RHS NEAR SEET BAR
16	GCP 24/6	310948.594	2339088.469	287.778	ON LHS NEAR PRO LOGISTICS PVT.LTD.
17	GCP 24/7	311201.494	2338992.779	285.808	ON RHS IN FRONT OF GUPTA DOMESTIC FUELS(N) LTD.
18	GCP 24/8	311349.989	2338985.051	286.345	ON LHS NEAR SHIV WEIGH BRIDGE
TRANSPORT NAGAR TO ASOLI VILLAGE					
1	GCP-25/1	311769.062	2338834.305	283.864	ON TOP OF PILLAR R/S NEAR KHANTE

S. No.	Point ID	Easting	Northing	MSL (m)	
					BHAWAN
2	GCP-25/2	311939.770	2338785.749	281.830	ON TOP OF PILLAR R/S NEAR CULVERT
3	GCP-25/3	312145.800	2338743.802	283.405	ON TOP OF PILLAR R/S NEAR HOUSE
4	GCP-25/4	312359.930	2338751.126	283.474	ON TOP OF PILLAR R/S NEAR CULVERT
5	GCP-25/5	312565.591	2338767.714	283.626	ON TOP OF PILLAR R/S INFRONT OF GODOWN
6	GCP-25/6	312731.770	2338784.120	282.134	ON TOP OF PILLAR R/S NEAR CULVERT
7	GCP-25/7	312962.329	2338807.894	281.061	ON TOP OF PILLAR R/S NEAR HALDIRAM FOODS INTERNATIONAL PVT.LTD.
8	GCP-25/8	313173.088	2338829.951	280.765	ON TOP OF PILLAR R/S NEAR LAND OF NILESH NAKADE

5.1.2.4. Establishment of Vertical Control



Establishment of vertical control was started from a known benchmark of Phase-1. From this location bench mark was transferred along the both corridor using three stadia method of leveling with Auto levels. Every loops of level have been closed and closing error of leveling loops has been worked with the formula given below:

$\sum$ BS - $\sum$ FS = $\sum$ RISE - $\sum$Fall = Last R.L – First R.L.

Closing error within permissible limit has been adjusted. Permissible error in leveling is 6√K mm where K is length of the loop in Km. The Leveling was carried out by a precision auto level with accuracy of ±6√K. Reduced levels of all traverse stations and permanent control points were taken by Double territory method. Bench mark has been established at interval of 500m along the corridor or as per instruction of site in- charge. Details of benchmarks are given in **Table 5.18, Table 5.19, Table 5.20, Table 5.21 & Table 5.22.**

Table for GCPs and Temporary Bench Marks (TBMs) of Ph-2 Extentions are same.

TABLE 5.18: LIST OF TEMPORARY BENCHMARKS OF CORRIDOR 1A – MIHAN TO MIDC ESR

S. No.	Point ID	Easting	Northing	MSL (m)	Description
1	TBM-A1	295620.101	2322707.788	295.454	ON TOP OF CD WORK R/S NEAR FIROJA AJID KHAN HOUSE
2	TBM-A1	295342.98	2322250.444	298.361	ON TOP OF CD WORK R/S TOWARDS WARSHADHARA ROAD
3	TBM-A3	295066.908	2321653.955	295.06	ON TOP OF CD WORK R/S NEAR OLD TOLL NAKA
4	TBM-2	294874.536	2321096.914	295.144	ON TOP ROAD BOUNDARY STONE L/S NEAR KM STONE HYDERABAD 465
5	TBM_11	291528.003	2315491.872	264.954	ON TOP OF PARAPET WALL OF MAJOR BRIDGE L/S
6	TBM_12	290886.513	2315538.235	264.916	ON TOP OF CD WORK R/S AT CHAINAGE 11772

TABLE 5.19: LIST OF TEMPORARY BENCHMARKS OF CORRIDOR 2A – AUTOMOTIVE SQUARE TO KANHAN RIVER

S. No.	Point ID	Easting	Northing	MSL (m)	Description
1	TBM_EX_P_27	304767.387	2343815.768	292.003	RHS ON TOP OF RETAINING WALL OF SHARDA WEIGHT BRIDGE
2	TBM_EX_P_28	305037.275	2344109.249	290.434	LHS ON COMPOUND WALL PLINTH OF JAIKA MOTORS
3	TBM_EX_P_29	305390.696	2344266.248	290.065	RHS ON TOP OF PIOLI RIVER BRIDGE
4	TBM_EX_P_30	305926.598	2344687.639	292.612	RHS ON TOP OF TREE OTTA
5	TBM_EX_P_31	306275.291	2344924.108	291.224	RHS ON TOP NALLA BRIDGE TOP
6	TBM_EX_P_32	306509.982	2345284.796	294.229	LHS ON OTTA OF CASINO BAR
7	TBM_EX_P_33	306848.387	2345368.239	293.447	RHS ON TOP OF PARAPET WALL OF THE JASHAN LAWN
8	TBM_EX_P_34	307053.602	2345536.151	296.551	LHS ON TOP OF RETAINING WALL KINGS HAVELI SUPER BAZAR
9	TBM_EX_P_35	307334.716	2345720.776	298.561	LHS ON TOP OF TELEPHONE MANHOLE
10	TBM_EX_P_36	307874.711	2346008.04	297.824	LHS ON TOP OF COMPOUND WALL PLINTH OF J.P. COLLEGE
11	TBM_EX_P_37	307957.671	2346095.81	297.223	RHS ON ON OTTA OF ELECTRIC POLE NEAR SAMEER SRUSHTI DHABA
12	TBM_EX_P_38	308169.785	2346161.245	294.528	RHS ON TOP OF CANAL NEAR UNNATI MOTORS
13	TBM_EX_P_39	308466.973	2346385.918	294.312	LHS ON TOP OF CULVERT NEAR

S. No.	Point ID	Easting	Northing	MSL (m)	Description
					INDIAN OIL PETROL PUMP
14	TBM_EX_P_40	308695.569	2346514.228	292.582	LHS ON TOP OF RETAINING WALL NEAR SHAGUN LAWN & HALL
15	TBM_EX_P_41	309032.869	2346696.629	290.155	LHS ON TOP OF CULVERT NEAR H.P. PETROL PUMP
16	TBM_EX_P_42	309249.191	2346793.227	289.457	RHS ON TOP OF CULVERT NEAR LAND OF SALIK BHAI WALLI
17	TBM_EX_P_43	309608.2	2346964.411	285.315	RHS ON TOP OF CULVERT NEAR INDIAN OIL PETROL PUMP
18	TBM EX_P_44	309941.232	2347149.193	284.633	RHS ON TOP OF BRIDGE NEAR OPEN LAND OF SANT NIRANKARI SATSANG BHAVAN
19	TBM_EX_P_45	310552.35	2347471.06	286.414	LHS ON TOP OF CULVERT NEAR OPEN LAND OF SUNIL AGRAWAL
20	TBM_EX_P_46	311486.741	2347645.193	281.816	RHS ON TOP OF CULVERT NEAR KALPATARU COLONY
21	TBM_EX_P_47	311866.536	2347817.196	281.575	LHS ON TOP OF MEDIAN NEAR GARUDA CHOWK
22	TBM_EX_P_48	311999.999	2347663.243	282.637	RHS ON TOP OF CULVERT NEAR H/O OF DHANRAJ YADAV
23	TBM_EX_P_49	312189.972	2347275.746	282.496	LHS ON TOP OF SHOP PLINTH OF ROYAL S.S. WORKS NEAR METHODIST CURCH
24	TBM_EX_P_50	312337.251	2347107.361	286.236	ON CENTERAL MEDIAN NEAR JAI AMBE WINE SHOP AT KAMPTEE
25	TBM_EX_P_51	312434.245	2347005.931	286.452	ON SIGNAL POLE PLINTH NEAR POLICE BOOTH AT KALMANA ROAD JUNCTION
26	TBM_EX_P_52	312960.15	2346795.755	287.343	RHS SIDE ON COMPOUND WALL PLINTH OF M.S. KUNTI PETROL PUMP
27	TBM_EX_P_53	313438.182	2346836.722	284.571	RHS SIDE PLINTH TOP OF VISHAKA KIRANA STORE
28	TBM_EX_P_54	313668.679	2346958.185	280.582	LHS SIDE ON WELL NEAR BALVANT BAHADURE HOUSE
29	TBM_EX_P_55	313960.082	2347070.433	280.226	RHS SIDE COMPOUND WALL PLINTH OF DHAMMADEEP SANGH BUDDHA VIHAR
30	TBM-EX_P_56	314435.697	2347599.585	280.431	ON TOP OF MATA TEMPLE OTTA
31	TBM_EX_P_57	315098.703	2347676.437	279.959	ON PILLAR L/S WALL COMPOUND
32	TBM_EX_P_58	315627.009	2347801.950	279.051	ON TOP OF CD WORK NEAR SAI BABA TEMPLE

TABLE 5.20: LIST OF TEMPORARY BENCHMARKS OF CORRIDOR 3A – LOKMANYA NAGAR TO HNGNA

S. No.	Point Id	Easting	Northing	Msl (m)	Description
1	TBM_EXP_12	291955.743	2335426.959	316.445	ON FOUNDATION OF STREET LIGHT ON RHS
2	TBM_EXP_13	291625.427	2335206.267	313.244	ON TOP OF CULVERT ON RHS
5	TBM_EXP_14	291334.954	2335006.427	319.011	ON TOP OF WATER VALVE CHAMBER ON RHS NEAR MIDC ROAD
6	TBM_EXP_15	291171.507	2334900.7	314.812	ON PLINTH OF COMPOUND WALL ON RHS IN FRONT OF RADHS BIHARI AGENCY
7	TBM_EXP_16	290936.878	2334732.992	313.862	ON PLINTH OF STRUCTURE ON RHS ON KAMNAPURE HIGH SCHOOL
8	TBM_EXP_17	290588.027	2334500.756	314.171	ON TOP OF WATER PIPE LINE ON RHS IN FRONT OF NILKAMAL APT.
9	TBM_EXP_18	290279.241	2334308.506	311.820	ON TOP OF WATER PIPE LINE ON RHS NEAR ABHIJIT PLANT
10	TBM_EXP_19	289941.042	2334157.557	312.632	ON TOP OF CULVERT ON RHS NEAR WANADONGRI ROAD
11	TBM-1	287629.659	2331735.173	302.943	Near shop of bhope

TABLE 5.21: LIST OF TEMPORARY BENCHMARKS OF CORRIDOR 4A – PRAJAPATI NAGAR TO TRANSPORT NAGAR

S. No.	Point ID	Easting	Northing	MSL (m)	Description
1	TBM_EX_P_20	308056.698	2339992.973	287.108	ON PLINTH OF COMPOUND WALL ON LHS
2	TBM_EX_P_21	308633.866	2339832.285	286.677	ON PLINTH OF STREET LIGHT ON LHS
5	TBM_EX_P_22	309281.829	2339805.305	292.919	ON TOP OF TREE OTTA ON LHS
6	TBM_EX_P_23	309881.063	2339384.779	293.250	ON PLINTH OF STREET LIGHT ON CENTRAL MEDIAN IN FRONT OF MITTAL CEMENT
7	TBM_EX_P 24	310122.318	2339319.586	289.306	ON TOP OF RETAINING WALL ON LHS
8	TBM_EX_P 25	310505.147	2339207.44	286.811	ON LHS ON TOP OF PATHWAY ON NALLA
9	TBM_EX_P 26	311060.055	2339058.828	286.609	ON LHS ON TOP OF CULVERT NEAR BARADWARI ROAD
10	TBM_EX_P 27	311993.366	2338825.453	-	ON TOP OF STRUCTURE ON LHS TOWARDS KAPSI ROAD
11	TBM_EX_P 28	312357.919	2338747.528	-	ON LHS ON TOP OF CULVERT NEAR TR. NAGAR ROAD
12	TBM_1	312711.858	2338782.455	283.161	ON TOP OF CULVERT R/S

TABLE 5.22: LIST OF TEMPORARY BENCHMARKS OF CORRIDOR 5 – VASUDEV NAGAR TO DATTAWADI

S. No.	Point ID	Easting	Northing	MSL (m)	Description
1	TBM_EXP_1	293659.567	2336797.066	334.949	ON MEDIAN AT BOTTOM OF 4/000 KM STONE
2	TBM_EXP_2	293474.989	2337139.679	336.223	ON MEDIAN AT TOP OF 3/600 METER STONE
5	TBM_EXP_3	293203.678	2337350.862	337.406	ON LHS ON TOP OF CULVERT NEAR SANVIJAY INDUSTRIES
6	TBM_EXP_4	292931.148	2337547.957	336.971	RIGHT SIDE ON TOP OF CULVERT
7	TBM_EXP_5	292801.426	2337711.537	338.210	ON TOP OF OFC STONE IN FRONT OF FACOR STEEL LIMITED
8	TBM_EXP_6	292779.783	2337908.829	338.300	RIGHT SIDE ON TOP OF CULVERT IN FRONT OF SEVA AUTOMOBILE
9	TBM_EXP_7	292746.114	2338212.139	342.774	RIGHT SIDE ON TOP OF CULVERT NEAR DAS WELT AUTO
10	TBM_EXP_8	292678.412	2338970.483	344.671	LEFT SIDE ON TOP OF CULVERT IN NEAR GMMCO LTD
11	TBM_EXP_9	292690.79	2339326.708	343.424	RIGHT SIDE ON TOP OF CULVERT NEAR RMC REDIMIX
12	TBM_EXP_10	292679.647	2339718.422	344.008	RIGHT SIDE ON TOP OF CULVERT NEAR THE INDIA THERMIT CARD LTD
13	TBM_EXP_11	292677.051	2340023.342	343.083	RIGHT SIDE ON TOP OF COMPOUND WALL RUMEN EMULSIFIERS

5.1.3. Detailed Survey of the Corridor

Based on Easting & Northing co-ordinates arrived by the traversing and Elevation by Precise Leveling, Detail survey was carried out along the proposed metro route for 100m wide corridor (50m either side of the centre line of the road) or upto Built line in charge using total stations of desired accuracy. At some places instrument having reflector-less facilities have been used for collecting details of features due to inaccessibility of the area.

Survey covered road/rail track showing important structures all the bye lanes, footpaths, dividers/central verges, roads, railway tracks, trees, manholes and other structures, drains, Storm water drains, H.T., L.T., Transmission lines, bridges, ROBs / RUBs / FOBs with type and spans, ponds, HFL and bed level of streams/drains, level crossing with their type, traction masts, signal posts, etc. Spot/ Ground levels were taken at 25 m intervals in longitudinal as well as traverse direction and at sudden change of levels.

Location of approach roads, main roads, lanes showing road/lane name, carriageway, footpaths, central verge, drains and the widths of all the main and approach roads and at locations where there is a sudden change in widths of roads were measured physically and marked on the drawings.

Details of Railway tracks along the proposed alignment including take off points, FOBs, transitions, crossings, switches and other details including electrical structures with their distances were taken.

Details of Religious structures such as temples, Gurudwaras, Mosques, Churches, monuments, tombs etc., clearly marking the Metro boundary all along the corridor and giving cross reference of these structures with reference to Metro boundary were taken.

5.1.3.1. Preparation of Drawings

Drawings were prepared in Auto CAD format in 1: 1000 scale as per project requirement showing all the manmade and natural features. Different features are shown in different layers. Attributes of all the features like name of the road its width, name of railway line, name of the building and its number of stories, width of drains and its HFL, Type of overhead crossings (Electric and Telephone lines) and its rating have been provided in these drawings.

Details of all the religious structure such as Temple Gurudwara, Church, Monuments, Tomb, etc have been shown in the drawing as per standard legend.

Spot levels have been shown in drawing to access the terrain of the area along with trees falling in said survey corridor of 100m. Control points, established during conducting the survey work, have been also shown in the drawings.

5.1.3.2. Site Verification of Features

Details of features shown in the drawings were verified at site and additional details were collected and incorporated in the drawing wherever needed.

5.1.4. Alignment Description

5.1.4.1. Corridor-1A: MIHAN to MIDC ESR

a. Alignment Description

The proposed alignment of Corridor-1A is extension of Reach 1 of Phase 1 and starts from Chainage 20200m before ECO Park Station and terminates near MIDC ESR at

Chainage 38852m. The total length of the corridor is about 18.768 Km, out of which 1.25 Km is at-grade (upto Ch. 21450m) and 17.518m elevated.

Total 10 stations (2 At-grade & 8 elevated) are proposed in this corridor, starting from ECO Park Station (Ch: 20462m) and terminating at MIDC ESR Station (Ch: 38352m)

The corridor is ummarized as under in **Table 5.23.**

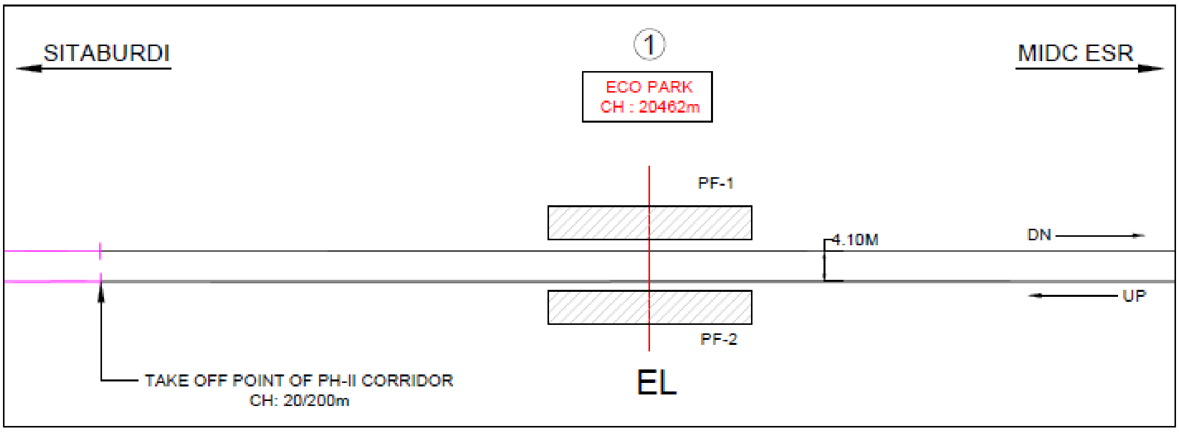
TABLE 5.23: ALIGNMENT DESCRIPTION OF CORRIDOR-1A

Description	Station	Chainage (m)	Intermediate Distance (m)
Start Point		20200	--
Stations	ECO Park (At-grade)	20462	262
	Metro City (At-grade)	21058	596
	Ashokvan	23843	2593
	Dongargaon	26693	2850
	Mohgaon	29878	3185
	Meghdoot CIDCO	32802	2924
	Butibori Police Station	33540	738
	MHADA Colony	34233	693
	MIDC KEC	37360	3127
	MIDC ESR	38352	992
Terminal Point		38852	500
Additional length for stabling entry/exits			116
Total		18768	

b. Take off Point

The alignment for Corridor 1A starts from Chainage 20200m and take off from Reach 1 of Phase 1 beyond ECO Park station as shown in the **Figure 5.10.**

FIGURE 5.10: TAKE OFF POINT FOR CORRIDOR-1A



c. **Reference Point**

For the planning convenience, the chainages are in continuation with Phase -1 North-South corridors.

d. **Starting / Terminal stations of Corridor-1A**

i) **ECO Park (North side terminal station)**

The north side station on the extension of Metro Phase-1 corridor is Eco Park Metro Station. The station is proposed elevated and rail level has been generally kept 14.5m above the ground level.

ii) **MIDC ESR Metro Station (South side terminal station)**

The south side station on the extension of Metro Phase-1 corridor is Transport Nagar Metro Station. The station is proposed elevated and rail level has been generally kept 14.5m above the ground level. It will serve the nearby localities of Wateghat, TakalghatTembhari areas.

Reversal/stabling facility has also been planned at Metro city station and beyond MIDC ESR Metro station.

e. **Mid-Terminal**

Mid-terminal provision has been kept and planned between Ashokvan station & Dongargaon station.

f. **Major/Minor Road, Railway Line and Nallah Crossings from ECO Park to MIDC ESR**

The roads, railway lines and nallahs from ECO Park to MIDC ESR are given in **Table 5.24, Table 5.25** and **Table 5.26** respectively.

TABLE 5.24: ROAD CROSSING STATEMENT FROM ECO PARK TO MIDC ESR

S.N.	Chainage (m)	Side	Type Road	Width (m)	Remarks
1	21617	LHS	BITUMEN ROAD	6.00	TOWARDS JAMTHA VILLAGE
2	23415	LHS	BITUMEN ROAD	19.00	TOWARDS JAMTHA VILLAGE
3	24475	LHS	BITUMEN ROAD	6.00	NAGPUR SHARIRIK SHIKSHAN
4	24584	RHS	BITUMEN ROAD	6.00	TOWARDS SANDESH CITY
5	24585	RHS	CART TRACK ROAD	3.00	TOWARDS SAFTY PACKAGE COMPANY
6	24685	LHS	CART TRACK ROAD	3.00	TO OPEN PLOT
7	24925	LHS	BITUMEN ROAD	6.00	TO OPEN FIELD
8	25003	RHS	BITUMEN ROAD	5.00	TOWARDS SUKAN GROUP OXFORD AGRO PLANTATION PVT. LTD.
9	25003	LHS	BITUMEN ROAD	10.00	NAGARAJUNA CONSTRUCTION

S.N.	Chainage (m)	Side	Type Road	Width (m)	Remarks
					COMPANY PVT. LTD.
10	25189	LHS	BITUMEN ROAD	5.00	TOWARDS CENTRAL POWER RESEARCH INSTITUTE
11	25630	LHS	W.B.M. ROAD	5.00	TOWARDS MY ASSETS INFRA MAI GROUP, NAGPUR
12	25680	RHS	CART TRACK ROAD	3.00	TO OPEN FIELD
13	26070	LHS	BITUMEN ROAD	5.00	TOWARDS GAIKWAD PATIL INTERNATIONAL SCHOOL
14	26362	RHS	BITUMEN ROAD	7.00	TOWARDS WARSHADHARA
15	26615	LHS	BITUMEN ROAD	3.00	TOWARDS DONGARGAON BASTI
16	26655	RHS	W.B.M. ROAD	3.00	TOWARDS VIJAY COLLEGE
17	26750	LHS	BITUMEN ROAD	3.00	TOWARDS MEDICAL HOSPITAL
18	26785	LHS	CEMENT ROAD	3.00	TOWARDS DONGARGAON BASTI
19	27000	RHS	BITUMEN ROAD	4.00	TOWARDS OLD TOLL NAKA
20	27169	LHS	BITUMEN ROAD	5.00	TOWARDS TOLL OFFICE BUILDING
21	27315	LHS	W.B.M. ROAD	3.00	TOWARDS OPEN FIELD
			BITUMEN ROAD	4.1	TOWARDS MAIN ROAD
22	27447	LHS	BITUMEN ROAD	5.00	TOWARDS MAIN ROAD
23	27550	LHS	CEMENT ROAD	8.00	TOWARDS WAKESHWAR
24	27658	LHS	CEMENT ROAD	7.00	TOWARDS MOSQUR
25	28262	LHS	CEMENT ROAD	3.2	TOWARDS FARM
27	28450	RHS	CEMENT ROAD	12.00	TOWARDS BHARAT PETROL PUMP
28	28500	LHS	CEMENT ROAD	12.00	TOWARDS RELIANCE PETROL PUMP
29	28500	RHS	CEMENT ROAD	12.00	TOWARDS BHARAT PETROL PUMP
30	28600	LHS	BITUMEN ROAD	7.00	TOWARDS BOTHALI
31	28975	RHS	W.B.M. ROAD	3.00	TOWARDS RAILWAY CROSSING
32	29685	RHS	CEMENT ROAD	3.00	TOWARDS MOHGAON BASTI
33	29750	LHS	BITUMEN ROAD	6.00	TOWARDS EXPLOSIVE COMPANY
34	29800	RHS	BITUMEN ROAD	5.00	TOWARDS MOHAGAON BASTI
35	29950	LHS	W.B.M. ROAD	3.00	TOWARDS FARM
36	32250	RHS	W.B.M. ROAD	5.00	TOWARDS SATGAON
37	32130	RHS	BITUMEN ROAD	6.00	TOWARDS MULAK COLLEGE
38	32570	LHS	CEMENT ROAD	4.00	TOWARDS MARUTI NAGAR
39	32730	RHS	BITUMEN ROAD	6.00	TOWARDS SATGAON
40	32730	LHS	W.B.M. ROAD	3.00	TOWARDS MARUTI NAGAR
41	33000	LHS	W.B.M. ROAD	4.00	TOWARDS BUTIBORI
42	33075	RHS	BITUMEN ROAD	5.00	TOWARDS INDIAN OIL PETROL PUMP
43	33075	LHS	CEMENT ROAD	3.00	TOWARDS SIDHIVINAYAK CONVENT
44	33240	RHS	BITUMEN ROAD	4.00	TOWARDS UKO BANK
45	33265	LHS	W.B.M. ROAD	3.00	TOWARDS NATIONAL MOTOR PARTS
46	33335	LHS	W.B.M. ROAD	3.00	TOWARDS GODAWARI NAGAR

S.N.	Chainage (m)	Side	Type Road	Width (m)	Remarks
47	33500	LHS	W.B.M. ROAD	4.00	TOWARDS GODAWARI NAGAR
48	33575	LHS	CART TRACK ROAD	3.00	TOWARDS JIJAMATA PRIMARY AND JR. COLLEGE
49	33700	LHS	CEMENT ROAD	16.00	TOWARDS RAILWAY STATION
50	33700	LHS	BITUMEN ROAD	19.00	TOWARDS WARDHA
51	33760	RHS	BITUMEN ROAD	6.00	TOWARDS SATGAON
52	33760	LHS	BITUMEN ROAD	5.00	TOWARDS I.T.I COLLEGE
53	33760	RHS	BITUMEN ROAD	7.00	TOWARDS SATGAON
54	33880	RHS	BITUMEN ROAD	8.00	TOWARDS SATGAON
55	33970	RHS	BITUMEN ROAD	8.00	TOWARDS RACHNNA HOSPITAL
56	34110	RHS	BITUMEN ROAD	4.00	TOWARDS SHOPPING COMPLEX
57	34210	RHS	BITUMEN ROAD	8.00	TOWARDS SATGAON
58	34290	LHS	BITUMEN ROAD	5.00	TOWARDS MAHADA COLONY
59	34290	LHS	W.B.M. ROAD	3.00	TOWARDS MAHADA COLONY
60	34380	LHS	BITUMEN ROAD	7.00	TOWARDS MAHADA COLONY
61	34790	LHS	BITUMEN ROAD	7.00	TOWARDS MAHADA COLONY
62	34970	LHS	BITUMEN ROAD	8.00	TOWARDS MAHADA COLONY
63	34925	RHS	BITUMEN ROAD	7.4	TOWARDS SATGAON
64	34925	LHS	BITUMEN ROAD	8.2	TOWARDS MAHADA COLONY
65	35115	RHS	W.B.M. ROAD	3.00	TOWARS INDO WORTH OFFICE
66	35215	LHS	W.B.M. ROAD	2.2	TOWARDS DREAM COLONY
67	35400	LHS	CART TRACK ROAD	3.4	TOWARDS SST BBORI MALL
68	35950	RHS	BITUMEN ROAD	16.00	TOWARDS SHARDA SHREE ISPAT LTD.
69	36100	RHS	BITUMEN ROAD	10.00	TOWARDS SHARDA SHREE ISPAT LTD.
70	36290	LHS	BITUMEN ROAD	5.00	TOWARDS G.G DANDEKAR MACHINE WORKS LTD.
71	36340	LHS	BITUMEN ROAD	8.00	TOWARDS G.G DANDEKAR MACHINE WORKS LTD.
72	36390	LHS	BITUMEN ROAD	8.00	TOWARDS PITAMBERA POLYMERS INDRUSTRIES PVT LTD
73	36675	RHS	BITUMEN ROAD	4.00	TOWARDS KINHI
74	36675	LHS	W.B.M. ROAD	3.00	TOWARDS SUKALI
75	36812	RHS	BITUMEN ROAD	3.00	TOWARDS L&T
76	36910	LHS	BITUMEN ROAD	6.00	TOWARDS SHILPA STEEL & POWER LTD.
77	37050	RHS	BITUMEN ROAD	9.00	TOWARDS VENUS ROLLING & MILLS PVT. LIMITED
78	37050	LHS	BITUMEN ROAD	6.00	TOWARDS SHILPA STEEL & POWER LTD.
79	37163	RHS	BITUMEN ROAD	5.00	TOWARDS JAIKA MOTORS
80	37200	LHS	BITUMEN ROAD	9.00	TOWARDS SHILPA STEEL & POWER

S.N.	Chainage (m)	Side	Type Road	Width (m)	Remarks
					LTD.
81	37275	LHS	BITUMEN ROAD	8.00	TOWARDS K.E.C. INTERNATIONAL LTD
82	37284	RHS	BITUMEN ROAD	8.00	TOWARDS GOYAL DHATU UDYOG PVT. LIMITED
83	37325	RHS	BITUMEN ROAD	8.00	TOWARDS GOYAL DHATU UDYOG PVT. LIMITED
84	37382	RHS	BITUMEN ROAD	8.00	TOWARDS SHYAMBABA RE-ROLLERS PVT.LTD.
85	37525	RHS	BITUMEN ROAD	18.00	TOWARDS TEMBHARI
86	37584	LHS	BITUMINOUS ROAD	4.17	TOWARDS K.E.C INTERNATIONAL LIMITED
87	37590	LHS	BITUMINOUS ROAD	6.83	TOWARDS K.E.C INTERNATIONAL LIMITED
88	37661	RHS	PAVEMENT ROAD	20.00	TOWARDS INDO WORTH INDIA LTD.
89	37830	LHS	BITUMINOUS ROAD	17	TOWARDS INDO WORTH INDIA LTD.
90	38030	RHS	WBM ROAD	3.76	TOWARDS SHRI.KANCHANVARNA HANUMAN TEMPLE
91	38150	LHS	BITUMINOUS ROAD	4.25	TOWARDS TEXPRINT OVERSEAS LIMITED
92	38300	RHS	BITUMINOUS ROAD	8.10	TOWARDS TEMBHARI
93	38338	RHS	BITUMINOUS ROAD	5.90	TOWARDS ORANGE CITY WELDMESH
94	38425	LHS	BITUMINOUS ROAD	4.47	TOWARDS MIDC FIRE STATION BACK SIDE

TABLE 5.25: RAILWAY CROSSING STATEMENT FOR MIHAN TO MIDC ESR

S.N.	Chainage (m)	Width (m)	Type	Remarks
1	21575	14.4	NAGPUR TO WARDHA BROAD GUAGE LINE	CURRENT STATUS: WORKING
2	31225	3.8	NAGPUR TO WARDHA BROAD GUAGE LINE	CURRENT STATUS: WORKING
3	31275	3.7	NAGPUR TO WARDHA BROAD GUAGE LINE	CURRENT STATUS: WORKING

TABLE 5.26: NALLAH CROSSING STATEMENT FOR MIHAN TO MIDC ESR

S.N.	Chainage (m)	Name of X-ing	Length of bridge	Bridge Type	Bed Level	HFL
1	23725	NALLA	3.183	BOX CULVERT	290.447	292.500
2	23945	NALLA	3.375	PIPE CULVERT	290.692	292.400
3	24070	NALLA	8.834	PIPE CULVERT	289.969	292.340
4	24970	NALLA	8.279	PIPE CULVERT	296.607	298.800
5	25825	NALLA	12.308	PIPE CULVERT	291.442	297.350

S.N.	Chainage (m)	Name of X-ing	Length of bridge	Bridge Type	Bed Level	HFL
6	26275	NALLA	7.969	PIPE CULVERT	296.242	297.950
7	28590	NALLA	6.456	PIPE CULVERT	289.310	291.600
8	29865	NALLA	4.212	BOX CULVERT	280.819	284.550
9	30575	NALLA	12.9	PIPE CULVERT	276.141	279.512
10	30975	NALLA	11.73	PIPE CULVERT	276.280	276.450
11	31275	NALLA	4.255	BOX CULVERT	276.000	279.100
12	33780	NALLA	1.458	PIPE CULVERT	267.284	269.850
13	33800	NALLA	1.243	PIPE CULVERT	265.857	266.750
14	34600	NALLA	29.599	BOX CULVERT	262.007	265.100
15	34610	NALLA	22.048	BOX CULVERT	262.007	265.250
16	35250	NALLA	6.469	BOX CULVERT	260.572	265.150
17	35750	NALLA	150.362	SLAB BRIDGE	252.774	269.500
18	36220	NALLA	1.660	PIPE CULVERT	265.339	267.150
19	36450	NALLA	9.837	PIPE CULVERT	262.336	264.950
20	36625	NALLA	9.951	PIPE CULVERT	262.696	264.910
21	37225	NALLA	16.708	BOX CULVERT	269.404	271.900
22	37550	NALLA	2.859	PIPE CULVERT	270.688	272.100
23	37775	NALLA	3.068	PIPE CULVERT	270.094	271.100
24	38000	NALLA	6.783	PIPE CULVERT	267.716	269.810
25	38090	NALLA	5.954	PIPE CULVERT	268.325	270.500
26	38125	NALLA	44.449	PIPE CULVERT	266.839	271.210

5.1.4.2. Corridor – 2A: Automotive Square to Kanhan River

The proposed alignment of Corridor-2A is an extension of Reach 2 of Phase 1 and starts from Chainage (-) 575m beyond Automotive Square and terminates near Kanhan River at Chainage (-) 13500. The total length of the corridor is about 12.925 Km and is completely elevated.

Total 12 elevated stations are proposed in this corridor, starting from Pili Nadi Station (Ch: -1409m) and terminating at Kanhan River Station (Ch: -13324m)

The corridor is summarised as under in **Table 5.27.**

TABLE 5.27: ALIGNMENT DESCRIPTION OF CORRIDOR-2A

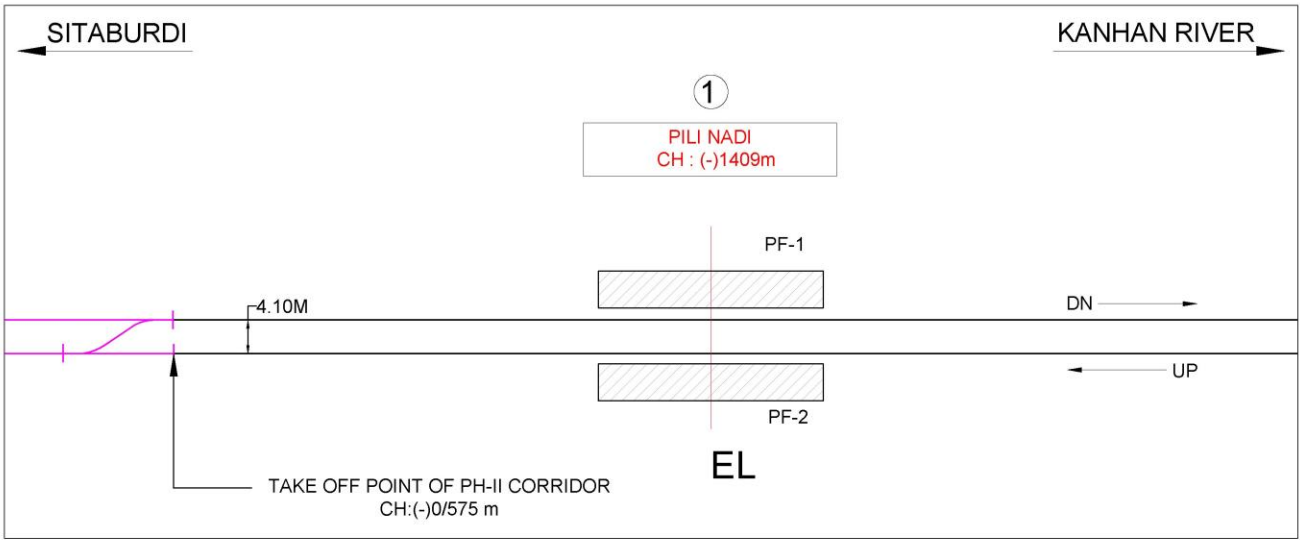
S.No.	Station	Chainage (m)	Intermediate Distance (m)
Start Point		-575	-
Stations	Pili Nadi	-1409	834
	Khasara Fata	-2286	877

S.No.	Station	Chainage (m)	Intermediate Distance (m)
	All India Radio	-3314	1028
	Khairi Fata	-5250	1936
	Lok Vihar	-6176	926
	Lekha Nagar	-7199	1023
	Cantonment	-8681	1482
	Kamptee Police Station	-9410	729
	Kamptee Municipal Council	-10225	815
	Dragon Palace	-11196	971
	Golf Club	-12468	1272
	Kanhan River	-13324	856
Termination Point		-13500	176
Total		12925m	

a. Take off Point

The alignment for Corridor 2A starts from Chainage (-)575 and take off from Reach 2 of Phase 1 beyond Automotive Square station as shown in the **Figure 5.11.**

FIGURE 5.11: TAKE OFF POINT FOR CORRIDOR-2A



b. Reference Point

For the planning convenience, the chainages are in continuation with Phase -1 North-South corridors.

c. Starting / Terminal stations of Corridor-2A

i. Pili Nadi (West side terminal station)

The starting station on Corridor-2A of the extension of Metro Phase-1 corridor is Pili Nadi Metro Station which lies on the west side of the Phase-1 corridor. The station is proposed elevated and rail level has been generally kept 14.5m above the ground level. Proposed metro station will provide connectivity to the residential areas of Dixit Nagar in the North and Azim Nagar in the South side of station.

ii. Kanhan River Metro Station (East side terminal station)

The east side station on the extension of Metro Phase-1 corridor is Kanhan River Metro Station. The station is proposed elevated and rail level has been generally kept 14.5m above the ground level. It will serve the nearby localities of Swami Vivekanand Nagar, Shankar Nagar and Shiv Nagar

Reversal/stabling facility has also been planned beyond Kanhan River Metro station.

d. Mid-Terminal

Mid-terminal provision has been kept and planned between Kamptee Police station and Municipal Corporation station

e. Major/minor Road, Railway Line and Nallah Crossings from Automotive Square to Kanhan River

The roads crossing from Automotive Square to Kanhan River are given in **Table 5.28** below.

TABLE 5.28: ROADS CROSSING STATEMENT FROM AUTOMOTIVE SQUARE TO KANHAN RIVER

S.No.	Chainage (m)	Side	Type road	Width(m)	Remarks
AUTOMOTIVE SQUARE TO BUDDH VIHAR					
1	-1100	RHS	BITUMEN ROAD	6.2	TOWARDS SMALL FACTORY AREA
2	-1325	RHS	BITUMEN ROAD	5.64	TOWARDS MAA BAMLESHWARI NAGAR
3	-1350	LHS	W.B.M. ROAD	7.47	TOWARDS PATEL NAGAR
4	-1485	LHS	W.B.M. ROAD	10.67	TOWARDS NARA
5	-1700	RHS	BITUMEN ROAD	5.4	TOWARDS PAHUNE LAYOUT
6	-1725	LHS	BITUMEN ROAD	8.06	TOWARDS UPPAL WADI INDUSTRIAL AREA
7	-1825	RHS	W.B.M. ROAD	4.41	TOWARDS RESIDENTAL AREA
8	-1830	LHS	W.B.M. ROAD	6.47	TOWARDS UPPAL WADI

S.No.	Chainage (m)	Side	Type road	Width(m)	Remarks
9	-2010	LHS	W.B.M. ROAD	3.24	TOWARDS KHASALA
10	-2300	LHS	BITUMEN ROAD	6.12	TOWARDS TOLI MASADA
11	-2630	RHS	BITUMEN ROAD	5.68	TOWARDS BHILGAON
12	-2750	LHS	W.B.M. ROAD	3.55	TOWARDS TAJ NEYAJI MASJID
13	-3000	LHS	W.B.M. ROAD	6.65	TOWARDS CHAMDI FACTORY
14	-3300	RHS	BITUMEN ROAD	4.23	TOWARDS BHILGAON
15	-3650	LHS	BITUMEN ROAD	4.5	TOWARDS SUMAN VIHAR SOCIETY
16	-4025	LHS	BITUMEN ROAD	5	TOWARDS OPEN AREA
17	-4025	LHS	BITUMEN ROAD	5.53	TOWARDS OPEN AREA
18	-4075	RHS	W.B.M. ROAD	2.94	TOWARDS OPEN AREA
19	-4350	LHS	W.B.M. ROAD	7.3	TOWARDS GLASS COMPANY
20	-4393	LHS	W.B.M. ROAD	4.79	TOWARDS KAWATHA VILLAGE
21	-4625	RHS	W.B.M. ROAD	3.02	TOWARDS OPEN AREA
22	-4725	LHS	BITUMEN ROAD	3.66	TOWARDS KHAIRI VILLAGE
23	-4880	RHS	W.B.M. ROAD	3.73	TOWARDS TOWARDS FIELD
24	-5035	RHS	W.B.M. ROAD	6.88	TOWARDS EDIFY SCHOOL
25	-5074	LHS	W.B.M. ROAD	6.56	TOWARDS KHAIRI VILLAGE
26	-5200	RHS	W.B.M. ROAD	5.27	TOWARDS JAIKA MOTORS
27	-5300	RHS	W.B.M. ROAD	4.569	TOWARDS RANALA VILLAGE
28	-5325	LHS	BITUMEN ROAD	15.67	TOWARDS DELHI PUBLIC SCHOOL
29	-5375	RHS	CEMENT ROAD	9.67	TOWARDS BUDDHIST TRAINING INSTITUTE
30	-5486	RHS	W.B.M. ROAD	11.45	TOWARDS BUDDHIST TRAINING INSTITUTE
31	-5525	LHS	W.B.M. ROAD	6.09	TOWARDS OPEN LAND
32	-6080	RHS	BITUMEN ROAD	8.03	TOWARDS BHARAT TOWN
33	-6110	RHS	BITUMEN ROAD	8.86	TOWARDS OPEN LAND
34	-6825	LHS	BITUMEN ROAD	7.4	TOWARDS DR. ROY BUNGLOW
35	-7242	RHS	BITUMEN ROAD	2.63	TOWARDS LEKHA NAGAR
36	-7284	RHS	BITUMEN ROAD	3.58	TOWARDS LEKHA NAGAR
37	-7415	RHS	BITUMEN ROAD	4.88	TOWARDS LEKHA NAGAR
38	-7630	RHS	BITUMEN ROAD	2.25	TOWARDS KALPATARU COLONY
39	-7680	RHS	BITUMEN ROAD	3.92	TOWARDS KALPATARU COLONY
40	-7708	RHS	BITUMEN ROAD	3.21	TOWARDS KALPATARU COLONY
41	-7754	RHS	BITUMEN ROAD	4.2	TOWARDS KALPATARU COLONY
42	-7821	RHS	BITUMEN ROAD	4.17	TOWARDS COLONY
43	-7964	RHS	W.B.M. ROAD	4.38	TOWARDS COLONY
44	-8224	LHS	BITUMEN ROAD	9.17	TOWARDS KHAPERKHEDA / DAHEGAON
45	-8355	RHS	BITUMEN ROAD	8.6	TOWARDS GRAVE YARD
46	-8423	RHS	BITUMEN ROAD	8.16	TOWARDS PAY ACCOUNTS OFFICE
47	-8528	RHS	BITUMEN ROAD	9.79	TOWARDS STATE BANK OF

S.No.	Chainage (m)	Side	Type road	Width(m)	Remarks
					INDIA
48	-8662	RHS	BITUMEN ROAD	4.06	TOWARDS NAGPUR
49	-8774	RHS	BITUMEN ROAD	3.65	TOWARDS KAMPTEE AREA
50	-8854	LHS	BITUMEN ROAD	4.07	TOWARDS WARISPURA
51	-8878	RHS	CEMENT ROAD	6.41	TOWARDS PRABHUDDHA NAGAR
52	-8932	LHS	CEMENT ROAD	4.76	TOWARDS KAMPTEE AREA
53	-8955	LHS	CEMENT ROAD	2.61	TOWARDS KAMPTEE AREA
54	-8961	RHS	CEMENT ROAD	2.47	TOWARDS KAMPTEE AREA
55	-8981	RHS	CEMENT ROAD	4	TOWARDS KAMPTEE AREA
56	-9015	RHS	CEMENT ROAD	4.64	TOWARDS KAMPTEE AREA
57	-9058	LHS	CEMENT ROAD	2.34	TOWARDS KAMPTEE AREA
58	-9072	RHS	CEMENT ROAD	2	TOWARDS KAMPTEE AREA
59	-9094	RHS	CEMENT ROAD	4.6	TOWARDS KAMPTEE AREA
60	-9097	LHS	BITUMEN ROAD	3.47	TOWARDS KAMPTEE AREA
61	-9121	RHS	CEMENT ROAD	4.99	TOWARDS KAMPTEE AREA
62	-9182	RHS	CEMENT ROAD	2.83	TOWARDS KAMPTEE AREA
63	-9216	RHS	CEMENT ROAD	4.47	TOWARDS KAMPTEE AREA
64	-9253	RHS	CEMENT ROAD	3.62	TOWARDS KAMPTEE AREA
65	-9258	LHS	CEMENT ROAD	4.13	TOWARDS KAMPTEE AREA
66	-9321	RHS	BITUMEN ROAD	4.82	TOWARDS KAMPTEE AREA
67	-9329	LHS	BITUMEN ROAD	15.44	TOWARDS GOYAL TALKIES
68	-9316	RHS	BITUMEN ROAD	4.65	TOWARDS BHOLI LAND
69	-9493	RHS	BITUMEN ROAD	6.75	TOWARDS KALAMANA
70	-9522	RHS	CEMENT ROAD	4.68	TOWARDS YADAV NAGAR
71	-9546	LHS	BITUMEN ROAD	5.12	TOWARDS KAMPTEE KRISHI UTPANNA BAZAR SAMITI
72	-9650	LHS	BITUMEN ROAD	13.87	TOWARDS GOYAL TALKIES
73	-9700	RHS	BITUMEN ROAD	3.85	TOWARDS YADAV NAGAR
74	-9775	RHS	BITUMEN ROAD	5.54	TOWARDS KAMPTEE STATION, BHIM NAGAR
75	-9900	LHS	BITUMEN ROAD	3.43	TOWARDS HARDAS NAGAR, BUDDHA VIHAR
76	-9943	LHS	BITUMEN ROAD	3.36	TOWARDS HARDAS NAGAR, BUDDHA VIHAR
77	-10031	RHS	BITUMEN ROAD	5.03	TOWARDS RAILWAY STATION
78	-10050	LHS	BITUMEN ROAD	5.1	TOWARDS HAIDARI SQUARE
79	-10189	LHS	BITUMEN ROAD	3.23	TOWARDS HAIDARI SQUARE
80	-10359	RHS	CEMENT ROAD	2.72	TOWARDS KAMPTEE AREA
81	-10424	RHS	CEMENT ROAD	3.04	TOWARDS BUDDHA VIHARHAIDARI SQUARE
82	-10502	LHS	CEMENT ROAD	4.34	TOWARDS KAMPTEE AREA
83	-10557	LHS	CEMENT ROAD	4.28	TOWARDS KAMPTEE AREA
84	-10755	LHS	CEMENT ROAD	2.73	TOWARDS KAMPTEE AREA
85	-10919	LHS	CEMENT ROAD	2.34	TOWARDS KAMPTEE AREA

S.No.	Chainage (m)	Side	Type road	Width(m)	Remarks
86	-10925	RHS	BITUMEN ROAD	6.69	TOWARDS GUMTHALA
87	-10958	LHS	CEMENT ROAD	1.76	TOWARDS KAMPTEE AREA
88	-10991	LHS	CEMENT ROAD	1.84	TOWARDS KAMPTEE AREA
89	-11034	LHS	BITUMEN ROAD	4.89	TOWARDS KAMPTEE AREA
BUDDH VIHAR TO KANHAN RIVER					
90	-11100	RHS	BITUMEN ROAD	5.57	TOWARDS GUMTHALA
91	-11080	RHS	CEMENT ROAD	4.64	TOWARDS DADA SAHEB KUMBHARE CHILDREN PARK
92	-11300	LHS	BITUMEN ROAD	7.36	TOWARDS GANDHI NAGAR
93	-11350	LHS	CEMENT ROAD	1.84	TOWARDS KAMPTEE
94	-11500	RHS	BITUMEN ROAD	2.75	TOWARDS KAMPTEE KAMSARI BAZAR
95	-11560	RHS	BITUMEN ROAD	2.64	TOWARDS KAMPTEE KAMSARI BAZAR
96	-11825	RHS	W.B.M. ROAD	2.70	TOWARDS DARGAH
97	-11850	LHS	BITUMEN ROAD	2.14	TOWARDS MAHADEV GHAT
98				5.60	TOWARDS KANHAN RIVER
99	12300	RHS	BITUMEN ROAD	4.00	TOWARDS 414 ASC BN MARKETING (T.A)
100	-12415	RHS	BITUMEN ROAD	3.00	TOWARDS 414 ASC BN MARKETING (T.A)
101	-12600	LHS	BITUMEN ROAD	5.50	TOWARDS INDIAN ARMY
				5.40	TOWARDS INDIAN ARMY
				4.11	TOWARDS INDIAN ARMY
102	-13025	LHS	BITUMEN ROAD	3.00	TOWARDS CHOTTI AJNI
103	-13125	LHS	CEMENT ROAD	4.00	TOWARDS SAI BABA TEMPLE
104	-13140	RHS	BITUMEN ROAD	9.40	TOWARDS BHANDARA

The railway lines crossing from Automotive Square to Kanhan River are given in **Table 5.29** below

TABLE 5.29: MAJOR RAILWAY CROSSING STATEMENT FROM AUTOMOTIVE SQUARE TO KANHAN RIVER

S.no.	Chainage (m)	Width (m)	Type	Remarks
1	-1770	1.676	KORADI POWER PLANT TO ITWARI RLY STATION SIDING BROAD GAUGE RAILWAY LINE (ELECTRIFIED)	CURRENT STATUS: WORKING
2	-1795	1.52	NAGPUR TO CHHINDWARA NARROW GAUGE RAILWAY LINE (NON-ELECTRIFIED)	CURRENT STATUS: ABANDONED
3	-1810	1.676	KHAPERKHEDA POWER PLANT TO KALMANA RLY STATION BROAD GAUGE RAILWAY LINE	CURRENT STATUS:

S.no.	Chainage (m)	Width (m)	Type	Remarks
			(ELECTRIFIED)	WORKING

The nallah crossings from Automotive Square to Kanhan River are given in **Table 5.30** below:

TABLE 5.30: NALLAH CROSSING STATEMENT FROM AUTOMOTIVE SQUARE TO KANHAN RIVER

S.no.	Chainage(m)	Type	Span(m)	Bridge type	Bed level	HFL
AUTOMOTIVE SQUARE TO BUDDH VIHAR (KAMPTEE)						
1	-950	RIVER	44	RCC BRIDGE	282.888	284.582
2	-2075	NALA	26.253	RCC BRIDGE	287.62	288.105
3	-2725	NALA	10.782	PIPE CULVERT	290.878	291.865
4	-4378	CANAL	6.745	PIPE CULVERT	293.159	293.823
5	-4463	NALA	5.385	PIPE CULVERT	293.94	294.111
6	-5633	NALA	6.519	PIPE CULVERT	287.699	288.011
7	-6144	NALA	6.116	PIPE CULVERT	282.265	282.939
8	-6393	NALA	31.397	RCC BRIDGE	279.542	280.489
9	-6885	NALA	4.948	PIPE CULVERT	284.993	285.773
10	-7113	NALA	8.304	PIPE CULVERT	283.572	284.476
11	-8062	NALA	9.105	PIPE CULVERT	277.55	278.008
12	-8525	NALA	4.119	PIPE CULVERT	279.91	280.346
13	-8700	NALA	34.875	RCC BRIDGE	274.92	276.811
14	-8785	NALA	30.692	RCC BRIDGE	274.628	276.549
15	-9340	NALA	4.066	PIPE CULVERT	284.326	284.655
16	-9816	NALA	1.722	PIPE CULVERT	284.135	285.445
BUDDH VIHAR TO KANHAN RIVER						
1	-11375	NALA	13.739	MINOR ARCH BRIDGE	266.416	277.559
2	-11950	NALA	6.433	PIPE CULVERT	277.529	278.756
3	-12081	NALA	6.539	PIPE CULVERT	276.98	278.539
4	-12664	NALA	5.157	PIPE CULVERT	277.284	279.634
5	-12884	NALA	6.346	MINOR BRIDGE	276.043	276.899

5.1.4.3. Corridor – 3A: Lokmanya Nagar to Hingna

a. Alignment Description

The proposed alignment of Corridor-3A is west extension of Reach 3 of Phase 1 and starts from Chainage 18218m beyond Lokmanya Nagar and terminates near Hingna at Chainage 24874.650m. The total length of the corridor is about 6.657 Km and is completely elevated.

Total 7 elevated stations are proposed in this corridor, starting from Hingna Mountview Station (Ch: 18761m) and terminating at Hingna Station (Ch: 24504m).

The corridor is summarised as under in **Table 5.31.**

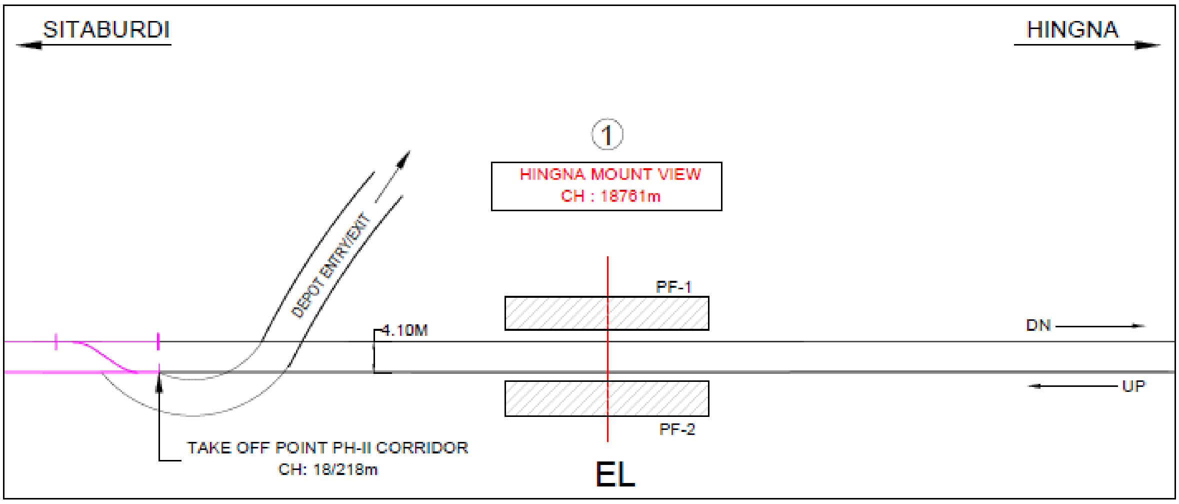
TABLE 5.31: ALIGNMENT DESCRIPTION OF CORRIDOR-3A

Description	Station	Chainage (m)	Intermediate Distance (m)
Start Point		18218	--
Stations	Hingna Mountview	18761	543
	Rajiv Nagar	19607	846
	Wanadongri	21006	1399
	APMC	21715	709
	Raipur	22823	1108
	Hingna Bus Station	23625	802
	Hingna	24504	879
Terminal Point		24875	371
Total		6657	

b. Take off Point

The alignment for Corridor 3A starts from Chainage 18218.57m and take off from Reach 3 of Phase 1 beyond Lokmanya Nagar station as shown in the **Figure 5.12.**

FIGURE 5.12: TAKE OFF POINT FOR CORRIDOR-3A



c. Reference Point

For the planning convenience, the chainages are in continuation with Phase -1 East-West corridors.

d. Starting/ Terminal stations of Corridor-3A

i) Hingna Mountview (East side terminal station)

The starting station on Corridor-3A of the extension of Metro Phase-1 corridors is Hingna Mountview Metro Station, located on the west side of Phase-1 corridor. The station is proposed elevated and rail level has been generally kept 14.5m above the ground level. Proposed metro station will provide connectivity to Lokmanya Nagar at east side of station.

ii) Hingna Metro Station (West side terminal station)

The west side station on the extension of Metro Phase-1 corridor is Hingna Metro Station. The station is proposed elevated and rail level has been generally kept 14.5m above the ground level. It will serve the nearby localities Hingna area.

Reversal/stabling facility has also been planned beyond Hingna Metro station.

e. Mid-Terminal

Mid-terminal provision has been kept and planned between Hingna Mount View station and Rajiv Nagar station.

f. Major/Minor Road, Railway Line and Nallah Crossings from Lokmanya Nagar to Hingna (Hingna)

The roads from Lokmanya Nagar to Hingna are given in **Table 5.32.**

TABLE 5.32: ROAD CROSSING STATEMENT FROM LOKMANYA NAGAR TO HINGNA

S. No.	Chainage (m)	Side	Type road	Width (m)	Remarks
1	18450	RIGHT	BITUMEN ROAD	5.5	TOWARDS MOHITE INDUSTRIAL AREA PH-III
2	18525	LEFT	CEMENT ROAD	3.0	TOWARDS METRO DEPOT AREA
3	18561	LEFT	CEMENT ROAD	3.0	TOWARDS METRO DEPOT AREA
4	18607	LEFT	CEMENT ROAD	3.2	TOWARDS LOKMANYA NAGAR
5	18633	LEFT	WBM ROAD	5.0	TOWARDS M.I.D.C. ROAD
6	18719	RIGHT	BITUMINUS ROAD	6.16	TOWARDS LOKMANYA NAGAR
7	18855	RIGHT	BITUMINUS ROAD	4.13	TOWARDS LOKMANYA NAGAR
8	18936	RIGHT	BITUMINUS ROAD	4.64	TOWARDS LOKMANYA NAGAR
9	18967	RIGHT	WBM ROAD	3.07	TOWARDS LOKMANYA NAGAR
10	18633	LEFT	BITUMINUS ROAD	5.00	TOWARDS M.I.D.C.
11	18662	LEFT	BITUMINUS ROAD	3.8	TOWARDS GAJANAN NAGAR
12	18717	RIGHT	BITUMINUS	11.593	TOWARDS AMAR NAGAR

S. No.	Chainage (m)	Side	Type road	Width (m)	Remarks
			ROAD		
13	18766	RIGHT	BITUMINUS ROAD	5.503	TOWARDS AMAR NAGAR
14	18856	LEFT	BITUMINUS ROAD	3.4	TOWARDS GAJANAN NAGAR
15	18900	RIGHT	BITUMINUS ROAD	9.8	TOWARDS M.I.D.C
16	18956	LEFT	CEMENT ROAD	4.989	TOWARDS GAJANAN NAGAR
17	19036	RIGHT	CEMENT ROAD	3.134	TOWARDS M.I.D.C
18	19070	LEFT	BITUMINUS ROAD	5.604	TOWARDS GAJANAN NAGAR
19	19258	LEFT	BITUMINUS ROAD	2.921	TOWARDS RAJIV NAGAR
20	19375	LEFT	CEMENT ROAD	2.83	TOWARDS RAJIV NAGAR
21	19418	LEFT	CEMENT ROAD	3.432	TOWARDS RAJIV NAGAR
22	19500	LEFT	CEMENT ROAD	3.163	TOWARDS RAJIV NAGAR
23	19520	RIGHT	CEMENT ROAD	3.65	TOWARDS RADHA KRISHUNA NAGRI
24	19570	LEFT	BITUMINUS ROAD	5.884	TOWARDS RAJIV NAGAR
25	19703	LEFT	BITUMINUS ROAD	4.841	TOWARDS RAJIV NAGAR
26	19766	LEFT	CEMENT ROAD	5.218	TOWARDS RAJIV NAGAR
27	19778	RIGHT	WBM ROAD	10.53	TOWARDS M.I.D.C.
28	19851	LEFT	CEMENT ROAD	3.824	TOWARDS RAJIV NAGAR
29	19980	LEFT	BITUMINUS ROAD	4.022	TOWER TESTING STATION. RICHARDSON AND KUDAS
30	20043	RIGHT	BITUMINUS ROAD	3.768	TOWARDS ADRASH COLONY
31	20101	RIGHT	CEMENT ROAD	4.256	TOWARDS SAI NAGAR, WANADONGRI VILLAGE
32	20107	LEFT	BITUMINUS ROAD	16.78	Y.C.C.E. OF ENGG
33	20168	RIGHT	WBM ROAD	5.553	TOWARDS MATOSHREE NAGAR
34	20292	RIGHT	WBM ROAD	12.623	TOWARDS SAI NAGAR WANADONGRI
35	20293	LEFT	BITUMINUS ROAD	12.597	Y.C.C.E. OF ENGG COLLAGE
36	20365	RIGHT	BITUMINUS ROAD	3.5	TOWARDS WANADONGIRI VILLAGE
37	20476	RIGHT	BITUMINUS ROAD	6.651	TOWARDS SHITLA MATA TEMPLE
38	20587	RIGHT	BITUMINUS	6.202	TOWARDS AMAR NAGAR,

S. No.	Chainage (m)	Side	Type road	Width (m)	Remarks
			ROAD		WANADONGRI
39	20638	RIGHT	BITUMINUS ROAD	5.27	TOWARDS WANADONGRI VILLAGE
40	20652	RIGHT	BITUMINUS ROAD	5.161	TOWARDS SAGAM
41	20653	RIGHT	BITUMINUS ROAD	6.161	TOWARDS WANADONGRI VILLAGE
42	20725	RIGHT	CEMENT ROAD	3.179	TOWARDS WANADONGRI VILLAGE
MAHATAMA GANDHI COLLEGE TO HINGNA					
S.N.	CHAINAGE (M)	SIDE	TYPE ROAD	WIDTH (M)	REMARKS
43	20875	LHS	BITUMINUS ROAD	5.4	TOWARDS VAIBHAV NAGAR
44	20885	RHS	CEMENT ROAD	3.00	TOWARDS WANADONGRI
45	20908	RHS	WBM ROAD	2.70	TOWARDS WANADONGRI WARD NO.01
46	20932	RHS	WBM ROAD	2.70	TOWARDS WANADONGRI OLD BASTI
47	20950	RHS	WBM ROAD	4.00	TOWARDS SAI MANDIR
48	21027	LHS	WBM ROAD	4.00	TOWARDS WAGHADHARA
49	21125	LHS	WBM ROAD	3.00	TOWARDS SHREE KRUSHNA NAGAR
50	21125	RHS	WBM ROAD	3.5	TOWARDS BABA SAHEB AMBEDKAR BOYS HOSTEL
51	21166	LHS	WBM ROAD	3.00	TOWARDS MAHAJANWADI
52	21266	LHS	BITUMINUS ROAD	3.50	TOWARDS MAHAJANWADI WARD NO.06
53	21373	LHS	WBM ROAD	3.70	TOWARDS MAHAJANWADI WARD NO.06
54	21411	RHS	WBM ROAD	3.40	TOWARDS LADI LAYOUT
55	21459	LHS	BITUMINUS ROAD	3.00	TOWARDS MAHAJANWADI WARD NO.06
56	21555	LHS	BITUMINUS ROAD	3.60	TOWARDS MAHAJANWADI WARD NO.06
57	21606	RHS	WBM ROAD	3.00	TOWARDS PARVATI PARK
58	21609	LHS	BITUMINUS ROAD	4.10	TOWARDS KRUSHI UTPAN BAZAR SAMITI MARKET
59	21627	RHS	WBM ROAD	3.50	TOWARDS PARVATI PARK

S. No.	Chainage (m)	Side	Type road	Width (m)	Remarks
60	21764	RHS	BITUMINUS ROAD	3.30	TOWARDS MAHAJANWADI WARD NO.01
61	21843	RHS	CEMENT ROAD	7.50	SMALL LENGTH ROAD ENDS AT NALLA
62	21888	LHS	BITUMINUS ROAD	3.30	TOWARDS KRUSHI UTPAN BAZAR SAMITI MARKET
63	22000	RHS	WBM ROAD	3.30	TOWARDS HP GODOWN
64	22074	RHS	WBM ROAD	3.00	TOWARDS REGENT HIGH SCHOOL
65	22101	LHS	BITUMINUS ROAD	3.00	TOWARDS HANUMAN NAGAR
66	22245	LHS	BITUMINUS ROAD	2.60	TOWARDS DR. BABASAHEB FARMER SAHKARI SUTGIRNI
67	22332	LHS	WBM ROAD	2.30	TOWARDS BHAGAT NAGAR
68	22355	LHS	WBM ROAD	4.00	TOWARDS BHAGAT NAGAR
69	22575	RHS	BITUMINUS ROAD	4.40	TOWARDS RAIPUR BAZAR ROAD
70	22597	RHS	BITUMINUS ROAD	3.00	TOWARDS HAAJRAT BABA BHOLA SHAHA AAULIYA
71	22658	LHS	BITUMINUS ROAD	3.50	TOWARDS PRATHAMIK AAROGYA CENTER
72	22675	RHS	CEMENT ROAD	3.50	TOWARDS BACHAT BHAWAN PANCHAYAT SAMITI
73	22680	LHS	BITUMINUS ROAD	3.60	TOWARDS REST HOUSE
74	22706	LHS	CEMENT ROAD	3.50	TOWARDS POLICE STATION
75	22719	LHS	CEMENT ROAD	4.00	TOWARDS POLICE STATION
76	22731	RHS	CEMENT ROAD	3.40	TOWARDS RAIPUR BAZAR ROAD
77	22783	RHS	BITUMINUS ROAD	5.20	TOWARDS RAIPUR BAZAR ROAD
78	22825	RHS	CEMENT ROAD	5.00	TOWARDS RAIPUR BAZAR ROAD
79	22850	LEFT	WBM ROAD	3.50	TOWARDS POLICE STATION
			BITUMINUS ROAD	3.00	TOWARDS HANUMAN NAGAR
80	22900	RHS	BITUMINUS	4.00	TOWARDS HINGNA BAZAR

S. No.	Chainage (m)	Side	Type road	Width (m)	Remarks
			ROAD		
81	22904	LEFT	CEMENT ROAD	6.50	TOWARDS SURAJ NAGAR
82	22989	LEFT	CEMENT ROAD	3.40	TOWARDS SURAJ NAGAR
83	23050	LEFT	CEMENT ROAD	5.40	TOWARDS WAGHADHARA
84	23060	RHS	CEMENT ROAD	7.30	TOWARDS HINGNA BAZAR
85	23290	RHS	BITUMINUS ROAD	7.40	TOWARDS PANCHAVATI PARK
86	23329	LEFT	BITUMINUS ROAD	6.80	TOWARDS GUMGOAN
87	23375	LEFT	CEMENT ROAD	5.40	TOWARDS RENUKA HALL
88	23407	RHS	BITUMINUS ROAD	11.60	TOWARDS PETROL PUMP
89	23450	LEFT	BITUMINUS ROAD	7.60	TOWARDS KANOLI BARA
90	23500	LEFT	BITUMINUS ROAD	6.50	TOWARDS HINGNA BUS STAND
91	23600	RHS	CEMENT ROAD	9.00	TOWARDS DREAM CITY
92	23642	LHS	CEMENT ROAD	3.00	TOWARDS JOGESHWAR PURI
93	23658	RHS	CEMENT ROAD	4.00	TOWARDS GANESH MANDIR
94	23779	RHS	BITUMINUS ROAD	2.70	TOWARDS BHOSLEWADI
95	23890	RHS	WBM ROAD	4.00	TOWARDS BHOSLEWADI
96	23925	LHS	WBM ROAD	3.20	TOWARDS KADWAS ROAD
97	23968	RHS	CEMENT ROAD	2.00	TOWARDS BHOSLEWADI

TABLE 5.33: RAILWAY CROSSING FROM LOKMANYA NAGAR TO HINGNA

S.N.	Chainage (m)	Width (m)	Type	Remarks
1	NA	NA	NA	NA

TABLE 5.34: NALLAH CROSSING STATEMENT FROM LOKMANYA NAGAR TO HINGNA

S.N.	Chainage (m)	TYPE	Length of bridge	BRIDGE TYPE	Bed level	HFL
1	21150	NALLA	5.03	PIPE CULVERT	301.444	302.484
2	21500	DRAIN	5.05	PIPE CULVERT	299.632	300.85
3	21750	DRAIN	4.91	PIPE CULVERT	297.356	297.937
4	21900	DRAIN	7.66	PIPE CULVERT	297.448	298.348
5	22150	DRAIN	3.95	PIPE CULVERT	295.289	296.389
6	22500	NALLA	33.74	SLAB BRIDGE	290.926	292.564
7	23175	RIVER	91.241	SLAB BRIDGE	286.751	291.395
8	23425	NALLA	12.44	BOX CULVERT	290.636	291.576
9	23650	NALLA	3.79	PIPE CULVERT	293.876	292.900

S.N.	Chainage (m)	TYPE	Length of bridge	BRIDGE TYPE	Bed level	HFL
10	23775	NALLA	8.79	PIPE CULVERT	293.320	294.950

5.1.4.4. Corridor-4A: Prajapati Nagar to Transport Nagar

a. Alignment Description

The proposed alignment of Corridor-4A is extension of Reach 4 of Phase 1 and starts from Chainage (-) 580m beyond Prajapati Nagar and terminates near Transport Nagar at Chainage (-) 6021m. The total length of the corridor is about 5.441 Km and is completely elevated.

Total 3 elevated stations are proposed in this corridor, starting from Pardi Station (Ch: -1365m) and terminating at Transport Nagar Station (Ch: -5126m)

The corridor is summarised as under in **Table 5.35.**

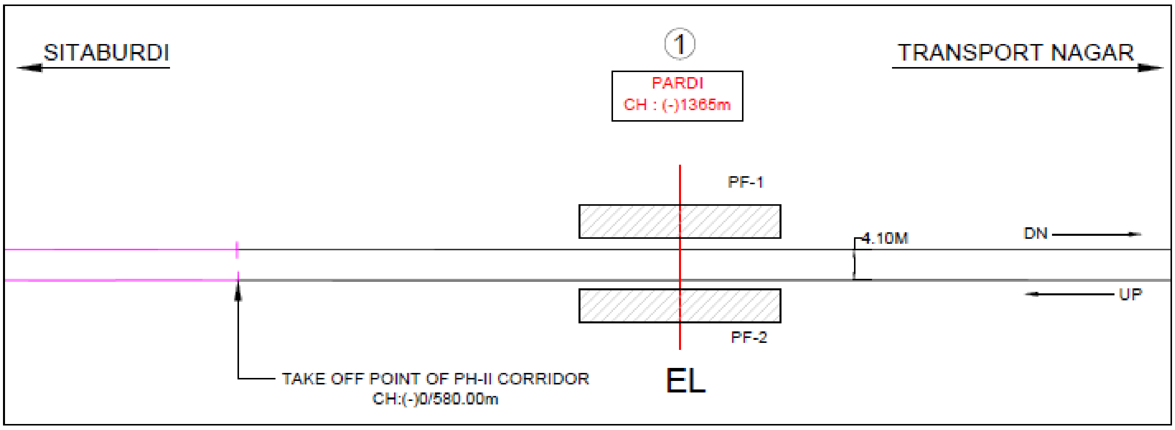
TABLE 5.35: ALIGNMENT DESCRIPTION OF CORRIDOR-4A

Description	Station	Chainage (m)	Intermediate Distance (m)
Start Point		-580	--
Stations	Pardi	-1365	785
	Kapsi Khurd	-3200	1835
	Transport Nagar	-5126	1926
Terminal Point		-6021	895
Total		5441	

b. Take off Point

The alignment for Corridor 4A starts from Chainage (-)580m and take off from Reach 4 of Phase 1 beyond Prajapati Nagar station as shown in the **Figure 5.13.**

FIGURE 5.13: TAKE OFF POINT FOR CORRIDOR-4A



c. Reference Point

For the planning convenience, the chainages are in continuation with Phase -1 East-West corridors.

d. Starting / Terminal stations of Corridor-4A

i) Pardi (West side terminal station)

The west side station on the extension of Metro Phase-1 corridor is Pardi Metro Station. The station is proposed elevated and rail level has been generally kept 14.5m above the ground level. Proposed metro station will provide connectivity to residential area of Mahajungpura.

ii) Transport Nagar Metro Station (East side terminal station)

The east side station on the extension of Metro Phase-1 corridor is Transport Nagar Metro Station. The station is proposed elevated and rail level has been generally kept 14.5m above the ground level. It will serve the nearby localities of Asoli village and Kapsi.

e. Major/minor Road, railway line and nallah crossings from Prajapati Nagar to transport nagar

The roads from Prajapati Nagar to Transport Nagar are given in **Table 5.36.**

TABLE 5.36: ROAD CROSSING STATEMENT FROM PRAJAPATI NAGAR TO TRANSPORT NAGAR

S. No.	Chainage (m)	Side	Type Road	Width (m)	Remarks
PRAJAPATI NAGAR TO TRANSPORT NAGAR					
1	-475	LHS	CEMENT ROAD	5.11	TOWARDS NETAJI NAGAR
2	-614	RHS	BITUMEN ROAD	3.95	TOWARDS OLD PARDI
3	-652	LHS	BITUMEN ROAD	4.124	TOWARDS SUBHAN NAGAR
4	-711	RHS	BITUMEN ROAD	5.626	TOWARDS CHANDRA NAGAR
5	-882	RHS	W.B.M. ROAD	6.046	TOWARDS BHANDEWADI
6	-986	LHS.	BITUMEN ROAD	4.046	TOWARDS DAHANGHAT
7	-1027	RHS	CEMENT ROAD	3.500	TOWARDS MASJID
8	-1096	RHS	BITUMEN ROAD	7.100	TOWARDS BHANDEWADI
9	-1124	RHS	BITUMEN ROAD	2.212	TOWARDS RHS BHANDEWADI
10	-1124	LHS	BITUMEN ROAD	5.073	TOWARDS BHAWANI MANDIR
11	-1225	RHS	BITUMEN ROAD	4.795	TOWARDS RHS THAOKARWADI
12	-1225	LHS	CEMENT ROAD	3.359	TOWARDS LHS BHAWANI MANDIR
13	-1289	RHS	BITUMEN ROAD	2.715	TOWARDS RHS MAHAJANPURA
14	-1289	LHS	CEMENT ROAD	4.405	TOWARDS LHS BHAWANI MANDIR
15	-1329	LHS	CEMENT ROAD	4.4	TOWARDS PARDI

S. No.	Chainage (m)	Side	Type Road	Width (m)	Remarks
16	-1367	RHS	BITUMEN ROAD	3.368	TOWARDS BHANDEWADI
17	-1423	LHS	CEMENT ROAD	2.264	TOWARDS SHARDA NAGAR
18	-1471	RHS	CEMENT ROAD	2.641	TOWARDS VINOBA BHAVE NAGAR
19	-1612	RHS	BITUMEN ROAD	5.024	TOWARDS MITTAL ENCLAVE
20	-1762	LHS	BITUMEN ROAD	5.109	TOWARDS NAVIN NAGAR
21	-1971	LHS	W.B.M. ROAD	4.151	TOWARDS R.S. CRANES
22	-2263	RHS	BITUMEN ROAD	4.623	TOWARDS SURAJ DAL MILL &RAVI DAL MILL
23	-2362	RHS	BITUMEN ROAD	5.225	TOWARDS PARDI SUB STATION
24	-2551	LHS	W.B.M. ROAD	5.522	TOWARDS NAVIN NAGAR
25	-2620	LHS	W.B.M. ROAD	5.541	TOWARDS NAVIN NAGAR
26	-2681	RHS	W.B.M. ROAD	5.686	TOWARDS NAGESHWAR NAGAR
27	-2756	LHS	W.B.M. ROAD	3.196	TOWARDS DESHI DARU SHOP
28	-2809	RHS	W.B.M. ROAD	4.946	TOWARDS ASHIRWAD DALMILL
29	-2882	RHS	BITUMEN ROAD	6.698	TOWARDS TATA MOTORS SERVICE STATION
30	-3056	LHS	BITUMEN ROAD	4.371	TOWARDS NAVIN NAGAR
31	-3366	RHS	W.B.M. ROAD	7.853	TOWARDS KAPSI KHURD
32	-3430	LHS	W.B.M. ROAD	5.556	TOWARDS BARADWARI
33	-3467	LHS	W.B.M. ROAD	3.715	TOWARDS BARADWARI
34	-3542	RHS	BITUMEN ROAD	3.924	TOWARDS GAYATRI DALMILL
35	-3663	LHS	BITUMEN ROAD	6.115	TOWARDS BARADWARI
36	-3728	RHS	W.B.M. ROAD	4.366	TOWARDS P.R. ROADWAYS
37	-3752	RHS	W.B.M. ROAD	4.442	TOWARDS NATIONAL TYRES
38	-4100	RHS	W.B.M. ROAD	9.479	TOWARDS GRIHALAXMI HOUSING AGENCY
39	-4130	LHS	W.B.M. ROAD	6.675	TOWARDS RANI SATIJI MANDIR
40	-4147	RHS	W.B.M. ROAD	5.713	TOWARDS MITTAL DHARAM KATA
41	-4209	RHS	W.B.M. ROAD	4.683	TOWARDS MITTAL DHARAM KATA
42	-4250	RHS/LHS	BITUMEN ROAD	51.574	HYDRABAD-JABALPUR BYPASS
43	-4612	LHS	BITUMEN ROAD	5.334	TOWARDS KAPSI
44	-4972	RHS	BITUMEN ROAD	15.30	TOWARDS TR. NAGAR
TRANSPORT NAGAR TO ASOLI VILLAGE					
1	-5170	RHS	BITUMEN ROAD	3.27	TOWARDS UMIYA TEMPLE
2	-5170	LHS	BITUMEN ROAD	8.52	TOWARDS KAPSI
3	-5910	RHS	CEMENT ROAD	3.84	TOWARDS ASOLI
4	-5930	LHS	CEMENT ROAD	6.50	TOWARDS KAPSI

S. No.	Chainage (m)	Side	Type Road	Width (m)	Remarks
5	-5975	RHS	BITUMEN ROAD	4.650	TOWARDS SHIV PANDHAN ASOLI

The railway crossings from Prajapati Nagar to Transport Nagar are given in **Table 5.37.**

TABLE 5.37: RAILWAY CROSSING STATEMENT FROM PRAJAPATI NAGAR TO TRANSPORT NAGAR

S.n.	Chainage(m)	Width(m)	Type	Remarks
1	NA	NA	NA	NA

The nallah crossings from Prajapati Nagar to Transport Nagar are given in **Table 5.38**.

TABLE 5.38: NALLAH CROSSING STATEMENT FROM PRAJAPATI NAGAR TO TRANSPORT NAGAR

S.no.	Chainage (m)	Type	Span (m)	Bridge Type	Bed Level	HFL
1	-825	NALLA	58.488	RCC MAJOR BRIDGE	279.896	283.420
2	-3075	NALLA	6.052	RCC	282.658	283.117
3	-3750	NALLA	11.542	RCC	282.857	284.197
4	-4935	NALLA	9.877	PIPE CULVERT	281.61	282.631
5	-5620	NALLA	14.69	PIPE CULVERT	278.476	280.7

5.1.4.5. Corridor-5: Vasudev Nagar To Dattawadi (Wadi)

a. Alignment Description

The proposed alignment of Corridor-5 is north extension of Reach 3 of Phase 1 and starts from Chainage 15600m beyond Vasudev Nagar and terminates near Dattawadi at Chainage 20089m. The total length of the corridor is about 4.489 Km and is completely elevated.

Total 3 elevated stations are proposed in this corridor, starting from Police Station MIDC Station (Ch: 15230m) and terminating at Dattawadi Station (Ch: 19831m).
The corridor is summarised as under in **Table 5.39.**

TABLE 5.39: ALIGNMENT DESCRIPTION OF CORRIDOR-5

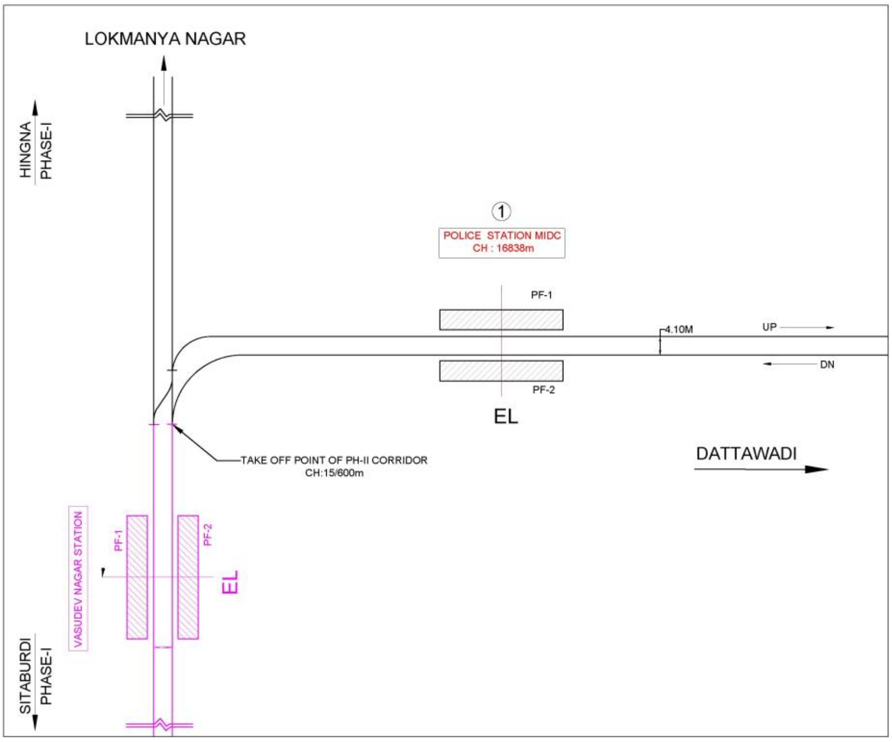
Description	Station	Chainage (m)	Intermediate Distance (m)
Start Point		15600	--
Stations	Police Station MIDC	16838	1238
	MIDC Hingna	19173	2335
	Dattawadi	19831	658
Terminal Point		20089	258

Description	Station	Chainage (m)	Intermediate Distance (m)
Total		4489	

b. Take off Point

The alignment for Corridor 5 starts from Chainage 15600m and take off from Reach 3 of Phase 1 beyond Police Station MIDC station as shown in the **Figure 5.14.**

FIGURE 5.14: TAKE OFF POINT FOR CORRIDOR-5



c. Reference Point

For the planning convenience, the chainages are in continuation with Phase -1 East-West corridors.

d. Starting/ Terminal stations of Corridor-5

i) Police Station MIDC (South side terminal station)

The starting station on Corridor-5 of the extension of Metro Phase-1 corridors is police station MIDC Metro Station, located on the southern side of Phase-1 corridor. The station is proposed elevated and rail level has been generally kept 14.5m above the ground level. Proposed metro station will provide connectivity to residential area of Pardsinga at north side of station.

ii) Dattawadi Metro Station (West side terminal station)

The west side station on the extension of Metro Phase-1 corridor is Dattawadi Metro Station. The station is proposed elevated and rail level has been generally kept 14.5m above the ground level. It will serve the nearby localities of Davlameti and Vayusena Nagar.

e. Major/Minor Road, Railway Line and Nallah Crossings from Vasudev Nagar to Dattawadi (Wadi)

The roads from Vasudev Nagar to Dattawadi are given in **Table 5.40.**

TABLE 5.40: ROAD CROSSING STATEMENT FROM VASUDEV NAGAR TO DATTAWADI (WADI)

S.No.	Chainage(m)	Side	Type road	Width(m)	Remarks
1	15805	RHS	BITUMEN ROAD	7.30	TOWARDS MIDC ROAD
2	15936	LHS	BITUMEN ROAD	7.256	TOWARDS HINGNA
3	16049	RHS	BITUMEN ROAD	7.547	TOWARDS RANGOLI BAR
4	16272	LHS	BITUMEN ROAD	6.832	TOWARDS MIDC ROAD
5	16820	LHS	BITUMEN ROAD	4.85	TOWARDS POLICE STATION
6	16850	RHS	BITUMEN ROAD	5.681	TOWARDS MIDC ROAD L/S-1
7	17200	LHS	BITUMEN ROAD	6.724	TOWARDS RAISONI COLLEGE
8	17750	RHS	BITUMEN ROAD	4.32	TOWARDS MIDC /ESR
9	17900	LHS	BITUMEN ROAD	5.5	TOWARDS MIDC ROAD
10	18323	LHS	BITUMEN ROAD	6.91	TOWARDS SONEGAON
11	18400	RHS	BITUMEN ROAD	7.30	TOWARDS L/SA P-26 ROAD
12	18650	RHS	BITUMEN ROAD	7.05	TOWARDS L/SA P-26 ROAD
13	19150	LHS	BITUMEN ROAD	7.3	TOWARDS MIDC L/S G-1 TO G-4
14	19350	RHS	BITUMEN ROAD	6.8	TOWARDS MIDC C-17 ROAD
15	19470	RHS	BITUMEN ROAD	4.5	TOWARDS (P)BLOCK ROAD
16	19625	RHS	WBM	4.5	TOWARDS MIDC
17	19630	LHS	BITUMEN ROAD	5.5	TOWARDS VITOBA COMPANY
18	19700	RHS	BITUMEN ROAD	3.87	TOWARDS MIDC WADI
19	19767	RHS	BITUMEN ROAD	5.00	TOWARDS MIDC WADI
20	19900	RHS	WBM ROAD	5.00	TOWARDS WADI

The railway crossings from Vasudev Nagar to Dattawadi are given in **Table 5.41.**

TABLE 5.41: RAILWAY CROSSING STATEMENT FROM VASUDEV NAGAR TO DATTAWADI (WADI)

S.no.	Chainage (m)	Width (m)	Type	Remarks
1	Nil	Nil	Nil	Nil

The nallah crossings from Vasudev Nagar to Dattawadi are given in **Table 5.42.**

TABLE 5.42: NALLAH CROSSING STATEMENT FROM VASUDEV NAGAR TO DATTAWADI (WADI)

S.NO.	CHAINAGE(M)	TYPE	SPAN(M)	BRIDGE TYPE	BED LEVEL	HFL

S.NO.	CHAINAGE(M)	TYPE	SPAN(M)	BRIDGE TYPE	BED LEVEL	HFL
1	19529	DRAIN	4.283	RCC	340.72	340.879
2	19578	DRAIN	6.474	BOX CULVERT	340.902	335.519
3	19655	NALLA	12.160	RCC	339.987	340.672
4	19900	NALLA	14.45	RCC	341.787	342.778

5.2. ANALYSIS OF CORRIDORS TO BE ELEVATED, UNDERGROUND OR AT-GRADE

The corridors so selected by traffic study are extension of Phase-1 corridors. The ROW along the corridors are sufficient to carry the alignment as elevated. Hence, none of the corridors in Phase-2 are underground.

5.3. DESIGN NORMS

The geometric design norms have been worked out based on detailed evaluation of passenger comfort, safety, experience and internationally accepted practices being followed in currently operating rapid transit and rail systems.

5.3.1. Principles for Metro Corridors

While fixing the proposed corridor, following requirements/ constraints have been kept in view:

i) To remain on the CL of the existing road or Government premises/land to the extent feasible.

ii) To utilize the existing road Right of Way (ROW) to the maximum extent in order to minimise the land acquisition and also length of diversions.

iii) To avoid dismantling of existing structures/Buildings etc. to the extent feasible.

iv) To avoid private built up areas, villages, habitation and religious structures etc. to the extent feasible.

v) To provide adequate clearance from existing Railway/ Highway structures.

vi) To satisfy the requirements of sound economic engineering practices

vii) To rationalise the location of proposed stations.

5.3.2. Geometric Design Parameters

5.3.2.1. Alignment Considerations : As far as possible-

- Tangent alignment has been maximized.

- Flattest possible curves have been proposed.
- Number of curves has been minimized.
- Maximum possible transition lengths, commensurate to operating speed have been proposed.
- Elevated alignment has been maximized.
- Number of gradients has been minimized.
- Flattest possible vertical curve has been proposed.
- Cants of appropriate values, commensurate to operating speed at specific locations have been proposed to counter the effect of centrifugal force.
- Vertical curves & transition curves of horizontal alignment do not overlap.
- Straight length (R>1000m) and Level (gradient = 0) for length of 170m has been maintained at station area considering future expansion.
- Alignment along culverts, bridges, nallahs crossings shall be straight without curves.
- Emergency crossovers (single crossover on both side) has been planned wherever required.
- Provision of stabling lines has been kept at terminal stations for 2 rakes.
- Pocket line arrangement has been planned at mid-terminals as per Train Operation Plan.

5.3.2.2. General Criteria

General Criteria used for the design purpose are given below in **Table 5.43.**

TABLE 5.43: DESIGN CRITERIA

S. No.	Criteria	Dimension
1	Gauge	1435 mm
2	Design Speed	90 Kmph
3	Max. Operational Speed	80 Kmph
4	Maximum Axle Load	16T
5	Electric Power Collection	25 KV AC (OHE)

5.3.2.3. Horizontal Alignment

Horizontal alignment gives the details of curves in horizontal plane as the entire alignment can-not be on straight. The alignment on mainline track shall consist of tangent sections connected to circular curves by spiral transitions.

Circular Curves

Circular curves shall be defined by their radii in meters. Larger radii shall be used whenever possible to improve the riding quality. The minimum radius of curvature for mainline track shall be governed by the design speeds and by the limits for cant but shall not be less than 120m. The horizontal curve parameters are tabulated below in **Table 5.44.**

TABLE 5.44: HORIZONTAL CURVE PARAMETERS

Description	Elevated Section
Desirable Minimum Radius	200 m
Absolute minimum Radius	120 m
Minimum curve radius at stations	1000 m
Maximum permissible cant (Ca)	110 mm*
Maximum cant deficiency (Cd)	85 mm
* The applied cant will be decided in relation to normal operating speeds at specific locations like stations/vicinity to stations.	

A) Reverse Curves

The use of reverse curves is discouraged but where necessary, the two curves have been separated by minimum 25 m. If provision of 25 m straight length is restricted by physical constraints, the two curves have provided without any straight in between.

B) Transition Curves

It is necessary to provide transition curves at both ends of the circular curves for smooth transition from straight section to curved section and vice-versa. **Table 5.45** shows required Length of transitions for Horizontal curves.

TABLE 5.45: LENGTH OF TRANSITIONS OF HORIZONTAL CURVES

Minimum Length	0.44 *actual cant (in mm) 0.44 * cant deficiency (in mm) whichever is higher
Desirable Length	0.72 *actual cant (in mm) 0.72 * cant deficiency (in mm) whichever is higher
Minimum Straight between two transition curves	25 m or NIL
Minimum horizontal curve length between two transition curves	25 m
No Overlap is allowed between transition curves and vertical curves	

5.3.2.4. Vertical Alignment

The purpose of this section is to establish criteria for use in all design stages of the vertical alignment and track centre of the viaduct, tunnel, station and depot area.

Elevated Section

As per para 2.12.2 of IRC: SP-73, "Minimum 5.50 m vertical clearance shall be provided from all points of the carriageway of project Highways to the nearest surface of the overpass structure". However, it is recommended to keep suitable margin for future raising of road by resurfacing etc. Rail level will also depend upon the type and detailed design of pier cap and super-structure elements.

Rail levels at elevated station locations have been proposed by providing minimum vertical clearance and con-course of 3.50 m. Structural design of con-course floor slabs and viaduct will also govern the final rail level. **Table 5.46** shows required Track centres and height for elevated station.

TABLE 5.46: TRACK CENTRE AND HEIGHT IN ELEVATED SECTION

Parameter	Minimum Track Centre	Minimum Rail Level above Ground Level
Mid-Section	4.10 m	9.50 m
Station w/o Scissor Cross-over	4.10 m	13.50 m
Station with Scissor Cross-over	4.50 m	13.50 m

5.3.2.5. Gradients

A) Mid-Section

The grade on the mid-sections shall not be generally steeper than 2.0%. However, there are a few situations, where steeper gradients are unavoidable, such as:

- Where the existing road gradient is more than 2% as the elevated section is kept parallel to the road surface to minimise the rail level (to reduce the pier height).

Suitable longitudinal grades with drains at the low point are proposed for assuring proper drainage.

B) Stations

Preferably, all stations have been planned on level stretch. There shall be no change of grade on turnouts on the track.

TABLE 5.47: GRADIENT PARAMETERS

Description	Desirable	Absolute Minimum
Gradient at Mid-Section	Upto 2%	Upto 4% (compensated)
Gradient at Stations	Level	Upto 0.25%

5.3.2.6. Vertical Curves

Vertical curves are to be provided when change in gradient exceeds 0.4%. However, it is recommended that all changes in grade shall be connected by a circular curve or by a parabolic curve.

It is proposed that vertical curves and transition curves of horizontal alignment do not overlap. Minimum radius and length of vertical curves are shown in **Table 5.48.**

TABLE 5.48: VERTICAL CURVE PARAMETERS

Parameter	Vertical Curve
Desirable Radius on Main line	2500 m
Absolute Minimum Radius on Main line	1500 m
Minimum Length of Vertical Curve	20 m

5.3.2.7. Design Speed

The Design speed has been taken as 90 Kmph. The maximum sectional speed will be 80 kmph, subject to further restriction by radius of horizontal curves, cant and cant deficiency. The parameters of radius of horizontal curve, cant and permitted speed are summarized below **Table 5.49** shows Radius, Cant and Permitted Speed as per SOD of the NMRCL.

TABLE 5.49: RADIUS, CANT AND PERMITTED SPEED

Radius (m)	Actual Cant (Ca) (mm)	Permitted Speed (km/h)
3000 or more	15	80
2800	15	80
2400	20	80
2000	20	80
1600	25	80
1500	30	80
1200	35	80
1000	40	80
800	55	80
600	70	80
500	90	80
450	95	75
400	105	75
350	110	70
300	110	65
200	110	50
190	110	50

Radius (m)	Actual Cant (Ca) (mm)	Permitted Speed (km/h)
175	110	50
150	110	45
120	110	40

5.3.3. Geotechnical Investigtion

5.3.3.1. Coverage

Geotechnical Investigation was carried out by RITES with the objective of determining subsurface profile of the underlying strata and required strength characteristics of the underlying soil / rock strata in order to propose the suitable substructure for elevated section, stations buildings and other buildings.

Geotechnical report includes field investigation, laboratory test results of the soil samples to evaluate the soil parameters and recommendations with regard to suitable sub-structure which may be adopted for various elevated structures.

5.3.3.2. Physiography & Climate

Nagpur district is one of the nine districts of Vidarbha region of Maharashtra State. It is situated on the eastern part of the State abutting Chindwada district of Madhya Pradesh in north. It is bounded by Wardha and Amravati districts in the west, Bhandara district in the east and Chandrapur district in the south. It lies between north latitudes 20°35’ and 21°44’ and east longitudes 78°15’ and 79°40’ and falls in Survey on India topo-sheets 55 K and P. The district has a geographical area of 9892 sq. km.

The district headquarters is located at Nagpur Town. For administrative convenience, the district is divided in 14 talukas viz, Nagpur (Urban), Saoner, Parseoni, Ramtek, Mouda, Kamthi, Kuhi, Bhiwapur, Umrer, Nagpur (Rural), Hingna, Katol, Narkhed and Kalmeshwar. It has a total population of 40.51 lakhas per 2001 census. The district has 29 towns, 1562 inhabited villages and 312uninhabited villages. The district forms part of Godavari basin. Wainganga River is the main river flowing through the district.

The climate of the district is characterized by a hot summer and general dryness throughout the year except during the south-west monsoon season, i.e., June to September. The mean minimum temperature is 12°C and means maximum temperature is more than 45°C. The normal annual rainfall (1901-1992) over the district ranges from about 1000 mm to 1200 mm. It is the minimum in the western parts around Katol (985.4mm) and increases in the eastern direction and reaches a maximum around Umrer (1213.6 mm). Rainfall data from 14 rain gauge stations for the periods 2002-2011 are given in table 3. The average annual rainfall for the last 10 years ranges from 753.9 in Hingni to 1164.9 in Umrer. It is also observed that all stations have recoded average annual rainfall within the range of district normal annual rainfall except at Hingni, Katol, Narkhed and Kamleshwar.

5.3.3.3. General Geology & Related Characteristics

The district forms part of Deccan Plateau having flat topped and terraced features. Eastward and northeastwards the landscape changes due to the change in the underlying rocks. The rocks of Gondwana series present a low rolling topography with a poor soil cover and vegetation. On the north the upland ranges are the extension of Satpuras which gradually narrows down towards west. South of these upland range stretches the Ambegad hills, the western extremity of which is the Nagpur district. The Ramtek temple is on the spur of this range. The Girad hill range extends along the southeast and separates the valley of the Kar from that of Jamb uptoKondhali. Another main hill range runs northwards through Katoltaluka from Kondhali to Kelod separating the Wardha and Wainganga valleys. The northeastern and east central parts of the district are drained by the Wainganga and its tributaries. The central and western portion is drained by the Wena which is a tributary of Wardha River. There are six types of soils found in Nagpur district.

The details are as follows:

1) Kali soils: These are black cotton soils which are fine grained clayey in texture and varies in depth from 1 m to 6 m or more and retain moisture. They are found around Kalmeshwar, Saoner and Nagpur.

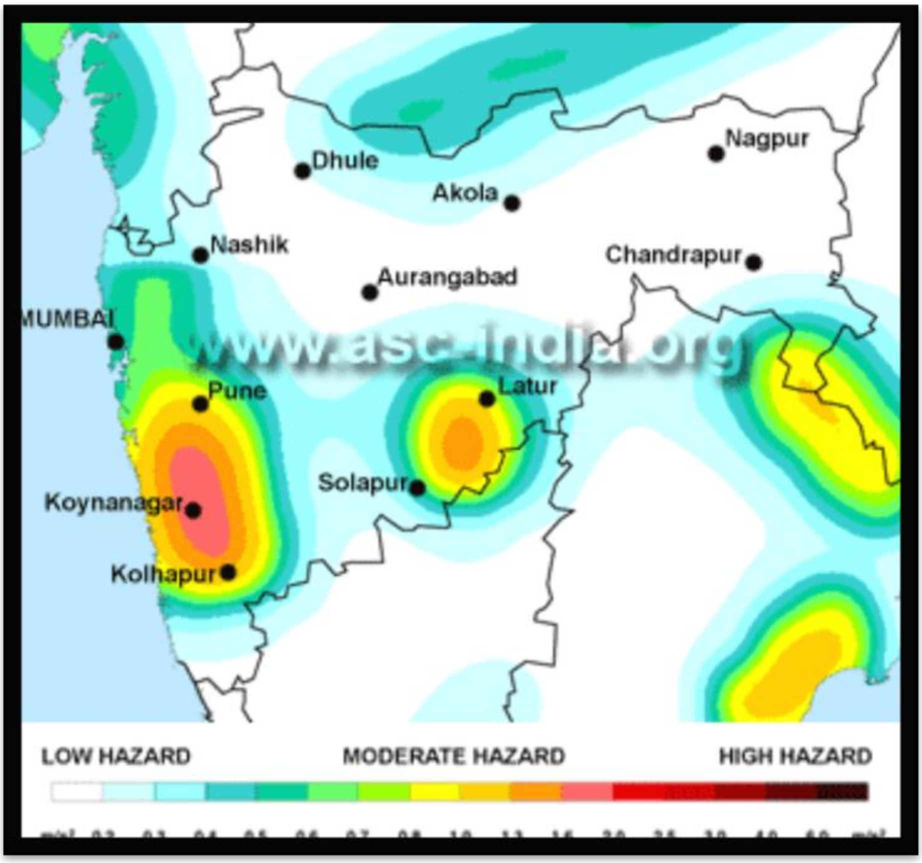
2) Morand soils: These are predominant in the district. They are black cotton soils with higher percentage of lime than the Kali soils. They are black, grey or light to dark brown in colour, clayey in texture and have a depth of about 1 to 3 m.

3) Khardi soils: They are shallow soils mixed with sand and found mainly in hills. These are grey in colour, clay loam in texture.

4) Bardi soils: They are red gravel covered with boulders found on summits and slopes of trap hills and are less fertile in nature.

5) Kachchar soils: They are mainly found in the banks of Kanhanriver and are alluvial soils, loamy in nature and vary in depth from 1 to 3 m.

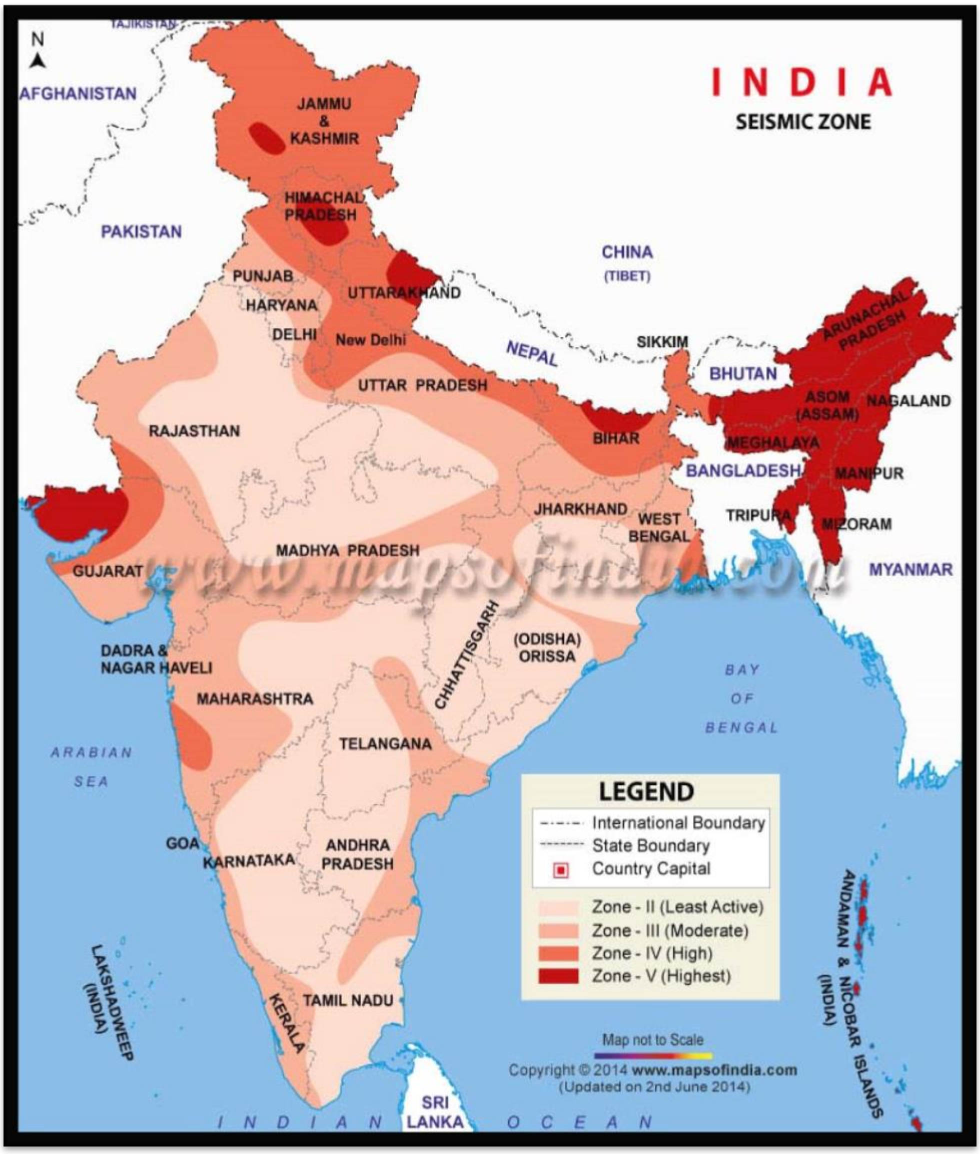
6) Wardi soils: They are red soils with a large amount of sand. They are shallower and clayey loam in nature. They are mainly found in the paddy tracts in the eastern part of the district.



The layers of freshwater sedimentary rock, usually known as intertrappeans, interbedded with the igneous lava-flows of the Deccan Trap, abound to the west of Nagpur. They vary from a few inches in thickness up to about 5 feet. Blanford notices several occurrences of these rocks, namely at Dhapewara, between Bokhara and Mahurjhari, at Takli, at Sitabaldi, and near Telinkheri. The character of these rocks is very variable; they may be calcareous, argillaceous, cherty, or composed of trap detritus. From some of the exposures in the Nagpur District, large numbers of fossils have been collected. The most famous locality is Takli. The collections made by Hislop, Hunter, and their friends included bones, probably reptilian, remains of a peninsula India the state of Maharashtra, along with Gujarat and Madhya Pradesh, has suffered from frequent earthquakes, both deadly and damaging, although not located on or near any plate boundaries.

All the earthquakes here, as in all of peninsula India, are interpolating events. In the 20th century alone, three earthquakes with magnitudes greater than 6.0 were recorded here. According to GSHAP data, the state of Maharashtra falls in a region of moderate to high seismic hazard. As per the 2002 Bureau of Indian Standards (BIS) map, Maharashtra also falls in Zones II, III & IV. Historically, parts of this state have experienced seismic activity in the M6.0-6.5 range. Approximate locations of selected towns and basic political state boundaries are displayed. This map can be reproduced in print or electronically for non-commercial use provided the embedded website link is not removed and use it to organise these maps on your computer for future reference.

FIGURE 5.15: SEISMIC MAP OF INDIA



5.3.3.4. Scope of Investigations

Field Investigation at the site were planned to determine the required strength characteristics of the underlying soil/rock to design the foundations of the proposed structure to be constructed. The Geotechnical investigation work includes:

a) Drilling of 150mm diameter boreholes in all kind of soil including gravels and cobbles, & 76 mm dia. drilling in Weathered Rock, Soft Rock & hard Rock up to depth ranging from 6m to 30m. Boreholes have been terminated at shallower depth after completing at least 3 m drilling in fresh and hard Rock. These bore holes have been drilled at an interval of about 1000m c/c distance along the alignment or at change of strata.

b) Conducting Standard Penetration test (SPT) at every 3.0 m interval upto borehole termination depth.

c) Collection of disturbed & undisturbed soil samples as per IS: 2132, IS: 1892.

d) Following laboratory tests were conducted on collected soil samples:

TABLE 5.50: LABORATORY TESTS ON SOIL

S. No.	Particulars of properties	Relevant is code	Disturbed samples	Undisturbed samples
1.	Sieve Analysis	IS 2720 (part IV)	✓	✓
2.	Natural Moisture Content	IS 2720 (part II)		✓
3.	Bulk/Dry Density	IS 2720 (part II)		✓
4.	Specific Gravity	IS 2720 (part III)		✓
5.	Atterberg's Limit	IS 2720 (part V)	✓	✓
6.	Direct Shear test	IS 2720 (part XIII)		✓
7.	Triaxial Shear Test	IS 2720 (part XI)		✓

e) Following laboratory tests were conducted on selected Rock samples:

TABLE 5.51: LABORATORY TESTS ON ROCK SAMPLES

S. No.	Particulars of properties	Relevant is code	Rock core samples
1.	Water Absorption	IS 1330	√
2.	Porosity	IS 1330	√
3.	Specific Gravity	IS 1330	√
4.	Uniaxial Compressive Strength	IS 8764	√
5.	Point load Index	IS 8764	√

5.3.3.5. Details Of Geotechnical Investigation

A. General

In total, **21 (Phase -IIB) + 34 (Extensions) = 55 BHs** have been drilled up to a maximum 30.00 m depth each for all along the length of proposed alignment. Details of Boreholes drilled are given in **Table 5.52**, **Table 5.53, Table 5.54, Table 5.55 & Table 5.56** below.

TABLE 5.52: MIHAN – MIDC ESR CORRIDOR OF ABOUT 18.65 KM

BH No	BH Location	Water Table (m B.G.L)	Depth of Borehole (m)	Chainage (m)
C-4/1	Near Eco Park Metro Station	3.00	10.50	20260
C-4/2	Near Metro City Station	3.00	12.00	20850
C-4/2(A)	Near Jamtha stadium railway crossing	6.20	12.00	21500
C-4/3	Near Gavsi-Manapur	2.00	16.00	22538
C-4/4	Near Ashok Van	5.00	10.50	23550
C-4/5	Near Sandesh City Crossing	3.80	13.50	24450
C-4/6	Gumgaon Railway Station	3.00	7.50	25500
C-4/7	Near Dongargaon	4.50	10.50	26500
C-4/8	Near Mohgaon	4.50	7.50	27350
C-4/9	Near Bothali Crossing	10.50	12.00	28500
C-4/10	Near Mohgaon Village	2.00	10.50	29275
C-4/11	Near CIDCO	3.00	15.00	30075
C-4/12	Near Venkatesh Hills Crossing	4.50	9.00	31285
C-4/13	Near Mulak Collage Crossing	3.70	12.00	32425
C-4/14	Near Butibori Police Station	3.00	10.50	33480
C-4/15	ITI Collage Crossing	3.50	10.50	33760
C-4/16	Mhada Colony & Balbharti Crossing	9.00	10.50	34390
C-4/17	Mhada Clony	6.00	30.00	35115
C-4/17(A)	Left bank of Vena river	6.00	21.00	35633
C-4/18	Near Sukali Crossing	4.00	25.50	35925
C-4/19	MIDC -I	3.50	12.00	37450
C-4/20	MIDC -II	4.00	13.50	38480

TABLE 5.53: SUMMARY OF BORE HOLES DRILLED ALONG CORRIDORS (AUTOMOTIVE SQUARE - KANHAN RIVER (KAMPTEE) CORRIDOR OF ABOUT 12.92 KM)

BH No	BH Location	Water Table (m B.G.L)	Depth of Borehole (m)	Chainage (m)
BH-13	Infront of NIT Parking Terminus	4.30	20.00	-675
C-1/1(A)	Near Pili Nadi	6.50	30.00	-960

BH No	BH Location	Water Table (m B.G.L)	Depth of Borehole (m)	Chainage (m)
BH-14	Near Railway Overbridge	5.00	20.00	-1850
BH-15	Near All India Radio Meto Station	4.00	21.00	-3400
BH-16	Near Mahindra Land	9.00	20.00	-4250
BH-17	Near HP Petrol Pump	3.50	15.00	-5350
BH-18	Near Indian Oil Petrol Pump	7.50	22.00	-6075
BH-19	Near Lekha Nagar Metro Station	3.60	21.00	-7525
BH-20	Near Cantonment Metro Station	7.00	20.00	-8725
BH-21	Near Relief Hospital	6.30	20.00	-9025
C-1/1	Near Dragon palace	3.70	27.00	-11475
C-1/2	Near officers' mess	4.60	24.00	-12450
C-1/3	Bank of river Kanhan	4.00	25.50	-13400

TABLE 5.54: LOKMANYA NAGAR - HINGNA CORRIDOR OF ABOUT 6.66 KM

BH No	BH Location	Water Table (m B.G.L)	Depth of Borehole (m)	Chainage (m)
BH-1	Near Indian Bureau of Mines	5.50	18.00	18200
BH-2	Near Datta Meghe Polytechnic College	Not met	10.00	19850
BH-3	Near Toll Booth Shed	5.00	15.00	20400
C-3/1	Near forest office, Wanadongari	Not met with	6.00	20765
C-3/2	Near Dangarpura crossing	6.00	15.00	21900
C-3/2(A)	Near Nala crossing	6.00	12.00	22485
C-3/3	Near Raipur Bridge	3.80	10.00	23100
C-3/4	Near Hingna Tehsil office	3.00	15.00	23750
C-3/5	Near Hingna Gramin Hospital	7.00	18.00	24815

TABLE 5.55: PRAJAPATI NAGAR TO TRANSPORT NAGAR CORRIDOR OF ABOUT 5.44 KM

BH No	BH Location	Water Table (m B.G.L)	Depth of Borehole (m)	Chainage (m)
BH-9	Near Pardi Bazaar Chowk	5.40	20.00	-250
BH-10	Near Mehar	5.40	20.00	-2175

BH No	BH Location	Water Table (m B.G.L)	Depth of Borehole (m)	Chainage (m)
	Celebration Lawn			
BH-11	Near Mahalaxmi Trading Corporation	1.50	20.00	-3050
C-2/2	Near Ghar Sansar Nagar chowk	2.70	30.00	- 4300
BH-12	Near Bharti Industries Rice Mill	2.40	20.00	-4475
C-2/1	Transport Nagar	9.00	30.00	- 5000

TABLE 5.56: VASUDEV NAGAR TO DATTAWADI CORRIDOR OF ABOUT 4.49 KM

BH No	BH Location	Water Table (m B.G.L)	Depth of Borehole (m)	Chainage (m)
BH-4	Near Honda Mascot Motors	6.00	10.00	15800
BH-5	Near Superior Drink Pvt. Ltd.	3.80	10.00	16725
BH-6	Near Ujjwal Ispat Pvt. Ltd.	4.20	10.00	18075
BH-7	Near Renault Showroom	2.20	10.00	19475
BH-8	Near Dattawadi Junction	2.50	10.00	20050

B. Standard Penetration Test (SPT)

SPT was conducted in the boreholes at every 3.0 m interval and change of strata as per specifications. Standard split spoon sampler attached to lower end of drill rods was driven in the boreholes by means of standard hammer of 63.50 kg falling freely from a height of 75 cm. The sampler was driven 45 cm as per specifications and number of blows required for each 15 cm penetration was recorded. The number of blows for the first 15 cm penetration was not taken into account as it is considered seating drive. The number of blows for next 30 cm penetration was designated as SPT 'N' value.

Wherever the total penetration was less than 45 cm, the number of blows & the depth penetrated is incorporated in respective bore logs. Disturbed Soil samples obtained from standard split spoon sampler were collected in polythene bags of suitable size. These samples were properly sealed, labeled, recorded and carefully transported to laboratory for testing.

C. Undisturbed Soil Samples (UDS)

UDS were collected from the boreholes at every 3.0 m interval & change of strata as per sampling specifications, in thin walled sampling tubes of 100 mm dia. and 450 mm length. These sampling tubes after retrieval from the boreholes were properly waxed and sealed at both ends. These were carefully labeled and transported to the laboratory for testing. UDS wherever could not recover due to presence of hard strata or slipped during lifting, were duly marked in the respective bore logs.

The depth of Ground Water Table was measured in all bore holes. The location plan of boreholes drilled is given below:

FIGURE 5.16: MIHAN TO MIDC ESR

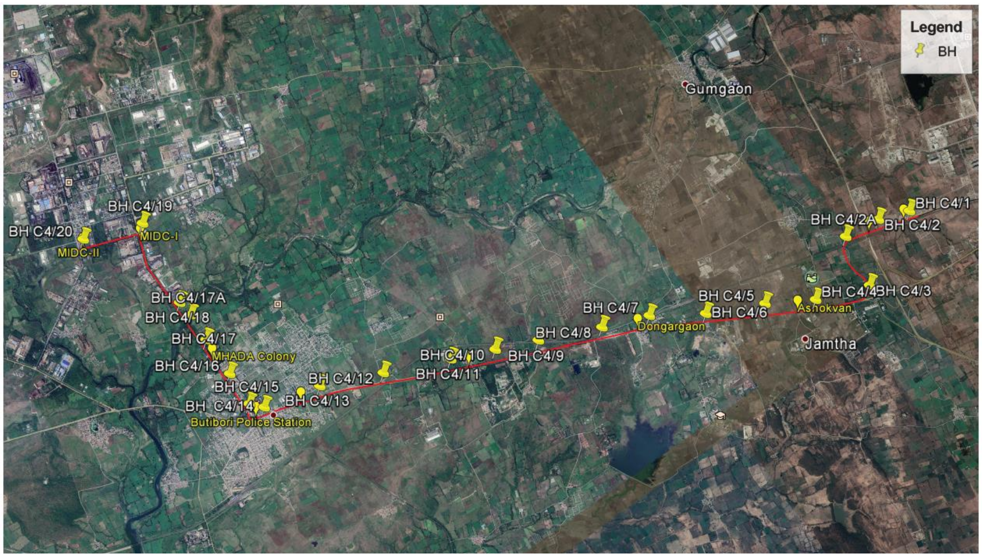


FIGURE 5.17: AUTOMOTIVE SQUARE TO KANHAN RIVER

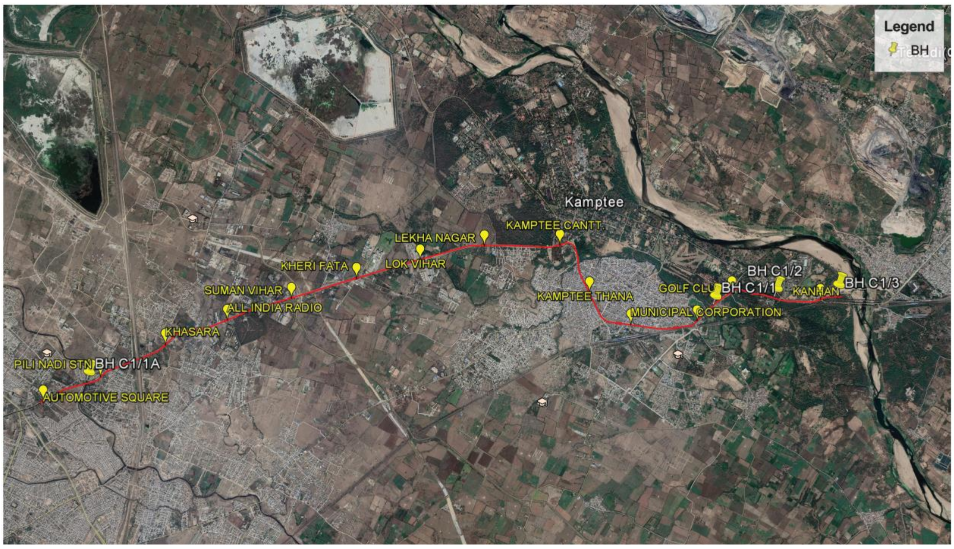


FIGURE 5.18: LOKMANYA NAGAR TO HINGNA

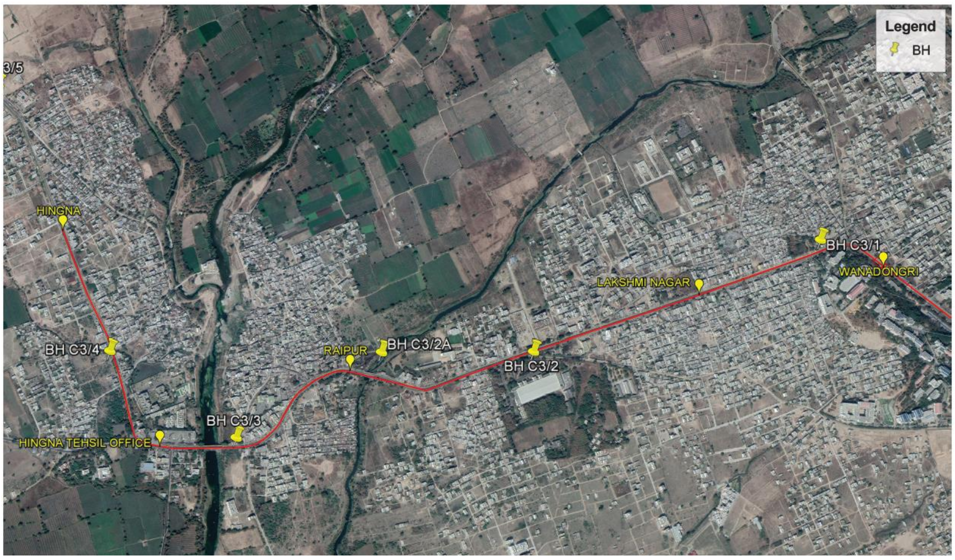


FIGURE 5.19: PRAJAPATI NAGAR TO TRANSPORT NAGAR

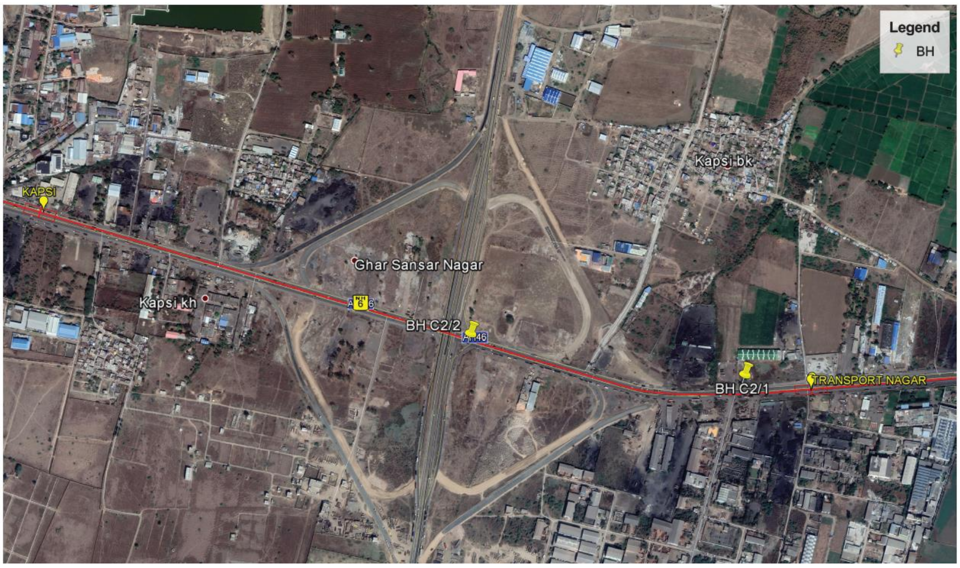


FIGURE 5.20: VASUDEV NAGAR TO DATTAWADI

5.3.3.6. Engineering Parameters of Each Layer

Sub Soil Profile

The sub-soil strata at proposed alignment are generally homogeneous and comprises of mainly three types of layers (based on field tests & laboratory test result data). Details of layer met along the various corridors are tabulated below in **Table 5.57, Table 5.58,**

Table 5.59, **Table 5.60** & **Table 5.61.**

LAYER TYPE-I: Overburden comprising of silty sandy soil with gravels and pebbles yellowish brown in colour.

LAYER TYPE-II: Moderately to highly weathered amygdaloidal basalt/augen gneiss.

LAYER TYPE-III: Bedrock Rock comprising fresh & hard Basalt with zeolite/ augen gneiss.

TABLE 5.57: DETAILS OF LAYER MET IN MIHAN - MIDC ESR CORRIDOR

BH Nos.	BH Location (Name of proposed metro stations)	LAYER TYPE –I Depth (m)		LAYER TYPE –II Depth (m)		LAYER TYPE –III Depth (m)	
		From	TO	From	TO	From	TO
C-4/1	Near Eco Park Metro Station	0.00	1.50	1.50	4.50	4.50	10.50
C-4/2	Near Metro City Station	0.00	1.50	1.50	9.00	9.00	12.00
C-4/2(A)	Near Jamtha stadium railway crossing	0.00	1.50	1.50	9.00	9.00	12.00
C-4/3	Near Gavsi-Manapur	0.00	4,50	4.50	12.00	12.00	16.00
C-4/4	Near Ashok Van	0.00	1.50	1.50	7.50	7.50	10.50
C-4/5	Near Sandesh City Crossing	-	-	0.00	10.50	10.50	13.50
C-4/6	Gumgaon Railway Station	0.00	1.50	1.50	4.50	4.50	7.50
C-4/7	Near Dongargaon	-	-	0.00	7.50	7.50	10.50
C-4/8	Near Mohgaon	-	-	0.00	4.50	4.50	7.50
C-4/9	Near Bothali Crossing	0.00	3.00	3.00	9.00	9.00	12.00
C-4/10	Near Mohgaon Village	-	-	0.00	7.50	7.50	10.50
C-4/11	Near CIDCO	-	-	0.00	12.00	12.00	15.00
C-4/12	Near Venkatesh Hills Crossing	-	-	0.00	6.00	6.00	9.00
C-4/13	Near Mulak Collage Crossing	0.00	4.50	4.50	9.00	9.00	12.00
C-4/14	Near Butibori Police	0.00	1.50	1.50	7.50	7.50	10.50

BH Nos.	BH Location (Name of proposed metro stations)	LAYER TYPE –I		LAYER TYPE –II		LAYER TYPE –III	
		Depth (m)		Depth (m)		Depth (m)	
		From	TO	From	TO	From	TO
	Station						
C-4/15	ITI Collage Crossing	-	-	0.00	7.50	7.50	10.50
C-4/16	Mhada Colony & Balbharti Crossing	-	-	0.00	6.00	6.00	10.50
C-4/17	MhadaClony	0.00	1.50	1.50	25.50	25.50	30.00
C-4/17(A)	Left bank of Vena river	0.00	4.50	4.50	18.00	18.00	21.00
C-4/18	Near Sukali Crossing	0.00	6.00	6.00	21.00	21.00	25.50
C-4/19	MIDC -I	0.00	7.50	7.50	9.00	9.00	12.00
C-4/20	MIDC -II	0.00	3.00	3.00	10.50	10.50	13.50

TABLE 5.58: DETAILS OF LAYER MET IN AUTOMOTIVE SQUARE - KANHAN RIVER (KAMPTEE) CORRIDOR

BH Nos.	BH Location (Name of proposed metro stations)	LAYER TYPE –I		LAYER TYPE –II		LAYER TYPE –III	
		Depth (m)		Depth (m)		Depth (m)	
		From	TO	From	TO	From	TO
BH-13	Infront of NIT Parking Terminus	0.00	20.00	-	-	-	-
C-1/1(A)	Near Pili Nadi	0.00	10.50	10.50	30.00	-	-
BH-14	Near Railway Overbridge	0.00	12.00	12.00	17.00	17.00	20.00
BH-15	Near All India Radio Metro Station	0.00	16.00	16.00	21.00	-	-
BH-16	Near Mahindra Land	0.00	13.50	13.50	20.00	-	-
BH-17	Near HP Petrol Pump	0.00	3.50	3.50	15.00	-	-
BH-18	Near Indian Oil Petrol Pump	0.00	7.50	7.50	22.00	-	-
BH-19	Near Lekha Nagar Metro Station	0.00	4.50	4.50	22.00	-	-
BH-20	Near Cantonment Metro Station	0.00	1.50	1.50	20.00	-	-
BH-21	Near Relief Hospital	0.00	1.00	1.00	20.00	-	-
C-1/1	Near Dragon palace	0.00	6.00	6.00	24.00	24.00	27.00
C-1/2	Near officer’s mess	0.00	15.00	15.00	24.00	-	-
C-1/3	Bank of river Kanhan	0.00	12.00	12.00	25.50	-	-

TABLE 5.59: DETAILS OF LAYER MET IN LOKMANYA NAGAR - HINGNA CORRIDOR

BH Nos.	BH Location (Name of proposed metro stations)	LAYER TYPE –I Depth (m)		LAYER TYPE –II Depth (m)		LAYER TYPE –III Depth (m)	
		From	TO	From	TO	From	TO
BH-1	Near Indian Bureau of Mines	0.00	2.50	2.50	12.00	12.00	18.00
BH-2	Near Datta Meghe Polytechnic College	0.00	1.00	1.00	5.00	5.00	10.00
BH-3	Near Toll Booth Shed	0.00	1.00	1.00	12.00	12.00	15.00
C-3/1	Near forest office, Wanadongari	0.00	1.50	1.50	3.00	3.00	6.00
C-3/2	Near Dangarpura crossing	0.00	1.50	1.50	9.00	9.00	15.00
C-3/2(A)	Near Nala crossing	0.00	3.00	3.00	9.00	9.00	12.00
C-3/3	Near Raipur Bridge	0.00	1.50	1.50	6.00	6.00	10.00
C-3/4	Near Hingna Tehsil office	0.00	6.50	6.50	10.50	10.50	15.00
C-3/5	Near HingnaGramin Hospital	0.00	1.50	1.50	7.50	7.50	13.50

TABLE 5.60: DETAILS OF LAYER MET IN PRAJAPATI NAGAR TO TRANSPORT NAGAR CORRIDOR

BH Nos.	BH Location (Name of proposed metro stations)	LAYER TYPE –I Depth (m)		LAYER TYPE –II Depth (m)		LAYER TYPE –III Depth (m)	
		From	TO	From	TO	From	TO
BH-9	Near Pardi Bazaar Chowk	0.00	1.00	1.00	10.50	10.50	20.00
BH-10	Near Mehar Celebration Lawn	0.00	4.50	4.50	16.5	16.5	20.00
BH-11	Near Mahalaxmi Trading Corporation	0.00	20.00	-	-	-	-
C-2/1	Transport Nagar	0.00	10.50	10.50	30.00	-	-
BH-12	Near Bharti Industries Rice Mill	0.00	5.50	5.50	20.00	-	-
C-2/2	Near Ghar Sansar Nagar chowk	0.00	9.00	9.00	28.50	28.50	30.00

TABLE 5.61: DETAILS OF LAYER MET IN VASUDEV NAGAR - DATTAWADI CORRIDOR

BH Nos.	BH Location (Name of proposed metro stations)	LAYER TYPE –I Depth (m)		LAYER TYPE –II Depth (m)		LAYER TYPE –III Depth (m)	
		From	TO	From	TO	From	TO
BH-4	Near Honda Mascot Motors	0.00	1.50	1.50	4.00	4.00	10.00
BH-5	Near Superior Drink Pvt. Ltd.	0.00	1.00	1.00	4.00	4.00	10.00
BH-6	Near Ujjwal Ispat Pvt. Ltd.	0.00	1.00	1.00	5.00	5.00	10.00

BH Nos.	BH Location (Name of proposed metro stations)	LAYER TYPE –I Depth (m)		LAYER TYPE –II Depth (m)		LAYER TYPE –III Depth (m)	
		From	TO	From	TO	From	TO
BH-7	Near Renault Showroom	0.00	0.50	0.50	4.50	4.50	10.00
BH-8	Near Dattawadi Junction	0.00	1.00	1.00	5.00	5.00	10.00

5.3.3.7. Foundation Analysis

A. Introduction

The structures along the proposed alignment have been explored by drilling of 30boreholes down to depth ranging from 6m to 30m below ground level.

Depth of Foundation in Soil

A foundation must have an adequate depth from considerations of adverse environmental influences. It must also be economically feasible in terms of overall structure. Depth of foundations in soil shall be decided as per clause 7 of IS: 1904 for special cases like; where volume change is expected / scour is expected / foundations on sloping ground / foundation on made up or filled up ground / frost action is expected etc.

B. Safe Bearing Pressure of Shallow Foundations

Estimate of Safe Bearing Pressure from the Core Strength

As per IS: 12070-1987, In case of rock mass with favorable characteristics (that is, rock surface is parallel to the base of the foundation, the load has no tangential component, the rock mass has no open discontinuities). The safe bearing pressure should be estimated from the equation:

$$qs = qc \times Nj$$

Where,

Qs = Safe bearing pressure (gross)

qc = Average UCS of the rock cores

Nj = Empirical coefficient depending upon the spacing of discontinuities.

$$= \frac{3 + S/B_f}{10\sqrt{(1 + 300\delta/S)}}$$

δ = Thickness of discontinuity in cm

S = Spacing of discontinuities in cm

Bf = Footing width in cm (Assumed)

Note: This formula gives safe gross bearing pressure with a factor of safety of 3.

The relationship given is valid for a rock mass with a spacing of discontinuities greater than 0.3 m, aperture (opening) of discontinuities less than 10 mm (15 mm if filled with soil or rock debris) and a foundation width of greater than 0·3 m.

Estimate of Safe Bearing Pressure (Qs) Based on Classification of Material

MATERIAL	qs(t/m2)
Massive crystalline bedrock including granite, diorite, gneiss, trap rock	1000
Foliated rocks such as schist or slate in sound condition	400
Bedded Limestone in sound condition	400
Sedimentary rock, including hard shales and sandstones	250
Soft or broken bedrock (excluding shale), and soft limestone	100
Soft shale	40

The calculation of bearing capacity, the distribution of stresses, and the prediction of settlement and the choice of allowable load will depend on the following factors, which should be fully considered during design:

i. Occurrences during Excavation

a. Undulating rock surface below a level ground;
b. Heterogeneity of rock mass (the bearing capacity may vary up to 10 times in apparently the same rock mass because of presence of localized fractures/ shear zones/ clay/ gauge/clay weathering/ alternate hard and soft beds, etc.
c. Solution and gas cavities;
d. Wetting, swelling and softening of shales/phyllite and expansive clays;
e. Bottom heave;
f. Potential unstable conditions of the slope and
g. High in situ horizontal stresses.

ii. Adjacent Construction Activities

a. Blasting (Controlled blasting techniques such as line drilling, cushion blasting and pre splitting are available if it is necessary to protect the integrity of the work just outside the excavation);
b. Excavation: and
c. Ground water lowering (excepting in highly pervious sedimentary rock, this phenomenon is rare in most of igneous and metamorphic rocks) and
d. Undesirable seismic response of the foundation.

iii. Other Effects

a. Scour and erosion (in case of abutments and piers);

b. Frost action;
c. Flooding (only erodible rocks like shale and phyllite); and
d. Undesirable seismic response of the foundation.

C. PILES IN INTERMEDIATE GEO-MATERIAL: (IRC: 78-2014)

Piles in rocks and weathered rocks of varying degree of weathering derive their capacity by end bearing and socket side resistance. The ultimate load carrying capacity may be calculated from one of the two approaches given below:

Where cores of the rock can be taken and unconfined compressive strength directly established using standard method of testing, the approach described in method 1 shall be used. In situations where strata is highly fragmented, where RQD is NIL or(CR+RQD)/2 is less than 30 percent, or where strata is not classified as a granular or clayey soil, or when the crushing strength is less than 10 MPa, the approach described in method 2 shall be used. Also, for weak rock like chalk, mud stone, clay stone, shale and other intermediate rocks, method 2 is applicable

METHOD 1:

$Q_u = R_e + R_{af} = K_{sp}.*q_c *d_f* A_b + A_s *C_{us}$

Q allow= (Re/3) + (Ra/6)

Where,

Qu = Ultimate capacity of pile socketed into rock in Newton

Q allow = Allowable capacity of Pile

Re = Ultimate end bearing

Raf = Ultimate side socket shear

K s p = An empirical co-efficient whose value ranges from 0.3 to 1.2 as per the table below for the rocks where core recovery is reported, and cores tested for uniaxial compressive strength.

(CR + RQD)/2	K_{sp}
30%	0.3
100%	1.2

CR = Core Recovery in percent

RQD - Rock Quality Designation in percent

For Intermediate values, Kp shall be linearly interpolated

qc = Average unconfined compressive strength of rock core below base of pile for the depth twice the diameter/least lateral dimension of pile in MPa

Ab= Cross-sectional area of base of pile

df = Depth factor = 1 + 0.4 x (Length of Socket / Diameter of Socket)

However, value of dfshould not be taken more than 1.2.

As = Surface area of socket

cus= Ultimate shear strength of rock along socket length,

= 0.225 √qc, but restricted to shear capacity of concrete of the pile, to be taken as 3.0 MPa for M 35 concrete in confined condition, which for other strength of concrete can be modified by a factor√ (fck/35)

METHOD: 2

This method is applicable when cores and or core testing results are not available, or when geo-material is highly fragmented. The shear strength of geo-material is obtained from its correlation with extrapolated SPT values for 300 mm of penetration is given in table below:

Shear Strength/ Consistency	Moderately weak	Weak	Very Weak
Approx N Value	300-200	200-100	100-60
Shear Strength /Cohesion in MPa	3.3-1.9	1.9-1.7	0.7-0.4

Qu = Re +Raf = Cub *Nc*Ab +Cus *As

Qallow=(Re/3) + (Raf/6)

Where,

Cub = Average shear strength below base of pile, for the depth equal to twice the diameter / least lateral dimension of pile, based on average 'N' Value of the region

Cus = Ultimate shear strength along socket length, to be obtained from table, based on average 'N' value of socket portion. This shall be restricted to shear capacity of concrete of the pile, to be taken as 3.0Mpa for M35 concrete in confined condition, which for other strengths of concrete can be modified by a factor √(fck/35) Intermediate values Cub and Cus can be interpolated linearly

L = Length of socket
Nc = 9
Qallow = Allowable capacity of pile

The extrapolated values of 'N' greater than 300 shall be limited to 300 while using this method.

5.3.3.8. Safe Bearing Capacity for Shallow and Pile Foundations

A. Safe Load Carrying Capacity Based on Method: 2 (IRC: 78-2014)

The safe pile load carrying capacity for various lengths and 1.2m diameters of piles has been calculated by using method 2 above as the rock is tabulated below in **Table 5.62, Table 5.63**, **Table 5.64**, **Table 5.65** & **Table 5.66.**

TABLE 5.62: SAFE LOAD CARRYING CAPACITY OF PILES RESTING ON ROCK (MIHAN - MIDC ESR CORRIDOR)

S. No	Location	Chainage (m)	Bore hole No	Dimension of pile		Safe load (Tonnes)
				Length (m)	Diameter (m)	
1.	Near Eco Park Metro Station	20260	C-4/1	8.00	1.0	191
					1.2	260
2.	Near Metro City Station	20850	C-4/2	10.00	1.0	196
					1.2	267
3.	Near Jamtha stadium railway crossing	21500	C-4/2(A)	9.00	1.0	193
					1.2	263
4.	Near Gavsi-Manapur	22538	C-4/3	14.00	1.0	245
					1.2	334
5.	Near Ashok Van	23550	C-4/4	8.00	1.0	191
					1.2	260
6.	Near Sandesh City Crossing	24450	C-4/5	12.00	1.0	202
					1.2	273
7.	Gumgaon Railway Station	25500	C-4/6	7.00	1.00	189
					1.20	258
8.	Near Dongargaon	26500	C-4/7	9.00	1.00	193
					1.20	263
9.	Near Mohgaon	27350	C-4/8	7.00	1.00	189
					1.20	258
10.	Near Bothali Crossing	28500	C-4/9	10.00	1.00	196
					1.20	267
11.	Near Mohgaon Village	29275	C-4/10	9.00	1.00	193
					1.20	263
12.	Near CIDCO	30075	C-4/11	13.00	1.00	242
					1.20	330
13.	Near Venkatesh Hills Crossing	31285	C-4/12	8.00	1.00	191
					1.20	260
14.	Near Mulak Collage Crossing	32425	C-4/13	10.00	1.00	196
					1.20	267
15.	Near Butibori Police Station	33480	C-4/14	9.00	1.00	193
					1.20	263
16.	ITI Collage Crossing	33760	C-4/15	9.00	1.00	193

S. No	Location	Chainage (m)	Bore hole No	Dimension of pile Length (m)	Diameter (m)	Safe load (Tonnes)
					1.20	263
17.	Mhada Colony &Balbharti Crossing	34390	C-4/16	8.00	1.00	191
					1.20	260
18.	Mhada Clony	35115	C-4/17	16.00	1.00	249
					1.20	338
19.	Left bank of Vena river	35633	C-4/17(A)	18.00	1.00	252
					1.20	342
20.	Near Sukali Crossing	35925	C-4/18	10.00	1.00	196
					1.20	267
21.	MIDC -I	37450	C-4/19	10.00	1.00	196
					1.20	267
22.	MIDC -II	38480	C-4/20	10.00	1.00	196
					1.20	267

TABLE 5.63: SAFE LOAD CARRYING CAPACITY OF PILES RESTING ON ROCK (AUTOMOTIVE SQUARE - KANHAN RIVER (KAMPTEE) CORRIDOR)

S. No	Location	Chainage (m)	Bore hole No	Dimension of pile Length (m)	Diameter (m)	Safe load (Tonnes)
1.	Infront of NIT Parking Terminus	-675	BH-13	14.00	1.0	221.00
					1.2	346.00
2.	Near Pili Nadi	960	C-1/1(A)	20.00	1.0	250
					1.2	339
3.	Near Railway Overbridge	-1850	BH-14	14.00	1.0	263.00
					1.2	366.00
4.	Near All India Radio Metro Station	-3400	BH-15	15.00	1.0	267.80
					1.2	368.90
5.	Near Mahindra Land	-4250	BH-16	14.00	1.0	255.00
					1.2	354.00
6.	Near HP Petrol Pump	-5350	BH-17	11.00	1.0	277.50
					1.2	374.70
7.	Near Indian Oil Petrol Pump	-6075	BH-18	12.00	1.0	203.0
					1.2	279.00
8.	Near Lekha Nagar Metro Station	-7525	BH-19	15.00	1.0	244.50
					1.2	365.20
9.	Near Cantonment Metro Station	-8725	BH-20	14.50	1.0	233.60
					1.2	345.40
10.	Near Relief Hospital	-9025	BH-21	15.00	1.0	244.60
					1.2	367.90
11.	Near Dragon palace	11475	C-1/1	15.00	1.0	248

S. No	Location	Chainage (m)	Bore hole No	Dimension of pile Length (m)	Diameter (m)	Safe load (Tonnes)
					1.2	337
12.	Near officers mess	12450	C-1/2	17.00	1.0	250
					1.2	339
13.	Bank of river Kanhan	13400	C-1/3	15.00	1.0	248
					1.2	337

TABLE 5.64: SAFE LOAD CARRYING CAPACITY OF PILES RESTING ON ROCK (LOKMANYA NAGAR - HINGNA CORRIDOR)

S.No	Location	Chainage (m)	Bore hole No	Dimension of pile Length (m)	Diameter (m)	Safe load (Tonnes)
1.	Near Indian Bureau of Mines	18200	BH-1	13.00	1.0	288.00
					1.2	399.40
2.	Near Datta Meghe Polytechnic College	19850	BH-2	7.00	1.0	260.00
					1.2	358.70
3.	Near Toll Booth Shed	20400	BH-3	14.00	1.0	256.40
					1.2	318.00
4.	Near forest office, Wanadongari	20765	C-3/1	6.00	1.0	186
					1.2	254
5.	Near Dangarpura crossing	21900	C-3/2	10.00	1.0	196
					1.2	267
6.	Near Nala crossing	22485	C-3/2(A)	10.00	1.0	196
					1.2	267
7.	Near Raipur Bridge	23100	C-3/3	9.00	1.0	193
					1.2	263
8.	Near Hingna Tehsil office	23750	C-3/4	12.00	1.0	202
					1.2	273
9.	Near HingnaGramin Hospital	24815	C-3/5	15.00	1.0	248
					1.2	337

TABLE 5.65: SAFE LOAD CARRYING CAPACITY OF PILES RESTING ON ROCK (PRAJAPATI NAGAR TO TRANSPORT NAGAR CORRIDOR)

S. No	Location	Chainage (m)	Bore hole No	Dimension of pile Length (m)	Diameter (m)	Safe load (Tonnes)
1.	Near Pardi Bazaar Chowk	-250	BH-9	12.00	1.0	278.80
					1.2	372.20
2.	Near Mehar Celebration Lawn	-2175	BH-10	15.00	1.0	284.50
					1.2	382.60
3.	Near Mahalaxmi Trading Corporation	-3050	BH-11	13.50	1.0	255.40
					1.2	345.60

4.	Near Ghar Sansar Nagar chowk	-4300	C-2/2	18.00	1.0	252
					1.2	342
5.	Near Bharti Industries Rice Mill	-4475	BH-12	15.00	1.0	266.10
					1.2	338.00
6.	Transport Nagar	- 5000	C-2/1	17.00	1.0	250
					1.2	339

TABLE 5.66: SAFE LOAD CARRYING CAPACITY OF PILES RESTING ON ROCK (VASUDEV NAGAR - DATTAWADI CORRIDOR)

S. No	Location	Chainage (m)	Bore hole No	Dimension of pile		Safe load (Tonnes)
				Length (m)	Diameter (m)	
1.	Near Honda Mascot Motors	15800	BH-4	7.00	1.0	246.01
					1.2	305.00
2.	Near Superior Drink Pvt. Ltd.	16725	BH-5	7.00	1.0	254.00
					1.2	366.00
3.	Near Ujjwal Ispat Pvt. Ltd.	18075	BH-6	9.00	1.0	283.00
					1.2	386.70
4.	Near Renault Showroom	19475	BH-7	7.50	1.0	266.40
					1.2	372.70
5.	Near Dattawadi Junction	20050	BH-8	9.00	1.0	288.70
					1.2	352.40

B. Safe Bearing Pressurefor Shallow Foundation Resting on Rock

Net Safe Bearing Capacity of shallow foundation at depot locations, where bed rock is met at shallow depth has been calculated as per equation above and tabulated below:

TABLE 5.67: SBC OF SHALLOW FOUNDATION (DEPOT LOCATION)

Bore hole no.	Depth of foundation (m)	Qc (Average UCS of the rock cores in T/m2)	Nj (Empirical coefficient depending upon the Spacing of discontinuities)	Qs (Safe bearing pressure in T/m2)
C-3/1 (Hingna Depot)	3.00	4900	0.1	490
C-4/1 (Mihan Depot)	5.00	4500	0.1	450

5.3.3.9. Conclusions & Recommendations

Fifty-Five boreholes have been drilled down to maximum depth of 30.00 m below ground level for sub soil/Rock exploration. Following is recommended for different type of foundations:

a. Since heavy loads are to be transferred to sub soil strata at viaduct part of alignment therefore Pile Foundations have been recommended for the proposed viaduct

b. The design safe load carrying capacity of Pile Foundation has been given in Table 6 to 9 above.

c. The load capacities of piles are based on empirical correlation's and should be confirmed by conducting **pile load test as per IS: 2911 (Part 4)** on test piles before execution of working piles.

d. Since the proposed site is situated in seismic Zone II of the seismic zonation map of India, suitable seismic coefficient commensurate to seismic Zone III (IS: 1893) should be adopted in the design of the structures.

e. **Socketing of Piles**: Present practice of socketing the piles in rock is being done, or rather being insisted upon, by cutting the sound rock for a minimum of 1D (for large diameter piles). If the pile diameter is 1.2 m, the socketing is to be done for a depth of 1.2 m by chiseling the sound hard rock. Chiseling the hard rock whose crushing strength is of the order of 1000 kg/cm² requires heavy chisel energy and chiseling for more time. Both of these aspects may cause damage to structure of rock.

Piles on rocks carry the load by point bearing. To ensure the proper contact between base of pile and rock surface, it is needed to socket the pile into hard rock by cutting through weathered and soft rock and by cutting the hard rock for a reasonable depth mainly to get the level surface of rock and to remove the top weathered surface of rock. This reasonable depth may vary from 150 mm to 300 mm. Further if soft and medium rocks are preceding the hard rock the socketing length may be counted from the level at which soft rock with N more than 50 has been met. Most of the times there are differences in recognizing the type of rock–weathered/soft/hard. First, the classification of rock layer is to be done properly. For this purpose, we can refer to field test reports like RQD, CRR and SPT results and crushing strength of rock core samples.

f. **Precautions to Be Taken in Rock Socketing:** Apart from drilling\chiseling the rock up to required depth of rock socketing, there are some more very important practical aspects to be observed:

(i) During rock socketing process, heavy chiseling of high torque drilling may produce vibrations. These vibrations may cause destabilization of soft rock/soil strata overlaying the rock layer. Thus the pile will lose friction component from these layers. Hence greater care should be taken to reduce the vibrations.

(ii) Rock socketing takes more time and also imparts disturbance to the layers over laying the rock strata. This disturbance will cause spalling of fine particles which will settle at the bottom. To remove these fine particles and other cuttings, the bore hole should be thoroughly washed with fresh bentonite slurry just before pouring concrete.

References:

i. IS 1892:1979 – Code of Practice for Sub-surface investigation for foundations.
ii. IS 78-2014 (Appendix 5/Method 2): Design and Construction of Pile Foundations
iii. IS 2720- Methods of Tests for Soils (Relevant parts)
iv. IS 2131- Method for Standard Penetration Test for Soils
v. Is 6403: 1981Code for practice for determination of Safe Bearing Capacity of shallow foundation on Soil.

5.3.4. Construction Methodology

Construction of elevated alignment involves following type of constructions: -

- Sub-structure - Columns on Open/Pile foundations with pier cap at top of columns. Alternatively, Portal arrangement is provided at certain locations.

- Superstructure by segmental construction of whole unit construction. Box segments are most common type of segmental construction. I-Girder and U-girder are most common type of non-segmental construction methods where the structural element for whole span length is pre-casted and launched in position.

5.3.4.1. Cast in-situ and Pre-Cast Construction

A. Cast in-situ construction

In cast in-situ construction method, structure is cast at its final location of use. This involves erection of temporary shuttering, scaffolding and support system for casting the structure. The temporary supports and shuttering is removed when the concrete is set and structure attains the strength to bear its dead weight and other loads. This method involves longer construction time and interference to road users for longer period. This method is restricted to casting of substructure - open foundation, pile, pile caps, columns; station structure; earth retaining structures.

B. Pre - cast construction

In this method, structural segments are pre-casted in casting yards, pre-stressed and then transported to the location of use and launched by means of suitable launching arrangement. The structural elements for superstructure i.e. box segments, I-Girders, U-girders and sometimes pile caps are casted by pre-cast technique. Precast construction may be segmental or non-segmental type.

Casting yard is required for casting of precast structural segments and other precast units like U-girder, I-Girder etc. The construction depot has arrangement for casting beds, curing and stacking area, batching plant with storage facilities for aggregates and cement, site testing laboratories, reinforcement steel yard and fabrication yard etc. An area of about 2.5 Ha to 3 Ha is required for each construction depot.

Pre-cast construction has following advantages: -

- Reduction in construction period due to concurrent working for substructure and superstructure.
- For segmental, pre-cast element (of generally 3.0m length), transportation from construction depot to site is easy and economical. For other type of construction i.e. I-Girder, U Girder etc. longer trailer and straighter roads are required but erection can be done by using road cranes in comparatively less time.
- As the pre-cast elements are cast on production line in a construction depot, better and uniform quality control can be exercised.
- This method reduces the interference to road users to minimum.

For casting of segments, both long line and short line method can be adopted. However, the long line method is more suitable for spans curved in plan while short line method is good for straight spans. A high degree of accuracy is required for setting out the curves on long line method for which pre-calculation of offsets is necessary. Match casting of segments is required in either method. The cast segments are cured on the bed as well as in stacking yard. Ends of the segments are to be made rough through sand blasting so that gluing of segments can be effective.

The segmental construction has following advantages.

- Segmental construction is an efficient and economical method for a large range of span lengths and types of structures. Structures with sharp curves and variable super elevation can be easily accommodated.
- It is easy to incorporate last minute changes in span configuration if the site situation so warrants.
- Segmental construction permits a reduction of construction time as segments are manufactured in a casting yard while substructure work is in progress and erected rapidly thereafter.
- Better quality control is possible in the casting yard.
- It is easier to transport smaller segments by road trailers on city roads.
- Interference to the traffic during construction is significantly reduced.

5.3.4.2. Structural System of Viaduct

A. Sub-structure

Two broad categories of sub-structure i.e Pile Foundation and Open foundation are considered for Metro Systems. For heavy/medium loads and loose/soft/filled up upper strata, Pile foundation systems are proposed. This requires lesser space and time for excavation. Pile load bearing capacity is calculated as per IS 2911 Part 2 & IRC- 78. At locations where, hard strata/rock are available close to ground level, open foundations may be adopted.

The viaduct superstructure will be supported on single cast-in-place RC pier. The shape of the pier follows the flow of forces. For the standard spans, the pier gradually widens at the top to support the bearing under the box webs. Circular pier of dia in the range of 1-5-1.7 m are commonly used as it occupies the minimum space at ground/road level where the alignment often follows the central verge of existing roads.

To prevent the direct collision of vehicle to pier, a Jersey Shaped crash barrier of 1.0m height above existing road level has been proposed all around the pier. A gap of 25mm has been also provided in between the crash barrier and outer face of pier. The shape of upper part of pier has been so dimensioned that the required minimum clearance of 5.5m is always available on road side beyond vertical plane drawn on outer face of crash barrier. In such a situation, the minimum height of rail above the existing road is 8.5m. The longitudinal center to center spacing of elastomeric/pot bearing over a pier would be about 1.8m.

The space between the elastomeric bearings will be utilized for placing the lifting jack required for the replacement of elastomeric bearing. An outward slope of 1:200 will be provided at pier top for the drainage due to spilling of rainwater, if any. The transverse spacing between bearings would be about 3.0m. The orientation and dimensions of the piers for the continuous units or steel girder (simply supported span) have to be selected to ensure minimum footprint at ground/road level traffic. Since the vertical and horizontal loads will vary from pier to pier, this will be catered to by selecting the appropriate structural dimensions.

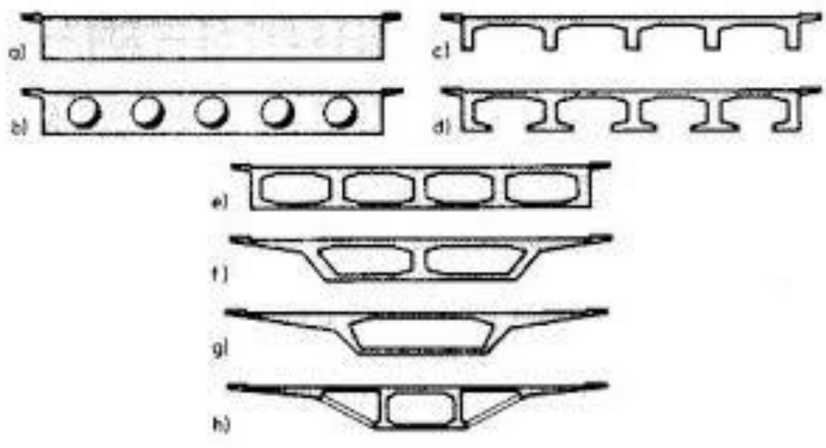
Pile caps are casted over the columns to support the superstructure. Soffit width of superstructure governs the width of pile cap. While box girder requires less width of pile, I-girder and U-girders require larger width of pile caps to support the full width of soffit of such superstructures. At locations where, elevated alignment moves from central verge of the road to side of the road and vice versa, Portal arrangement is made instead of column and pile cap. Also, at locations where elevated alignment takes a perpendicular left or right turn, portal type arrangement is provided to provide support to superstructure.

B. Superstructure

The choice of superstructure has to be made keeping in view the ease of constructability, maximum safety, least disturbance and inconvenience to road users and maximum standardization of the form-work for wide span ranges. Following types of superstructure may be considered.

i. Precast segmental box girder using external unbonded tendon.
ii. Precast U-Channel superstructure with internal pre-stressing.
iii. Precast U-Channel segmental superstructure using external unbonded tendon.
iv. I-Girder with internal pre-stressing.
v. Special spans

FIGURE 5.21: TYPES OF SUPERSTRUCTURE



Three types of superstructures are further deliberated as under: -

a. Precast Segmental Box Girder using External Unbonded Tendon

The superstructure shall be constructed "span by span" sequentially, starting at one end of a continuous stretch and finishing at the other end. A number of launching girders will be required so as to work on different stretches simultaneously to enable completion of the project in time.

For Box girder segmental construction, normally span of 31m is kept by providing 9 segments of 3m length and two end segments of 2m length each. The other standard spans (c/c of pier) comprises of 25m, 28 m, 22m, 19m & 16m, which shall be made by removing/adding standard segments of 3.0m each from the center of the span.

The number of "breaks" in the stretch can be identified by number of continuous units. The suggested method of erection will be detailed in the construction drawings. The launching girder (or, more accurately, the "assembly truss") is capable of supporting the entire dead load of one span and transferring it to the temporary brackets attached to the pier. The governing weight of the segments will be of the order of 55 M.T. The launching girder is slightly greater than two span lengths. It must be able to negotiate sharp curves in conjunction with temporary brackets.

Transportation of segments from casting yard to the sites of erection will be effected by appropriately designed low-bedded trailers (tyre-mounted). The segments can be lifted and erected using erection portal gantry moving on launching girder.

FIGURE 5.22: LAUNCHING OF BOX GIRDER SEGMENTS

In such construction, the pre-stressing is placed outside the structural concrete (inside the box section) and protected with high density polyethylene tubes which are grouted with special wax or cement. The match cast joints at the interface of two segments are provided with shear keys as in traditional segmental construction.

The main advantages of externally pre-stressed pre-cast segmental construction can be summarized as follows: -

- Simplification of all post-tensioning operations, especially installation of tendons.
- Reduction in structural concrete thickness as no space is occupied by the tendons inside the concrete.
- Good corrosion protection due to tendons in polyethylene ducts; the grout inspection is easier and leaks, if any, can be identified during the grouting process.

- Simplified segment casting. There is no concern about alignment of tendons. Increased speed of construction.

- Replacement of tendons in case of distress is possible and can be done in a safe and convenient manner.

- Facilitates inspection and monitoring of tendons during the entire service life of the structure.

However, higher depth and higher construction-transportation- erection cycle time are disadvantages of Box Girder.

b. Precast U-Channel Superstructure with Internal Pre-stressing

The single/Double U type of viaduct structure is also a pre-cast construction with internal pre-stressing. Double U-Girders are provided for 25-28m span. For shorter spans, Single U girders may be provided.

FIGURE 5.23: PRECAST U-CHANNEL SUPERSTRUCTURE

The main advantages for this type of structural configuration of superstructure are: -

- Possibility to lower the longitudinal profile by approximately 1m compared to conventional design.
- Saving in construction and erection cycle time.
- Built in structural elements capable to maintain the coaches on the bridge in case of derailment (a standard barrier design allows this).
- Built in cable support and system function.
- Built in maintenance and evacuation path on either side of the track.
- Built in sound barrier.

However, Single U- girder has weight in the range of 300 MT per unit and it is difficult to transport girder of such length and weight. To reduce the weight per girder, double U- girder may be used, but it results into wider track center of 4.6 m to accommodate the two inside walls of the two girders.

FIGURE 5.24: LAUNCHING OF U-CHANNEL GIRDER

c. **Precast U-Channel Segmental Superstructure with Internal Pre-stressing**

In this arrangement, superstructure consists of U-shape segments. These are to be launched in a similar way as box segments. This type of superstructure results in shallow depth of superstructure in comparison to box type segments.

d. **Precast I-Girder Superstructure with Internal Pre-stressing**

Precast I-Girders for various span ranges 20-34 m can be designed. At locations with restricted head room, I-Girder with span range of 20m may be used. Precast, pre-stressed I-Girders are casted in casting yard, transported to site and erected as 3/4 I-girders per span (depending upon Detailed design) by using road cranes, connected together at site by casting diaphragm wall and thereafter top slab is casted at site. The depth of I-girder is comparable to

Box girder. Since unit length of I-Girder is for full span, their transportation is not possible for all locations. However, the unit weight of I-Girder is approximately in the range of 70 MT, which is almost half when compared to Double U-girder and hence can be launched with lower capacity road cranes. Deck Slab of I-Girder can easily be planned to accommodate curved alignment. I-Girders are most suitable for station locations, where Box and 'U' Girders are not continued.

FIGURE 5.25: LAUNCHING OF I-GIRDER

e. Special span configuration

Regular spans upto 31m span are not suitable for crossing large openings like road over bridges, wide surface road crossings, railway tracks, wide canals etc. Cantilever construction Method using PSC spans are used in such situation. Some of common span arrangements are suggested as under: -

- 34m + 45m + 34m
- 34m + 60m + 34m
- 75m + 105m + 75m

Other span configurations may also be designed as per specific site requirement.

Other alternatives are to use steel span. Steel span of upto 60m have been used in Metro systems in India.

FIGURE 5.26: CLC SPAN 75M + 105M + 75M AND STEEL SPAN 60M

Recommendation

The Design and Build Contractor may choose any type of super structure keeping in view site conditions, availability of construction time and other resources i.e. road cranes/launching girders/shuttering etc. Combination of above type of superstructure may also be chosen. Appropriate special spans may be provided for specific locations.

5.3.4.3. Construction of Elevated Stations

Elevated stations with elevated concourse over the road are proposed for elevated stretch of alignment. To keep the rail level low, it is proposed not to take viaduct through the stations. Thus, a separate structural configuration is required, with shorter spans and lower depth of superstructure, although this may necessitate the break in the launching operations at each station location.

Sub-structure for the station portion will also be similar to that of viaduct and will be carried out in the same manner. Two configurations as under are available for elevated station super-structure: -

a. Three-legged portal structure supporting concourse and platform level decks through series of Precast I girders resting on the Portal beam ledge.
b. Cantilever structure with single centre pier with the arms extending in transverse direction at concourse level and platform level. - Concourse and Platform decks are supported by I girders resting on extended pier arms.

Comparative analysis of above two types of structural arrangements is shown in **Table 5.68.**

TABLE 5.68: COMPARATIVE ANALYSIS OF TYPES OF STRUCTURAL ARRANGEMENTS

Item	Three-legged portal structure	Cantilever Structure
General	Three-legged portal structure is best suited for stations having high traffic load requiring more width. Central median of 3.0 m can be	Cantilever station is more suitable for densely populated downtown areas having narrow ROW. The main elevated superstructure is already

Item	Three-legged portal structure	Cantilever Structure
	created to position the Central leg of the portal. This median can also divide the road traffic into two carriageways on either side of the median. Entry structures can be built beyond the carriageway on either side.	supported on cantilever pier caps. To accommodate the platform width (approx. 4m each), total 8m additional width of cantilever is required. The station rooms, entry/exit staircases etc. may be planned by providing more width at these locations only and such wider width can be supported on portal.
Merit	• Three-legged portal is a better structural arrangement with respect to vibration induced by the train loads, long term deflections of the concrete members etc., • The concentrated loads coming from escalators and stair cases connecting concourse level to platform level are effectively transferred to the ground through portal legs in the shortest path. • Need for Bus bays, drop/pick up points is avoided as the outmost lane can be used for this purpose.	• Station structure will be compact and economical. • No need to provide Service road to access adjoining properties. • The concentrated loads coming from escalators and stair cases connecting concourse level to platform level are to be transferred to the ground through portal arrangement.
Demerit	• Cost of the station structure will be more due to large built up area. Wherever there is scope of property development, same may be planned at Concourse level to use the available space. • Service lane need to be provided to ensure access to adjoining properties.	• There is need for Bus bays, drop/pick up points.

Typical Elevated Station

The elevated station is generally located on the road median 140 m long and 24 m wide and is a three-level structure. Passenger area on concourse is spread throughout the length of the station, with staircases leading from either side of the road. Passenger facilities as well as operational areas are provided at the concourse level. Typically, the concourse is divided into public and non-public zones. The non-public zone or the restricted zone contains station operational areas. The public zone is further divided into paid and unpaid areas. Area left over in the unpaid zone, after accommodating the passenger movement and other station facilities is earmarked for commercial utilization.

Since the stations are planned generally in the middle of the road, minimum vertical clearance of 5.50 m has been provided under the concourse. Concourse floor level is about 7.0 m above the road. Consequently, platforms are at a level of about 13.0 m from the road. To reduce physical and visual impact of the elevated station, stations have been made transparent with minimum walls on the sides. **Figure 5.28** shows a typical cross section of elevated station.

FIGURE 5.27: TYPICAL BOX GIRDER VIADUCT SECTION

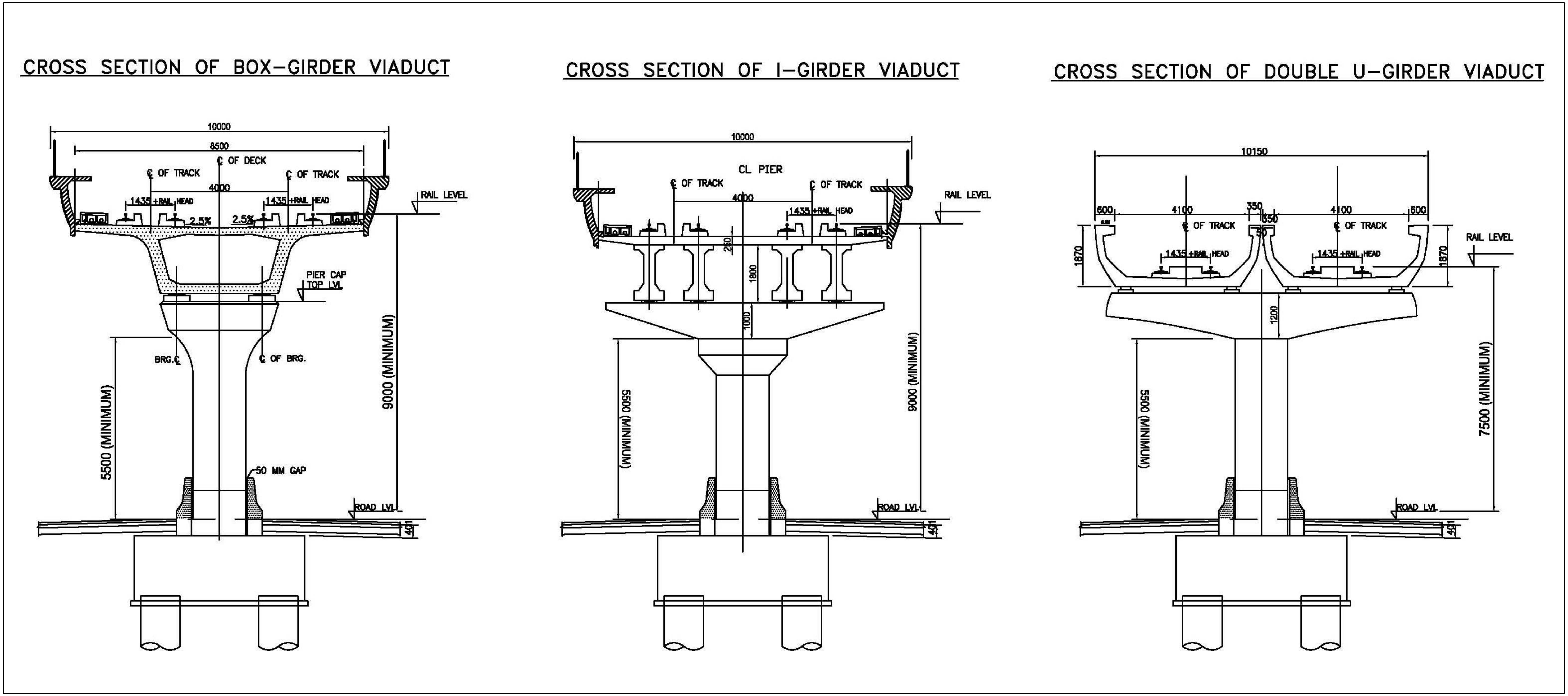
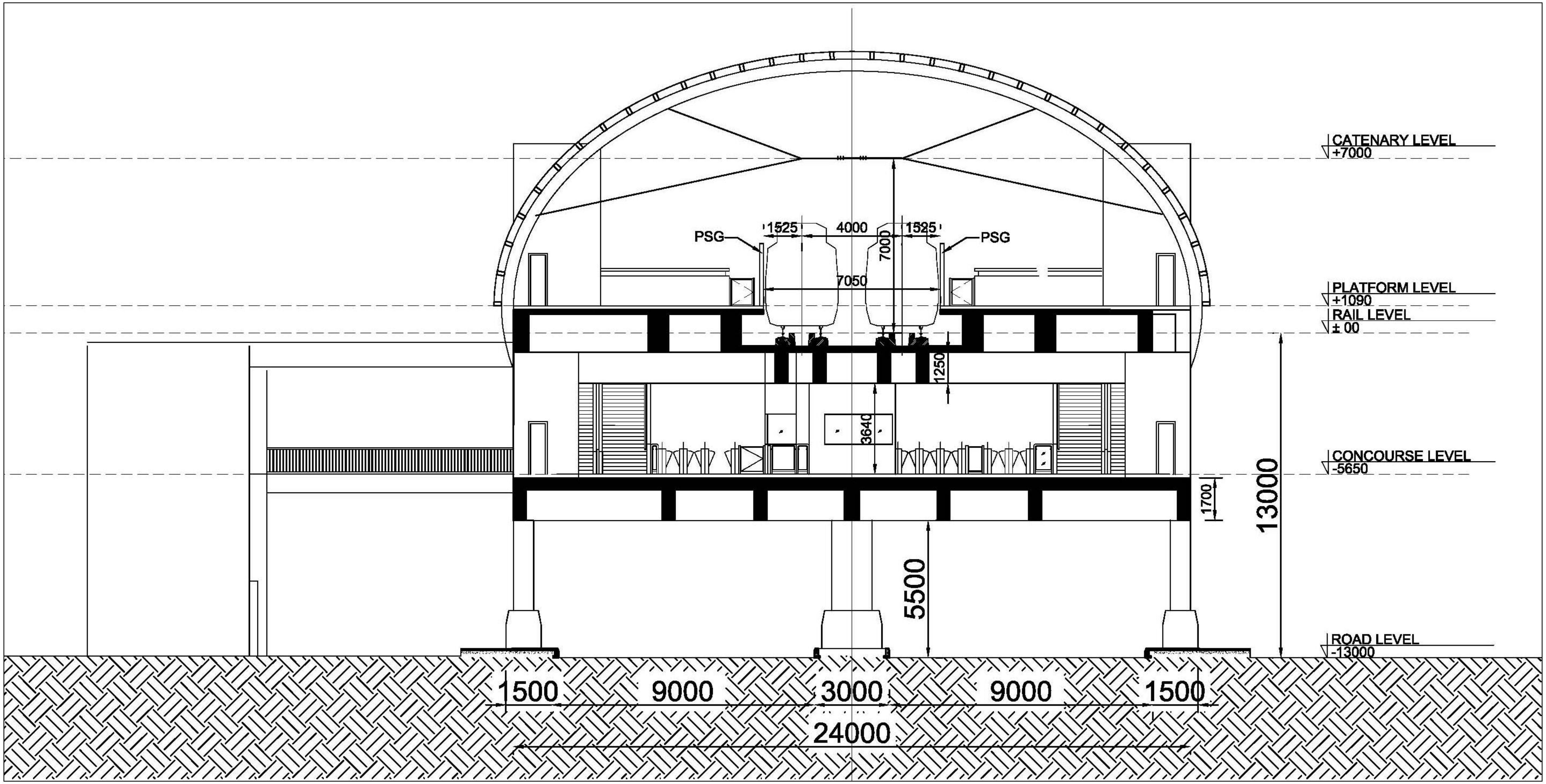


FIGURE 5.28: TYPICAL ELEVATED STATION



5.3.4.4. Grade of Concrete

It is proposed to carry out construction work with design mix concrete. Computerized Automatic Batching Plants will be installed. Following grades of concrete are proposed for various members as per design requirement/durability considerations.

i. Piles: M-35
ii. Pile cap and open foundation: M-35
iii. Piers: M-40/M-50
iv. All pre-cast elements for viaduct and stations: M-45
v. Tunnel segments: M-45
vi. Cantilever piers and portals: M-45 /M-50/M-60
vii. Other miscellaneous structures: M-30

For all main structures, permeability test of concrete is recommended to ensure impermeable concrete.

5.3.4.5. Reinforcement and Pre-stressed Steel

It is proposed to use HYSD 500 or TMT steel as reinforcement bars. For pre-stressing work, low relaxation high tensile steel strands with the configuration 12 T 13 and or 19 K 15 is recommended (confirming to IS:14268).

5.3.5. Traffic Management Plan During Construction

The aim of the traffic management measures is to relieve, wherever possible, or minimize the (short term) disruption to normal traffic likely to be caused by the construction of the metro works. The traffic management measures would need to cope, in safety, with all aspects of traffic, including those generated from

- Goods vehicles
- Public transport
- Essential services
- Pedestrian movement
- Local and through private traffic

The organization of traffic during construction activities is proposed to be phased into and coordinated with the long term strategic traffic plans under CMP.

5.3.5.1. Typical Traffic Diversion Plan

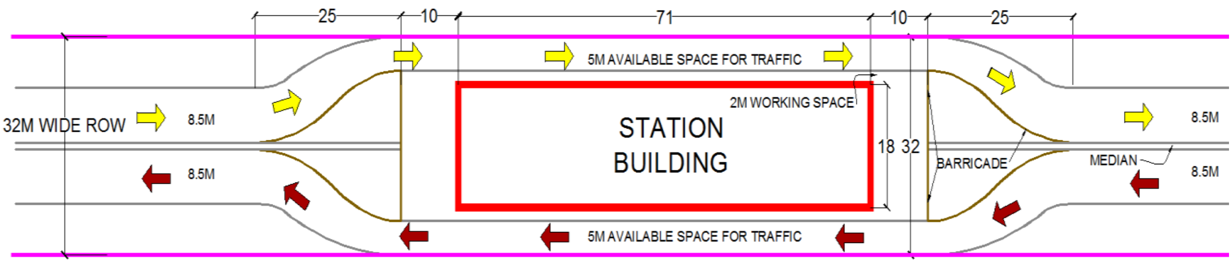
The typical traffic diversion plans have been prepared based on two scenarios as under:

Scenario 1: - At stations where ROW> 32m
Scenario 2:- At stations where ROW< 32m

At stations where ROW> 32m

At stations where, existing ROW is more than 32m, traffic will be diverted on both sides of the proposed station built up area during construction. The typical traffic diversion plan for such stations is shown in **Figure 5.29.** To increase the available space width for traffic, the option of construction of station in two sequences (half by half method) can be adopted.

FIGURE 5.29: TYPICAL TRAFFIC DIVERSION PLAN (ROW> 32M)



At stations where ROW< 32m

At some of the stations existing ROW is between 22m to 32m, so the traffic will be diverted on such locations one side of the proposed station during construction and construction of station will be done half by half method in sequence. The typical traffic diversion plans for such stations are shown in **Figure 5.30** & **Figure 5.31.**

FIGURE 5.30: TYPICAL TRAFFIC DIVERSION PLAN (ROW< 32M)

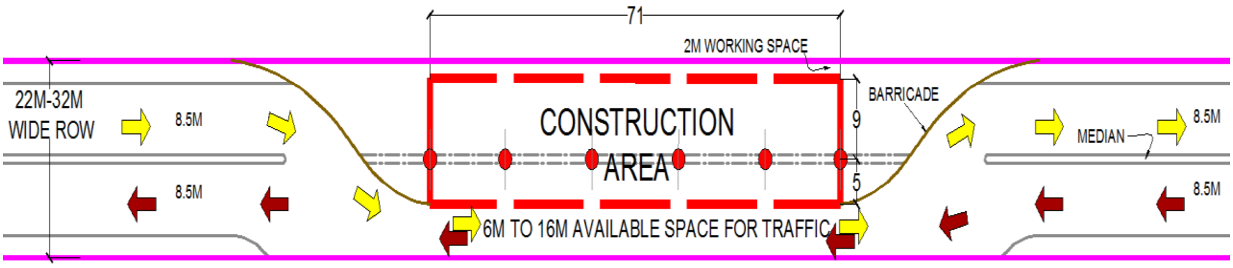
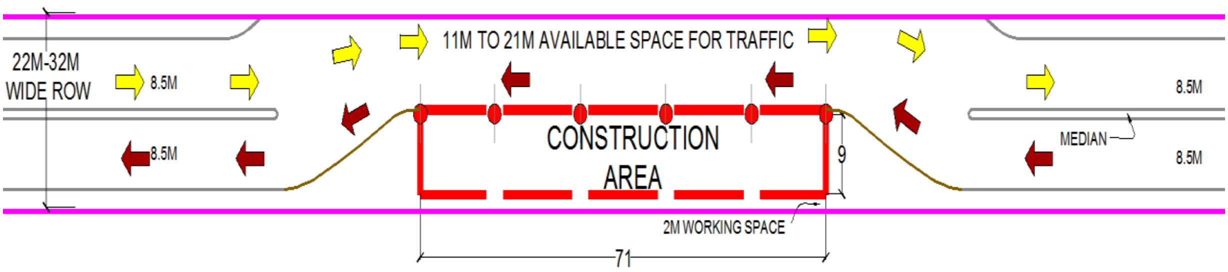


FIGURE 5.31: TYPICAL TRAFFIC DIVERSION PLAN



5.4. GEOMETRIC DESIGN OF CORRIDORS INCLUDING PLAN / PROFILE

5.4.1. Alignment Design Considerations

Following considerations have been kept in view, while designing the alignment:

a) The alignment has been proposed to cover the high-density traffic corridors and origination/destination centers.

b) The elevated alignment has been generally proposed along the median of the road.

c) Track Centre of 4.1m has been proposed for elevated section so as to provide flexibility of adopting Box Girders for superstructure with viaduct width of 8.5m.

d) Effort has been made to minimize disruption to road traffic during construction phase.

5.4.2. Alignment Design of Corridor -1A

5.4.2.1. Horizontal Curvature

A total of 28 curves have been provided on the entire length of the alignment. The minimum radius of curve (≤150m) are 145m (beyond Butibori Police Station), 145m (beyond MIDC KEC Station) and 132.05m (beyond MIDC ESR Station. About 27.57% of the length of the alignment is on curves. The abstract and details of curves are indicated in **Table 5.69** & **Table 5.70** respectively.

TABLE 5.69: ABSTRACT OF HORIZONTAL CURVES OF CORRIDOR-1A

S.N	Curve Radius	No. of Occurrences	Length	Percentage
1	≤150	3	824.68	16.72
2	>150 <300	3	938.15	19.02
3	≥300 ≤ 500	3	543.34	11.02
4	>500 ≤ 800	2	283.32	5.75
5	>800 ≤ 1000	5	746.97	15.15
6	>1000	13	1594.84	32.34
	Total	29	4931.30	100.00

TABLE 5.70: DETAILS OF HORIZONTAL CURVES OF CORRIDOR 1A – MIHAN TO MIDC ESR

Curve No	Chainage		Direction	Radius	Intersection Angle			Transition Length		Tangent Length	Curve Length	Total Curve Length	Straight Between
	From	To			D	M	S	In	Out				
1	20515.86	20594.08	Right	1002	3	11	40.2	20	20	39.12	38.22	78.22	--
2	21427.80	21735.25	Left	-160	90	14	28.68	55	55	189.40	197.46	307.46	833.72
3	21809.85	21987.22	Left	-400	18	8	38.4	50	50	89.27	77.37	177.37	74.59
4	22052.80	22206.06	Left	-300.2	18	27	2.88	55	55	77.13	43.25	153.25	65.59
5	22206.06	22369.46	Right	260.6	23	29	43.8	55	55	82.59	53.40	163.40	Nil
6	22369.47	22836.77	Right	211.9	111	17	8.88	55	55	339.47	357.30	467.30	Nil
7	23190.22	23310.75	Right	1500	3	23	8.16	25	25	60.28	70.53	120.53	353.45
8	23925.95	24006.62	Right	4000	0	33	45.36	15	15	40.34	50.67	80.67	615.20
9	24135.26	24239.89	Right	3500	1	13	50.52	20	20	52.32	64.63	104.63	128.64
10	25130.26	25204.73	Right	5000	0	24	19.08	15	15	37.24	44.47	74.47	890.37
11	25956.61	26048.17	Right	6000	0	26	6.72	15	15	45.78	61.56	91.56	751.88
12	26308.90	26653.34	Left	-2000	9	0	10.44	30	30	172.55	284.44	344.44	260.73
13	27050.94	27169.00	Right	3000	1	31	19.92	20	20	59.03	78.06	118.06	397.60
14	28601.51	28679.80	Left	-10000	0	13	58.44	10	10	39.14	58.29	78.29	1432.52
15	29398.65	29482.71	Right	12000	0	12	40.68	10	10	42.03	64.06	84.06	718.85
16	30144.65	30292.23	Right	700	8	28	55.56	40	40	73.91	67.59	147.59	661.93
17	30330.42	30466.15	Left	-750	7	11	5.28	40	40	67.94	55.73	135.73	38.19
18	32001.26	32203.49	Left	-1000	9	31	14.16	30	30	101.33	142.23	202.23	1535.11
19	32572.10	32696.03	Right	1250	4	10	54.84	30	30	61.99	63.93	123.93	368.61

Curve No	Chainage		Direction	Radius	Intersection Angle			Transition Length		Tangent Length	Curve Length	Total Curve Length	Straight Between
	From	To			D	M	S	In	Out				
20	33244.29	33386.92	Left	-1100	5	31	12.36	30	30	71.37	82.64	142.64	548.26
21	33579.68	33840.14	Right	145	77	8	24.36	65	65	149.24	130.46	260.46	192.75
22	35042.03	35195.38	Left	-15000	0	16	53.76	30	30	76.68	93.36	153.36	1201.89
23	35424.65	35561.77	Left	-830	6	25	17.76	40	40	68.62	57.12	137.12	229.27
24	35605.82	35724.53	Right	830	5	15	36.36	40	40	59.39	38.71	118.71	44.05
25	35755.71	35908.45	Right	830	7	27	56.88	40	40	76.46	72.74	152.74	31.18
26	35966.21	36102.37	Left	-830	6	22	54.12	40	40	68.14	56.16	136.16	57.76
27	36865.40	37078.11	Right	420	20	5	25.08	65	65	107.20	82.71	212.71	763.02
28	37399.18	37691.31	Left	-145	89	27	0.72	65	65	178.02	162.13	292.13	321.07
29	38438.98	38711.07	Left	-132.05	89	30	42.48	65	65	165.48	142.09	272.09	747.67

5.4.2.2. Gradients

A total 38 number of change of gradients has been provided in the entire Corridor-1A. Flattest gradient is level provided on 48.24% of alignment including the stations and steepest gradient is 3.50%. The abstract and details of gradients are given in **Table 5.71** & **Table 5.72** respectively.

TABLE 5.71: ABSTRACT OF GRADIENTS OF CORRIDOR-1A

S.No.	Description	No's of Occurrences	Length (m)	% Length
1	Level (0%)	17	9341.26	50.63
2	>0% to 1%	10	4849.95	26.28
3	>1% to 2%	10	4023.92	21.81
4	>2% to 3%	0	0.00	0.00
5	>3%	1	236.57	1.28
	TOTAL	38	18452	100.00

TABLE 5.72: DETAILS OF GRADIENTS OF CORRIDOR-1A

S.No.	Chainage		Length	Rail Level		Gradient	Remarks
	From	To		From	To		
1	20400	21277	877	295.72	295.72	0.00	Level
2	21277	21514	237	295.72	304.00	3.50	Rise
3	21514	21658	145	304.00	304.00	0.00	Level
4	21658	21908	250	304.00	302.50	-0.60	Fall
5	21908	22284	376	302.50	302.50	0.00	Level
6	22284	22454	170	302.50	303.40	0.53	Rise
7	22454	22869	415	303.40	303.40	0.00	Level
8	22869	23156	287	303.40	308.50	1.78	Rise
9	23156	24463	1307	308.50	308.50	0.00	Level
10	24463	25397	934	308.50	315.71	0.77	Rise
11	25397	25862	465	315.71	308.10	-1.64	Fall
12	25862	26088	226	308.10	311.38	1.45	Rise
13	26088	26594	507	311.38	313.60	0.44	Rise
14	26594	26807	212	313.60	313.60	0.00	Level
15	26807	27108	301	313.60	308.00	-1.86	Fall
16	27108	28293	1185	308.00	304.35	-0.31	Fall

S.No.	Chainage		Length	Rail Level		Gradient	Remarks
	From	To		From	To		
17	28293	28844	551	304.35	304.35	0.00	Level
18	28844	29440	596	304.35	298.27	-1.02	Fall
19	29440	29753	313	298.27	300.00	0.55	Rise
20	29753	29991	238	300.00	300.00	0.00	Level
21	29991	30663	672	300.00	290.30	-1.44	Fall
22	30663	31431	768	290.30	290.30	0.00	Level
23	31431	31951	520	290.30	291.20	0.17	Rise
24	31951	32365	414	291.20	291.20	0.00	Level
25	32365	32632	267	291.20	293.85	0.99	Rise
26	32632	32926	294	293.85	293.85	0.00	Level
27	32926	33319	393	293.85	286.75	-1.80	Fall
28	33319	33689	370	286.75	286.75	0.00	Level
29	33689	33893	204	286.75	283.10	-1.79	Fall
30	33893	34351	457	283.10	283.10	0.00	Level
31	34351	34673	322	283.10	276.75	-1.97	Fall
32	34673	35308	635	276.75	276.75	0.00	Level
33	35308	35493	186	276.75	278.15	0.75	Rise
34	35493	36685	1192	278.15	278.15	0.00	Level
35	36685	37243	558	278.15	288.00	1.77	Rise
36	37243	37540	297	288.00	288.00	0.00	Level
37	37540	38059	519	288.00	292.10	0.79	Rise
38	38059	38852	793	292.10	292.10	0.00	Level

5.4.2.3. Special Span

Details of locations having special spans arrangement are given in **Table 5.73.**

TABLE 5.73: LOCATION OF SPECIAL SPANS CORRIDOR – 1A

S.No	Location	Chainage		Configuration Special span
		From	To	
1	Railway Crossing near Metro City Station	21551	21599	32m + 48m + 32m

S.No	Location	Chainage		Configuration
		From	To	Special span
2	Railway Crossing at Railway Milestone 812/21-22	31218	31266	32m + 48m + 32m

5.4.3. Alignment Design of Corridor -2A

5.4.3.1. Horizontal Curvature

Although the topology of Nagpur is not very undulating and the terrain type is plain, yet the existing road has frequent horizontal curves to negotiate the densely built up areas. The proposed alignment also negotiates frequent horizontal curves to follow the existing road median. At some places there are sharp turns and curves along the road and this necessitates provision of sharp curves on metro alignment also.

Total 30 nos. horizontal curves have been provided on entire lengths of the alignment of Corridor 2A. The minimum radius of curves is 130m near Kamptee Cantt. About 57.62% alignment is on straight & about 42.38% of alignment is on curves. The abstract of curves is indicated in **Table 5.74** and details of curves are shown in **Table 5.75.**

TABLE 5.74: ABSTRACT OF HORIZONTAL CURVES OF CORRIDOR 2A

S.No.	Curve Radius	No. of Occurrences	Length	Percentage
1	≤150	1	272.96	4.95
2	>150 <300	9	1681.92	30.53
3	≥300 ≤ 500	2	333.05	6.05
4	>500 ≤ 800	2	397.76	7.22
5	>800 ≤ 1000	2	553.07	10.04
6	>1000	14	2270.65	41.21
	Total	30	5509.40	100.00

TABLE 5.75: DETAILS OF HORIZONTAL CURVES OF CORRIDOR 2A – AUTOMOTIVE SQUARE TO KANHAN RIVER

Curve No	Chainage		Direction	Radius	Intersection Angle			Transition Length		Tangent Length	Curve Length	Total Curve Length	Straight Between
	From	To			D	M	S	In	Out				
1	-13141.87	-12926.32	Right	418	21	11	29.4	60	60	108.75	95.55	215.55	--
2	-12703.03	-12507.85	Right	575	14	16	33.24	50	50	98.00	95.18	195.18	223.30
3	-12340.47	-12222.97	Left	-305	13	22	16.68	45	45	58.95	27.50	117.50	167.38
4	-12196.29	-12078.92	Right	250	16	21	1.8	45	45	58.98	27.36	117.36	26.68
5	-11998.11	-11785.80	Left	-155	54	16	13.44	65	65	112.78	82.30	212.30	80.82
6	-11595.96	-11251.66	Left	-1493	12	9	4.32	25	25	172.76	294.30	344.30	189.84
7	-11156.39	-10944.59	Right	213.5	39	14	6.36	65	65	109.21	81.81	211.81	95.27
8	-10768.68	-10472.02	Right	1005	15	7	15.24	30	30	149.12	236.66	296.66	175.91
9	-9888.58	-9574.31	Right	256	55	28	21	65	65	168.36	184.27	314.27	583.44
10	-9359.88	-9311.00	Right	4500	0	17	39.12	10	10	24.44	28.88	48.88	214.43
11	-9179.91	-9108.91	Left	-3000	1	2	27.96	15	15	35.50	41.01	71.01	131.09
12	-9022.93	-8863.95	Right	290	18	20	27.24	65	65	80.00	28.99	158.99	85.98
13	-8642.09	-8369.14	Left	-130	98	9	19.08	50	50	176.14	172.96	272.96	221.85
14	-8369.13	-8023.22	Right	1004.75	18	21	2.88	20	20	174.41	305.92	345.92	Nil
15	-7868.06	-7758.83	Right	4000	1	12	36	15	15	54.62	79.24	109.24	155.15
16	-7606.29	-7455.82	Left	-2200	3	18	50.76	15	15	75.26	120.47	150.47	152.53
17	-7092.48	-6889.90	Left	-565	15	35	5.64	45	45	101.83	112.58	202.58	363.34
18	-6347.65	-6259.47	Right	3000	1	14	6.36	15	15	44.09	58.18	88.18	542.25
19	-5773.16	-5655.17	Left	-4000	1	16	59.16	15	15	59.00	87.99	117.99	486.31

Curve No	Chainage		Direction	Radius	Intersection Angle			Transition Length		Tangent Length	Curve Length	Total Curve Length	Straight Between
	From	To			D	M	S	In	Out				
20	-5089.28	-4976.05	Left	-8000	0	25	16.68	15	15	56.62	83.23	113.23	565.89
21	-4495.86	-4393.41	Right	7900	0	22	49.08	15	15	51.23	72.45	102.45	480.19
22	-3792.32	-3495.28	Left	-2785	5	28	50.88	15	15	148.64	267.03	297.03	601.09
23	-3229.37	-3113.44	Left	-2175	2	26	29.76	12	12	57.97	91.93	115.93	265.92
24	-3088.37	-2816.64	Right	814	17	13	12.36	25	25	136.82	221.73	271.73	25.07
25	-2588.51	-2407.64	Left	-195	35	18	16.92	60	60	92.67	60.87	180.87	228.13
26	-2204.44	-2030.36	Right	279.5	22	12	50.4	65	65	87.85	44.08	174.08	203.20
27	-1737.74	-1668.37	Left	-4000	0	27	51.84	15	15	34.69	39.37	69.37	292.62
28	-1346.87	-1204.42	Left	-198	26	27	3.6	50	50	72.20	42.45	142.45	321.51
29	-1204.33	-1034.55	Right	198	34	23	39.48	50	50	86.94	69.78	169.78	Nil
30	-789.43	-508.09	Left	-890	15	30	47.16	35	35	141.47	211.34	281.34	245.12

5.4.3.2. Gradient

While designing vertical alignment, efforts have been made to avoid frequent gradients. The number of gradients has been kept to minimum, however, due to ground profile, difference in rail level of viaduct over mid section and station location, horizontal alignment and switch over ramps, gradients are inevitable. Efforts have been made to provide the gradients as flat as possible, subject to ground profile.

A total 48 number of change of gradients has been provided in the Corridor-2A. Flattest gradient is level provided for 52.28% of the alignment. Steepest gradient is 2.19%. The abstract and details of gradients are given in **Table 5.76** & **Table 5.77** respectively.

TABLE 5.76: ABSTRACT OF GRADIENTS OF CORRIDOR-2A

S.No.	Description	No's of Occurrences	Length (m)	Percentage
1	Level (0%)	24	6796.07	52.28
2	>0% to 1%	4	468.55	3.60
3	>1% to 2%	18	4966.82	38.21
4	>2% to 3%	2	768.56	5.91
5	>3%	0	0.00	0.00
	TOTAL	48	13000	100.00

TABLE 5.77: DETAILS OF GRADIENTS OF CORRIDOR-2A

S.No.	Chainage		Length	Rail Level		Gradient (%)	Remarks
	From	To		From	To		
1	-13500	-13049	451	295.30	295.30	0.00	Level
2	-13049	-12874	175	295.30	291.80	-2.00	Fall
3	-12874	-12727	147	291.80	291.80	0.00	Level
4	-12727	-12583	143	291.80	294.20	1.68	Rise
5	-12583	-12364	220	294.20	294.20	0.00	Level
6	-12364	-12138	226	294.20	290.50	-1.64	Fall
7	-12138	-11544	594	290.50	290.50	0.00	Level
8	-11544	-11304	239	290.50	294.80	1.80	Rise
9	-11304	-11060	244	294.80	294.80	0.00	Level
10	-11060	-10856	204	294.80	291.28	-1.72	Fall
11	-10856	-10351	505	291.28	301.15	1.96	Rise
12	-10351	-9674	676	301.15	301.15	0.00	Level
13	-9674	-9530	145	301.15	301.55	0.28	Rise
14	-9530	-9335	194	301.55	301.55	0.00	Level
15	-9335	-9062	273	301.55	297.60	-1.45	Fall
16	-9062	-8557	505	297.60	297.60	0.00	Level
17	-8557	-8066	491	297.60	291.30	-1.28	Fall
18	-8066	-7810	256	291.30	291.30	0.00	Level
19	-7810	-7319	490	291.30	301.75	2.13	Rise
20	-7319	-7008	312	301.75	301.75	0.00	Level

S.No.	Chainage		Length	Rail Level		Gradient (%)	Remarks
	From	To		From	To		
21	-7008	-6691	316	301.75	295.50	-1.98	Fall
22	-6691	-6517	175	295.50	295.50	0.00	Level
23	-6517	-6304	213	295.50	299.50	1.88	Rise
24	-6304	-6073	231	299.50	299.50	0.00	Level
25	-6073	-6017	56	299.50	299.00	-0.89	Fall
26	-6017	-5724	293	299.00	299.00	0.00	Level
27	-5724	-5363	360	299.00	305.00	1.66	Rise
28	-5363	-5152	212	305.00	305.00	0.00	Level
29	-5152	-5029	123	305.00	304.25	-0.61	Fall
30	-5029	-4768	261	304.25	304.25	0.00	Level
31	-4768	-4623	145	304.25	305.24	0.68	Rise
32	-4623	-4366	258	305.24	305.23	0.00	Fall
33	-4366	-4020	346	305.23	309.00	1.09	Rise
34	-4020	-3635	385	309.00	309.00	0.00	Level
35	-3635	-3434	201	309.00	313.00	1.99	Rise
36	-3434	-3175	260	313.00	313.00	0.00	Level
37	-3175	-2705	469	313.00	303.60	-2.00	Fall
38	-2705	-2630	75	303.60	303.60	0.00	Level
39	-2630	-2387	243	303.60	306.55	1.21	Rise
40	-2387	-2117	270	306.55	306.55	0.00	Level
41	-2117	-1887	230	306.55	311.00	1.93	Rise
42	-1887	-1702	185	311.00	311.00	0.00	Level
43	-1702	-1526	176	311.00	308.25	-1.56	Fall
44	-1526	-1276	250	308.25	308.25	0.00	Level
45	-1276	-1120	156	308.25	306.00	-1.45	Fall
46	-1120	-987	133	306.00	306.00	0.00	Level
47	-987	-709	278	306.00	312.10	2.19	Rise
48	-709	-500	209	312.10	312.10	0.00	Level

* Note: All the change points are provided with Vertical curves

5.4.3.3. Special Span & Portals

Details of locations having special span arrangement are given in **Table 5.78.**

TABLE 5.78: LOCATION OF SPECIAL SPANS CORRIDOR – 2A

S. No	Location	Chainage		Special span Configuration
		From	To	
1	Pilli Nadi crossing	-929	-974	45m
2	Railway Crossing between Pili Nadi & Khasara Fata Metro Station	-1750	-1825	75m

5.4.4. Alignment Design of Corridor -3A

5.4.4.1. Horizontal Curvature

A total of 13 curves have been provided on the entire length of corridor-3A alignment. The minimum radius of curves (≤150 m) is 150m (at Chainage 22300m), 140m and 135m (on either side of Vena River). About 34.40% of the length of the alignment is on curves. The abstract and details of curves are indicated in **Table 5.79** and **Table 5.81** respectively.

TABLE 5.79: ABSTRACT OF HORIZONTAL CURVES OF CORRIDOR-3A

S.No	Curve Radius	No. of Occurrences	Length	Percentage
1	≤150	3	593.78	25.93
2	>150 <300	3	721.62	31.51
3	≥300 ≤ 500	1	179.65	7.85
4	>500 ≤ 800	2	338.10	14.77
5	>800 ≤ 1000	0	0.00	0.00
6	>1000	4	456.72	19.95
	Total	13	2289.87	100.00

5.4.4.2. Gradients

A total 19 number of change of gradients has been provided in the entire Corridor-3A. Flattest gradient is level provided on 55.43% of alignment including the stations and steepest gradient is 3.27%. The abstract and details of gradients are given in **Table 5.80** & **Table 5.82** respectively.

TABLE 5.80: ABSTRACT OF GRADIENTS OF CORRIDOR-3A

S.No.	Description	No's of Occurrences	Length (m)	% Length
1	Level (0%)	9	3690	55.43
2	>0% to 1%	0	0	0.00
3	>1% to 2%	7	2042	30.68
4	>2% to 3%	2	728	10.94
5	>3%	1	197	2.95
	TOTAL	19	6657	100.00

TABLE 5.81: DETAILS OF HORIZONTAL CURVES OF CORRIDOR 3A – LOKMANYA NAGAR TO HINGNA

Curve No	Chainage		Direction	Radius	Intersection Angle			Transition Length		Tangent Length	Curve Length	Total Curve Length	Straight Between
	From	To			D	M	S	In	Out				
1	18288.67	18438.45	Right	580	10	12	36.72	45	45	75.04	59.78	149.78	--
2	19334.00	19399.60	Right	6500	0	17	32.64	10	10	32.80	45.60	65.60	895.55
3	19961.74	20141.38	Right	500	13	4	53.4	65	65	90.11	49.65	179.65	562.14
4	20537.43	20774.49	Left	-160	59	29	33.36	70	70	127.73	97.06	237.06	396.05
5	20774.65	20911.57	Right	1570	3	32	26.52	30	30	68.48	76.92	136.92	Nil
6	22030.32	22139.22	Left	-1800	2	24	5.04	25	25	54.46	58.90	108.90	1118.75
7	22212.25	22384.18	Right	150	40	30	18.36	65	65	88.74	41.94	171.94	73.03
8	22472.29	22783.49	Left	-195	70	31	14.52	70	70	174.46	171.19	311.19	88.11
9	22892.64	23073.53	Right	140	49	16	57	60	60	94.95	60.89	180.89	109.15
10	23314.65	23555.60	Right	135	76	28	32.52	60	60	137.83	120.95	240.95	241.12
11	23713.81	23902.14	Left	-700	11	11	30.84	50	50	94.40	88.32	188.32	158.21
12	23937.45	24082.74	Right	1200	5	0	50.04	40	40	72.68	65.30	145.30	35.31
13	24606.21	24779.58	Left	-250	24	30	3.6	65	65	87.69	43.37	173.37	523.47

TABLE 5.82: DETAILS OF GRADIENTS OF CORRIDOR-3A

S.No.	Chainage		Length	Rail Level		Gradient	Remarks
	From	To		From	To		
1	18218	18246	28	333.85	333.85	0.00	Level
2	18246	18372	125	333.85	332.00	-1.48	Fall
3	18372	19735	1364	332.00	332.00	0.00	Level
4	19735	20185	450	332.00	322.21	-2.18	Fall
5	20185	20651	466	322.21	327.27	1.08	Rise
6	20651	20848	197	327.27	320.85	-3.27	Fall
7	20848	21122	274	320.85	320.85	0.00	Level
8	21122	21473	350	320.85	314.10	-1.93	Fall
9	21473	21805	332	314.10	314.10	0.00	Level
10	21805	22083	278	314.10	308.50	-2.01	Fall
11	22083	22430	347	308.50	308.50	0.00	Level
12	22430	22683	253	308.50	311.60	1.22	Rise
13	22683	22985	302	311.60	311.60	0.00	Level
14	22985	23189	205	311.60	307.50	-2.00	Fall
15	23189	23295	105	307.50	307.50	0.00	Level
16	23295	23468	174	307.50	310.00	1.44	Rise
17	23468	23811	343	310.00	310.00	0.00	Level
18	23811	24280	469	310.00	316.50	1.39	Rise
19	24280	24875	595	316.50	316.50	0.00	Level

5.4.4.3. Special Span & Portals

Details of locations having special span arrangement are given in **Table 5.83.**

TABLE 5.83: LOCATION OF SPECIAL SPANS CORRIDOR – 3A

S. No	Location	Chainage		Special span Configuration
		From	To	
1	Nallah crossing	12475	12525	50m
2	Venna River crossing	23140	23250	110m

5.4.5. Alignment Design of Corridor -4A

5.4.5.1. Horizontal Curvature

A total of 10 curves have been provided on the entire length of corridor-4A alignment. The minimum radius of curves of 310 m has been provided in this corridor. About 26.99% of the length of the alignment is on curves. The abstract and details of curves are indicated in **Table 5.84** & **Table 5.85** respectively.

TABLE 5.84: ABSTRACT OF HORIZONTAL CURVES OF CORRIDOR-4A

S.No.	Curve Radius	No. of Occurrences	Length	Percentage
1	≤150	0	0.00	0.00
2	>150 <300	0	0.00	0.00
3	≥300 ≤ 500	3	706.97	46.59
4	>500 ≤ 800	3	514.43	33.90
5	>800 ≤ 1000	0	0.00	0.00
6	>1000	4	295.92	19.50
	Total	10	1517.32	100.00

TABLE 5.85: DETAILS OF HORIZONTAL CURVES OF CORRIDOR 4A – PRAJAPATI NAGAR TO TRANSPORT NAGAR

Curve No	Chainage		Direction	Radius	Intersection Angle			Transition Length		Tangent Length	Curve Length	Total Curve Length	Straight Between
	From	To			D	M	S	In	Out				
1	-4934.12	-4679.56	Right	565	20	26	37.68	50	50	128.44	154.56	254.56	--
2	-3713.32	-3650.20	Left	-5000	0	19	49.8	15	15	31.56	33.12	63.12	966.24
3	-3043.96	-2959.42	Right	2000	1	30	20.16	20	20	42.27	44.54	84.54	606.24
4	-2573.37	-2281.78	Right	500	28	9	8.64	45	45	148.40	201.59	291.59	386.05
5	-1991.10	-1713.77	Left	-310	41	3	12.24	55	55	143.84	167.33	277.33	290.68
6	-1549.55	-1470.24	Right	20000	0	6	37.08	15	15	39.66	49.32	79.32	164.21
7	-1282.86	-1213.92	Left	-1500	1	31	15.24	20	20	34.47	28.94	68.94	187.38
8	-1145.97	-1007.92	Right	500	10	23	40.92	45	45	69.18	48.05	138.05	67.95
9	-790.64	-699.34	Right	525	7	8	27.6	25	25	45.70	41.31	91.31	217.28
10	-634.96	-466.40	Left	-600	12	9	49.68	40	40	84.54	88.57	168.57	64.37

5.4.5.2. Gradients

A total 14 number of change of gradients has been provided in the entire Corridor-4A. Flattest gradient is level provided on 48.03% of alignment including the stations and steepest gradient is 2.42%. The abstract and details of gradients are given in **Table 5.86** & **Table 5.87** respectively.

TABLE 5.86: ABSTRACT OF GRADIENTS OF CORRIDOR-4A

S.No.	Description	No's of Occurrences	Length (m)	% Length
1	Level (0%)	5	2700	48.03
2	>0% to 1%	3	943	16.78
3	>1% to 2%	4	1531	27.24
4	>2% to 3%	2	447	7.94
5	>3%	0	0	0.00
	TOTAL	14	5621	100.00

TABLE 5.87: DETAILS OF GRADIENTS OF CORRIDOR-4A

S. No.	Chainage		Length	Rail Level		Gradient	Remarks
	From	To		From	To		
1	-6021	-4538	1483	298.65	298.65	0.00	Level
4	-4538	-4333	205	298.65	303.50	2.37	Rise
5	-4333	-4197	136	303.50	303.50	0.00	Level
6	-4197	-3955	242	303.50	297.64	-2.42	Fall
7	-3955	-3763	192	297.64	296.15	-0.78	Fall
8	-3763	-3512	251	296.15	298.38	0.89	Rise
9	-3512	-3306	206	298.38	301.20	1.37	Rise
10	-3306	-3088	218	301.20	301.20	0.00	Level
11	-3088	-2883	206	301.20	298.37	-1.38	Fall
12	-2883	-2382	500	298.37	303.29	0.98	Rise
13	-2382	-1593	789	303.29	318.50	1.93	Rise
14	-1593	-1185	408	318.50	318.50	0.00	Level
15	-1185	-854	331	318.50	312.00	-1.97	Fall
16	-854	-400	454	312.00	312.00	0.00	Level

S. No.	Chainage		Length	Rail Level		Gradient	Remarks
	From	To		From	To		
1	-6021	-4538	1483	298.65	298.65	0.00	Level
4	-4538	-4333	205	298.65	303.50	2.37	Rise

5.4.6. Alignment Design of Corridor -5

5.4.6.1. Horizontal Curvature

A total of 9 curves have been provided on the entire length of corridor-3 alignment. The minimum radius of curves is 128 m beyond Vasudev Nagar station towards Ring Road. About 26.21% of the length of the alignment is on curves. The abstract and details of curves are indicated in **Table 5.88** and **Table 5.89** respectively.

TABLE 5.88: ABSTRACT OF HORIZONTAL CURVES OF CORRIDOR-5

S.No.	Curve Radius	No. of Occurrences	Length	Percentage
1	≤150	1	191.30	16.26
2	>150 <300	4	631.63	53.68
3	≥300 ≤ 500	1	116.13	9.87
4	>500 ≤ 800	0	0.00	0.00
5	>800 ≤ 1000	1	110.11	9.36
6	>1000	2	127.40	10.83
	Total	9	1176.57	100.00

TABLE 5.89: DETAILS OF HORIZONTAL CURVES OF CORRIDOR 5 – VASUDEV NAGAR TO DATTAWADI

Curve No	Chainage		Direction	Radius	Intersection Angle			Transition Length		Tangent Length	Curve Length	Total Curve Length	Straight Between
	From	To			D	M	S	In	Out				
1	15614.50	15805.80	Right	128	63	9	0	50	50	104.29	91.30	191.30	--
2	15805.81	15936.22	Left	-289.6	15	32	35.16	50	50	65.51	30.41	130.41	Nil
3	16004.40	16120.53	Right	500	8	5	25.08	45	45	58.14	26.13	116.13	68.17
4	16120.53	16180.97	Right	1580	1	23	6.36	15	15	30.22	30.44	60.44	Nil
5	16474.57	16628.57	Left	-200	29	28	24.96	50	50	78.33	54.00	154.00	293.60
6	17181.22	17401.95	Right	190	51	17	24.36	50	50	116.86	120.73	220.73	552.66
7	18153.00	18263.11	Right	1000	4	21	8.28	30	30	55.08	50.11	110.11	751.05
8	19503.57	19570.53	Right	2500	1	2	36.6	20	20	33.48	26.97	66.97	1240.46
9	19655.29	19781.79	Left	-260	16	30	45.36	50	50	63.58	26.50	126.50	84.76

5.4.6.2. Gradients

A total 10 number of change of gradients has been provided in the entire Corridor-5. Flattest gradient is level provided on 27.71% of alignment including the stations and steepest gradient is 2.11%. The abstract and details of gradients are given in **Table 5.90** & **Table 5.91** respectively.

TABLE 5.90: ABSTRACT OF GRADIENTS OF CORRIDOR-5

S.No.	Description	No's of Occurrences	Length (m)	% Length
1	Level (0%)	2	1232.75	27.71
2	>0% to 1%	3	1165.77	26.20
3	>1% to 2%	4	1720.29	38.67
4	>2% to 3%	1	330.02	7.42
5	>3%	0	0.00	0.00
	TOTAL	10	4449	100.00

TABLE 5.91: DETAILS OF GRADIENTS OF CORRIDOR-5

S. No.	Chainage		Length (m)	Rail Level		Gradient	Remarks
	From	To		From	To		
1	15612	15724	112	344.81	342.66	-1.92	Fall
2	15724	16150	426	342.66	345.00	0.55	Rise
3	16150	16371	221	345.00	345.80	0.36	Rise
4	16371	16723	352	345.80	352.30	1.85	Rise
5	16723	16953	230	352.30	352.30	0.00	Level
6	16953	17278	325	352.30	347.80	-1.39	Fall
7	17278	18210	932	347.80	358.07	1.10	Rise
8	18210	18728	518	358.07	353.55	-0.87	Fall
9	18728	19058	330	353.55	360.50	2.11	Rise
10	19058	20061	1003	360.50	360.50	0.00	Level

5.4.6.3. Special Span & Portals

Details of locations having special span arrangement are given in **Table 5.92**

TABLE 5.92: LOCATION OF SPECIAL SPANS CORRIDOR – 4A

S. No	Location	Chainage		Special span Configuration
		From	To	
1	Nag River crossing	-790	-850	60m
2	Outer ring road crossing	-4235	-4280	45m

5.4.7. Stations

- Stations have been located so as to serve major passenger catchment areas and to enable convenient integration with other modes of transport.
- Stations vary in complexity along the route and have been located by an interactive process influenced by ridership forecasts, availability of open land, interchange requirements with other modes of transport, construction feasibility, inter station distance, alignment, utilities, road and pedestrian requirements, future infrastructural developments and joint site visits & consultations with NMRCL.
- List of stations along with their chainage and inter-station distances (ISD) are given in **Table 5.93.**

TABLE 5.93: LIST OF STATIONS

S.No.	Station	Chainage (m)	Intermediate Distance (m)	Cumulative Distance (m)	Elevated/ Underground
CORRIDOR-1A: MIHAN TO MIDC ESR					
Start Point		20200	-	0	
1	ECO Park	20462	-	0	At grade
2	Metro City	21057	595	595	At grade
3	Ashokvan	23843	2786	3381	Elevated
4	Dongargaon	26693	2850	6231	Elevated
5	Mohgaon	29878	3185	9416	Elevated
6	Meghdoot CIDCO	32802	2924	12340	Elevated
7	Butibori Police Station	33540	738	13078	Elevated
8	MHADA Colony	34233	693	13771	Elevated
9	MIDC KEC	37360	3127	16898	Elevated
10	MIDC ESR	38352	992	17890	Elevated
Termination Point		38852	500	18652	
CORRIDOR-2A: AUTOMOTIVE SQUARE TO KANHAN RIVER					
Start Point		-575	-	0	
1	Pili Nadi	-1409	-	0	Elevated
2	Khasara Fata	-2286	877	877	Elevated
3	All India Radio	-3314	1028	1905	Elevated
4	Khairi Fata	-5250	1936	3841	Elevated
5	Lok Vihar	-6176	926	4767	Elevated
6	Lekha Nagar	-7199	1023	5790	Elevated
7	Cantonment	-8681	1482	6850	Elevated

S.No.	Station	Chainage (m)	Intermediate Distance (m)	Cumulative Distance (m)	Elevated/ Underground
8	Kamptee Police Station	-9410	729	8001	Elevated
9	Kamptee Municipal Council	-10225	815	8816	Elevated
10	Dragon Palace	-11196	971	9787	Elevated
11	Golf Club	-12468	1272	11059	Elevated
12	Kanhan River	-13324	856	11915	Elevated
Termination Point		-13500	176	12925	Elevated
CORRIDOR-3A: LOKMANYA NAGAR TO HINGNA					
Start Point		18218	-	0	
1	Hingna Mountview	18761	-	0	Elevated
2	Rajiv Nagar	19607	846	846	Elevated
3	Wanadongri	21006	1399	2245	Elevated
4	APMC	21715	709	2954	Elevated
5	Raipur	22823	1108	4062	Elevated
6	Hingna Bus Station	23625	802	4864	Elevated
7	Hingna	24532	907	5771	Elevated
Termination Point		24875	371	6657	
CORRIDOR-4A: PRAJAPATI NAGAR TO TRANSPORT NAGAR					
Start Point		-580	-	0	
1	Pardi	-1365	-	0	Elevated
2	Kapsi Jhurd	-3200	1835	1835	Elevated
3	Transport Nagar	-5026	1826	3661	Elevated
Termination Point		-6021	895	5441	
CORRIDOR-5: VASUDEV NAGAR TO DATTAWADI					
Start Point		15600	-	0	
1	Police Station MIDC	16831	-	0	Elevated
2	MIDC Hingna	19162	2331	2331	Elevated
3	Dattawadi	19838	676	3007	Elevated
Termination Point		20089	258	4489	

FIGURE 5.32: SCHEMATIC DIAGRAM OF NAGPUR METRO CORRIDOR-1A: MIHAN TO MIDC ESR

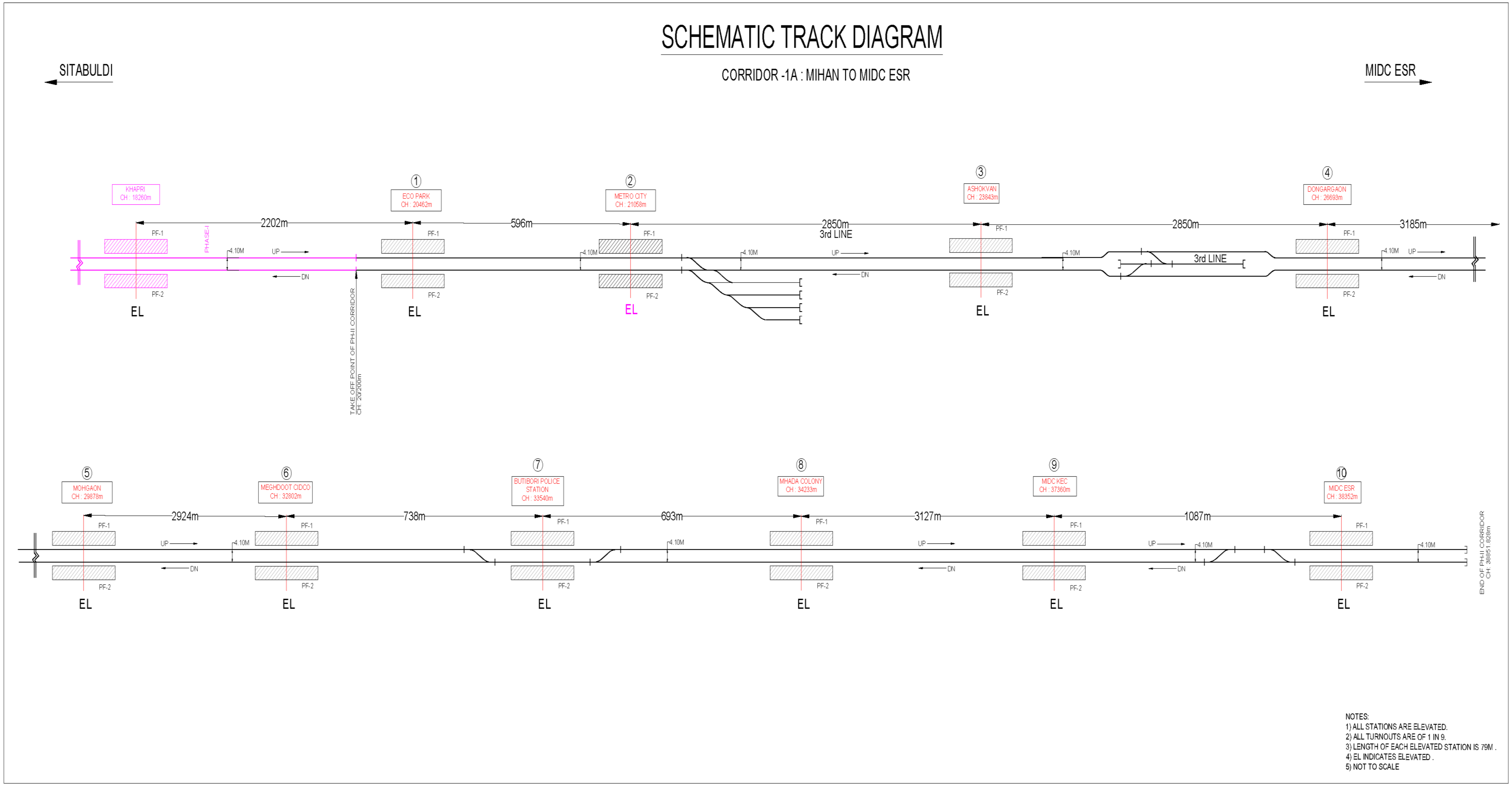


FIGURE 5.33: CORRIDOR-2A: AUTOMOTIVE SQUARE TO KANHAN RIVER

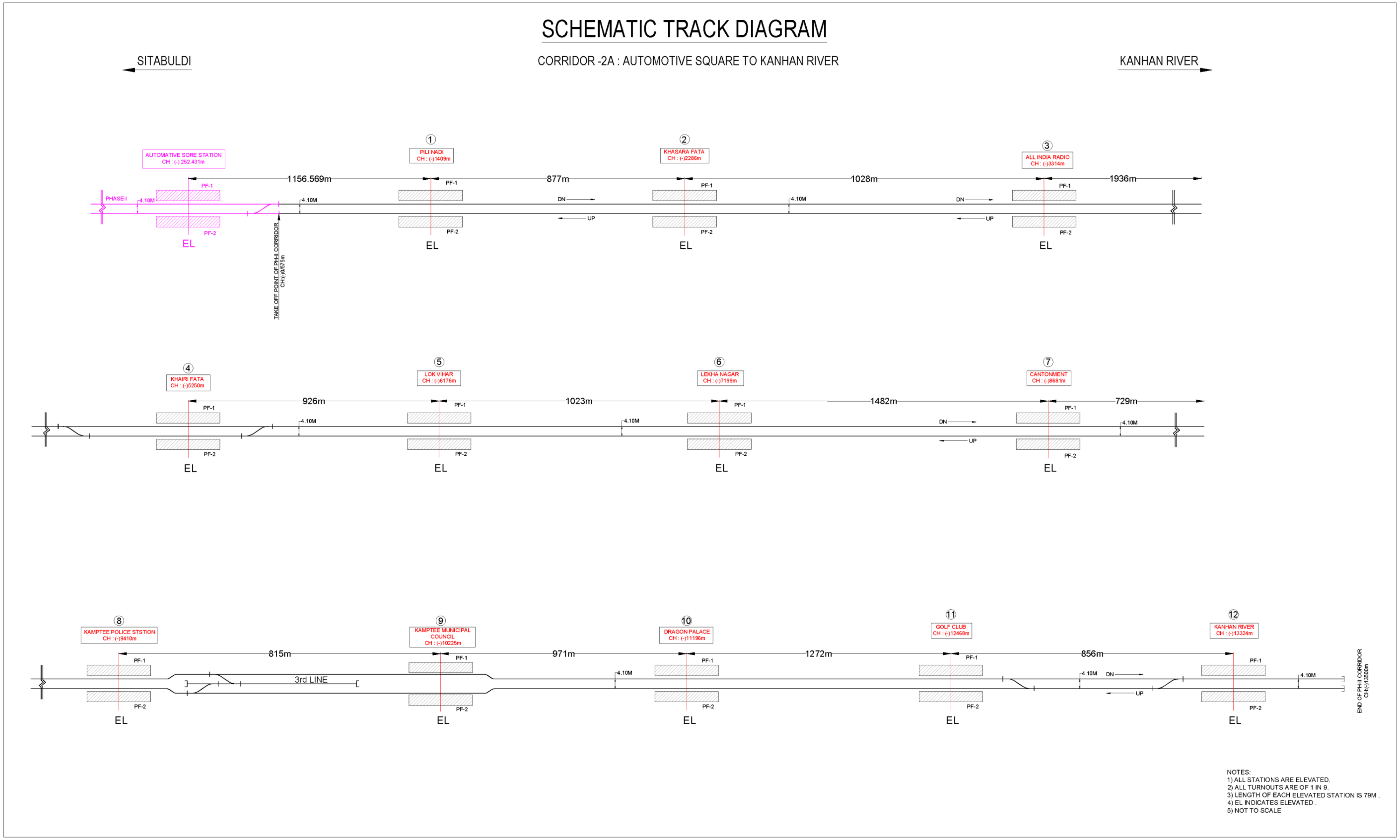


FIGURE 5.34: CORRIDOR-3A: LOKMANYA NAGAR TO HINGNA

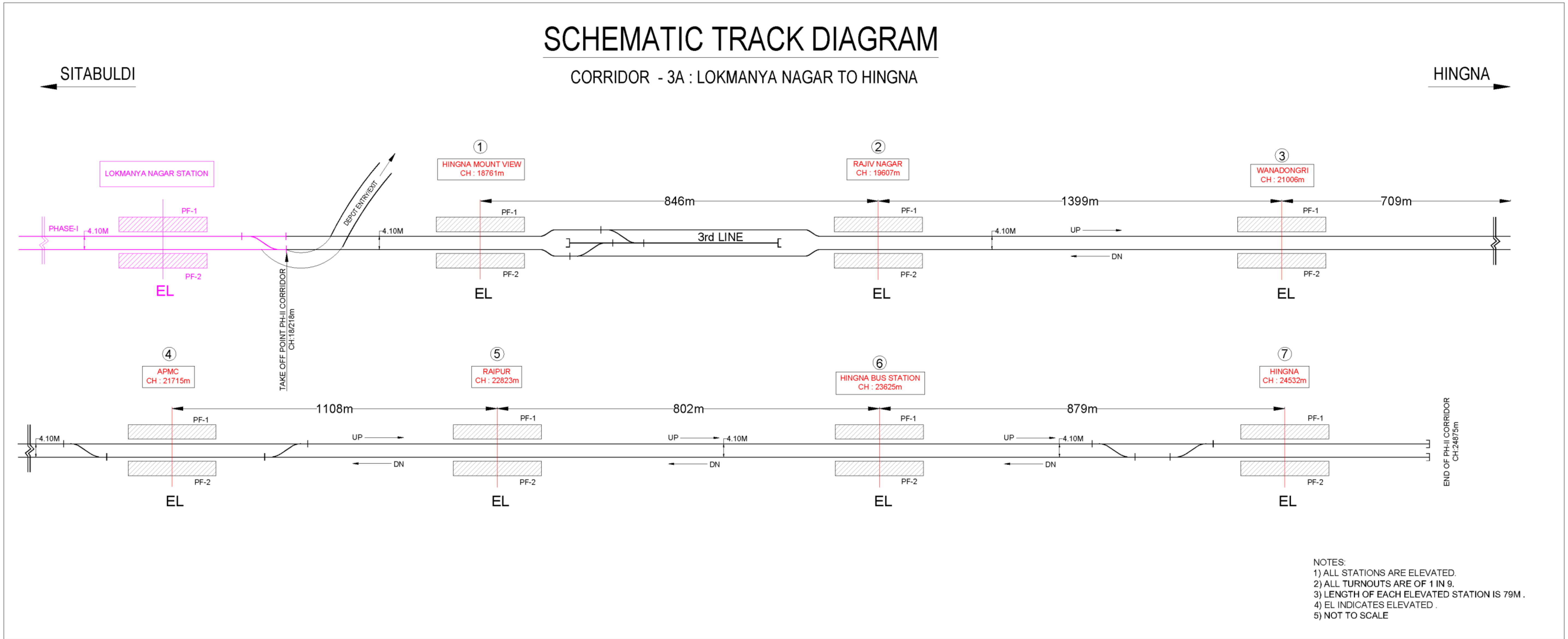


FIGURE 5.35: CORRIDOR-4A: PRAJAPATI NAGAR TO TRANSPORT NAGAR

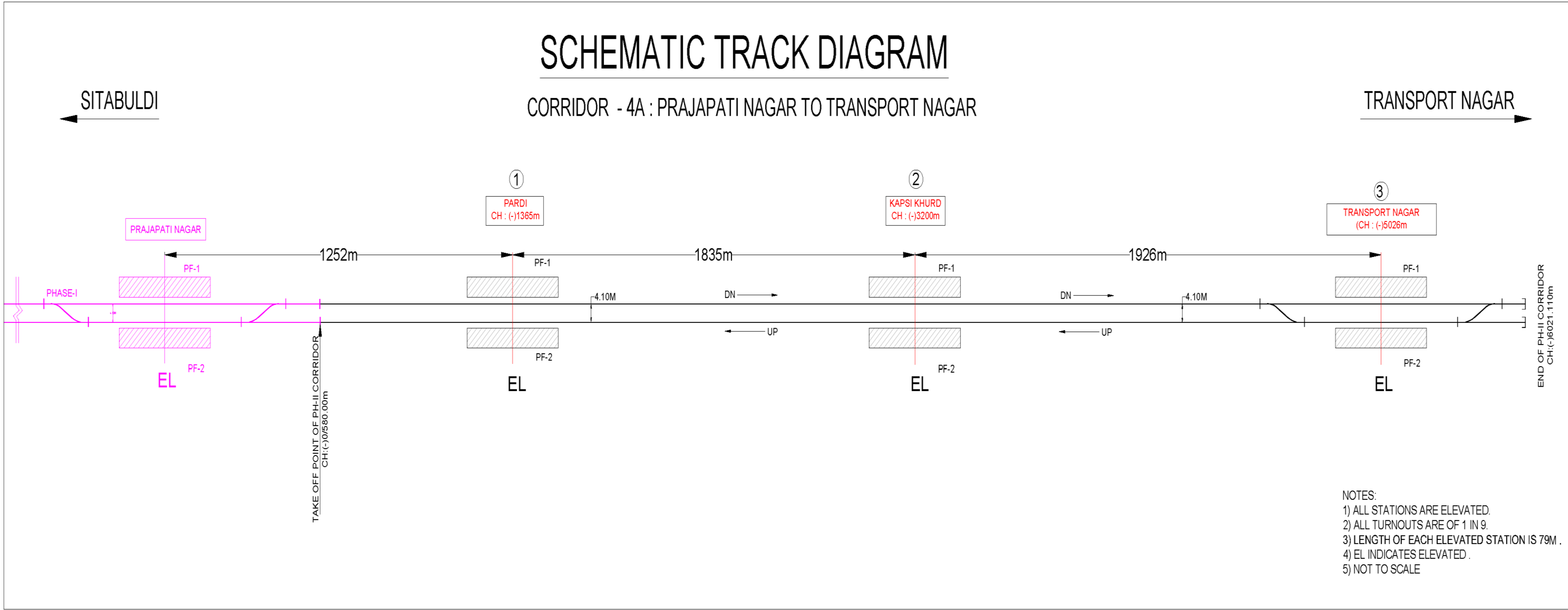
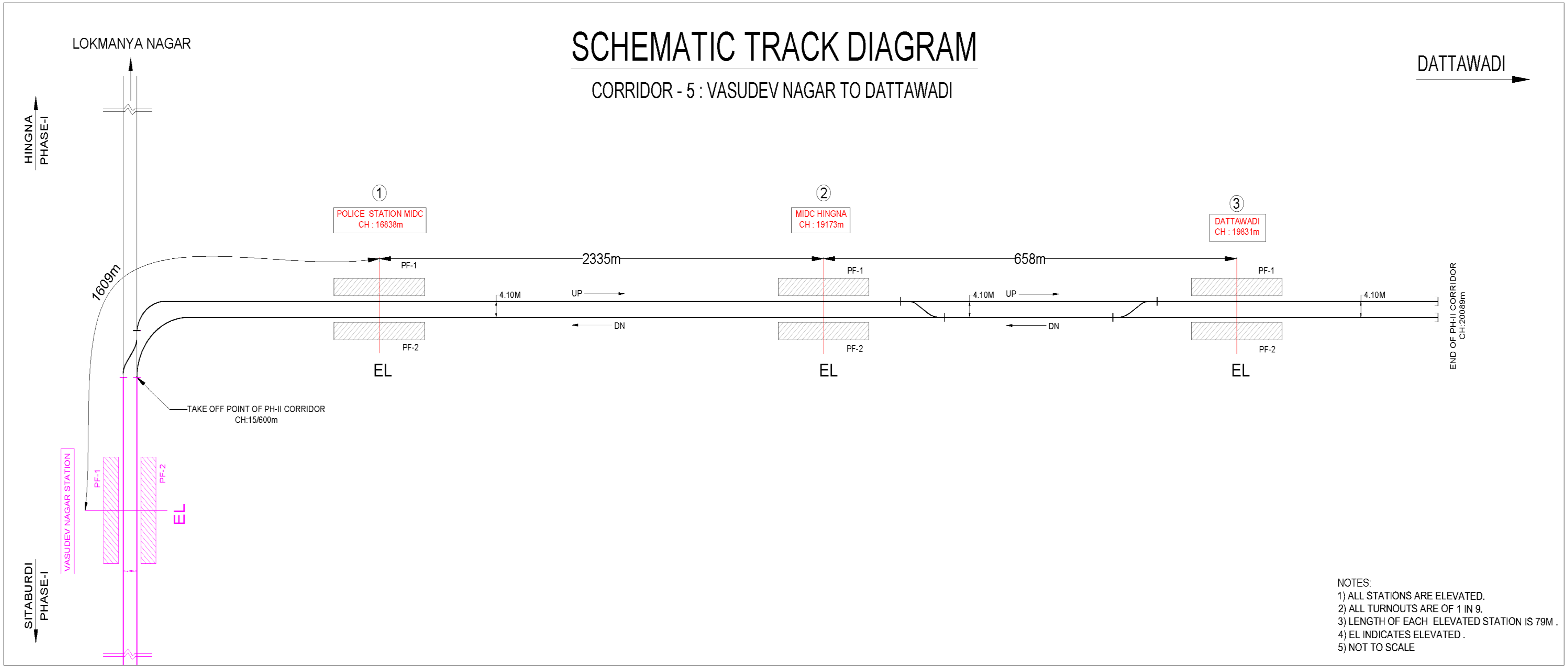


FIGURE 5.36: CORRIDOR-5: VASUDEV NAGAR TO DATTAWADI



5.5. IDENTIFICATION OF EXISTING SERVICE / UTILITIES

5.5.1. Introduction

- Large number of sub-surface, surface and overhead utility services viz. sewers, water mains, storm water drains, gas pipe lines, telephone/ communication cables, Overhead power transmission lines, power cables, traffic signals, etc. exists all along the proposed alignment.

- These utility services are essential and have to be maintained in working order during different stages of construction, by temporary/permanent diversions and relocation or by supporting in position. Any interruption to these will have serious repercussions on the most sensitive suburban services and direct impact on the public besides set back in construction and project implementation schedule & costs. Therefore, meticulous detailed survey and planning will be required to protect/divert the utility services.

- Accordingly, overhead utiliites were identified during physical survey of corridor. Moreover, liaison with concernd utitlity owners was made for identificaton and mapping of various underground utilities. No trenching / GPR survey etc. was conducted for underground utilities.

5.5.2. Agencies for Utility Services

Organizations/ Departments with concerned utility services are mentioned in **Table 5.94.**

TABLE 5.94: UTILITY RESPONSIBILITY DEPARTMENTS

S.no.	Organization/Deptt	Utility Services
1.	Nagpur Municipal Corporation. (KMC)	Roads, surface water drains, nallahs, Sewerage and drainage conduits, sewerage treatment plants, pumping stations, Water mains and their service lines, including hydrants, water treatment plants, pumping stations, Gardens etc.
2.	Public Works Deptt. (PWD)	Road construction & maintenance.
3.	Irrigation and Flood Department, Nagpur	Nallahs/flood water drains etc.
4.	MSEDCL Sub Division, Nagpur	Power cables and their appurtenances H.T. and L.T. lines, their pylons, electric light posts, pole mounted transformers, etc.
5.	Nagpur Traffic Police.	Traffic signal posts, junction boxes and cable connections, etc.
6.	BSNL (Bharat Sanchar Nigam Ltd.)	Telecommunication cables, junction boxes, telephone posts, O.H. lines, etc.

S.no.	Organization/Deptt	Utility Services
7.	TATA Tele Services	Telecommunication cables, junction boxes, telephone posts, O.H. lines, etc.
8.	Reliance Info. Ltd	Telecommunication cables, junction boxes, telephone posts, O.H. lines, etc.
9.	Central Railway	Railway crossings, signals, railway bridges, etc.

5.5.3. Guidelines for Diversion of Underground Utilities

While planning for diversion of underground utility services viz. sewer lines, water pipelines, cables, etc., during construction of MRTS, following guidelines have been adopted:

- Utility services have to be kept operational during the entire construction period and after completion of project. All proposals should therefore, ensure their uninterrupted functioning.
- Sewer lines and water supply lines are mainly affected in underground cut and cover construction. These services are proposed to be maintained by temporarily replacing them with CI/Steel pipelines and supporting them during construction, these will be encased in reinforced cement concrete after completion of construction and retained as permanent lines.
- Where permanent diversion of the affected utility is not found feasible, temporary diversion with CI/Steel pipes without manholes is proposed during construction. After completion of construction, these will be replaced with conventional pipes and manholes.
- The elevated viaduct does not pose much of a difficulty in negotiating the underground utility services, especially those running across the alignment. The utilities infringing at pier location can be easily diverted away from the pile cap location.
- In case a major utility is running along/across the alignment which cannot be diverted or the diversion of which is difficult, time consuming and uneconomical, the spanning arrangement of the viaduct and layout of piles in the foundation may be suitably adjusted to ensure that no foundation needs be constructed at the location. The utility service can also be encased within the foundation piles.

5.5.4. Sewer Lines, Storm Water Drains and Water Lines

The storm water drains and water pipe lines generally exists either side of under main carriageway or at some places on the central verge, as a result of subsequent road widening. However, majority of sewer lines are running in the centre of the road. The major sewer, storm water drains and water pipe lines mains running across the alignment and likely to be affected due to location of column foundations, are proposed to be taken care of by relocating the column supports of viaduct by change in span or by suitably adjusting the layout of pile foundations. Where, this is not feasible, lines will be suitably diverted. Provision has been made in the project cost estimate towards diversion of utility service lines. Summary of sewer lines & storm water drains and water pipe lines affected are indicated in **Table 5.95.**

TABLE 5.95: WATER SUPPLY AND SEWER LINE UTILITIES

S. No	Utility	From Ch. (m)	To Ch. (m)	LHS/ RHS	Affected Length (M)	Dia/Size	Position of Alignment	Remarks
CORRIDOR 2A – AUTOMOTIVE SQUARE TO BUDDH VIHAR (KAMPTEE)								
1	SWD	-550	-750	RIGHT SIDE		STORM WATER DRAIN RCC SLAB, DEPTH=2.3 FEETS	PARALLEL	
2	SWD	-640	-950	LEFT SIDE		STORM WATER DRAIN RCC SLAB, DEPTH=2.3 FFETS	PARALLEL	
3	SWD	-625	-855	LEFT SIDE	475	STORM WATER DRAIN RCC SLAB, DEPTH=2.3 FFETS	PARALLEL	
4	SWD	-1125	-1564	RIGHT SIDE	100	STORM WATER DRAIN RCC SLAB, DEPTH=2.3 FFETS	PARALLEL	WAY TO BANDARA
5	SWD	-1268	-1496	RIGHT SDE	375	STORM WATER DRAIN RCC SLAB, DEPTH=2.3 FFETS	PARALLEL	
6	SEWER LINE	-1364	-1548	LEFT SIDE	215	SEWER LINE DEPTH=3.5 FFETS, DIA=12 INCHS	PARALLEL	
7	SEWER LINE	-1558	-2056	LEFT CROSSING		SEWER LINE DEPTH=3.5 FFETS, DIA=12 INCHS	PERPENDICULAR	WAY TO UPPAL WADI
8	SEWER LINE	-1658	-2589	RIGHT SIDE	200	SEWER LINE DEPTH=3.5 FFETS, DIA=12 INCHS	PARALLEL	
9	SEWER LINE	-1868	-5426	RIGHT CROSSING		SEWER LINE DEPTH=3.5 FFETS, DIA=12 INCHS	PERPENDICULAR	WAY TO BANCHARA
10	SEWER LINE	RAILWAY TRACKS NEAR PILLI NADI TO KAMPTEE NALA (CONTONMENT AREA) NO SEWER LINE USE ONLY SEPTIC TANK PART BY NMC ASSI NAGAR AREA.						
CORRIDOR 4A – PRAJAPATI NAGAR TO TRANSPORT NAGAR								
1	SWD	364	904	RIGHT SIDE	540	STORM WATER DRAIN BOX SLAB, DEPTH=2.5M	PARALLEL	

S. No	Utility	From Ch. (m)	To Ch. (m)	LHS/ RHS	Affected Length (M)	Dia/Size	Position of Alignment	Remarks
2	SWD	364	904	LEFT SIDE	540	STORM WATER DRAIN BOX SLAB, DEPTH=2.5M	PARALLEL	
3	SEWAR	989	1114	LEFT	125	OUTLET VALVE SEWER, DEPTH=15-20 FEETS, DIA=1.5 FEETS	PARALLEL	
4	SEWER	1494	1494	RAD CROSSING		COVER DRAIN WITH SEWER LINE	PERPENDICULAR	
5	SEWER	1504	1504	ROAD CROSSING		COVER DRAIN WITH SEWER LINE	PERPENDICULAR	
6	SEWER	1504	1734	RIGHT SIDE	230	COVER DRAIN WITH SEWER LINE	PARALLEL	WAY TO MITTAL ENCLAVE
CORRIDOR 5 – VASUDEV NAGAR TO DATTAWADI (WADI)								
1	SWD	15625	15725	RIGHT SIDE	100	STORM WATER DRAIN, DEPTH=0.60M	PARALLEL	

5.5.5. Telecom Cables, OFC, Ducts and Trench

At several places, telecom cables, OFC, ducts and trenches of Vodafone, Idea, Aircel, Airtel and BSNL are also running along and across the proposed corridors and few of them are likely to be affected.

5.5.6. Above Ground Utilities

Above ground utilities namely Power transmission lines, transformers are running along and across the proposed corridors and few of them are likely to be affected. Detail of transformers and HT Lines are presented in **Table 5.96.**

TABLE 5.96: DETAILS OF HT CROSSING

S.N.	Utility	From Ch. (m)	To Ch. (m)	LHS/ RHS	Position of alignment	Height	Remarks
CORRIDOR 1A – MIHAN TO MIDC ESR							
1	HT LINE	31250		ACROSS	PERPENDICULAR	12.00	
CORRIDOR 2A - AUTOMOTIVE SQUARE TO KANHAN RIVER							
1	N/A	N/A		N/A	N/A	N/A	
CORRIDOR 3A - LOKMANYA NAGAR TO HINGNA							
1	HT LINE	22143		ACROSS	PERPENDICULAR	8 M	
CORRIDOR 4A – PRAJAPATI NAGAR TO TRANSPORT NAGAR							
1	HT LINE	5775		-	PERPENDICULAR	11.00	
CORRIDOR 5 - VASUDEV NAGAR TO DATTAWADI (WADI)							
1	HT POWER LINE	16265		6.20	-	1	16265

S.N.	Utility	From Ch. (m)	To Ch. (m)	LHS/ RHS	Position of alignment	Height	Remarks
2	HT POWER LINE	16285		6.68	-	2	16285
3	HT POWER LINE	17005		6.42	-	3	17005
4	HT POWER LINE	17010		5.02	-	4	17010
5	HT POWER LINE	17110		7.01	-	5	17110
6	HT POWER LINE	18900		6.81	-	6	18900

TABLE 5.97: ELECTRICAL (MSEDCL) UTILITIES

S. No	Utility	From Ch. (m)	To Ch. (m)	LHS/RHS	Affected Length (m)	Dia/Size	Position of Alignment	Remarks
CORRIDOR 2A – AUTOMOTIVE SQUARE TO KANHAN RIVER								
1	ELECTRICAL	-654	-789	ROAD CROSSING		33KV NEW FEEDER BHILGAON 2 NOS, CABLE, DEPTH=7 FEETS	PERPENDICULAR	
2	ELECTRICAL	-687	-889	RIGHT SIDE	80	33KV NEW FEEDER BHILGAON 2 NOS, CABLE, DEPTH=7 FEETS	PARALLEL	
3	ELECTRICAL	-688	-895	LEFT SIDE	50	33KV CABLE, DEPTH=7FEETS	PARALLEL	
4	ELECTRICAL	-874	-1675	ROAD CROSSING		33KV CABLE, DEPTH=7 FEETS	PERPENDICULAR	
5	ELECTRICAL	-1675	-1800	RIGHT SIDE	125	33KV CABLE, DEPTH=7 FEETS	PARALLEL	
6	ELECTRICAL	-1760	-2000	LEFT SIDE	240	11KV CABLE KHUSADA FEEDER, DEPTH=7 FEETS	PARALLEL	
7	ELECTRICAL	-2000	-2000	ROAD CRSSING		11KV CABLE KHUSADA FEEDER, DEPTH=7 FEETS	PERPENDICULAR	
8	ELECTRICAL	-2000	-2325	RIGHT SIDE	325	2 NOS,CABLE 33 KV,300SQ	PARALLEL	

S. No	Utility	From Ch. (m)	To Ch. (m)	LHS/RHS	Affected Length (m)	Dia/Size	Position of Alignment	Remarks
						MM,DEPTH=1.0M BHILGAON SUB STATION		
9	ELECTRICAL	-8450	-8460	RIGHT SIDE	10	11KV, 240SQ MM LINK CABLE	PARALLEL	
10	ELECTRICAL	-8775		RIGHT SIDE		11KV, 240SQ MM, DEPTH=1.0M	PARALLEL	ALONG THE ROAD NC OFFICE
CORRIDOR 3A – LOKMANYA NAGAR TO HINGNA								
1	MESEB NAGPUR	18526	19584	RIGHT SIDE	380	11 KV U/G CABLE 300 SQ.MM DOUBLE CIRCUIT DEPT.=1.2MTS & O/H LINE	PARALLEL	
2	MESEB NAGPUR	19568	19568	ROAD CROSSING		11 KV U/G CABLE 300 SQ.MM DOUBLE CIRCUIT DEPT.=1.2MTS & O/H LINE	PERPENDICULAR	
3	MESEB NAGPUR	19854	20546	RIGHT SIDE	1295	1 KV U/G CABLE 300 SQ.MM DOUBLE CIRCUIT DEPT.=1.2MTS &	PARALLEL	

S. No	Utility	From Ch. (m)	To Ch. (m)	LHS/RHS	Affected Length (m)	Dia/Size	Position of Alignment	Remarks
						11KV O/H LINE DOUBLE CIRCUIT		
4	MESEB NAGPUR	19987	20054	RIGHT SIDE	120	LT U/G CABLE 25 SQ. MM,3.5 FEET DEPTH	PARALLEL	
CORRIDOR 4A – PRAJAPATI NAGAR TO TRANSPORT NAGAR								
1	ELECTRICAL	114	604	LEFT SIDE	490	SONBA FEEDER 11 KV	PARALLEL	
2	ELECTRICAL	114	604	LEFT SIDE	490	TARAGAON TRANSFORMER 11 KV	PARALLEL	
3	ELECTRICAL	114	584	LEFT SIDE	470	2X2 NOS CABLE BHANDARA 3 &4 ,11KV 300SQMM FEEDER	PARALLEL	
4	ELECTRICAL	584	584	ROAD CROSSING		2X2 NOS CABLE BHANDARA 3 &4 ,11KV 300SQMM FEEDER	PERPENDICULAR	
5	ELECTRICAL	114	2454	RIGHT SIDE	2340	U/G 2X2 NOS CABLE 33 KV, 300SQ MM SNDL ELECTRICAL CABLE, DEPTH=2.0M	PARALLEL	
6	ELECTRICAL	614	614	ROAD CROSSING		11KV HB TOWN	PERPENDICULAR	

S. No	Utility	From Ch. (m)	To Ch. (m)	LHS/RHS	Affected Length (m)	Dia/Size	Position of Alignment	Remarks
						FEEDER 300SQMM		
7	ELECTRICAL	614	614	ROAD CROSSING		GOMANI FEEDER 11KV	PERPENDICULAR	
8	ELECTRICAL	614	614	ROAD CROSSING		OTC528	PERPENDICULAR	
9	ELECTRICAL	614	1249	LEFT SIDE	635	11 KV BHAWANI FEEDER 300SQMM SINGLE RUN	PARALLEL	
10	ELECTRICAL	614	889	RIGHT SIDE	275	GOMANI FEEDER 11KV	PARALLEL	
11	ELECTRICAL	889	889	ROAD CROSSING		11KV HB TOWN FEEDER 300SQMM SINGLE RUN	PERPENDICULAR	
12	ELECTRICAL	889	994	LEFT SIDE	470	11KV GOMTI FEEDER 300SQMM, DEPTH=1.0M	PARALLEL	
13	ELECTRICAL	994	994	ROAD CROSSING		11KV GOMTI FEEDER 300SQMM, DEPTH=1.0M	PERPENDICULAR	
14	ELECTRICAL	1849	1849	ROAD CROSSING		11KV RAJESH COSTING FEEDER 300SQ MM		
15	ELECTRICAL	2464	2464	ROAD CROSSING		SUBHAN NAGAR 1&2, 11KV-300SQ MM	PERPENDICULAR	
16	ELECTRICAL	2464	2464	ROAD CROSSING		DOUBLE X 2	PERPENDICULAR	

S. No	Utility	From Ch. (m)	To Ch. (m)	LHS/RHS	Affected Length (m)	Dia/Size	Position of Alignment	Remarks
						WARDHAMAN NAGAR 33 KV, 300SQMM		
17	ELECTRICAL	314	2469	LEFT SIDE	2155	DOUBLE X 2 WARDHAMAN NAGAR 33 KV, 300SQMM	PARALLEL	
18	ELECTRICAL	2674	2674	ROAD CROSSING		33KV, 300 SQMM 1NO,CABLE, DEPTH=2.0M	PERPENDICULAR	
19	ELECTRICAL	3204	3204	NALA CROSSING		11KV, 300 SQMM 2 NOS,CABLE, DEPTH=2.0M	PERPENDICULAR	
20	ELECTRICAL	3539	3539	ROAD CROSSING		11KV, 300 SQMM 2 NOS,CABLE, DEPTH=2.0M	PERPENDICULAR	
21	ELECTRICAL	4228	4229	ROAD CROSSING		11KV, 300 SQMM 2 NOS,CABLE, DEPTH=2.0M	PERPENDICULAR	
22	ELECTRICAL	4329	4414	LEFT FLY OVER CROSSING	85	33KV, 300 SQMM 2 NOS,CABLE, DEPTH=2.0M	PARALLEL	
CORRIDOR 5 – VASUDEV NAGAR TO DATTAWADI (WADI)								
	NO ELECTRICAL LINE LYING IN THIS ROUTE (VASUDEV NAGAR TO AMRAVATI ROAD (WADI)CORRIDOR)							

TABLE 5.98: TELECOM (BSNL) UTILITIES

S. No	Utility	From Ch. (m)	To Ch. (m)	LHS/RHS	Affected Length (M)	Dia/Size	Position of Alignment	Remarks
CORRIDOR 2A–AUTOMOTIVE SQUARE TO KANHAN RIVER								
	OPTICAL FIBRE CABLES							
1	BSNL	-658	-889	RIGHT SIDE	100	22 NOS DUCT(CONCRETE) ,12FIBER& 24 FIBER, OFC ,DEPTH=1.65M)	PARALLEL	NGP-NARI-KMPT-SSA CABLE
2	BSNL	-854	-1054	ROAD CROSSING		22 NOS DUCT(CONCRETE) ,12FIBER& 24 FIBER, OFC ,DEPTH=1.65M)	DIAOGNAL	NGP-NARI-KMPT-SSA CABLE
3	BSNL	-985	-1256	LEFT SDE		22 NOS DUCT(CONCRETE) ,12FIBER& 24 FIBER, OFC ,DEPTH=1.65M)	PARALLEL	NGP-NARI-KMPT-SSA CABLE
4	BSNL	-2546	-5698	ROGHT SIDE	250	22 NOS DUCT(CONCRETE) ,12FIBER& 24 FIBER, OFC ,DEPTH=1.65M)	PARALLEL	NGP-NARI-KMPT-SSA CABLE
	COPPER CABLES							
1	BSNL	-1100	-1568	LEFT SIDE		DUCT NO-3, COPPER CABLE-200PIAR/ 100 PAIR- 2 NOS, DEPTH=1.0MM	PARALLEL	COPPER CABLE
2	BSNL	-5987	-1650	LEFT SIDE	1650	DUCT NO=7, COPPER CABLE-200PIAR- 2 NOS,	PARALLEL	COPPER CABLE

S. No	Utility	From Ch. (m)	To Ch. (m)	LHS/RHS	Affected Length (M)	Dia/Size	Position of Alignment	Remarks
						DEPTH=1.0MM		
3	BSNL	-3568	-1895	ROAD CROSSING	-	PILLER NO-20, COPPER CABLE 100 PAIR, DEPTH 1.0M)	PERPENDICULAR	COPPER CABLE
4	BSNL	-1660	-1660	ROAD CROSSING	-	BARRIIED CROSSING,COPPER CABLE 50 PAIR, DEPTH 1.0M)	PERPENDICULAR	BHILGAON T POINT
5	BSNL	-1650	-4075	LEFT SIDE	1425	DUCT NO-3, COPPER CABLE-200PIAR/ 100 PAIR- 2 NOS, DEPTH=1.0MM	PARALLEL	COPPER CABLE
6	BSNL	-6400	-7450	LEFT SIDE	1050	DUCT COPPER CABLE 50 PAIR 1 NO. DEPTH=1.M	PARALLEL	ASHA HOSPITAL TO DRAGGAN PLACE
7	BSNL	-6400	-7450	RIGHT SDE	1050	DUCT COPPER CABLE 100 PAIR 1 NO. DEPTH=1.M	PARALLEL	
8	BSNL	-7450	-8200	RIGHT SIDE	750	DUCT COPPER CABLE 800 PAIR 1 NO. DEPTH=1.M	PARALLEL	
9	BSNL	-7750	-7750	RIGHT CROSSING	-	DUCT COPPER CABLE 800 PAIR 1 NO. DEPTH=1.M	PERPENDICULAR	
10	BSNL	-7775	-7775	CROSSING	-	DUCT COPPER CABLE 800 PAIR 1 NO. DEPTH=1.M		DISTRIBUTION LINE
11	BSNL	-8200	-8475	RIGHT SIDE	275	DUCT COPPER CABLE 400 PAIR		

S. No	Utility	From Ch. (m)	To Ch. (m)	LHS/RHS	Affected Length (M)	Dia/Size	Position of Alignment	Remarks
						1 NO. DEPTH=1.M		
12	BSNL	-8365	-8365	LEFT SIDE		DUCT COPPER CABLE 400 PAIR 1 NO. DEPTH=1.M		DISTRIBUTION LINE
13	BSNL	-8465	-8465	LEFT SIDE		DUCT COPPER CABLE 200 PAIR 1 NO. DEPTH=1.M		DISTRIBUTION LINE
14	BSNL	-8465		RIGHT SIDE		DUCT COPPER CABLE 100 PAIR 1 NO. DEPTH=1.M		UPTO DRAGGAN PLACE RUB
15	BSNL	-8660	-8925	LEFT SIDE	265	DUCT COPPER CABLE 100 PAIR 1 NO. DEPTH=1.M		UPTO CANTOMENT AREA
16	BSNL	-8660	-8660	ROAD CROSSING		DUCT COPPER CABLE 100 PAIR 1 NO. DEPTH=1.M		DISTRIBUTION LINE
	WTR (LONG DISTANCE CABLE)							
1	BSNL	-659	-7500	LEFT SIDE		NP-KAMPIT-RAMTEK-DUCT=22 NOS.OFC(12 FIBER/24 FIBER) DEPTH= 4 FEETS	PARALLEL	NP-KAMPIT-RAMTEK
CORRIDOR 3A – LOKMANYA NAGAR TO HINGNA								
	OPTICAL FIBRE CABLES							
1	BSNL	18564	19700	ROAD RIGHT SIDE	4050	BSNL OFC(48 FIBER/24 FIBER), DEPTH-1.20 MTR)	PARALLEL	OFE

S. No	Utility	From Ch. (m)	To Ch. (m)	LHS/RHS	Affected Length (M)	Dia/Size	Position of Alignment	Remarks
2	BSNL	20625	20625	RIGHT CROSSING		BSNL OFC(48 FIBER/24 FIBER), DEPTH-1.20 MTR)	DIOGNAL	OFC
	COPPER CABLES							
1	BSNL COPPER	20854	20854	LEFT SIDE	900	BSNL U/G CABLE 2000 PAIR COPPER& ,400 PAIR U/G COPPER CABLE, DEPTH=1.65 M	PARALLEL	COPPER CABLE
2	BSNL COPPER	21548	22548	LEFT SIDE	1100	BSNL U/G CABLE 800 PAIR COPPER DEPTH=1.65 M	PARALLEL	COPPER CABLE
3	BSNL COPPER	21645	21645	LEFT SIDE	300	BSNL U/G CABLE 100 PAIR 1 NO. COPPER & ,800 PAIR 1 NO U/G COPPER CABLE, DEPTH=1.65 M	PARALLEL	COPPER CABLE
4	BSNL COPPER	21849	21849	LEFT SIDE	900	BSNL U/G CABLE 100 PAIR 1 NO. COPPER ,DEPTH=1.65 M		OPTICAL FIBRE
5	BSNL COPPER	22548	22548	ROAD CROSSING	650	BSNL U/G CABLE 50 PAIR 1 NO. COPPER ,DEPTH=1.65 M		OPTICAL FIBRE
	WTR (LONG DISTANCE CABLE)							
1	BSNL WTR	22654	22654	RIGHT SIDE	4050	BSNLWTROFC CABLE-12 FIBER/24 FIBER DEPTH=1.0M	PARALLEL	BSNL WTR

S. No	Utility	From Ch. (m)	To Ch. (m)	LHS/RHS	Affected Length (M)	Dia/Size	Position of Alignment	Remarks
2	BSNL WTR	23564	23564	RIGHT CROSSING		BSNLWTROFC CABLE-12 FIBER/24 FIBER DEPTH=1.0M	DIOGNAL	BSNL WTR
CORRIDOR 4A – PRAJAPATI NAGAR TO TRANSPORT NAGAR								
	COPPER CABLES							
1	BSNL COPPER			RIGHT SIDE		BSNL U/G CABLE 3 NOS (1200 PAIR/400 PAIR/100 PAIR COPPER ,DEPTH=1.00M	PARALLEL	COPPER CABLE
2	BSNL COPPER			ROAD CROSSING		BSNL U/G CABLE 3 NOS (1200 PAIR/400 PAIR/100 PAIR COPPER ,DEPTH=1.00 M	PERPENDICULAR	COPPER ABLE
3	BSNL COPPER			LEFT SIDE		BSNL U/G CABLE 3 NOS (1200 PAIR/400 PAIR/100 PAIR COPPER ,DEPTH=1.00 M	PARALLEL	
4	BSNL COPPER			LEFT CROSSING		BSNL U/G CABLE 1 NO 100 PAIR COPPER ,DEPTH=1.00 M	PERPENDICULAR	P-23
5	BSNL COPPER			LEFT		BSNL U/G CABLE 2 NOS (800PAIR/100 PAIR COPPER ,DEPTH=1.00 M	PARALLEL	
6	BSNL COPPER	494	494	ROAD CROSSING		BSNL U/G CABLE 2 NOS (400PAIR/100 PAIR COPPER	PERPENDICULAR	

S. No	Utility	From Ch. (m)	To Ch. (m)	LHS/RHS	Affected Length (M)	Dia/Size	Position of Alignment	Remarks
						,DEPTH=1.00 M		
7	BSNL COPPER	114	114	ROAD CROSSING		BSNL U/G CABLE 3 NOS (200 PAIR/100 PAIR/100 PAIR COPPER ,DEPTH=1.00 M	PERPENDICULAR	P-34
8	BSNL COPPER	114	114	ROAD CROSSING		BSNL U/G CABLE 1NO(100PAIR COPPER ,DEPTH=1.00 M	PERPENDICULAR	TO BHAWANI TEMPLE
9	BSNL COPPER	114	114	RIGHT	1310	BSNL U/G CABLE 4NOS(100 PAIR/100PAIR/200PAIR/400 PAIR COPPER ,DEPTH=1.00 M	PARALLEL	P-34 TO CONNECTED P-38
10	BSNL COPPER	114	114	ROAD CROSSING		BSNL U/G CABLE 1NO(100PAIR COPPER ,DEPTH=1.00 M	PERPENDICULAR	
11	BSNL COPPER	114	114	LEFT SIDE	960	BSNL U/G CABLE 1NO(100 PAIR COPPER ,DEPTH=1.00 M	PARALLEL	UPTO NMC NAKA
12	BSNL COPPER	114	114	RIGHT SIDE	660	BSNL U/G CABLE 1NO(50PAIR COPPER ,DEPTH=1.00 M	PARALLEL	TO MSEB OFFICE
	WTR /OPTICAL FIBRE CABLES (BOTH)							
1	BSNL(OFC+WTR)	-650	-650	LEFT CROSSINGG		BSNL (WTR) OFC CABLE 40MM DUCT 8 NOS,24 FIBER. DEPTH=1.65M(OPEN TRANCH)	PERPENDICULAR	FROM KALAMNA BSNLX-CHANGE
2	BSNL(OFC+WTR	-650	-700	LEFT	50	BSNL (WTR) OFC CABLE 40MM	PARALLEL	WTR CABLE

S. No	Utility	From Ch. (m)	To Ch. (m)	LHS/RHS	Affected Length (M)	Dia/Size	Position of Alignment	Remarks
						DUCT 8 NOS,24 FIBER. DEPTH=1.65M(OPEN TRANCH)		
3	BSNL(OFC+WTR	-650	-650	ROAD CROSSING		BSNL (WTR) OFC CABLE 40MM DUCT 8 NOS, 24 FIBER. DEPTH=1.65M(OPEN TRANCH)	PERPENDICULAR	WTR CABE
4	BSNL(OFC+WTR	-650	3650	RIGHT SIDE	3500	BSNL (WTR) OFC CABLE 40MM DUCT 8 NOS,24 FIBER. DEPTH=1.65M(OPEN TRANCH)	PARALLEL	WTR CABLE
5	BSNL(OFC+WTR	3314	4699	RIGHT SIDE	1335	BSNL (WTR) OFC CABLE 40MM DUCT 8 NOS,24 FIBER. DEPTH=1.65M(HDD)	PARALLEL	WTR CABLE
CORRIDOR 5 – VASUDEV NAGAR TO DATTAWADI								
	OPTICAL FIBRE CABLES							
1	BSNL	15625	15725	RIGHT SUDE	100	PRIMARY DUCT CABLE, OFC (48F-2 NOS, 24F-2 NOS, 6F-1 NO.	PARALLEL	HINGNA CMZDC-NAGPUR SSA)
2	BSNL	15725	15725	ROAD CROSSING		PRIMARY DUCT CABLE, OFC (48F-2 NOS, 24F-2 NOS, 6F-1 NO.	PERPENDICULAR	HINGNA CMZDC-NAGPUR SSA)
3	BSNL	15750	15750	CROSSING(L/R)		PRIMARY DUCT CABLE, OFC (48F-2 NOS, 24F-2 NOS, 6F-1	DIOGNAL	HINGNA CMZDC-

S. No	Utility	From Ch. (m)	To Ch. (m)	LHS/RHS	Affected Length (M)	Dia/Size	Position of Alignment	Remarks
						NO.		NAGPUR SSA)
4	BSNL	15725	16300	LEFT	575	PRIMARY DUCT CABLE, OFC (48F-2 NOS, 24F-2 NOS, 6F-1 NO.	PARALLEL	HINGNA CMZDC-NAGPUR SSA
5	BSNL	16300	16925	LEFT	625	PRIMARY DUCT CABLE, OFC (48F-2 NOS,24F-1 NO,6F-2 NOS.	PARALLEL	HINGNA CMZDC-NAGPUR SSA
6	BSNL	16925	17425	LEFT	500	PRIMARY DUCT CABLE, OFC (48F-1 NO, 12F-1 NO, 6F-1 NO.	PARALLEL	HINGNA CMZDC-NAGPUR SSA
7	BSNL	17425	19700	LEFT	2275	PRIMARY DUCT CABLE, OFC (48F-2 NOS,12F-1 NO,6F-2 NOS.	PARALLEL	HINGNA CMZDC-NAGPUR SSA
8	BSNL	19700	20050	LEFT	350	PRIMARY DUCT CABLE, OFC (48F-2 NOS, 12 F-5 NOS, 6F-1 NO.96F-1 NO.)	PARALLEL	HINGNA CMZDC-NAGPUR SSA
9	BSNL	20060	20060	RIGH SID		PRIMARY DUCT CABLE, OFC (48F/ 12 F-/6F/96F.	PERPENDICULAR	HINGNA CMZDC-NAGPUR SSA
10	BSNL	20060	20060	LEFT SIDE		PRIMARY DUCT CABLE, OFC (48F-/,12 F-/6F	PERPENDICULAR	HINGNA CMZDC-

S. No	Utility	From Ch. (m)	To Ch. (m)	LHS/RHS	Affected Length (M)	Dia/Size	Position of Alignment	Remarks
								NAGPUR SSA
	COPPER CABLES							
1	BSNL COPPER	15725	16925	LEFT SIDE	1200	JILLY FIELD COPPER CABLE, U/G BSNL CABLE200 PAIR, 1200PAIR, DEPTH=1.5M.	PARALLEL	COPPER CABLE
2	BSNL COPPER	15880	15880	ROAD CROSSING (RIGHT)		JILLY FIELD COPPER CABLE, U/G BSNL CABLE200 PAIR, 1200PAIR, DEPTH=1.5M.	PERPENDICULAR	COPPER CABLE
3	BSNL COPPER	16035	16035	RIGHT SIDE		U/G BSNL CABLE200 PAIR, DEPTH=1.5M.	PERPENDICULAR	COPPER CABLE
4	BSNL COPPER	16925	18350	LEFT SIDE	1425	800PAIR JOLLY DIELD CABLE 1 NO, THROUGH DUCT,400IR CABLE BARRIED 3 NOS.DEPTH= 1.5M	PARALLEL	COPPER CABLE
5	BSNL COPPER	18350	18350	ROAD CROSSING (RHS)		400PAIR BURRIED U/G CABLE	PARALLEL	COPPER CABLE
6	BSNL COPPER	18350	19150	LEFT SIDE	800	100PAIR CABLE 3 NOS BURRIED	PARALLEL	COPPER CABLE
7	BSNL COPPER	19150	19450	LEFT SIDE	250	100 PAIR U/G CABLE 2NOS BURRIED	PARALLEL	COPPER CABLE
8	BSNL COPPER	19400	19825	LEFT SIDE	425	50 PAIR U/G CABLE 2NOS	PARALLEL	COPPER CABLE

S. No	Utility	From Ch. (m)	To Ch. (m)	LHS/RHS	Affected Length (M)	Dia/Size	Position of Alignment	Remarks
						BURRIED		
9	BSNL COPPER	19825	20060	LEFT SIDE	235	BSNL U/G CABLE 2000 PAIR ,1600 PAIR 1 NO,THROUGHOUT DUCT, 400 PAIR 2 NOS BURRIED	PARALLEL	COPPER CABLE
10	BSNL COPPER	20060	20060	LEFT SDE		BSNL U/G CABLE 2000 PAIR,1600 PAIR	PERPENDICULAR	COPPER CABLE
11	BSNL COPPER	20060	20060	RIGHT SIDE		BSNL U/G CABLE 800 PAIR	PERPENDICULAR	COPPER CABLE
	WTR (LONG DISTANCE CABLE)							
1	BSNL WTR	15625	15700	RIGHT	75	BSNLWTROFC CABLE-12 FIBER/24 FIBER DEPTH=1.0M	PARALLEL	OFC
2	BSNL WTR	15700	15775	ROAD CROSSING	50	BSNLWTROFC CABLE-12 FIBER/24 FIBER DEPTH=1.0M	DIOGNAL	OFC
3	BSNL WTR	15750	20050	LEFT SIDE	4310	BSNLWTROFC CABLE-12 FIBER/24 FIBER DEPTH=1.0M	PARALLEL	OFC
4	BSNL WTR	20060	20060	LEFT SIDE		BSNLWTROFC CABLE-12 FIBER/24 FIBER DEPTH=1.0M	PERPENDICULAR	OFC
5	BSNL WTR	20060	20060	LEFT SIDE		BSNLWTROFC CABLE-12	PERPENDICULAR	OFC

S. No	Utility	From Ch. (m)	To Ch. (m)	LHS/RHS	Affected Length (M)	Dia/Size	Position of Alignment	Remarks
						FIBER/24 FIBER DEPTH=1.0M		

TABLE 5.99: TELECOM (AIRTEL) UTILITIES

S. No	Utility	From Ch. (m)	To Ch. (m)	LHS/RHS	Affected Length (m)	Dia/Size	Position of Alignment	Remarks
CORRIDOR 2A–AUTOMOTIVE SQUARE TO KANHAN RIVER								
1	AIRTEL	-1050	-1300	RIGHT SIDE	250	AIRTEL OFC CABLE,40MM DUCT,200 48F CABLE	PARALLEL	
2	AIRTEL	-1300	-1568	RIGHT SIDE	150	AIRTEL OFC CABLE,40MM DUCT,200 248F CABLE 1 NO,1.65M DEPTH	PARALLEL	
3	AIRTEL	-1450	-4750	RIGHT SIDE	2625	AIRTEL OFC ,40MM DUCT 200,248 F CABLE 1 NO,1.65M DEPTH	PARALLEL	
4	AIRTEL	-4075	-4075	ROAD CROSSING	-	AIRTEL OFC ,40MM DUCT 200,248 F CABLE 1 NO,1.65M DEPTH	PERPENDICULAR	
CORRIDOR 2 – LOKMANYA NAGAR TO HINGNA								
1	AIRTEL			LHS		AIRTEL OFC ,40MM DUCT, CABLE		Phase-I Alignment
2	AIRTEL	17650	18650	RIGHT SIDE	100	AIRTEL OFC ,40MM DUCT,2	PARALLEL	MIDC

S. No	Utility	From Ch. (m)	To Ch. (m)	LHS/RHS	Affected Length (m)	Dia/Size	Position of Alignment	Remarks
						NOs, GREEN & ORANGE,48 F CABLE		IDEA TAPPING POINT FOR AIRTEL
3	AIRTEL	18650	18650	RIGHT CROSSING	-	AIRTEL OFC ,40MM DUCT,2 NOs, GREEN & ORANGE,48 F CABLE	PERPENDICULAR	
4	AIRTEL	19370	19370	RHS CROSSING	-	AIRTEL OFC ,40MM DUCT,2 NOs, GREEN & ORANGE,48 F CABLE	PERPENDICULAR	WAY TO AIRTEL TOWER
5	AIRTEL	19370	20050	RHS	680	AIRTEL OFC ,40MM DUCT,2 NO ,GREEN & ORANGE,48 F CABLE,1MM DEPTH	PARALLEL	
6	AIRTEL	20050	20050	RHS CROSSING	-	96 F, 200F, 40MM DUCT, 4 NOS. (HDD)	PERPENDICULAR	
CORRIDOR 4A –PRAJAPATI NAGAR TO TRANSPORT NAGAR								
1	AIRTEL	NO AIRTEL LINE LYING IN THIS ROUTE (PRAJAPATI NAGAR TO TRANSPORT NAGAR (KAPSI)						
CORRIDOR 5 –VASUDEV NAGAR TO DATTAWADI (WADI)								
1	AIRTEL	NO AIRTEL LINE LYING IN THIS ROUTE (VASUDEV NAGAR TO DATTAWADI (WADI)						

TABLE 5.100: TELECOM (IDEA/VODAFONE) UTILITIES

S.No	Utility	From Ch. (m)	To Ch. (m)	LHS/RHS	Affected Length (m)	Dia/Size	Position of Alignment	Remarks
CORRIDOR 2A–AUTOMOTIVE SQUARE TO KANHAN RIVER								
1	IDEA	-500	-7850	LEFT SIDE	7450	1)BLUE DUCT 40MMØ , 2)PINK DUCT 40Ø	PARALLEL	

S.No	Utility	From Ch. (m)	To Ch. (m)	LHS/RHS	Affected Length (m)	Dia/Size	Position of Alignment	Remarks
						IDEA 48FX1,VODAFONE48FX1		
2	IDEA	-7475	-7475	ROAD CROSSING	-	IIDEA + VODAFONE,48 F EACH	PARALLEL	
CORRIDOR 3A – LOKMANYA NAGAR TO HINGNA								
1	IDEA/VODAFONE	18500	19500	RIGHT SIDE	1350	IDEA & VODAFONE , 48 OFC BOTH 40 MM 2X2=4 DUCT,DEPTH 1.2MM	PARALLEL	OFC
2	IDEA/VODAFONE	20050	21050	RIGHT SIDE	2550	IDEA WITH VODAFONE OFC 40 MM DUCT G 2X2=4 DUCT 48 IDEA OFC & VODAFONE ALSO.	PARALLEL	OFC
CORRIDOR 4A –PRAJAPATI NAGAR TO TRANSPORT NAGAR								
1	VODAFONE	-650	-650	ROAD CROSSING		VODAFONE 40MM	PERPENDICULAR	
						2 NOS DUCT,96 FIBRE		
2	VODAFONE	-750	-750	ALIGNMENT CROSSING		VODAFONE 40MM 2 NOS DUCT,96 FIBRE HDD,OPEN TRENCH 1.3	PERPENDICULAR	
CORRIDOR 5 –VASUDEV NAGAR TO DATTAWADI (WADI)								
1	IDEA	15925	15925	ROAD CROSSING	-	DEA 40MM, DUCT 2 NO. 96 OFC, AVERAGE 1MH(OPEN TRENCH)	PERPENDICULAR	
2	IDEA	15925	20050	RIGHT SIDE	4125	DEA OFC 40MM, DUCT 2 NO. 96 OFC, (OPEN	PARALLEL	

S.No	Utility	From Ch. (m)	To Ch. (m)	LHS/RHS	Affected Length (m)	Dia/Size	Position of Alignment	Remarks
						TRENCH)		
3	IDEA	20050	20050	RIGHT CROSSING	-	DEA OFC 40MM, DUCT 2 NO. 96 OFC, (OPEN TRENCH)	PERPENDICULAR	

TABLE 5.101: TELECOM (RELIANCE) UTILITIES

S.No	Utility	From Ch. (m)	To Ch. (m)	LHS/RHS	Affected Length (M)	Dia/Size	Position of Alignment	Remarks
CORRIDOR 3A – LOKMANYA NAGAR TO HINGNA								
1	RELAINCE	18524	19524	RIGHT SIDE	1650	RELIANCE OFC CABLE, 6 NOs., 40MM	PARALLEL	OFC
2	RELAINCE	20054	20054	RIGHT SIDE	700	RELIANCE OFC CABLE, 7 NOs., 40MM	PARALLEL	OFC
3	RELAINCE	20650	20850	RIGHT SIDE	1550	RELIANCE OFC CABLE, 6 NOs., 40MM	PARALLEL	OFC

TABLE 5.102: TELECOM (RELIANCE JIO) UTILITIES

S. No	Utility	From Ch. (m)	To Ch. (m)	LHS/RHS	Affected Length (M)	Dia/Size	Position of Alignment	Remarks
CORRIDOR 3A – LOKMANYA NAGAR TO HINGNA								
1	RELAINCE JIO	18750	20750	RIGHT SIDE	3900	RELIANCE JIO-7 DUCT ROUTE 96F,288F,48F,DEPTH-1.2 TO 1.65M	PARALLEL	OFC
2	RELAINCE JIO	21546	21546	LEFT SIDE	1200	RELIANCE JIO-7 DUCT ROUTE	PARALLEL	OFC

S. No	Utility	From Ch. (m)	To Ch. (m)	LHS/RHS	Affected Length (M)	Dia/Size	Position of Alignment	Remarks
						96F,288F,48F,DEPTH-1.2 TO 1.65M		
3	RELAINCE JIO	22980	22980	RIGHT SIDE	1550	RELIANCE JIO-7 DUCT ROUTE 96F,288F,48F,DEPTH-1.2 TO 1.65M	PARALLEL	OFC

Note: The Diversion Plan and physical diversion of Telephone Cable will be executed by the Concerned Agency as per standard practice. Therefore, location of such Telephone cables has been marked in utility plan for further consideration purpose as stated.

5.6. LAND REQUIREMENT

5.6.1. Main Component

Land will be required for the following main components:

- MRTS Structure (including Route Alignment), Station Building, Platforms, Entry/Exit Structures, Traffic Integration Facilities, Depots, etc.
- Receiving/Traction Sub-stations
- Radio Towers
- Temporary Construction Depots and work sites.

5.6.2. Land for Traffic integration

Govt. land has been proposed for integration with Rail system, Metro corridors and Bus system.

5.6.3. Land for Maintenance Depot

As per Rolling stock requirement evaluated in respective chapter, existing depots at MIHAN & Hingna are sufficient to cater rakes for ridership upto 2031 with provision of mid-terminal & terminal stabling of rakes. Hence, no additional Depot (& Land) is proposed in Phase-2.

5.6.4. Land for TSS, RSS, ASS and DG Sets

Exisitng RSS for Phase-1 are sufficient for Phase-2 also, hence, no, land is required.

5.6.5. Temporary Construction Depot

During construction period, huge quantities of construction materials like reinforcing bars, cement, steel sections, shutters, pre-cast segments etc. are to be stored and sufficient land is required for storage of these materials.

Also, large numbers of pre-cast tunnel segments are required for construction of tunnels for which a large Open area is required for setting up of casting yard. As far as possible, this area will be in temporary construction depot.

Since the area of land being acquired permanently at most of the stations is bare minimum, the land required for construction depots purpose is identified throughout the corridor, in the vicinity of the stations on temporary acquisition basis. These sites will be obtained on lease temporarily for the construction period. After completion of construction, these will be handed over back to the land-owning agency. It is proposed that construction yard locations being used in Phase-1 construction shall be continued for Phase-2 also.

5.6.6. Summary of Land Requirement

Abstract of land requirements for different components of corridors are given in **Table 5.103** to **Table 5.107.**

TABLE 5.103: CORRIDOR-1A: LAND & STRUCTURES REQUIREMENT (IN HA)

Ownership	Purpose	Permanent Land (In HA)	Temporary Land (In HA)	Structures (Floor area) (In HA)
Central Govt	Alignment / Stations, ancillary building, Misc., etc	0	0	0
	Total	**0**	**0**	**0**
State Govt	Alignment / Stations, ancillary building, Misc., etc	0	0	0
	Casting Yard (Approx.)	0	10	0
	Total	**0**	**10**	**0**
Private	Alignment / Stations, ancillary building, Misc., etc	4.3522	0	0.0621
	Parking cum PD	0.2467	0	0
	Total	**4.5989**	**0**	**0.0621**
Grand Total		**4.5989**	**10**	**0.0621**

TABLE 5.104: CORRIDOR-2A: LAND & STRUCTURES REQUIREMENT (IN HA)

Ownership	Purpose	Permanent Land (In HA)	Temporary Land (In HA)	Structures (Floor area) (In HA)
Central Govt.	Alignment / Stations, ancillary buildings, Misc., RSS etc	0.6175	0	0
	Parking cum PD	0.6397	0	0
	Total	**1.2572**	**0**	**0**
State Govt	Alignment / Stations, ancillary building, Misc, etc	0.1302	0	0
	Parking cum PD	0	0	0
	Casting Yard (Approx.)	0	10	0
	Total	**0.1302**	**10**	**0**
Private	Alignment / Stations, ancillary building, Misc, etc	0.6731	0	0.0869
	Parking cum PD	0	0	0
	Total	0.6731	0	0.0869
Grand Total		**2.0605**	**10**	**0.0869**

TABLE 5.105: CORRIDOR-3A: LAND & STRUCTURES REQUIREMENT (IN HA)

Ownership	Purpose	Permanent Land (In HA)	Temporary Land (In HA)	Structures (Floor area) (In HA)
Central Govt	Alignment / Stations, ancillary building, Misc., etc	0	0	0
State Govt	Alignment / Stations, ancillary building, Misc., etc	0.4217	0	0.0424
	Parking cum PD	0.3994	0	0

Ownership	Purpose	Permanent Land (In HA)	Temporary Land (In HA)	Structures (Floor area) (In HA)
	Casting Yard (Approx.)	0	10	0
	Total	**0.8211**	**10**	**0.0424**
Private	Alignment / Stations, ancillary building, Misc., etc	1.1207	0	0.2152
	Parking cum PD	0	0	0
	Total	**1.1207**	**0**	**0.2152**
Grand Total		**1.9418**	**10**	**0.2576**

TABLE 5.106: CORRIDOR-4A: LAND & STRUCTURES REQUIREMENT (IN HA)

Ownership	Purpose	Permanent Land (In HA)	Temporary Land (In HA)	Structures (Floor area) (In HA)
Central Govt	Alignment / Stations, ancillary building, Misc., etc	0	0	0
State Govt	Alignment / Stations, ancillary building, Misc., etc	0.1954	0	0.0456
	Parking cum PD	0.226	0	0
	Casting Yard (Approx.)	0	10	0
	Total	**0.4214**	**10**	**0.0456**
Private	Alignment / Stations, ancillary building, Misc., etc	0.3248	0	0.0944
	Parking cum PD	0	0	0
	Total	**0.3248**	**0**	**0.0944**
Grand Total		**0.7462**	**10**	**0.14**

TABLE 5.107: CORRIDOR-5: LAND & STRUCTURES REQUIREMENT (IN HA)

Ownership	Purpose	Permanent Land (In HA)	Temporary Land (In HA)	Structures (Floor area) (In HA)
Central Govt	Alignment / Stations, ancillary building, Misc., etc	0	0	0
State Govt	Alignment / Stations, ancillary building, Misc., etc	0.1079	0	0
	Parking cum PD	0.29	0	0
	Casting Yard (Approx.)	0	10	0
	Total	**0.3979**	**10**	**0**
Private	Alignment / Stations, ancillary building, Misc., etc	0.5	0	0.2217
	Parking cum PD	0	0	0
	Total	**0.5**	**0**	**0.2217**
Grand Total		**0.8979**	**10**	**0.2217**

5.7. OWNERSHIP DETAILS OF THE LAND REQUIRED FOR THE CORRIDOR

Corridor wise land details are given in **Table 5.108, Table 5.109, Table 5.110, Table 5.111 & Table 5.112.**

TABLE 5.108: CORRIDOR 1A – MIHAN TO MIDC ESR

S.No.	Location	Plot No.	Chainage (m)		Area(sqm)		Ownership (Govt./Pvt.)	Purpose	Properties Affected	No. of Properties	Floor Area(sqm)
			From	To	Permanent	Temporary					
1	Near Railway Crossing, Jamtha Village	AMR-1	21250	21573	6215	0	Private	Viaduct Construction	Nil	0	0
2	Near Railway Crossing, Jamtha Village	AMR-2	21575	21617	708	0	Private	Viaduct Construction	Nil	0	0
3	Towards Jamtha Village Road	AMR-3	21617	21766	2852	0	Private	Viaduct Construction	Nil	0	0
4	Towards Jamtha Village Road	AMR-4	21773	21965	3110	0	Private	Viaduct Construction	Nil	0	0
5	Towards Byepass Road, Jamtha Village	AMR-5	22073	22339	215	0	Private	Viaduct Construction	Nil	0	0
6	Towards Byepass Road, Jamtha Village	AMR-6	22356	22742	5378	0	Private	Viaduct Construction	2G+0	2	514
7	Opp. Suretech Hospital	AMR-7	23807	23857	448	0	Private	Station Construction (Ashokvan)	Nil	0	0
8	Near Dongargaon Basti	AMR-8	26653	26700	3469	0	Private	Station Construction (Dongargaon)	4G+0	4	61

S.No.	Location	Plot No.	Chainage (m)		Area(sqm)		Ownership (Govt./Pvt.)	Purpose	Properties Affected	No. of Properties	Floor Area(sqm)
			From	To	Permanent	Temporary					
9	Near Hanuman Temple, Mohgaon Basti	AMR-9	29843	29891	1305	0	Private	Station Construction (Mohgaon)	Nil	0	0
10	Near Rail Over Bridge	AMR-10	30292	30770	9246	0	Private	Viaduct Construction	Nil	0	0
11	Near Rail Over Bridge	AMR-11	30773	31087	4901	0	Private	Viaduct Construction	Nil	0	0
12	Near A K Motor Garage	AMR-12	32794	32836	190	0	Private	Station Construction (Meghdoot CIDCO)	Nil	0	0
13	Near Parate Complex	AMR-13	33666	33766	1518	0	Private	Viaduct Construction	Nil	0	0
14	Near HP Industrial Lube Services	AMR-14	34220	34275	886	0	Private	Station Construction (MHADA Colony)	Nil	0	0
15	Near KEC International Ltd.	AMR-15	37488	37591	1544	0	Private	Viaduct Construction	2G+0	2	46
16	Opp. Orange City Weldmesh	AMR-16	38340	38388	517	0	Private	Station Construction (MIDC ESR)	Nil	0	0

S.No.	Location	Plot No.	Chainage (m)		Area(sqm)		Ownership (Govt./Pvt.)	Purpose	Properties Affected	No. of Properties	Floor Area(sqm)
			From	To	Permanent	Temporary					
17	Near NH-7	AMR-17	38525	38612	1020	0	Private	Viaduct Construction	Nil	0	0
18	Opp. Suretech Hospital	Parking-1	23875	23913	1312	0	Private	Parking (Ashokvan)	Nil	0	0
19	Opp. Orange City Weldmesh	Parking-2	38439	38475	1155	0	Private	Parking (MIDC ESR)	Nil	0	0
20	Near Railway Crossing, Jamtha Village				45702	0	-	Depot (Area & Rate has been taken in Phase-1)	Nil	0	0
	Total				**45989**	**0**				**8**	**621**

TABLE 5.109: CORRIDOR 2A - AUTOMOTIVE SQUARE TO KANHAN RIVER

S.No.	Location	Plot No.	Chainage (m)		Area(sqm)		Ownership (Govt./Pvt.)	Purpose	Properties Affected	No. of Properties	Floor Area(sqm)
			From	To	Permanent	Temporary					
1	Near Jai Pipe Company	AKN-1	-1365	-1450	430	0	Private	Station Construction (Pili Nadi)	Nil	0	0
2	Opp J K Cons. & Infrastructure (India) Pvt. Ltd.	AKN-2	-2256	-2300	185	0	Private	Station Construction (Khasara Fata)	5G+0	5	95

S.No.	Location	Plot No.	Chainage (m)		Area(sqm)		Ownership (Govt./Pvt.)	Purpose	Properties Affected	No. of Properties	Floor Area(sqm)
			From	To	Permanent	Temporary					
3	Opp to MSEB Upkendra Mandal	AKN-3	-3302	-3352	331	0	Private	Station Construction (All India Radio)	Nil	0	0
4	Near K K Cons.	AKN-4	-5237	-5287	241	0	Private	Station Construction (Khairi Fata)	Nil	0	0
5	Opp. Land of N Kumar Housing Infrastructure Pvt. Ltd.	AKN-5	-6163	6213	258	0	Private	Station Construction (Lok Vihar)	Nil	0	0
6	Opp. Raksha Mangylaya Awas, Lekha Nagar	AKN-6	-7186	-7235	255	0	Private	Station Construction (Lekha Nagar)	G+0	1	131
7	Near Kamptee Cantonment Area	AKN-7	-8488	-8500	31	0	Private	Viaduct Construction	Nil	0	0
8	Near Kamptee Cantonment Area	AKN-8	-8614	-8656	1299	0	Govt. (Central)	Station Construction (Cantonment)	Nil	0	0
9	Near Gajake Balaji Mandir	AKN-9	-9425	-9448	2015	0	Private	Station Construction (kamptee Police Station)	4G+0	4	109
10	Near Maitri Sanwad Kendra	AKN-10	-10251	-10275	1104	0	Private	Station Construction (Kamptee Municipal Council)	2G+0	2	278

S.No.	Location	Plot No.	Chainage (m)		Area(sqm)		Ownership (Govt./Pvt.)	Purpose	Properties Affected	No. of Properties	Floor Area(sqm)
			From	To	Permanent	Temporary					
11	Near Tehsil Office Kamptee	AKN-11	-10237	-10261	124	0	Govt. (State)	Station Construction (Kamptee Municipal Council)	Nil	0	0
12	Near Open Land Dada Saheb Kumbhare Children park	AKN-12	-11190	-11246	1881	0	Private	Station Construction (Dragan Palace)	5G+0	5	256
13	Near Samajik Vanikaran Vibhag, Nagpur	AKN-13	-12419	-12512	556	0	Govt. (State)	Station Construction (Golf Club)	Nil	0	0
14	Opp Samajik Vanikaran Vibhag, Nagpur	AKN-14	-12438	-12488	622	0	Govt. (State)	Station Construction (Golf Club)	Nil	0	0
15	Towards Kanhan River	AKN-15	-13281	-13367	1876	0	Govt. (Central)	Station Construction (Kanhan River)	Nil	0	0
16	Near Kamptee Cantonment Area	Parking-1	-8555	-8656	4413	0	Govt. (Central)	Parking Area (Cantonment)	Nil	0	0
17	Towards Kanhan River	Parking-2	-13353	-13450	1984	0	Govt. (Central)	Parking Area (Kanhan River)	Nil	0	0
18	Towards Kanhan River	RSS	-13450	-13518	3000	0	Govt. (Central)	RSS (Kanhan River)	Nil	0	0
	Total				**20605**	**0**				**17**	**869**

TABLE 5.110: CORRIDOR 3A - LOKMANYA NAGAR TO HINGNA

S.No.	Location	Plot No.	Chainage (m)		Area(sqm)		Ownership (Govt./Pvt.)	Purpose	Properties Affected	No. of Properties	Floor Area(sqm)
			From	To	Permanent	Temporary					
1	Opp. Vrundavan Residency Boys Hostel	HIN-1	18724	18740	530	0	Private	Station Construction (Hingna Mount View)	Nil	0	0
2	Near Neelkamal Apartment	HIN-2	19612	19650	1833	0	Private	Station Construction (Rajiv Nagar)	G+0	1	194
3	Near Dr. Babasaheb Ambedkar College of Engineering & Research	HIN-3	20600	20690	213	0	Private	Viaduct Construction	Nil	0	0
4	Near Dr. Matkar Clinic	HIN-4	20954	21012	1525	0	Private	Station Construction (Wanadongri)	Nil	0	0
5	Near Maa Tuljabhawani Jhunka Bhakar	HIN-5	21717	21760	1683	0	Private	Station Construction (APMC)	G+0	1	128
6	Near Gurukul Shri Sant Ravidas	HIN-6	22520	22565	276	0	Private	Viaduct Construction	Nil	0	0
7	Near Police Station, Raipur	HIN-7	22687	22745	239	0	Govt. (State)	Viaduct Construction	Nil	0	0
8	Near Police Station, Raipur	HIN-8	22745	22868	3191	0	Govt. (State)	Station Construction (Raipur)	2G+0 & G+0 (Staircase)	3	239

S.No.	Location	Plot No.	Chainage (m)		Area(sqm)		Ownership (Govt./Pvt.)	Purpose	Properties Affected	No. of Properties	Floor Area(sqm)
			From	To	Permanent	Temporary					
9	Near Laxmi Kirana Store, Hanuman Nagar	HIN-9	22875	22900	23	0	Private	Viaduct Construction	Nil	0	0
10	Opp. Central Co-Op Bank Ltd.	HIN-10	22939	23143	2161	0	Private	Viaduct Construction	16G+0 & 1G+1	17	883
11	Nearv VBL Public School	HIN-11	23391	23583	1371	0	Private	Viaduct Construction	9G+0 & G+2	10	878
12	Near Nagar Panchayat Commericial Complex	HIN-12	23585	23641	787	0	Govt. (State)	Station Construction (Hingna Bus Station)	10G+0	10	185
13	Near Vijay Vinkar Society	HIN-13	24500	24524	1592	0	Private	Station Construction (Hingna)	3G+0	3	69
14	Near Vrundavan Residency Boys Hostel	Parking-1	18628	18711	1220	`0	Govt. (State)	Parking (Hingna Mount View)	Nil	0	0
14	Near Vrundavan Residency Boys Hostel	Parking-2	24754	24780	2160	0	Govt. (State)	Parking (Hingna Mount View)	Nil	0	0
15	Near Govt. Hospital (Rural) Hingna	Parking-3	24754	24780	614	0	Govt. (State)	Parking (Hingna)	Nil	0	0

S.No.	Location	Plot No.	Chainage (m)		Area(sqm)		Ownership (Govt./Pvt.)	Purpose	Properties Affected	No. of Properties	Floor Area(sqm)
			From	To	Permanent	Temporary					
16	Opp. Priyadarshani Polytechnic				269468	0	-	Depot (Area & Rate has been taken in Phase-1)	Nil	0	0
	Total				**19418**	**0**				**45**	**2576**

TABLE 5.111: CORRIDOR 4A - PRAJAPATI NAGAR TO TRANSPORT NAGAR

S.No.	Location	Plot No.	Chainage (m)		Area(sqm)		Ownership (Govt./Pvt.)	Purpose	Properties Affected	No. of Properties	Floor Area(sqm)
			From	To	Permanent	Temporary					
1	Near Prakash Krushi Mahavidyalaya	PTR-1	-1389	-1436	1954	0	Govt. (State)	Station Construction (Pardi)	G+0	1	456
2	Near Radha Krishna Hardware	PTR-2	-1384	-1404	1026	0	Private	Station Construction (Pardi)	3G+0	3	297
3	Near Agarwal Group	PTR-3	-3209	-3237	2222	0	Private	Station Construction (Kapsi Khurd)	2G+0 & 2G+0 (sheds)	4	647
4	Near Prakash Krushi Mahavidyalaya	Parking-1	-1411	-1436	460	0	Govt. (State)	Parking (Pardi)	Nil	0	0
5	Near Bharat Petroleun	Parking-2	-5059	-5161	1800	0	Govt. (State)	Parking (Transport Nagar)	Nil	0	0

S.No.	Location	Plot No.	Chainage (m)		Area(sqm)		Ownership (Govt./Pvt.)	Purpose	Properties Affected	No. of Properties	Floor Area(sqm)
			From	To	Permanent	Temporary					
	Total				**7462**	**0**				**8**	**1400**

TABLE 5.112: CORRIDOR 5 - VASUDEV NAGAR TO DATTAWADI

S.No.	Location	Plot No.	Chainage (m)		Area(sqm)		Ownership (Govt./Pvt.)	Purpose	Properties Affected	No. of Properties	Floor Area(sqm)
			From	To	Permanent	Temporary					
1	Near Rukmani Apartment	WAD-1	15633	15708	993	0	Private	Viaduct Construction	5G+0 & B+G+2	6	2217
2	Near LG Company Pvt. Ltd.	WAD-2	15741	15855	1039	0	Private	Viaduct Construction	Nil	0	0
3	Near Shirish Plastic & Industries	WAD-3	16852	16870	661	0	Private	Station Construction (Police Station MIDC)	Nil	0	0
4	Near MIDC Post Office	WAD-4	16822	16868	581	0	Govt. (State)	Station Construction (Police Station MIDC)	Nil	0	0
5	Opp. Facor Steel Ltd.	WAD-5	17291	17332	22	0	Private	Viaduct Construction	Nil	0	0
6	Near Afcons Infrastructure Ltd.	WAD-6	19124	19159	1765	0	Private	Station Construction (MIDC Hingna)	Nil	0	0

S.No.	Location	Plot No.	Chainage (m)		Area(sqm)		Ownership (Govt./Pvt.)	Purpose	Properties Affected	No. of Properties	Floor Area(sqm)
			From	To	Permanent	Temporary					
7	Near Chevrolet Tajashree	WAD-7	19794	19847	498	0	Govt. (State)	Station Construction (Dattawadi)	Nil	0	0
8	Opp. Chevrolet Tajashree	WAD-8	19800	19848	520	0	Private	Station Construction (Dattawadi)	Nil	0	0
9	Near Chevrolet Tajashree		19847	19900	2900	0	Govt. (State)	Parking (Dattawadi)	Nil	0	0
	Total				**8979**	**0**				**6**	**2217**

ANNEXURE 5.1: LIST OF TREES IN CORRIDOR 1A

SN	TREE NO.	SPECIES	GIRTH IN M.	HEIGHT IN M.	SN	TREE NO.	SPECIES	GIRTH IN M.	HEIGHT IN M.
LEFT SIDE					RIGHT SIDE				
1	E01	KARANJI	1.52	3.7	1	E5	SHIMDI	1.3	6.7
2	E02	SHISHUM	1.02	5.0	2	E6	NEEM	1.31	3.0
3	E03	BABUL	0.82	3.0	3	E7	BABUL	0.48	4.0
4	Width at chainage 1100 corrected	BABUL	0.84	3.0	4	E9	NEEM	1.16	3.7
5	E08	BABUL	1.28	4.9	5	E10	NEEM	0.96	3.7
6	E16	SAG	0.34	2.4	6	E11	BADAM	1.36	4.6
7	E17	PALAS	0.92	4.3	7	E12	SAG	0.89	4.0
8	E20	BABUL	1.26	5.5	8	E13	BABUL	1.34	4.9
9	E21	BABUL	1.17	4.6	9	E14	BABUL	1.39	6.1
10	E22	BABUL	1.20	6.1	10	E15	CHICHWA	0.98	6.1
11	E29	SAG	0.55	3.7	11	E18	CHICHWA	0.56	2.1
12	E30	BABUL	0.76	6.1	12	E19	NEEM	0.84	4.0
13	E32	BABUL	1.26	6.7	13	E23	SAG	0.8	7.0
14	E33	SAG	0.54	6.1	14	E24	SAG	0.96	7.0
15	E34	SAG	0.66	6.1	15	E25	SAG	0.72	6.7
16	E35	SAG	0.56	6.1	16	E26	NEEM	1.18	6.1
17	E36	SAG	1.10	6.1	17	E27	MANGO	1.12	6.7
18	E37	NEEM	0.45	3.0	18	E28	NEEM	1.47	6.4
19	E38	BOR	0.63	3.0	19	E31	BABUL	2.07	4.0
20	E39	JAMUN	1.82	6.7	20	E41	KARANJI	0.52	2.4
21	E40	BABUL	0.90	4.9	21	E42	KARANJI	0.43	2.1
22	E43	PALAS	1.34	4.9	22	E47	CHICHWA	0.61	2.4
23	E44	PALAS	0.86	4.3	23	E48	BABUL	1.83	4.9
24	E45	PALAS	0.75	4.6	24	E55	NEEM	1.2	3.7
25	E46	BABUL	1.25	5.5	25	E58	SAG	0.76	2.4
26	E49	BABUL	1.99	5.5	26	E62	SAG	0.48	1.8
27	E50	CHINCH	1.35	4.6	27	E63	SAG	0.94	4.6
28	E51	CHICHWA	0.50	2.7	28	E71	SAGWAN	1.12	5.0
29	E52	SHIRAS	0.53	4.3	29	E72	SAGWAN	0.78	4.0
30	E53	SHIRAS	0.49	0.0	30	E73	SAGWAN	0.62	3.0
31	E54	SHIRAS	1.03	2.4	31	E74	SAGWAN	0.95	5.0
32	E56	CHICHWA	0.78	2.7	32	E75	SAGWAN	0.88	5.0
33	E57	SAG	0.99	6.1	33	E76	SAGWAN	1.15	4.5
34	E59	KARANJI	0.83	3.7	34	E77	SAGWAN	0.46	4.5
35	E60	KARANJI	0.61	4.0	35	E78	SAGWAN	0.41	5.0
36	E61	BABUL	1.50	6.1	36	E79	SAGWAN	0.95	5.0
37	E64	BABUL	0.85	3.0	37	E80	SAGWAN	0.9	5.0
38	E65	BABUL	1.97	6.1	38	E81	SAGWAN	0.75	4.5
39	E66	SAG	1.77	6.4	39	E85	SAGWAN	0.39	4.0
40	E67	SAG	0.80	4.6	40	E85_A	SAGWAN	0.38	4.0
41	E68	SAG	0.72	5.5	41	E86	SAGWAN	0.32	5.0
42	E69	SAGWAN	0.55	6.0	42	E87	SAGWAN	0.68	5.0
43	E70	SAGWAN	0.57	6.0	43	E88	SAGWAN	1.18	6.0
44	E82	SAGWAN	1.78	6.0	44	E89	SAGWAN	0.41	4.0
45	E83	SAGWAN	1.25	7.0	45	E99	CHICHWA	0.36	2.0

SN	TREE NO.	SPECIES	GIRTH IN M.	HEIGHT IN M.	SN	TREE NO.	SPECIES	GIRTH IN M.	HEIGHT IN M.
LEFT SIDE					RIGHT SIDE				
46	E84	SHIRAS	0.80	5.5	46	E100	CHICHWA	0.62	6.0
47	E90	SAGWAN	0.54	6.0	47	E101	CHICHWA	0.48	3.5
48	E91	SAGWAN	0.75	6.0	48	E102	HIWAR	0.42	2.0
49	E92	SAGWAN	0.55	6.0	49	E106	PIPAL	2.8	5.0
50	E93	SAGWAN	0.45	6.0	50	E107	HIWAR	0.98	4.0
51	E94	SAGWAN	0.48	6.0	51	E108	BADAM	1	7.0
52	E95	SAGWAN	0.78	6.0	52	E109	PIPAL	2.11	7.0
53	E96	SAGWAN	1.07	7.0	53	E110	SAGWAN	0.83	6.5
54	E97	PALAS	0.32	2.0	54	E111	NEEM	0.9	5.0
55	E98	NEEM	0.48	3.5	55	E113	COCONUT	1.3	2.5
56	E103	PALAS	0.40	2.0	56	E114	COCONUT	1.4	1.4
57	E104	KARANJI	0.50	3.0	57	E115	NEEM	1.1	5.0
58	E105	KARANJI	1.62	3.0	58	E116	NEEM	0.8	6.0
59	E112	SHIRAS	0.58	3.5	59	E117	SHISHUM	1.38	7.0
60	E142	CHICHWA	0.83	6.0	60	E118	NEEM	0.96	6.0
61	E144	BOR	0.73	3.0	61	E119	PIPAL	0.65	3.0
62	E145	SUBABHUD	0.38	3.0	62	E120	NEEM	0.8	4.5
63	E146	SUBABHUD	0.45	3.0	63	E121	NEEM	0.41	3.0
64	E149	KARANJI	0.90	4.0	64	E122	SHIRAS	1.16	5.0
65	E150	SUBABHUD	0.56	3.0	65	E123	SHIRAS	1.2	6.0
66	E151	SUBABHUD	0.69	4.0	66	E124	SHIRAS	0.65	5.0
67	E152	SUBABHUD	0.52	4.0	67	E125	SHIRAS	0.85	5.0
68	E153	KARANJI	0.99	4.0	68	E126	CHICHWA	1.3	6.0
69	E155	KARANJI	0.62	4.0	69	E127	CHICHWA	0.75	5.5
70	E158	KARANJI	0.59	3.0	70	E128	CHICHWA	0.82	6.0
71	E159	KARANJI	1.60	4.0	71	E129	CHICHWA	0.68	6.0
72	E160	KARANJI	0.57	3.8	72	E130	CHICHWA	0.65	6.0
73	E161	KARANJI	0.48	4.0	73	E131	SHIRAS	0.6	6.0
74	E162	SUBABHUD	0.80	3.0	74	E132	SHIRAS	0.53	5.0
75	E166	KARANJI	0.7	4.0	75	E133	SHIRAS	1.22	6.0
76	E167	KARANJI	0.50	3.5	76	E134	SHIRAS	1.32	6.0
77	E168	KARANJI	0.62	4.0	77	E135	SHIRAS	0.37	5.0
78	E169	KARANJI	0.83	4.0	78	E136	SHIRAS	0.93	5.6
79	E172	HIWAR	1.12	6.0	79	E137	SHIRAS	0.85	6.0
80	E173	SHIRAS	0.62	6.0	80	E138	BABUL	1.04	6.0
81	E174	PALAS	0.42	2.0	81	E139	CHILATI	1.06	5.8
82	E175	HIWAR	0.56	3.0	82	E140	CHILATI	0.78	6.0
83	E176	KARANJI	0.51	5.0	83	E141	CHILATI	0.6	6.0
84	E178	SHIRAS	0.46	4.0	84	E143	HIWAR	0.62	2.5
85	E179	NEEM	0.90	6.0	85	E147	HIWAR	0.5	4.0
86	E180	SUBABUL	1.00	7.0	86	E148	HIWAR	1.65	4.0
87	E181	CHICHWA	0.82	3.5	87	E154	NEEM	0.62	5.0
88	E182	KARANJI	0.75	6.0	88	E156	BOR	0.59	2.0
89	E183	KARANJI	0.47	5.0	89	E157	BOR	0.72	3.0
90	E191	SHIRUS	0.82	4.0	90	E163	KARANJI	0.60	3.0
91	E192	CHICHWA	0.50	5.0	91	E164	KARANJI	1.18	4.0
92	E193	KARANJI	0.54	5.0	92	E165	KARANJI	0.63	3.0
93	E194	KARANJI	0.62	5.0	93	E170	KARANJI	1.17	6.0
94	E198	SUBABUL	0.51	6.0	94	E171	HIWAR	2.04	2.8

SN	TREE NO.	SPECIES	GIRTH IN M.	HEIGHT IN M.	SN	TREE NO.	SPECIES	GIRTH IN M.	HEIGHT IN M.
LEFT SIDE					RIGHT SIDE				
95	E199	SUBABUL	0.68	7.0	95	E177	KARANJI	0.85	3.0
96	E200	PALAS	0.83	5.0	96	E184	KARANJI	0.85	3.0
97	E201	KARANJI	0.65	6.0	97	E185	KARANJI	0.53	3.0
98	E202	SUBABUL	1.47	7.0	98	E186	KARANJI	0.62	3.0
99	E203	NEEM	0.39	3.0	99	E187	KARANJI	0.68	3.0
100	E204	CHICHWA	0.45	2.0	100	E188	KARANJI	0.62	2.0
101	E205	SUBABUL	0.67	6.0	101	E189	KARANJI	0.75	2.5
102	E206	HIWAR	0.62	5.0	102	E190	KARANJI	0.60	3.0
103	E207	BABUL	0.96	6.0	103	E195	KARANJI	0.43	3.0
104	E208	SUBABUL	0.78		104	E196	KARANJI	0.83	3.0
105	E209	SUBABUL	0.85	6.0	105	E197	HIWAR	1.87	4.0
106	E210	SUBABUL	1.03	7.0	106	E221	NEEM	1.12	6.0
107	E211	SUBABUL	0.91	6.0	107	E236	KARANJI	2.12	7.0
108	E212	SUBABUL	0.85	7.0	108	E241	NEEM	0.86	6.0
109	E213	SHARAS	0.62	6.0	109	E246	HIWAR	1.12	5.0
110	E214	NEEM	1.32	7.0	110	E251	SHIRAS	0.71	5.0
111	E215	SHIRAS	0.75	5.0	111	E258	SUBABUL	1.48	7.0
112	E216	GULMOHAR	0.52	7.0	112	E259	SUBABUL	1.60	7.0
113	E217	CHICHWA	0.54	3.0	113	E260	SUBABUL	1.03	7.0
114	E218	CHICHWA	0.47	3.0	114	E261	COCONUT	1.60	8.0
115	E219	CHICHWA	0.65	4.0	115	E262	ASHOKA	0.56	6.0
116	E219_A	KARANJI	0.38	4.0	116	E268	SUBABUL	0.82	6.0
117	E219_B	KARANJI	0.57	6.0	117	E269	SUBABUL	0.58	7.0
118	E220	NEEM	1.08	7.0	118	E270	SUBABUL	0.42	6.0
119	E222	NEEM	1.32	7.0	119	E271	SUBABUL	0.65	7.0
120	E223	KARANJI	0.68	5.0	120	E272	PALAS	0.45	2.0
121	E224	KARANJI	0.67	6.5	121	E273	PALAS	0.52	2.0
122	E225	PALAS	0.52	4.0	122	E274	PALAS	0.47	2.0
123	E226	PALAS	0.47	4.0	123	E275	PALAS	0.55	2.0
124	E227	PALAS	0.49	4.0	124	E276	HIWAR	0.67	3.0
125	E228	PALAS	0.58	4.0	125	E277	SUBABUL	0.82	3.0
126	E229	NEEM	1.19	6.0	126	E278	PALAS	0.70	2.0
127	E230	PALAS	0.88	5.0	127	E279	HIWAR	0.37	2.0
128	E231	KARANJI	1.22	6.0	128	E282	PALAS	0.57	3.0
129	E232	KARANJI	0.72	6.0	129	E283	PALAS	0.73	3.0
130	E233	KARANJI	0.60	5.5	130	E284	PALAS	0.40	2.0
131	E234	KARANJI	0.64	6.0	131	E285	PALAS	0.56	2.0
132	E235	KARANJI	0.65	6.0	132	E286	PALAS	0.52	2.0
133	E237	KARANJI	0.65	5.5	133	E287	NEEM	0.87	3.0
134	E238	KARANJI	0.92	6.0	134	E289	HIWAR	0.48	2.0
135	E239	KARANJI	0.80	6.0	135	E290	PALAS	0.40	2.0
136	E240	NEEM	0.58	5.0	136	E295	SHIRAS	0.32	4.0
137	E242	PALAS	1.37	5.0	137	E296	SHIRAS	2.35	6.0
138	E243	KARANJI	0.80	6.0	138	E297	PALAS	0.80	2.0
139	E244	KARANJI	0.45	5.0	139	E304	SHIRAS	0.52	3.0
140	E245	KARANJI	0.85	6.0	140	E305	HIWAR	0.82	4.0
141	E247	SHIRUS	0.95	3.0	141	E306	BABUL	0.68	4.0
142	E248	KARANJI	0.55	4.0	142	E307	SHIRAS	0.95	5.0
143	E249	KARANJI	0.65	5.0	143	E308	KARANJI	1.28	6.0

SN	TREE NO.	SPECIES	GIRTH IN M.	HEIGHT IN M.	SN	TREE NO.	SPECIES	GIRTH IN M.	HEIGHT IN M.
LEFT SIDE					RIGHT SIDE				
144	E250	KARANJI	0.56	6.0	144	E311	SHIRAS	1.80	5.0
145	E252	SUBABUL	1.00	7.0	145	E312	HIWAR	0.45	4.0
146	E253	KARANJI	0.75	7.0	146	E313	BOR	0.48	3.0
147	E254	KARANJI	0.90	7.0	147	E314	PALAS	0.52	4.0
148	E255	KARANJI	0.82	7.0	148	E315	PALAS	0.62	6.0
149	E256	SHIRUS	1.08	6.0	149	E316	HIWAR	0.85	6.0
150	E257	PALAS	1.10	6.0	150	E317	SHIRUS	0.92	6.0
151	E263	CHICHWA	2.48	6.0	151	E327	SHIRAS	0.42	2.0
152	E264	SUBABUL	1.02	7.0	152	E328	BABUL	0.67	4.0
153	E265	JAMUN	0.30	2.0	153	E333	CHICHORA	0.91	4.6
154	E266	CHICHWA	1.28	5.0	154	E339	NEEM	0.65	2.7
155	E267	GULMOHAR	0.75	6.0	155	E340	BABUL	0.88	3.0
156	E280_A	GULMOHAR	0.90	5.0	156	E341	NEEM	0.40	2.4
157	E280	GULMOHAR	0.88	6.0	157	E342	BABUL	0.67	4.9
158	E281	GULMOHAR	0.94	6.0	158	E343	NEEM	0.57	3.7
159	E288	NEEM	1.09	7.5	159	E344	SHIRUS	0.69	1.2
160	E291	HIWAR	0.58	3.0	160	E345	BABUL	0.76	5.2
161	E292	PALAS	0.48	2.5	161	E346	NEEM	0.79	3.0
162	E293	PALAS	0.98	3.0	162	E347	BABUL	0.77	5.2
163	E294	PALAS	0.5	3	163	E348	BABUL	0.7	3.048
164	E298	PALAS	0.6	3	164	E353	BABUL	0.5	4.2672
165	E298_A	MAYRUG	0.9	7	165	E354	BABUL	0.5	3.9624
166	E299	MAYRUG	0.7	7	166	E355	BABUL	0.5	3.9624
167	E300	PALAS	0.5	5	167	E356	BABUL	0.7	3.6576
168	E301	HIWAR	0.9	4	168	E357	BABUL	1.4	5.4864
169	E302	PALAS	0.4	3	169	E358	BABUL	0.0	3.9624
170	E303	PALAS	0.45	3.0	170	E359	BABUL	0.58	3.7
171	E309	PALAS	0.48	5.0	171	E360	BABUL	0.8	3.7
172	E310	PALAS	0.57	5.0	172	E366	NEEM	1.11	4.9
173	E318	GULMOHAR	0.98	7.0	173	E367	HIWAR	0.95	2.4
174	E319	SIMAR	0.37	6.0	174	E368	BABUL	1.12	3.4
175	E320	SIMAR	0.42	6.0	175	E369	BADAM	0.71	4.0
176	E321	PALAS	0.37	3.0	176	E370	NEEM	0.6	2.7
177	E322	PALAS	0.45	3.0	177	E371	BABUL	0.38	2.4
178	E323	CHICHWA	1.60	6.0	178	E372	PALAS	0.43	2.4
179	E324	GULMOHAR	1.45	7.0	179	E374	HIWAR	1.65	4.6
180	E325	GULMOHAR	1.43	7.0	180	E376	HIWAR	0.82	2.4
181	E326	GULMOHAR	1.60	7.0	181	E377	BABUL	0.97	4.0
182	E329	BABUL	1.03	3.0	182	E378	BABUL	0.48	2.7
183	E330	KARANJI	0.72	3.7	183	E381	SAG	0.92	4.6
184	E331	KARANJI	0.39	2.1	184	E382	SAG	1.3	6.1
185	E332	PALAS	0.48	2.7	185	E383	SAG	0.65	4.6
186	E334	BOR	0.39	3.0	186	E384	SAG	0.83	5.5
187	E335	PALAS	0.42	2.7	187	E385	SAG	0.9	5.8
188	E336	CHICHBILAI	0.95	3.7	188	E386	SAG	0.68	4.9
189	E337	PALAS	0.72	2.1	189	E387	SAG	0.8	4.9
190	E338	PALAS	0.63	4.0	190	E388	NEEM	0.98	3.7
191	E349	KARANJI	0.60	4.0	191	E389	SAG	0.98	4.6
192	E350	KARANJI	0.83	4.0	192	E390	SAG	0.8	4.6

SN	TREE NO.	SPECIES	GIRTH IN M.	HEIGHT IN M.	SN	TREE NO.	SPECIES	GIRTH IN M.	HEIGHT IN M.
LEFT SIDE					RIGHT SIDE				
193	E351	CHINCH	3.25	6.4	193	E400	SAG	0.91	3.7
194	E352	SHIRUS	0.98	5.0	194	E401	SAG	1.26	4.6
195	E361	SHIRUS	1.95	5.5	195	E402	SAG	0.85	5.2
196	E362	NEEM	0.87	3.0	196	E403	SAG	0.8	6.1
197	E363	CHICHWA	0.82	3.7	197	E404	SAG	0.71	6.0
198	E364	CHICHWA	0.87	4.0	198	E405	SAG	0.85	5.8
199	E365	CHICHWA	0.90	5.0	199	E406	SAG	0.91	5.8
200	E373	KARANJI	1.38	7.0	200	E407	SAG	0.9	3.0
201	E375	PALAS	0.48	2.4	201	E408	SAG	0.59	4.9
202	E379	BABUL	0.96	4.6	202	E409	SAG	0.79	5.6
203	E380	BABUL	0.98	4.9	203	E410	SAG	0.62	4.9
204	E422	CHICHWA	0.64	2.4	204	E411	NEEM	1.3	5.2
205	E423	CHICHWA	1.39	4.9	205	E412	SAG	0.55	3.7
206	E424	CHICHWA	0.77	4.6	206	E413	SAG	0.72	3.7
207	E435	BABUL	0.70	3.0	207	E414	SAG	0.73	4.6
208	E438	BABUL	0.18	3.7	208	E415	NEEM	1.08	5.5
209	E439	KARANJI	0.82	4.6	209	E416	SAG	0.56	5.8
210	E440	NEEM	0.76	4.0	210	E417	SAG	0.86	5.5
211	E441	PIPAL	1.55	3.7	211	E418	KARANJI	0.72	4.0
212	E442	JAMUN	0.84	3.7	212	E419	SAG	0.62	5.5
213	E443	CHICHWA	0.67	3.0	213	E420	BABUL	0.83	4.6
214	E444	CHICHWA	0.48	1.5	214	E421	BABUL	0.84	4.0
215	E445	CHICHWA	1.48	6.1	215	E425	BABUL	0.4	2.4
216	E448	CHICHWA	1.17	6.1	216	E426	SHISHUM	1	1.8
217	E449	PALAS	1.25	4.0	217	E427	KARANJI	0.56	1.8
218	E450	SHIRUS	2.80	4.9	218	E428	KARANJI	0.42	1.5
219	E458	SHIRUS	0.90	4.9	219	E429	KARANJI	0.89	1.5
220	E461	SHIRUS	0.92	3.7	220	E430	KARANJI	0.72	1.5
221	E462	NEEM	0.40	3.0	221	E431	JAMUN	0.63	3.0
222	E466	NEEM	0.32	2.4	222	E432	NEEM	0.63	4.0
223	E467	BADAM	0.61	2.4	223	E433	JAMUN	0.65	3.7
224	E468	NEEM	0.82	3.0	224	E434	JAMUN	0.49	3.0
225	E469	BADAM	0.44	2.7	225	E436	NEEM	1.17	3.7
226	E475	NEEM	1.29	2.4	226	E437	SHISHUM	0.97	1.2
227	E476	NEEM	0.85	3.0	227	E446	BABUL	1	3.0
228	E477	CHICHWA	1.23	3.7	228	E447	BABUL	0.35	4.0
229	E478	NEEM	0.19	1.5	229	E451	BABUL	1	4.0
230	E479	BABUL	1.00	3.7	230	E452	BABUL	0.9	4.0
231	E482	SAG	0.92	4.6	231	E453	BABUL	0.99	4.3
232	E483	PIPAL	0.50	1.5	232	E454	SIMAR	1.02	4.0
233	E484	NEEM	0.54	2.1	233	E455	BABUL	1.1	3.7
234	E485	BOR	0.48	1.8	234	E456	CHICHWA	0.72	1.8
235	E486	BOR	0.43	1.8	235	E457	BABUL	0.42	4.0
236	E488	SAGWAN	0.57	1.8	236	E459	CHICHWA	7	4.0
237	E489	BADAM	0.82	1.5	237	E460	BABUL	1.11	5.5
238	E490	CHICHWA	0.70	1.5	238	E463	BABUL	1.38	4.9
239	E496	CHICHWA	0.68	3.0	239	E464	BABUL	2.1	4.6
240	E497	CHICHWA	0.30	1.8	240	E465	KARANJI	1.12	1.2
241	E501	PALAS	0.57	2.7	241	E470	BABUL	1.69	5.2

SN	TREE NO.	SPECIES	GIRTH IN M.	HEIGHT IN M.	SN	TREE NO.	SPECIES	GIRTH IN M.	HEIGHT IN M.
LEFT SIDE					RIGHT SIDE				
242	E502	NEEM	0.63	2.4	242	E471	BABUL	1.53	5.5
243	E503	CHICHWA	0.82	1.8	243	E472	BABUL	1.07	4.9
244	E504	NEEM	1.57	1.2	244	E473	BABUL	1.23	4.9
245	E511	CHICHWA	0.61	1.5	245	E474	BABUL	0.82	3.0
246	E521	BABUL	1.16	4.9	246	E480	CHINCH	2.7	5.5
247	E533	NEEM	0.62	2.4	247	E481	CHINCH	2.83	6.1
248	E534	NEEM	0.60	2.4	248	E487	NEEM	0.78	2.4
249	E541	MAYRUNG	0.75	1.8	249	E491	BABUL	0.75	2.7
250	E545	BADAM	0.82	3.0	250	E492	KARANJI	0.82	6.0
251	E553	BOR	0.45	1.2	251	E493	SHIRAS	0.62	4.0
252	E554	PANJHARA	0.67	2.4	252	E494	BABUL	1.19	2.7
253	E555	CHICHBULAI	1.07	4.6	253	E495	NEEM	1.60	4.6
254	E556	NILGIRI	0.62	4.9	254	E498	BOR	1.96	1.8
255	E557	BOR	0.50	2.0	255	E499	CHICHWA	1.13	3.0
256	E558	PALAS	0.76	2.4	256	E500	CHICHWA	1.45	2.7
257	E559	SAG	0.54	3.0	257	E505	CHICHWA	0.55	3.0
258	E560	BASS	3.22	7.0	258	E506	BABUL	1.38	5.5
259	E561	BASS	2.34	6.0	259	E507	KARANJI	1.19	3.7
260	E562	BABUL	1.42	1.8	260	E508	KARANJI	0.73	3.0
261	E563	BABUL	0.82	4.6	261	E509	BABUL	0.76	4.9
262	E564	BABUL	0.47	2.4	262	E510	CHICHWA	0.70	3.0
263	E565	BABUL	0.76	3.0	263	E512	CHICHWA	0.87	1.5
264	E566	NEEM	0.87	3.0	264	E513	CHICHWA	0.64	1.8
265	E567	BABUL	1.16	2.7	265	E514	CHICHWA	0.72	3.0
266	E568	CHICHORA	0.34	2.1	266	E515	CHICHWA	0.59	4.0
267	E569	BABUL	0.93	1.8	267	E516	BABUL	1.30	3.0
268	E570	NEEM	1.03	2.1	268	E517	BABUL	0.93	2.7
269	E571	BABUL	0.81	1.5	269	E518	SHIRAS	1.40	3.7
270	E572	BABUL	0.72	1.8	270	E519	SHIRAS	0.96	2.7
271	E577	HIWAR	0.64	3.0	271	E520	SHIRAS	0.59	3.0
272	E578	PALAS	0.72	1.8	272	E522	SHIRAS	0.42	2.4
273	E579	BABUL	0.86	2.7	273	E523	CHICHWA	0.54	2.1
274	E580	PALAS	0.88	2.1	274	E524	CHICHWA	0.42	3.0
275	E581	BABUL	0.99	3.4	275	E525	CHICHWA	0.56	1.8
276	E582	PALAS	1.23	3.4	276	E526	CHICHWA	0.77	2.1
277	E583	KARANJI	0.42	3.0	277	E527	CHICHWA	0.82	1.8
278	E593	BABUL	0.32	1.5	278	E528	CHICHWA	0.57	1.8
279	E594	BABUL	0.54	2.1	279	E529	CHICHWA	0.83	4.0
280	E601	BABUL	0.38	2.4	280	E530	CHICHWA	0.18	2.1
281	E602	MAYRUNG	0.68	6.0	281	E531	ASHOKA	0.36	2.1
282	E603	SUBABUL	0.82	7.0	282	E532	ASHOKA	0.66	3.7
283	E609	MAYRUNG	0.98	8.0	283	E535	SHIRAS	0.58	3.3
284	E613	SIMAR	0.50	6.0	284	E536	SHIRAS	0.89	4.0
285	E614	MAYRUNG	0.82	6.0	285	E537	SHIRAS	0.32	2.0
286	E615	JAMUN	0.33	4.0	286	E538	SHIRAS	0.57	2.5
287	E616	NEEM	0.94	4.0	287	E539	SHIRAS	0.91	2.7
288	E617	MUGNACHYA SHENGA	0.85	5.0	288	E540	KARANJI	0.62	2.1
289	E622	BABUL	0.48	3.0	289	E542	KARANJI	0.75	3.5

SN	TREE NO.	SPECIES	GIRTH IN M.	HEIGHT IN M.	SN	TREE NO.	SPECIES	GIRTH IN M.	HEIGHT IN M.
LEFT SIDE					RIGHT SIDE				
290	E623	BABUL	0.44	3.0	290	E543	PIPAL	1.12	4.0
291	E624	TIMBER	0.30	2.0	291	E544	PIPAL	1.26	4.0
292	E625	BABUL	0.43	3.0	292	E546	SHIRUS	0.48	3.0
293	E634_A	HIWAR	0.41	3.0	293	E547	SHIRUS	0.71	3.0
294	E634	SHISHUM	0.63	6.0	294	E548	CHICHWA	0.58	2.7
295	E635	SHISHUM	0.76	6.0	295	E549	CHICHWA	0.69	2.7
296	E636	SHISHUM	0.80	5.0	296	E550	CHICHWA	0.65	2.4
297	E637	CHILATI	0.68	3.0	297	E551	NEEM	1.26	4.6
298	E638	SHISHUM	1.22	6.0	298	E552	BOR	0.48	3.0
299	E639	SHISHUM	0.69	6.0	299	E573	CHICHBULAI	0.68	1.8
300	E640	SHISHUM	0.72	6.0	300	E574	BEL	0.98	4.6
301	E641	SHISHUM	0.84	6.0	301	E575	SHISHUM	1.35	4.6
302	E642	SHISHUM	0.89	6.0	302	E576	NEEM	2.24	3.4
303	E643	CHILATI	0.46	3.0	303	E584	BABUL	0.62	1.5
304	E644	SHISHUM	0.88	5.0	304	E585	BABUL	0.87	4.6
305	E645	SHISHUM	0.80	6.0	305	E586	BABUL	0.68	2.4
306	E646	SHISHUM	0.84	6.0	306	E587	SHISHUM	0.72	5.0
307	E647	CHILATI	0.42	2.0	307	E588	BABUL	0.88	2.4
308	E648	SHISHUM	0.82	6.0	308	E589	BABUL	0.73	2.4
309	E649	CHILATI	0.30	2.0	309	E590	BABUL	0.53	2.4
310	E650	SHISHUM	0.82	7.0	310	E591	BABUL	0.63	2.4
311	E651	SHISHUM	0.56	5.0	311	E592	SHISHUM	0.83	3.7
312	E658	SHISHUM	0.70	6.0	312	E595	SHISHUM	0.58	2.7
313	E659	SHISHUM	1.13	5.0	313	E596	BABUL	0.68	2.7
314	E660	SHISHUM	0.82	6.0	314	E597	BABUL	0.82	2.7
315	E661	SHISHUM	0.64	6.0	315	E598	BABUL	0.53	1.8
316	E662	SHISHUM	0.66	5.0	316	E599	BABUL	0.58	1.5
317	E663	SHISHUM	0.92	6.0	317	E600	BABUL	0.38	1.8
318	E665	SHISHUM	0.87	7.0	318	E604	BABUL	0.60	5.0
319	E665-A	SHISHUM	0.54	5.0	319	E605	BABUL	0.85	6.0
320	E671	SHISHUM	0.60	6.0	320	E606	BABUL	0.55	4.0
321	E677	SHISHUM	0.85	6.0	321	E607	BABUL	0.72	5.0
322	E678	SHISHUM	0.96	7.0	322	E608	SHIRAS	0.61	3.0
323	E679	SHISHUM	0.83	6.0	323	E610	BABUL	0.30	2.0
324	E680	SHISHUM	0.68	6.0	324	E611	MAYRUNG	0.34	3.0
325	E681	SHISHUM	0.80	6.0	325	E612	NEEM	1.12	6.0
326	E682	CHILATI	0.38	4.0	326	E618	BABUL	0.42	3.0
327	E683	BABUL	0.76	4.0	327	E619	NEEM	1.42	7.0
328	E684	SHISHUM	0.67	3.0	328	E620	BABUL	0.35	2.0
329	E685	SHISHUM	0.74	2.7	329	E621	BABUL	0.58	4.0
330	E686	SHISHUM	0.63	3.4	330	E626	HIWAR	0.80	3.0
331	E687	PALAS	0.52	3.0	331	E627	HIWAR	0.72	3.0
332	E688	SHISHUM	0.78	6.0	332	E628	HIWAR	0.62	3.0
333	E689	SHISHUM	0.74	6.0	333	E629	PALAS	0.62	4.0
334	E698	SHISHUM	0.49	6.0	334	E630	PALAS	0.92	5.0
335	E699	SHISHUM	0.74	6.0	335	E631	PALAS	0.53	3.0
336	E700	SHISHUM	0.66	7.0	336	E632	AJAN	0.63	7.0
337	E701	SHISHUM	0.70	6.0	337	E633	PALAS	0.86	6.0
338	E702	SHISHUM	0.73	6.0	338	E652	PALAS	0.76	3.0

SN	TREE NO.	SPECIES	GIRTH IN M.	HEIGHT IN M.	SN	TREE NO.	SPECIES	GIRTH IN M.	HEIGHT IN M.
LEFT SIDE					RIGHT SIDE				
339	E703	SHISHUM	0.62	6.0	339	E653	SHISHUM	0.5	5.0
340	E704	PALAS	0.60	3.0	340	E654	SHISHUM	0.53	4.0
341	E705	SHISHUM	0.72	6.0	341	E655	SHISHUM	0.39	5.0
342	E706	SHISHUM	0.68	6.0	342	E656	SHISHUM	0.35	4.0
343	E707	SHISHUM	0.70	6.0	343	E657	SHISHUM	0.53	5.0
344	E708	SIMAR	1.00	5.0	344	E664	BABUL	0.64	4.0
345	E709	SHISHUM	0.69	6.0	345	E666	SHISHUM	0.38	5.0
346	E710	PALAS	0.80	4.0	346	E667	SHISHUM	0.5	5.0
347	E711	SHISHUM	0.83	6.0	347	E668	SHISHUM	0.4	5.0
348	E712	SHISHUM	0.60	5.0	348	E669	SHISHUM	0.44	5.0
349	E715	SHISHUM	0.74	6.0	349	E670	SHISHUM	0.48	5.0
350	E716	SHISHUM	0.72	6.0	350	E672	SHISHUM	0.47	5.0
351	E717	SHISHUM	0.80	6.0	351	E673	SHISHUM	0.45	5.0
352	E720	SHISHUM	0.80	6.0	352	E674	SHISHUM	0.36	5.0
353	E721	SHISHUM	0.72	6.0	353	E675	SHISHUM	0.37	5.0
354	E722	SHISHUM	0.69	6.0	354	E676	SHISHUM	0.32	5.0
355	E723	PALAS	0.87	5.0	355	E690	SHISHUM	0.46	5.0
356	E724	SHISHUM	0.75	6.0	356	E691	SHISHUM	0.52	5.0
357	E725	SHISHUM	0.72	7.0	357	E692	SHISHUM	0.48	5.0
358	E726	SHISHUM	1.05	6.0	358	E693	SHUBABUL	0.58	7.0
359	E729	SHISHUM	0.72	6.0	359	E693A	SHISHUM	0.54	5.0
360	E730	SHISHUM	0.84	6.0	360	E694	PALAS	1.15	5.0
361	E731	SHIRAS	0.89	7.0	361	E695	PALAS	0.72	5.0
362	E732	SHISHUM	0.81	7.0	362	E696	PALAS	0.54	5.0
363	E733	SHISHUM	0.73	7.0	363	E697	PALAS	0.97	5.0
364	E734	SHISHUM	0.74	6.0	364	E713	SHIRAS	0.81	6.0
365	E735	SHISHUM	0.60	6.0	365	E714	PALAS	0.45	5.0
366	E736	SHISHUM	0.65	6.5	366	E718	SAGWAN	0.47	6.0
367	E737	PALAS	0.92	5.0	367	E719	SHIRAS	1	6.0
368	E738	SHISHUM	0.74	6.0	368	E727	PALAS	1.28	7.0
369	E739	SHISHUM	0.62	6.0	369	E728	PALAS	0.85	5.0
370	E740	SHISHUM	0.71	7.0	370	E742	PALAS	1.68	6.0
371	E741	HIWAR	1.22	4.0	371	E749	PALAS	1.15	7.0
372	E743	SHISHUM	0.68	6.0	372	E750	PALAS	0.85	5.0
373	E744	SHISHUM	0.71	6.5	373	E751	HIWAR	1.1	5.0
374	E745A	SHISHUM	0.74	6.0	374	E752	PALAS	0.9	5.0
375	E746B	SHISHUM	0.58	6.0	375	E753	PALAS	1.7	6.0
376	E745	CHILATI	0.78	3.0	376	E754	PALAS	0.55	6.0
377	E746	PALAS	0.60	4.0	377	E755	PALAS	0.57	5.0
378	E747	SHISHUM	0.75	6.5	378	E771	PALAS	1.31	6.0
379	E748	SHISHUM	0.78	6.5	379	E772	PALAS	0.63	5.0
380	E756	SHISHUM	0.83	6.0	380	E773	PALAS	0.52	5.0
381	E757	SHISHUM	0.96	7.0	381	E795	HIWAR	1.23	6.0
382	E758	SHISHUM	0.73	6.0	382	E796	BABUL	1	5.0
383	E759	SHISHUM	0.85	6.0	383	E797	HIWAR	1.38	7.0
384	E760	SHISHUM	0.72	6.5	384	E798	PALAS	1.58	7.0
385	E761	SHISHUM	0.78	6.0	385	E807	NEEM	2.14	7.0
386	E762	SHISHUM	0.58	6.5	386	E808	BABUL	0.45	4.0
387	E763	CHILATI	0.62	3.0	387	E809	NEEM	1.8	7.0

SN	TREE NO.	SPECIES	GIRTH IN M.	HEIGHT IN M.	SN	TREE NO.	SPECIES	GIRTH IN M.	HEIGHT IN M.
LEFT SIDE					RIGHT SIDE				
388	E764	SHISHUM	0.58	6.0	388	E818	CHICHWA	0.83	1.8
389	E765	SHISHUM	0.73	6.5	389	E819	CHICHWA	0.92	2.7
390	E766	PALAS	0.57	3.0	390	E820	CHICHWA	0.52	2.4
391	E767	SHISHUM	0.91	7.0	391	E821	CHICHWA	0.87	2.7
392	E768	SHISHUM	0.92	6.0	392	E822	PALAS	0.65	2.1
393	E769	PALAS	0.52	3.0	393	E836	KARANJI	0.89	2.7
394	E770	SHISHUM	0.94	6.0	394	E837	KARANJI	0.61	3.4
395	E774	SHISHUM	0.91	6.0	395	E838	KARANJI	0.84	3.4
396	E775	HIWAR	0.97	4.0	396	E839	CHICHWA	0.87	3.0
397	E776	PALAS	0.79	3.0	397	E840	CHICHWA	0.93	3.7
398	E777	SHISHUM	0.62	6.0	398	E841	CHICHWA	0.94	2.1
399	E778	SHISHUM	0.86	6.5	399	E842	NEEM	0.42	1.5
400	E779	SHISHUM	0.32	6.0	400	E843	NEEM	0.43	1.5
401	E780	PALAS	0.55	4.0	401	E844	NEEM	0.74	2.4
402	E781	PALAS	0.48	4.0	402	E845	NEEM	0.57	2.4
403	E782	SHISHUM	0.98	6.5	403	E846	NEEM	0.76	2.7
404	E783	SHISHUM	0.88	6.0	404	E847	NEEM	0.76	2.7
405	E784	SHISHUM	0.82	6.0	405	E848	NEEM	0.62	2.4
406	E785	CHICHWA	0.60	6.0	406	E849	NEEM	0.48	1.5
407	E786	PALAS	0.42	3.0	407	E850	NEEM	0.97	3.4
408	E787	PALAS	0.60	3.0	408	E851	NEEM	0.92	3.4
409	E788	SHISHUM	0.90	6.0	409	E852	NEEM	0.91	2.7
410	E789	SHISHUM	0.80	6.0	410	E866	BABUL	0.63	3.0
411	E790	SHISHUM	0.93	6.0	411	E867	BABUL	0.64	3.0
412	E791	SHISHUM	0.93	6.0	412	E872	NEEM	0.88	5.0
413	E792	PALAS	0.67	4.0	413	E873	SHABABUL	0.76	7.0
414	E792A	SHISHUM	0.98	6.0	414	E874	PALAS	1.1	5.0
415	E793	SHISHUM	0.90	6.0	415	E875	SHABABUL	0.87	5.0
416	E794	SHISHUM	0.75	6.0	416	E876	SHISHUM	0.76	6.0
417	E799	SHISHUM	0.87	6.0	417	E879	CHICHWA	0.78	6.0
418	E800	SHISHUM	0.72	6.0	418	E880	CHICHWA	1.22	5.0
419	E801	SHISHUM	0.34	4.0	419	E881	CHICHWA	0.92	5.0
420	E802	HIWAR	0.94	3.0	420	E882	CHICHWA	0.95	5.0
421	E803	SHISHUM	1.11	6.0	421	E884	KHAIR	0.33	7.0
422	E804	SHISHUM	0.43	5.0	422	E885	CHICHWA	0.67	6.0
423	E805	SHISHUM	1.00	6.0	423	E894	PALAS	1.32	6.0
424	E806	SHISHUM	0.85	6.5	424	E895	SHUBABUL	0.75	6.0
425	E810	SHISHUM	1.06	6.0	425	E896	SHUBABUL	0.68	6.0
426	E811	SHISHUM	0.48	5.0	426	E899	SHISHUM	0.70	6.0
427	E812	SHISHUM	0.70	6.0	427	E900	SHISHUM	0.87	6.0
428	E813	SHISHUM	0.88	6.5	428	E901	SHISHUM	0.67	6.0
429	E814	SHISHUM	0.87	6.0	429	E902	SHUBABUL	0.59	6.0
430	E815	SHISHUM	0.75	6.0	430	E909	NEEM	2.08	6.0
431	E816	BABUL	0.98	2.7	431	E910	PALAS	0.55	5.0
432	E816A	NEEM	0.41	2.1	432	E911	PALAS	0.60	5.0
433	E817	NEEM	0.57	2.1	433	E912	CHICHWA	0.50	6.0
434	E817A	NEEM	0.40	1.8	434	E913	CHICHWA	0.98	6.0
435	E823	BABUL	0.27	1.8	435	E916	SHUBABUL	0.70	5.0
436	E824	BABUL	0.52	2.7	436	E917	SHISHUM	0.65	6.0

SN	TREE NO.	SPECIES	GIRTH IN M.	HEIGHT IN M.	SN	TREE NO.	SPECIES	GIRTH IN M.	HEIGHT IN M.
LEFT SIDE					RIGHT SIDE				
437	E825	PALAS	0.41	2.4	437	E918	BOR	0.66	6.0
438	E826	NEEM	0.31	3.0	438	E919	SHISHUM	1.06	6.0
439	E827	BABUL	0.78	2.4	439	E920	SHISHUM	0.76	6.0
440	E828	NEEM	0.48	3.0	440	E921	SAGWAN	0.52	7.0
441	E829	BABUL	0.38	1.5	441	E922	SAGWAN	0.68	7.0
442	E830	NEEM	0.26	2.4	442	E923	SAGWAN	0.58	7.0
443	E831	NEEM	0.67	1.8	443	E924	SHISHUM	1.65	6.0
444	E832	NEEM	0.82	3.0	444	E925	SAGWAN	1.60	7.0
445	E833	NEEM	0.79	2.1	445	E926	SHISHUM	1.83	6.0
446	E834	NEEM	0.32	1.5	446	E927	SAGWAN	0.58	7.0
447	E835	NEEM	0.74	2.7	447	E939	SHISHUM	0.53	6.0
448	E853	BABUL	0.45	1.5	448	E940	SHISHUM	0.69	6.0
449	E854	NEEM	0.79	2.7	449	E941	PALAS	0.98	6.0
450	E855	NEEM	0.98	3.0	450	E942	MAYRUNG	1.33	8.0
451	E856	NEEM	0.73	2.4	451	E943	NEEM	3.20	7.0
452	E857	BABUL	0.53	2.7	452	E975	GULMOHOR	1.27	6.0
453	E858	NEEM	0.61	1.8	453	E976	GULMOHOR	0.85	6.0
454	E859	NEEM	0.63	2.4	454	E977	GULMOHOR	0.78	6.0
455	E860	BABUL	0.82	3.0	455	E978	GULMOHOR	0.77	6.0
456	E861	BABUL	0.53	3.0	456	E979	GULMOHOR	0.84	7.0
457	E862	CHINCH	0.40	2.4	457	E980	SHISHUM	0.87	6.0
458	E863	NILGIRI	0.68	4.6	458	E981	MAYRUNG	0.65	7.0
459	E864	NEEM	0.63	1.5	459	E982	NEEM	1.35	6.0
460	E865	NEEM	0.64	1.8	460	E983	MAYRUNG	0.70	6.0
461	E868	NEEM	0.54	1.8	461	E984	GULMOHOR	0.62	6.0
462	E869	NEEM	0.53	1.8	462	E985	GULMOHOR	0.50	6.0
463	E870	NEEM	0.42	2.4	463	E986	PALAS	0.72	5.0
464	E871	NEEM	0.53	2.4	464	E987	GULMOHOR	0.67	6.0
465	E877	NEEM	1.08	7.0	465	E988	PALAS	0.66	6.0
466	E878	AAJAN	1.62	7.0	466	E989	GULMOHOR	0.69	5.0
467	E883	CHICH	0.65	5.0	467	E990	SHISHUM	0.91	6.0
468	E886	SUBABUL	1.33	4.0	468	E991	GULMOHOR	0.72	6.0
469	E887	SUBABUL	0.76	3.0	469	E992	GULMOHOR	0.87	6.0
470	E888	SUBABUL	0.54	3.0	470	E993	PALAS	0.49	5.0
471	E889	SUBABUL	1.14	3.0	471	E994	SHISHUM	1.10	6.0
472	E890	GULMOHAR	0.74	6.0	472	E995	SHISHUM	1.03	6.0
473	E891	GULMOHAR	0.65	6.0	473	E996	SHISHUM	0.81	6.0
474	E892	GULMOHAR	0.36	6.0	474	E997	PALAS	0.51	6.0
475	E893	SUBABUL	0.74	3.0	475	E998	SHISHUM	1.52	7.0
476	E897	SUBABUL	0.60	4.0	476	E999	SHISHUM	0.92	6.0
477	E898	SUBABUL	0.72	4.0	477	E1000	SHISHUM	0.79	6.0
478	E903	GULMOHAR	0.85	6.0	478	E1001	SHISHUM	0.73	6.0
479	E904	SUBABUL	1.28	3.0	479	E1002	GULMOHOR	0.60	6.0
480	E905	GULMOHAR	0.31	6.0	480	E1003	SHISHUM	0.77	6.0
481	E906	SUBABUL	0.99	3.0	481	E1004	GULMOHOR	0.71	7.0
482	E907	MAYRUG	0.62	4.0	482	E1005	PALAS	0.62	5.0
483	E908	GULMOHAR	0.98	6.0	483	E1006	GULMOHOR	0.90	7.0
484	E914	GULMOHAR	0.90	4.0	484	E1007	CHICH	2.00	7.0
485	E915	GULMOHAR	1.10	6.0	485	E1010	GULMOHOR	0.86	6.0

SN	TREE NO.	SPECIES	GIRTH IN M.	HEIGHT IN M.	SN	TREE NO.	SPECIES	GIRTH IN M.	HEIGHT IN M.
LEFT SIDE					RIGHT SIDE				
486	E928	GULMOHAR	0.86	6.0	486	E1011	SHISHUM	1.19	7.0
487	E929	CHICHWA	0.80	6.0	487	E1012	GULMOHOR	0.70	7.0
488	E930	CHICHWA	0.69	5.0	488	E1013	PALAS	0.86	5.0
489	E931	CHICHWA	0.86	5.0	489	E1014	SHISHUM	1.51	7.0
490	E932	CHICHWA	0.78	6.0	490	E1015	SAGWAN	0.65	7.0
491	E933	CHICHWA	0.78	6.0	491	E1016	PALAS	0.45	6.0
492	E934	SUBABUL	0.69	4.0	492	E1017	GULMOHOR	0.67	7.0
493	E935	SUBABUL	0.72	5.0	493	E1018	PALAS	0.60	5.0
494	E936	SUBABUL	0.59	5.0	494	E1019	PALAS	1.25	6.0
495	E937	KARANJI	0.59	5.0	495	E1020	SAGWAN	0.70	7.0
496	E938	KARANJI	0.67	5.0	496	E1021	SAGWAN	0.44	6.0
497	E944	SHISHUM	0.55	6.0	497	E1022	SAGWAN	0.94	7.0
498	E945	SHISHUM	1.02	5.0	498	E1023	SAGWAN	1.98	7.0
499	E946	SHISHUM	0.61	5.0	499	E1028	SAG	0.52	7.0
500	E947	SHISHUM	1.44	6.0	500	E1029	SAG	0.5	7.0
501	E948	SHISHUM	0.40	5.0	501	E1030	SAG	0.97	7.0
502	E949	SHISHUM	0.63	6.0	502	E1031	GULMOHOR	1.08	6.0
503	E950	SHISHUM	0.47	6.0	503	E1032	SUBABUL	0.77	6.0
504	E950_A	SHISHUM	0.64	6.0	504	E1033	SAGWAN	0.69	6.0
505	E951	SHISHUM	0.66	6.0	505	1033A	SAGWAN	0.94	6.0
506	E952	SHISHUM	0.62	6.0	506	E1034	SAGWAN	0.98	7.0
507	E953	SHISHUM	0.46	5.0	507	E1035	SAGWAN	0.78	7.0
508	E954	SHISHUM	0.71	6.0	508	E1036	PALAS	0.68	4.0
509	E955	SHISHUM	0.44	6.0	509	E1037	PALAS	1.16	3.0
510	E956	SHISHUM	0.51	5.0	510	E1038	SAGWAN	0.92	6.0
511	E957	SHISHUM	0.52	6.0	511	E1039	SAGWAN	0.98	7.0
512	E958	SHISHUM	0.44	6.0	512	E1040	PALAS	0.61	4.0
513	E959	SHISHUM	0.54	6.0	513	E1041	SAGWAN	0.58	7.0
514	E960	SHISHUM	0.39	5.0	514	E1042	SAGWAN	0.82	6.0
515	E960A	SHISHUM	0.60	6.0	515	E1043	SAGWAN	1.25	7.0
516	E961	SHISHUM	0.68	6.0	516	E1044	SAGWAN	1.22	7.0
517	E962	SHISHUM	0.42	5.5	517	E1047	SAGWAN	0.48	6.0
518	E963	SHISHUM	0.77	6.0	518	E1048	SAGWAN	0.52	6.0
519	E964	SHISHUM	0.36	5.0	519	E1049	SAGWAN	1.25	7.0
520	E965	SHISHUM	0.51	6.0	520	E1052	SAGWAN	1.12	7.0
521	E966	SHISHUM	0.40	5.0	521	E1053	SAGWAN	1.16	7.0
522	E967	SHISHUM	0.40	5.0	522	E1054	SAG	1.37	7.0
523	E968	SHISHUM	0.45	6.0	523	E1055	SABABUL	0.87	7.0
524	E969	SHISHUM	0.60	6.0	524	E1056	SAG	0.52	6.0
525	E970	SHISHUM	0.85	6.0	525	E1057	SAG	0.54	5.0
526	E971	SHISHUM	0.49	6.0	526	E1062	SAGWAN	0.85	6.0
527	E972	SUBABUL	0.64	3.0	527	E1063	SAG	1.17	7.0
528	E973	BABUL	0.70	6.0	528	E1064	SAG	0.44	6.0
529	E974	AAJAN	13.00	6.0	529	E1065	SAG	0.57	6.0
530	E1008	SAGWAN	0.60	5.0	530	E1066	SAG	0.6	6.0
531	E1009	MAYRUG	1.32	7.0	531	E1067	SAG	0.46	6.0
532	E1024	SUBABUL	0.77	3.0	532	E1068	SAG	0.62	7.0
533	E1025	SHISHUM	0.50	6.0	533	E1069	SAGWAN	1.42	6.0
534	E1026	SHISHUM	0.80	6.0	534	E1070	PALAS	1.02	6.0

SN	TREE NO.	SPECIES	GIRTH IN M.	HEIGHT IN M.	SN	TREE NO.	SPECIES	GIRTH IN M.	HEIGHT IN M.
LEFT SIDE					RIGHT SIDE				
535	E1027	KARANJI	0.59	6.0	535	E1075	SAGWAN	0.87	7.0
536	E1045	BABUL	0.85	6.0	536	E1076	SAG	0.46	6.0
537	E4046	GULMOHAR	1.08	8.0	537	E1077	SAGWAN	1.1	7.0
538	E1050	GULMOHAR	1.68	6.0	538	E1078	SAGWAN	0.46	5.0
539	E1051	GULMOHAR	1.26	4.0	539	E1079	PALAS	0.72	5.0
540	E1058	PALAS	0.60	5.0	540	E1080	SAGWAN	0.56	5.0
541	E1059	CHICHWA	1.32	8.0	541	E1081	SAGWAN	0.71	7.0
542	E1060	PALAS	0.51	4.0	542	E1082	SAGWAN	0.58	7.0
543	E1061	CHICHWA	1.19	8.0	543	E1083	SAGWAN	0.46	5.0
544	E1071	CHICHORA	1.02	8.0	544	E1084	PALAS	1.6	6.0
545	E1072	CHICHORA	0.53	6.0	545	E1085	SAGWAN	0.65	7.0
546	E1073	SAGWAN	0.60	7.0	546	E1086	SAGWAN	1.2	7.0
547	E1074	SUBABUL	1.62	8.0	547	E1092	PALAS	0.97	5.0
548	E1087	GULMOHAR	0.61	7.0	548	E1093	BABUL	1.26	5.0
549	E1088	GULMOHAR	0.63	7.0	549	E1094	SAGWAN	0.5	4.0
550	E1089	GULMOHAR	1.30	8.0	550	E1095	HIWAR	0.6	5.0
551	E1090	GULMOHAR	0.90	5.0	551	E1096	PALAS	0.62	5.0
552	E1091	GULMOHAR	0.88	8.0	552	E1097	SAGWAN	0.52	6.0
553	E1092	GULMOHAR	1.15	6.0	553	E1098	GULMOHOR	1	6.0
554	E1108	GULMOHAR	0.93	6.0	554	E1099	BABUL	1.53	5.0
555	E1109	GULMOHAR	1.08	7.0	555	E1100	GULMOHOR	1.28	7.0
556	E1110	GULMOHAR	1.30	7.0	556	E1101	PALAS	0.93	5.0
557	E1111	GULMOHAR	1.09	7.0	557	E1102	GULMOHOR	0.88	7.0
558	E1112	GULMOHAR	0.70	7.0	558	E1103	GULMOHOR	0.93	7.0
559	E1124	GULMOHAR	1.06	8.0	559	E1104	GULMOHOR	0.95	5.0
560	E1125	GULMOHAR	0.94	5.0	560	E1105	BABUL	0.82	7.0
561	E1126	GULMOHAR	0.63	5.0	561	E1106	BABUL	0.83	3.0
562	E1127	GULMOHAR	0.80	7.0	562	E1107	PALAS	0.63	5.0
563	E1128	GULMOHAR	1.02	7.0	563	E1113	BABUL	1	6.0
564	E1129	GULMOHAR	0.64	5.0	564	E1114	BABUL	0.38	5.0
565	E1130	GULMOHAR	1.00	6.0	565	E1115	BABUL	0.59	5.0
566	E1154	PANJHARA	0.58	3.0	566	E1116	BABUL	0.75	7.0
567	E1159	NEEM	0.40	6.0	567	E1117	VAD	2.16	6.0
568	E1160	CHICHORA	0.48	5.0	568	E1118	BABUL	1	7.0
569	E1165	CHICHORA	0.66	5.0	569	E1119	BABUL	0.63	7.0
570	E1166	NEEM	1.17	7.0	570	E1120	KNIR	1.31	6.0
571	E1172	AAJAN	1.20	7.0	571	E1121	BABUL	1.15	7.0
572	E1173	SISAM	0.60	5.0	572	E1122	BABUL	1.2	7.0
573	E1182	HIWAR	0.62	5.0	573	E1123	BABUL	0.58	7.0
574	E1183	PALAS	0.72	5.0	574	E1131	GULMOHOR	1.32	5.0
575	E1187	NEEM	0.54	5.0	575	E1132	GULMOHOR	1.21	5.0
576	E1192	CHICHORA	1.03	3.0	576	E1133	PALAS	0.8	5.0
577	E1200	CHICHORA	0.64	5.0	577	E1134	GULMOHOR	1.18	6.0
578	E1221	SAGWAN	0.65	6.0	578	E1135	GULMOHOR	0.84	6.0
579	E1222	SAGWAN	0.60	6.0	579	E1136	GULMOHOR	1.26	7.0
580	E1223	SAGWAN	0.92	8.0	580	E1137	GULMOHOR	0.87	6.0
581	E1224	SAGWAN	0.81	8.0	581	E1138	PALAS	0.78	5.0
582	E1225	SAGWAN	0.80	8.0	582	E1139	PALAS	0.63	5.0
583	E1226	SAGWAN	1.10	8.0	583	E1140	PANJARA	1.62	7.0

SN	TREE NO.	SPECIES	GIRTH IN M.	HEIGHT IN M.	SN	TREE NO.	SPECIES	GIRTH IN M.	HEIGHT IN M.
LEFT SIDE					RIGHT SIDE				
584	E1227	SAGWAN	0.80	8.0	584	E1141	GULMOHOR	0.7	7.0
585	E1228	SAGWAN	0.90	6.0	585	E1142	GULMOHOR	0.75	7.0
586	E1229	SAGWAN	0.51	5.0	586	E1143	PALAS	1.35	6.0
587	E1230	SAGWAN	0.38	4.0	587	E1144	GULMOHOR	0.88	7.0
588	E1238	SISAM	0.85	6.0	588	E1145	GULMOHOR	0.65	6.0
589	E1239	HIWAR	0.85	6.0	589	E1146	PALAS	1.10	6.0
590	E1240	PANJHARA	1.10	6.0	590	E1147	GULMOHOR	0.90	6.0
591	E1241	NILGIRI	1.80	8.0	591	E1148	GULMOHOR	0.80	5.0
592	E1242	CHICHWA	0.46	6.0	592	E1149	GULMOHOR	0.68	6.0
593	E1243	CHICHWA	0.46	5.0	593	E1150	PANJARA	0.86	4.0
594	E1244	SUBABUL	1.35	6.0	594	E1151	GULMOHOR	0.70	3.0
595	E1245	PALAS	1.08	5.0	595	E1152	GULMOHOR	1.01	7.0
596	E1253	SISAM	1.65	7.0	596	E1153	GULMOHOR	0.62	7.0
597	E1263	GULMOHAR	1.00	5.0	597	E1154	GULMOHOR	1.07	4.0
598	E1264	GULMOHAR	1.11	6.0	598	E1155	GULMOHOR	0.50	7.0
599	E1265	GULMOHAR	0.75	6.0	599	E1156	GULMOHOR	0.11	6.0
600	E1266	GULMOHAR	1.00	3.0	600	E1157	GULMOHOR	0.50	5.0
601	E1275	SISAM	0.85	6.0	601	E1158	NEEM	3.42	8.0
602	E1276	PANJHARA	0.91	4.0	602	E1161	GULMOHOR	1.08	7.0
603	E1277	GULMOHAR	1.08	8.0	603	E1162	GULMOHOR	0.81	8.0
604	E1278	GULMOHAR	0.99	6.0	604	E1163	GULMOHOR	1.45	6.0
605	E1279	PANJHARA	1.86	5.0	605	E1164	PALAS	0.84	6.0
606	E1280	SIMAR	0.76	6.0	606	E1167	PALAS	0.80	5.0
607	E1283	NEEM	3.55	7.0	607	E1168	GULMOHOR	0.72	7.0
608	E1284	JAMBH	0.65	3.0	608	E1169	PALAS	0.93	3.0
609	E1285	GULMOHAR	1.61	8.0	609	E1170	GULMOHOR	0.70	6.0
610	E1289	GULMOHAR	1.02	8.0	610	E1171	KARANJI	0.48	4.0
611	E1290	GULMOHAR	0.85	6.0	611	E1174	KARANJI	1.70	8.0
612	E1291	GULMOHAR	0.86	7.0	612	E1175	GULMOHOR	0.70	3.0
613	E1292	GULMOHAR	0.88	8.0	613	E1176	GULMOHOR	0.62	5.0
614	E1293	SUBABUL	0.92	7.0	614	E1177	GULMOHOR	0.82	5.0
615	E1294	GULMOHAR	1.06	7.0	615	E1178	GULMOHOR	0.72	5.0
616	E1295	GULMOHAR	0.84	7.0	616	E1179	SUBABUL	0.71	7.0
617	E1296	GULMOHAR	1.10	8.0	617	E1180	GULMOHOR	0.74	4.0
618	E1301	NEEM	0.68	6.0	618	E1181	GULMOHOR	1.08	4.0
619	E1302	GULMOHAR	1.19	6.0	619	E1184	GULMOHOR	1.21	5.0
620	E1306	GULMOHAR	1.90	6.0	620	E1185	GULMOHOR	1.18	5.0
621	E1307	PANJHARA	1.10	5.0	621	E1186	GULMOHOR	0.61	5.0
622	E1308	GULMOHAR	0.98	8.0	622	E1188	GULMOHOR	1.45	5.0
623	E1320	PANJHARA	0.82	6.0	623	E1189	GULMOHOR	1.11	8.0
624	E1321	GULMOHAR	0.80	7.0	624	E1190	HIWAR	0.58	5.0
625	E1322	GULMOHAR	1.20	6.0	625	E1191	PALAS	0.78	5.0
626	E1323	NEEM	0.80	6.0	626	E1193	GULMOHOR	1.20	6.0
627	E1324	KARNJA	0.40	5.0	627	E1194	GULMOHOR	0.90	7.0
628	E1325	PIPAL	1.10	4.0	628	E1195	PALAS	0.82	6.0
629	E1333	GULMOHAR	1.07	6.0	629	E1196	PALAS	0.74	5.0
630	E1334	GULMOHAR	1.00	5.0	630	E1197	PALAS	0.58	3.0
631	E1335	GULMOHAR	1.08	6.0	631	E1198	KARANJI	1.61	5.0
632	E1348	GULMOHAR	0.83	6.0	632	E1199	NEEM	1.55	7.0

SN	TREE NO.	SPECIES	GIRTH IN M.	HEIGHT IN M.	SN	TREE NO.	SPECIES	GIRTH IN M.	HEIGHT IN M.
LEFT SIDE					RIGHT SIDE				
633	E1349	GULMOHAR	1.42	7.0	633	E1201	PALAS	1.14	6.0
634	E1350	GULMOHAR	1.05	7.0	634	E1202	PALAS	0.60	5.0
635	E1351	GULMOHAR	0.99	7.0	635	E1203	SABABUL	0.79	5.0
636	E1352	GULMOHAR	0.89	7.0	636	E1204	SABABUL	0.85	5.0
637	E1353	GULMOHAR	0.90	7.0	637	E1205	SABABUL	1.10	6.0
638	E1354	GULMOHAR	1.07	8.0	638	E1206	CHICHWA	0.85	5.0
639	E1355	GULMOHAR	0.90	7.0	639	E1207	PALAS	0.71	4.0
640	E1356	JAMBH	0.40	5.0	640	E1208	PALAS	0.88	5.0
641	E1357	SIRAS	1.03	6.0	641	E1209	PALAS	0.53	5.0
642	E1360	GULMOHAR	1.20	7.0	642	E1210	PALAS	1.00	5.0
643	E1361	GULMOHAR	0.80	7.0	643	E1211	PALAS	0.61	1.0
644	E1362	GULMOHAR	0.77	6.0	644	E1212	HIWAR	0.72	5.0
645	E1363	GULMOHAR	0.67	5.0	645	E1213	PALAS	1.30	6.0
646	E1364	GULMOHAR	0.88	6.0	646	E1214	HIWAR	1.16	5.0
647	E1365	GULMOHAR	0.36	7.0	647	E1215	GULMOHOR	0.97	5.0
648	E1376	NEEM	0.56	4.0	648	E1216	PALAS	1.62	7.0
649	E1377	NEEM	0.64	4.0	649	E1217	TEMBOOR	1.28	8.0
650	E1378	SHIRAS	0.46	4.0	650	E1218	NEEM	1.36	6.0
651	E1379	NEEM	1.07	5.0	651	E1219	SAGWAN	0.66	4.0
652	E1383	PIPAL	4.50	7.0	652	E1220	GULMOHOR	0.69	5.0
653	E1384	NEEM	1.50	6.0	653	E1231	CHICHWA	1.15	8.0
654	E1385	SIRAS	0.69	6.0	654	E1232	SUBABUL	0.96	6.0
655	E1386	AJAH	0.88	6.0	655	E1233	SIRAS	0.94	5.0
656	E1393	KARNJA	0.58	4.0	656	E1234	BABUL	1.36	6.0
657	E1394	AJAH	1.54	7.0	657	E1235	PALAS	1.56	7.0
658	E1395	SIRAS	0.48	5.0	658	E1236	SIRAS	1.23	7.0
659	E1398	NEEM	1.02	5.0	659	E1237	PALAS	0.47	4.0
660	E1405	AJAH	1.32	6.0	660	E1246	SAGWAN	0.45	6.0
661	E1410	PALAS	1.01	6.0	661	E1247	NEEM	1.30	5.0
662	E1412	GULMOHAR	1.14	8.0	662	E1248	SAGWAN	0.58	6.0
663	E1413	CHICHBULAI	0.98	6.0	663	E1249	SAGWAN	0.59	6.0
664	E1414	GULMOHAR	1.19	8.0	664	E1250	SAGWAN	0.61	6.0
665	E1415	GULMOHAR	1.20	9.0	665	E1251	NEEM	1.10	6.0
666	E1416	GULMOHAR	0.97	9.0	666	E1252	SAGWAN	0.60	5.0
667	E1417	GULMOHAR	1.83	9.0	667	E1254	NEEM	0.88	8.0
668	E1418	GULMOHAR	0.76	7.0	668	E1255	PALAS	0.83	4.0
669	E1419	GULMOHAR	1.81	8.0	669	E1256	SAGWAN	0.85	6.0
670	E1420	GULMOHAR	0.97	8.0	670	E1257	SAGWAN	0.85	5.0
671	E1421	GULMOHAR	1.20	8.0	671	E1258	SAGWAN	0.8	7.0
672	E1422	GULMOHAR	1.20	7.0	672	E1259	SAGWAN	0.96	8.0
673	E1423	GULMOHAR	1.45	7.0	673	E1260	SAGWAN	0.4	5.0
674	E1424	GULMOHAR	1.05	5.0	674	E1261	SAGWAN	1.14	7.0
675	E1425	GULMOHAR	1.40	7.0	675	E1262	SAGWAN	1.16	8.0
676	E1426	BABUL	0.92	7.0	676	E1267	SIRAS	0.66	5.0
677	E1427	GULMOHAR	1.18	7.0	677	E1268	SIRAS	0.87	5.0
678	E1438	GULMOHAR	0.79	7.0	678	E1269	SIRAS	0.46	4.0
679	E1439	GULMOHAR	0.93	7.0	679	E1270	SIRAS	0.7	6.0
680	E1440	NEEM	2.60	7.0	680	E1271	SIRAS	1.28	6.0
681	E1443	GULMOHAR	0.75	6.0	681	E1272	GULMOHOR	0.86	7.0

SN	TREE NO.	SPECIES	GIRTH IN M.	HEIGHT IN M.	SN	TREE NO.	SPECIES	GIRTH IN M.	HEIGHT IN M.
LEFT SIDE					RIGHT SIDE				
682	E1444	GULMOHAR	0.86	7.0	682	E1273	SAGWAN	0.92	8.0
683	E1445	GULMOHAR	0.70	7.0	683	E1274	SAGWAN	0.52	5.0
684	E1446	GULMOHAR	1.07	7.0	684	E1281	SAGWAN	1.58	8.0
685	E1447	GULMOHAR	1.07	7.0	685	E1282	SAGWAN	0.89	7.0
686	E1448	GULMOHAR	0.69	7.0	686	E1286	SIRAS	0.98	6.0
687	E1449	GULMOHAR	0.69	7.0	687	E1287	CHINCH	1.98	7.0
688	E1450	GULMOHAR	1.10	7.0	688	E1288	GULMOHOR	1	6.0
689	E1451	CHICHWA	0.72	7.0	689	E1297	CHICHORA	1.61	7.0
690	E1452	GULMOHAR	0.69	7.0	690	E1298	SAGWAN	0.86	7.0
691	E1453	GULMOHAR	0.76	7.0	691	E1299	SAGWAN	0.93	7.0
692	E1454	GULMOHAR	0.95	7.0	692	E1300	SIRAS	0.95	5.0
693	E1455	GULMOHAR	0.65	5.0	693	E1303	SIRAS	1.54	7.0
694	E1456	GULMOHAR	0.90	7.0	694	E1304	SAGWAN	1.24	7.0
695	E1457	GULMOHAR	0.84	7.0	695	E1305	KARANJI	0.52	6.0
696	E1458	GULMOHAR	0.64	5.0	696	E1309	SIRAS	1.14	7.0
697	E1459	GULMOHAR	0.90	7.0	697	E1310	SAG	0.55	5.0
698	E1460	GULMOHAR	0.98	8.0	698	E1311	SAG	1.05	5.0
699	E1461	GULMOHAR	0.88	7.0	699	E1312	SAG	0.7	5.0
700	E1469	SUBABUL	1.01	6.0	700	E1313	GULMOHOR	0.97	7.0
701	E1470	GULMOHAR	1.10	8.0	701	E1314	SIRAS	1.1	6.0
702	E1471	GULMOHAR	0.75	7.0	702	E1315	CHICHORA	4.56	6.0
703	E1472	GULMOHAR	0.78	6.0	703	E1316	SAGWAN	0.59	7.0
704	E1473	GULMOHAR	0.70	8.0	704	E1317	SAGWAN	0.58	7.0
705	E1474	GULMOHAR	0.70	7.0	705	E1318	SAGWAN	0.6	6.0
706	E1475	GULMOHAR	1.04	7.0	706	E1319	SIRAS	1	5.0
707	E1476	GULMOHAR	1.20	8.0	707	E1326	GULMOHOR	1.98	5.0
708	E1477	GULMOHAR	1.23	8.0	708	E1327	SIRAS	1.23	7.0
709	E1478	GULMOHAR	1.13	6.0	709	E1328	GULMOHOR	1.07	7.0
710	E1479	GULMOHAR	0.57	7.0	710	E1329	GULMOHOR	0.82	8.0
711	E1482	GULMOHAR	0.90	6.0	711	E1330	CHICHBULAI	2.62	8.0
712	E1483	GULMOHAR	0.80	8.0	712	E1331	AJAH	2.09	7.0
713	E1484	GULMOHAR	0.91	7.0	713	E1332	GULMOHOR	0.25	7.0
714	E1485	GULMOHAR	0.78	8.0	714	E1336	SAGWAN	0.89	8.0
715	E1486	GULMOHAR	0.83	8.0	715	E1337	SAGWAN	0.64	7.0
716	E1487	GULMOHAR	0.90	6.0	716	E1338	SAGWAN	0.84	6.0
717	E1488	GULMOHAR	0.90	6.0	717	E1339	BIHADA	1.28	9.0
718	E1489	GULMOHAR	0.85	7.0	718	E1340	BABUL	1.27	7.0
719	E1490	GULMOHAR	1.03	7.0	719	E1341	SIRAS	0.87	6.0
720	E1496	BOR	1.19	4.0	720	E1342	SAGWAN	0.93	6.0
721	E1498	PANJRA	0.45	4.0	721	E1343	SIRAS	1.49	8.0
722	E1500	GULMOHAR	0.85	7.0	722	E1344	SAGWAN	1	7.0
723	E1501	GULMOHAR	0.90	7.0	723	E1345	PANJRA	0.94	5.0
724	E1502	HIWAR	0.62	5.0	724	E1346	AJAH	1.25	6.0
725	E1503	PALAS	0.54	4.0	725	E1347	SIRAS	2.88	9.0
726	E1504	PALAS	0.98	4.0	726	E1358	SIRAS	1.91	8.0
727	E1505	SAGWAN	0.42	4.0	727	E1359	GULMOHOR	1.24	6.0
728	E1506	SAGWAN	0.61	4.0	728	E1366	SAGWAN	0.55	5.0
729	E1508	GULMOHAR	1.00	6.0	729	E1367	SAGWAN	0.76	5.0
730	E1509	GULMOHAR	0.85	6.0	730	E1368	SAGWAN	0.6	5.0

SN	TREE NO.	SPECIES	GIRTH IN M.	HEIGHT IN M.	SN	TREE NO.	SPECIES	GIRTH IN M.	HEIGHT IN M.
LEFT SIDE					RIGHT SIDE				
731	E1513	GULMOHAR	1.04	6.0	731	E1369	SIRAS	2.05	7.0
732	E1514	SAGWAN	0.36	6.0	732	E1370	MANGO	2.84	7.0
733	E1515	SAGWAN	0.40	4.0	733	E1371	SIRAS	0.48	5.0
734	E1516	PALAS	1.10	8.0	734	E1372	GULMOHOR	1.1	6.0
735	E1517	PALAS	0.86	5.0	735	E1373	GULMOHOR	1.47	8.0
736	E1518	PALAS	0.70	5.0	736	E1374	GULMOHOR	1.28	6.0
737	E1522	PALAS	0.50	4.0	737	E1375	GULMOHOR	1.9	8.0
738	E1523	PALAS	0.51	4.0	738	E1380	PANJRA	1.42	7.0
739	E1524	PALAS	0.45	4.0	739	E1381	KARANJA	1.43	8.0
740	E1525	PALAS	0.93	6.0	740	E1382	SIRAS	0.91	6.0
741	E1526	PALAS	0.67	7.0	741	E1387	PANJRA	0.87	4.0
742	E1532	PALAS	0.79	4.0	742	E1388	SIRAS	0.42	5.0
743	E1533	GULMOHAR	0.90	7.0	743	E1389	GULMOHOR	0.73	6.0
744	E1534	GULMOHAR	1.03	8.0	744	E1390	GULMOHOR	1.17	5.0
745	E1535	GULMOHAR	1.05	7.0	745	E1391	GULMOHOR	0.93	6.0
746	E1536	GULMOHAR	0.72	7.0	746	E1392	AJAH	2.26	7.0
747	E1537	GULMOHAR	0.76	7.0	747	E1396	PANJRA	3.1	6.0
748	E1541	SAGWAN	0.54	6.0	748	E1397	PANJRA	2.12	7.0
749	E1542	NEEM	0.36	4.0	749	E1399	AJAH	2.88	8.0
750	E1548	GULMOHAR	0.87	6.0	750	E1400	AJAH	3.2	7.0
751	E1551	BABUL	1.11	6.0	751	E1401	NEEM	4.30	7.0
752	E1552	BABUL	0.84	6.0	752	E1402	AJAH	0.90	5.0
753	E1555	KARNJA	1.07	5.0	753	E1403	SIRAS	1.43	6.0
754	E1556	SAGWAN	1.10	5.0	754	E1404	AJAH	1.28	5.0
755	E1557	SAGWAN	1.00	5.0	755	E1406	AJAH	1.05	5.0
756	E1558	SAGWAN	0.63	5.0	756	E1407	AJAH	1.25	6.0
757	E1559	HIWAR	0.70	5.0	757	E1408	AJAH	0.80	5.0
758	E1560	SAGWAN	0.70	5.0	758	E1409	AJAH	0.90	6.0
759	E1561	BIHAD	1.23	5.0	759	E1409A	NEEM	0.85	5.0
760	E1562	BIHAD	1.09	7.0	760	E1411	AJAH	1.34	5.0
761	E1563	CHICHBULAI	1.54	9.0	761	E1428	GULMOHOR	1.45	7.0
762	E1564	BIHAD	1.89	7.0	762	E1429	GULMOHOR	1.45	7.0
763	E1565	KARNJA	1.35	5.0	763	E1430	GULMOHOR	0.82	6.0
764	E1566	AAJAN	0.92	6.0	764	E1431	GULMOHOR	1.05	6.0
765	E1567	SAGWAN	0.97	8.0	765	E1432	NEEM	0.84	5.0
766	E1568	PALAS	1.09	5.0	766	E1433	GULMOHOR	1.01	5.0
767	E1569	SAGWAN	0.92	7.0	767	E1434	BABUL	0.87	5.0
768	E1570	SAGWAN	0.85	6.0	768	E1435	GULMOHOR	0.97	6.0
769	E1571	SAGWAN	0.48	5.0	769	E1436	GULMOHOR	1.27	7.0
770	E1575	BOR	1.26	3.0	770	E1437	BABUL	0.76	5.0
771	E1576	SAGWAN	0.48	5.0	771	E1441	GULMOHOR	1.09	7.0
772	E1577	SAGWAN	0.76	5.0	772	E1442	AAJAN	1.18	6.0
773	E1585	HIWAR	0.59	4.0	773	E1462	GULMOHOR	1.10	7.0
774	E1586	BIHAD	1.68	7.0	774	E1463	GULMOHOR	1.13	7.0
775	E1592	BIHAD	1.23	7.0	775	E1464	GULMOHOR	1.28	6.0
776	E1593	BABUL	1.02	6.0	776	E1465	HIWAR	0.43	4.0
777	E1594	HIWAR	0.84	4.0	777	E1466	BABUL	0.82	4.0
778	E1596	BOR	0.76	6.0	778	E1467	HIWAR	0.59	3.0
779	E1597	BABUL	1.07	6.0	779	E1468	SAGWAN	0.70	4.0

SN	TREE NO.	SPECIES	GIRTH IN M.	HEIGHT IN M.	SN	TREE NO.	SPECIES	GIRTH IN M.	HEIGHT IN M.
LEFT SIDE					RIGHT SIDE				
780	E1598	CHICHBULAI	0.64	5.0	780	E1480	NEEM	0.76	6.0
781	E1599	KARNJI	0.83	5.0	781	E1481	CHICHBULAI	1.38	5.0
782	E1600	NEEM	1.24	7.0	782	E1491	GULMOHOR	0.91	6.0
783	E1601	PANJRA	1.34	6.0	783	E1492	GULMOHOR	1.31	7.0
784	E1602	NEEM	0.70	5.0	784	E1493	KARANJA	0.59	5.0
785	E1603	PALAS	1.06	6.0	785	E1494	PALAS	1.01	5.0
786	E1604	CHCHBULAI	2.34	7.0	786	E1495	GULMOHOR	1.28	7.0
787	E1605	SAGWAN	0.92	7.0	787	E1497	CHINCH	0.98	6.0
788	E1606	CHICHBULAI	1.62	6.0	788	E1499	GULMOHOR	1.11	7.0
789	E1607	HIWAR	1.01	5.0	789	E1507	GULMOHOR	0.89	5.0
790	E1608	HIWAR	1.18	5.0	790	E1510	NEEM	0.84	5.0
791	E1609	HIWAR	1.11	6.0	791	E1511	SAGWAN	0.43	4.0
792	E1610	SAGWAN	0.97	6.0	792	E1512	GULMOHOR	1.80	6.0
793	E1611	PALAS	0.82	6.0	793	E1519	PALAS	0.58	6.0
794	E1612	SAGWAN	0.78	7.0	794	E1520	GULMOHOR	1.02	6.0
795	E1613	SAGWAN	0.72	7.0	795	E1521	HIWAR	0.38	3.0
796	E1614	PALAS	1.19	7.0	796	E1527	PALAS	1.16	5.0
797	E1615	PALAS	0.94	6.0	797	E1528	PALAS	0.55	3.0
798	E1616	HIWAR	1.04	3.0	798	E1529	PALAS	0.79	5.0
799	E1617	PALAS	1.58	6.0	799	E1530	CHICHORA	0.65	5.0
800	E1618	CHICHBULAI	0.97	3.0	800	E1531	PALAS	0.78	5.0
801	E1619	NEEM	1.23	7.0	801	E1538	GULMOHOR	1.40	6.0
802	E1620	PALAS	0.92	6.0	802	E1539	GULMOHOR	0.93	5.0
803	E1621	PALAS	1.02	5.0	803	E1540	GULMOHOR	0.97	5.0
804	E1622	PALAS	1.12	6.0	804	E1543	GULMOHOR	1.30	7.0
805	E1632	CHICHBULAI	1.64	3.0	805	E1544	NEEM	0.76	4.0
806	E1633	HIWAR	0.86	5.0	806	E1545	GULMOHOR	1.20	7.0
807	E1634	HIWAR	0.78	5.0	807	E1546	HIWAR	0.48	5.0
808	E1635	HIWAR	1.64	4.0	808	E1547	PALAS	1.06	5.0
809	E1639	TEMBOR	0.62	2.0	809	E1549	SAGWAN	0.32	5.0
810	E1640	HIWAR	0.47	3.0	810	E1550	GULMOHOR	1.58	6.0
811	E1641	NEEM	0.60	5.0	811	E1553	GULMOHOR	1.06	7.0
812	E1642	HIWAR	0.70	5.0	812	E1554	GULMOHOR	1.38	8.0
813	E1643	HIWAR	0.84	5.0	813	E1572	NEEM	1.86	4.0
814	E1644	PIPAL	2.24	5.0	814	E1573	BIHADA	2.20	7.0
815	E1645	SAG	0.23	4.0	815	E1574	BIHADA	2.44	7.0
816	E1646	SAG	0.49	5.0	816	E1578	PALAS	4.61	7.0
817	E1647	SAGWAN	0.54	5.0	817	E1579	NEEM	1.40	8.0
818	E1648	SAGWAN	0.48	5.0	818	E1580	BIHADA	0.96	5.0
819	E1649	SAGWAN	0.63	6.0	819	E1581	BIHADA	1.30	6.0
820	E1650	SAGWAN	0.78	6.0	820	E1582	BIHADA	0.83	4.0
821	E1651	SAGWAN	0.66	5.0	821	E1583	BIHADA	2.24	6.0
822	E1652	SAG	0.88	7.0	822	E1587	MANGO	1.30	5.0
823	E1653	BIHAD	2.23	7.0	823	E1588	MANGO	2.10	5.0
824	E1654	SAG	0.56	5.0	824	E1589	MANGO	1.82	6.9
825	E1655	KARNJI	0.38	6.0	825	E1590	MANGO	1.09	7.0
826	E1656	SISAM	0.34	2.0	826	E1591	MANGO	2.85	7.0
827	E1657	KARANJI	0.96	5.0	827	E1595	MANGO	2.80	7.0
828	E1658	KARANJI	0.91	5.0	828	E1623	BIHADA	1.34	8.0

SN	TREE NO.	SPECIES	GIRTH IN M.	HEIGHT IN M.	SN	TREE NO.	SPECIES	GIRTH IN M.	HEIGHT IN M.
LEFT SIDE					RIGHT SIDE				
829	E1659	CHICHWA	1.02	5.0	829	E1624	BIHADA	1.07	6.0
830	E1660	CHICHWA	0.84	5.0	830	E1625	NEEM	0.84	6.0
831	E1661	GULMOHAR	0.50	5.0	831	E1626	BOR	0.57	3.0
832	E1662	PALAS	1.40	7.0	832	E1627	SAGWAN	0.98	8.0
833	E1665	KARANJI	0.26	5.0	833	E1628	MANGO	2.68	7.0
834	E1681	NEEM	1.15	6.0	834	E1629	KARNJA	1.07	7.0
835	E1682	NEEM	0.49	4.0	835	E1630	PIPAL	1.23	5.0
836	E1694	KARANJI	0.57	5.0	836	E1631	NEEM	0.74	5.0
837	E1695	KARANJI	0.34	3.0	837	E1636	HIWAR	1.34	3.0
838	E1696	KARANJI	0.61	4.0	838	E1637	HIWAR	0.84	3.0
839	E1701	GULMOHAR	0.96	6.0	839	E1638	HIWAR	0.93	4.0
840	E1703	SIRAS	0.68	5.0	840	E1663	BIHADA	1.83	7.0
841	E1704	SIRAS	0.54	5.0	841	E1664	SAG	1.23	4.0
842	E1705	SIRAS	0.42	5.0	842	E1666	SIRAS	0.73	6.0
843	E1706	SIRAS	0.38	5.0	843	E1667	SIRAS	0.8	6.0
844	E1708	SIRAS	0.34	5.0	844	E1668	SIRAS	0.99	6.0
845	E1709	KARANJI	0.46	4.0	845	E1669	SIRAS	0.66	6.0
846	E1712	SIRAS	1.12	6.0	846	E1670	SIRAS	0.76	6.0
847	E1713	PANJHARA	1.07	6.0	847	E1671	SIRAS	0.75	6.0
848	E1714	SIRAS	1.07	6.0	848	E1672	SIRAS	1.15	7.0
849	E1717	SIRAS	1.08	8.0	849	E1673	SIRAS	0.84	5.0
850	E1718	KARANJI	1.23	7.0	850	E1674	KARANJI	0.76	5.0
851	E1719	KARANJI	0.96	6.0	851	E1675	KARANJI	0.93	6.0
852	E1720	SIRAS	1.43	5.0	852	E1676	SIRAS	0.88	6.0
853	E1721	SIRAS	0.79	5.0	853	E1677	SIRAS	0.9	7.0
854	E1722	SIRAS	1.28	7.0	854	E1678	SIRAS	0.91	6.0
855	E1724	NILGIRI	1.03	8.0	855	E1679	SIRAS	0.73	5.0
856	E1725	PANJARA	0.82	5.0	856	E1680	SIRAS	0.84	4.0
857	E1728	PANJARA	0.47	5.0	857	E1683	HIWAR	1.2	4.0
858	E1729	PANJARA	0.84	5.0	858	E1684	SIRAS	0.87	6.0
859	E1730	SAGWAN	0.87	5.0	859	E1685	SIRAS	1.05	6.0
860	E1731	PANJARA	0.92	5.0	860	E1686	SIRAS	0.79	6.0
861	E1735	NEEM	0.86	5.0	861	E1687	SIRAS	1.05	6.0
862	E1737	SUBABUL	1.54	8.0	862	E1688	SAGWAN	0.7	4.0
863	E1738	NEEM	0.88	6.0	863	E1689	SAGWAN	0.25	5.0
864	E1740	NEEM	1.86	7.0	864	E1690	SAGWAN	0.46	5.0
865	E1741	BADAM	0.75	7.0	865	E1691	GULMOHAR	1.63	6.0
866	E1742	BADAM	1.00	7.0	866	E1692	BABUL	2	6.0
867	E1743	BADAM	0.80	6.0	867	E1693	GULMOHAR	1.3	5.0
868	E1744	NEEM	1.11	7.0	868	E1697	HIWAR	1.49	5.0
869	E1745	NEEM	1.48	7.0	869	E1698	KARANJI	0.35	5.0
870	E1746	KARANJI	0.79	4.0	870	E1699	BABUL	0.72	5.0
871	E1747	GULMOHAR	0.91	5.0	871	E1700	BABUL	1.9	6.0
872	E1748	KARANJI	0.77	6.0	872	E1702	HIWAR	1.03	6.0
873	E1749	PALAS	0.62	5.0	873	E1707	SIRAS	1.04	6.0
874	E1750	SIRAS	0.78	6.0	874	E1710	BABUL	1.63	6.0
875	E1751	KARANJI	0.51	6.0	875	E1711	NEEM	1.43	6.0
876	E1752	KARANJI	0.95	6.0	876	E1715	HIWAR	0.97	5.0
877	E1753	KARANJI	0.66	6.0	877	E1716	NEEM	1.9	7.0

SN	TREE NO.	SPECIES	GIRTH IN M.	HEIGHT IN M.	SN	TREE NO.	SPECIES	GIRTH IN M.	HEIGHT IN M.
LEFT SIDE					RIGHT SIDE				
878	E1754	KARANJI	1.48	6.0	878	E1723	NEEM	1.5	7.0
879	E1755	SIRAS	1.18	6.0	879	E1726	GULMOHAR	0.84	7.0
880	E1756	KARANJI	0.78	7.0	880	E1727	BABUL	1.2	5.0
881	E1757	BABUL	0.52	6.0	881	E1732	HIWAR	0.48	4.0
882	E1758	KARANJI	0.96	5.0	882	E1733	GULMOHAR	1.06	8.0
883	E1759	KARANJI	1.42	6.0	883	E1734	BABUL	1.76	7.0
884	E1760	NEEM	0.84	6.0	884	E1736	GULMOHAR	1.5	7.0
885	E1761	GULMOHAR	1.25	8.0	885	E1739	BABUL	1.65	7.0
886	E1762	KARANJI	1.62	7.0	886	E1763	KARANJI	0.48	3.0
887	E1765	KARANJI	0.47	6.0	887	E1764	SIRAS	0.42	3.0
888	E1766	KARANJI	0.62	5.0	888	E1764A	SIRAS	0.61	5.0
889	E1767	SIRAS	0.72	6.0	889	E1778	NEEM	0.62	5.0
890	E1768	SIRAS	0.64	5.0	890	E1779	KARANJA	0.82	2.0
891	E1769	SIRAS	0.93	6.0	891	E1794	BABUL	0.77	4.0
892	E1770	SIRAS	0.59	5.0	892	E1807	BABUL	0.26	8.0
893	E1771	BADAM	0.48	6.0	893	E1808	NEEM	1.85	6.0
894	E1772	KARANJI	0.68	5.0	894	E1809	NEEM	2.26	7.0
895	E1773	KARANJI	0.53	5.0	895	E1813	BABAM	0.68	6.0
896	E1774	KARANJI	0.73	7.0	896	E1814	ASHOKA	0.67	5.0
897	E1775	KARANJI	0.62	4.0	897	E1815	KARANJI	0.76	8.0
898	E1776	KARANJI	0.92	6.0	898	E1816	GULMOHAR	1.69	7.0
899	E1777	KARANJI	0.91	7.0	899	E1823	GULMOHAR	0.88	5.0
900	E1780	ASHOKA	0.64	5.0	900	E1824	HIWAR	0.82	5.0
901	E1781	KARANJI	0.74	6.0	901	E1849	PALAS	0.68	4.0
902	E1782	KARANJI	1.06	6.0	902	E1850	PALAS	0.56	6.0
903	E1783	KARANJI	0.64	4.0	903	E1852	HIWAR	0.58	5.0
904	E1784	KARANJI	0.47	6.0	904	E1853	GULMOHAR	1.07	8.0
905	E1785	KARANJI	0.89	6.0	905	E1855	NEEM	0.62	5.0
906	E1786	KARANJI	0.72	4.0	906	E1856	KARANJI	0.48	4.0
907	E1787	KARANJI	0.67	4.0	907	E1856A	PIPAL	0.62	5.0
908	E1788	KARANJI	0.32	5.0	908	E1861	NEEM	1.57	6.0
909	E1789	KARANJI	0.79	6.0	909	E1862	NEEM	1.68	7.0
910	E1790	SIRAS	1.01	7.0	910	E1863	NEEM	1.18	6.0
911	E1791	KARANJI	0.58	6.0	911	E1864	NEEM	1.34	6.0
912	E1792	KARANJI	0.91	6.0	912	E1865	NEEM	0.92	6.0
913	E1793	KARANJI	0.54	6.0	913	E1866	NEEM	1.12	6.0
914	E1795	SIRAS	1.47	6.0	914	E1868	NEEM	1.14	6.0
915	E1796	BABUL	0.72	6.0	915	E1871	NEEM	0.74	6.0
916	E1797	KARANJI	0.72	5.0	916	E1875	NEEM	1.16	6.0
917	E1798	KARANJI	0.74	5.0	917	E1876	NEEM	1.08	6.0
918	E1799	GULMOHAR	0.88	7.0	918	E1878	NEEM	0.87	5.0
919	E1800	KARANJI	0.63	4.0	919	E1879	BABUL	0.57	5.0
920	E1801	KARANJI	0.48	6.0	920	E1880	HIWAR	0.52	4.0
921	E1802	GULMOHAR	0.86	7.0	921	E1881	NEEM	0.36	6.0
922	E1803	PIPAL	1.81	7.0	922	E1882	NEEM	1.86	7.0
923	E1804	GULMOHAR	0.85	6.0	923	E1883	NEEM	1.25	5.0
924	E1805	GULMOHAR	0.65	6.0	924	E1884	HIWAR	0.48	4.0
925	E1806	GULMOHAR	0.68	6.0	925	E1891	BOR	1.00	6.0
926	E1810	KARANJI	0.58	6.0	926	E1892	KARANJI	0.95	5.0

SN	TREE NO.	SPECIES	GIRTH IN M.	HEIGHT IN M.	SN	TREE NO.	SPECIES	GIRTH IN M.	HEIGHT IN M.
LEFT SIDE					RIGHT SIDE				
927	E1811	NEEM	0.93	7.0	927	E1901	SHOWCASE	1.09	7.0
928	E1812	SIRAS	0.84	5.0	928	E1902	SUBABUL	0.95	3.0
929	E1817	GULMOHAR	1.08	6.0	929	E1903	SHOWCASE	1.40	8.0
930	E1818	SHISHAM	1.39	6.0	930	E1904	CHICHWA	0.70	5.0
931	E1819	GULMOHAR	1.63	7.0	931	E1905	GULMOHAR	2.30	8.0
932	E1820	KARANJI	0.37	5.0	932	E1906	NEEM	0.39	5.0
933	E1821	SIRAS	0.62	5.0	933	E1907	GULMOHAR	0.98	6.0
934	E1822	NEEM	0.87	6.0	934	E1918	NEEM	0.74	5.0
935	E1825	SIRAS	0.72	6.0	935	E1940A	SIRAS	0.65	6.0
936	E1826	SIRAS	0.59	5.0	936	E1941	SIRAS	0.85	5.0
937	E1827	NEEM	0.68	5.0	937	E1942	SIRAS	0.52	7.0
938	E1828	NEEM	0.78	5.0	938	E1943	SIRAS	0.80	7.0
939	E1829	SAG	0.32	6.0	939	E1944	GULMOHAR	1.18	8.0
940	E1830	KARANJI	0.47	5.0	940	E1945	SIRAS	1.01	9.0
941	E1831	SIRAS	0.42	5.0	941	E1946	SIRAS	0.77	4.0
942	E1832	SIRAS	0.76	7.0	942	E1947	SIRAS	1.88	8.0
943	E1833	KARANJI	0.38	5.0	943	E1948	GULMOHAR	2.00	8.0
944	E1834	SIRAS	0.48	5.0	944	E1949	GULMOHAR	1.24	8.0
945	E1835	SIRAS	0.74	7.0	945	E1950	SIRAS	0.56	6.0
946	E1836	SIRAS	0.63	5.0	946	E1951	SIRAS	0.43	4.0
947	E1837	PALAS	1.60	7.0	947	E1952	SIRAS	0.51	6.0
948	E1838	SIRAS	0.72	6.0	948	E1952A	SIRAS	0.87	6.0
949	E1839	SIRAS	0.84	7.0	949	E1953	SIRAS	0.47	4.0
950	E1840	KARANJI	0.28	5.0	950	E1954	SIRAS	0.55	6.0
951	E1841	SAGWAN	0.52	6.0	951	E1955	SAGWAN	0.97	6.0
952	E1842	SIRAS	0.53	6.0	952	E1956	SIRAS	1.47	5.0
953	E1843	SHISHAM	0.89	4.0	953	E1957	SIRAS	1.07	4.0
954	E1844	UMARI	1.28	7.0	954	E1958	SIRAS	1.13	6.0
955	E1845	SIRAS	0.84	7.0	955	E1959	SIRAS	0.84	5.0
956	E1846	SIRAS	1.38	6.0	956	E1960	SIRAS	0.82	5.0
957	E1847	SIRAS	0.83	5.0	957	E1961	SIRAS	0.62	4.0
958	E1848	SIRAS	0.63	6.0	958	E1962	SIRAS	0.51	6.0
959	E1851	SIRAS	1.09	5.0	959	E1963	SIRAS	0.39	5.0
960	E1854	NEEM	0.72	6.0	960	E1964	SIRAS	0.72	5.0
961	E1857	NEEM	0.81	6.0	961	E1965	SIRAS	0.80	5.0
962	E1858	WAD	0.92	6.0	962	E1966	SIRAS	0.57	4.0
963	E1859	SIRAS	0.59	6.0	963	E1967	SIRAS	0.69	4.0
964	E1860	NEEM	1.06	6.0	964	E1968	SIRAS	0.52	5.0
965	E1867	NEEM	0.52	5.0	965	E1969	SIRAS	0.78	6.0
966	E1869	SIRAS	0.36	4.0	966	E1977	SHISHAM	2.08	7.0
967	E1870	CHICHWA	0.38	4.0	967	E1978	SHISHAM	1.28	7.0
968	E1872	SIRAS	1.08	6.0	968	E1979	CHICHWA	0.75	6.0
969	E1873	SIRAS	1.76	6.0	969	E1980	GULMOHAR	0.98	6.0
970	E1874	SIRAS	0.72	5.0	970	E1981	NILGIRI	1.32	7.0
971	E1877	GULMOHAR	0.56	6.0	971	E1984	NILGIRI	0.99	6.0
972	E1885	SIRAS	0.61	4.0	972	E1993	CHICHWA	0.48	4.0
973	E1886	SIRAS	0.61	6.0	973	E1994	SIRAS	1.10	6.0
974	E1887	SIRAS	0.68	6.0	974	E1995	SIRAS	0.96	6.0
975	E1888	SIRAS	0.53	6.0	975	E1996	SIRAS	0.90	5.0

SN	TREE NO.	SPECIES	GIRTH IN M.	HEIGHT IN M.	SN	TREE NO.	SPECIES	GIRTH IN M.	HEIGHT IN M.
LEFT SIDE					RIGHT SIDE				
976	E1889	SIRAS	0.54	6.0	976	E1997	CHICHWA	1.25	6.0
977	E1890	SIRAS	0.72	6.0	977	E2008	SIRAS	0.69	5.0
978	E1893	SIRAS	0.48	6.0	978	E2009	CHICHWA	0.99	6.0
979	E1894	SIRAS	0.43	6.0	979	E2010	SHISHAM	0.85	5.0
980	E1895	SIRAS	0.42	6.0	980	E2011	CHICHWA	1.03	6.0
981	E1896	SIRAS	0.68	6.0	981	E2012	GULMOHAR	0.87	6.0
982	E1897	SIRAS	0.54	4.0	982	E2013	SIRAS	1.04	6.0
983	E1898	SIRAS	0.38	6.0	983	E2014	CHICHWA	0.83	5.0
984	E1899	SIRAS	0.60	5.0	984	E2015	CHICHWA	1.26	6.0
985	E1900	SIRAS	0.90	5.0	985	E2020	CHICHWA	0.98	6.0
986	E1908	GULMOHAR	1.30	6.0	986	E2021	SIRAS	0.81	6.0
987	E1909	GULMOHAR	1.12	6.0	987	E2022	SIRAS	0.56	3.0
988	E1910	GULMOHAR	1.60	6.0	988	E2023	SIRAS	0.62	4.0
989	E1911	GULMOHAR	1.60	5.0	989	E2024	CHICHWA	0.87	6.0
990	E1912	GULMOHAR	1.23	5.0	990	E2028	SHISHAM	1.09	6.0
991	E1913	GULMOHAR	1.37	6.0	991	E2029	CHICHWA	0.75	6.0
992	E1914	GULMOHAR	0.81	6.0	992	E2030	CHICHWA	0.69	5.0
993	E1915	GULMOHAR	1.00	7.0	993	E2031	SIRAS	0.45	4.0
994	E1916	GULMOHAR	0.73	7.0	994	E2037	CHICHWA	0.80	5.0
995	E1917	GULMOHAR	1.87	5.0	995	E2038	CHICHWA	0.89	6.0
996	E1919	WAD	1.05	5.0	996	E2039	SIRAS	0.79	6.0
997	E1920	SIRAS	0.94	7.0	997	E2040	KARANJI	0.52	4.0
998	E1921	SAG	0.56	5.0	998	E2041	CHICHWA	0.68	4.0
999	E1922	NILGIRI	1.39	9.0	999	E2042	CHICHWA	0.78	6.0
1000	E1923	SIRAS	2.07	8.0	1000	E2052	CHICHWA	1.24	6.0
1001	E1924	SIRAS	2.06	9.0	1001	E2053	CHICHWA	0.93	5.0
1002	E1925	SIRAS	1.60	8.0	1002	E2054	SIRAS	1.04	5.0
1003	E1926	SIRAS	1.26	5.0	1003	E2055	CHICHWA	1.04	6.0
1004	E1927	SIRAS	1.47	7.0	1004	E2067	SHISHAM	1.3	6.0
1005	E1928	SIRAS	0.72	7.0	1005	E2068	KARANJI	1	6.0
1006	E1929	SIRAS	0.84	8.0	1006	E2069	CHICHWA	0.85	6.0
1007	E1930	SIRAS	0.96	7.0	1007	E2070	CHICHWA	0.95	6.0
1008	E1931	SIRAS	1.95	8.0	1008	E2071	CHICHWA	0.97	6.0
1009	E1932	SIRAS	0.87	4.0	1009	E2072	CHICHWA	1.22	6.0
1010	E1933	GULMOHAR	0.84	5.0	1010	E2073	SIRAS	1.42	6.0
1011	E1934	GULMOHAR	1.53	8.0	1011	E2074	CHICHWA	1.55	6.0
1012	E1935	SIRAS	1.67	8.0	1012	E2078	SUBABUL	0.63	6.0
1013	E1936	NEEM	0.92	5.0	1013	E2079	SIRAS	1.4	6.0
1014	E1937	SIRAS	1.01	5.0	1014	E2083	SIRAS	1.23	6.0
1015	E1938	GULMOHAR	1.66	8.0	1015	E2087	SIRAS	1.06	6.0
1016	E1939	GULMOHAR	1.00	7.0	1016	E2088	SIRAS	1.08	6.0
1017	E1940	GULMOHAR	0.52	6.0	1017	E2089	CHICHWA	1.12	7.0
1018	E1970	NEEM	1.56	7.0	1018	E2090	CHICHWA	0.88	6.0
1019	E1971	SHISHAM	1.24	6.0	1019	E2091	CHICHWA	0.38	5.0
1020	E1972	SHISHAM	0.43	4.0	1020	E2092	SIRAS	0.86	5.0
1021	E1973	NEEM	0.92	4.0	1021	E2093	SIRAS	0.96	6.0
1022	E1974	PALAS	0.73	5.0	1022	E2094	SIRAS	1.06	6.0
1023	E1975	SHISHAM	1.15	5.0	1023	E2095	SIRAS	0.7	5.0
1024	E1976	SAGWAN	0.68	5.0	1024	E2096	SIRAS	1.4	6.0

SN	TREE NO.	SPECIES	GIRTH IN M.	HEIGHT IN M.	SN	TREE NO.	SPECIES	GIRTH IN M.	HEIGHT IN M.
LEFT SIDE					RIGHT SIDE				
1025	E1982	SHISHAM	1.02	6.0	1025	E2106	PALAS	1.65	5.0
1026	E1983	SIRAS	1.22	6.0	1026	E2107	PALAS	0.7	5.0
1027	E1985	NEEM	0.76	5.0	1027	E2108	HIWAR	0.78	4.0
1028	E1986	SIRAS	0.73	6.0	1028	E2109	HIWAR	0.92	6.0
1029	E1987	SIRAS	0.56	4.0	1029	E2110	HIWAR	0.6	5.0
1030	E1988	NEEM	0.37	4.0	1030	E2111	SIRAS	1.47	7.0
1031	E1989	SHISHAM	0.90	5.0	1031	E2112	SIRAS	1.82	7.0
1032	E1990	SHISHAM	0.57	5.0	1032	E2113	HIWAR	0.6	5.0
1033	E1991	SIRAS	0.84	6.0	1033	E2114	SIRAS	1.52	6.0
1034	E1992	SIRAS	1.60	6.0	1034	E2115	SIRAS	1.23	6.0
1035	E1998	CHICHWA	1.00	5.0	1035	E2125	SIRAS	1.19	6.0
1036	E1999	CHICHWA	0.89	5.0	1036	E2126	SIRAS	0.9	5.0
1037	E2000	SHISHAM	0.86	4.0	1037	E2127	SHISHAM	0.97	5.0
1038	E2001	SHISHAM	0.86	4.0	1038	E2128	SHISHAM	0.8	5.0
1039	E2002	SHISHAM	1.22	6.0	1039	E2129	SHISHAM	0.73	3.0
1040	E2003	SIRAS	0.72	5.0	1040	E2131	SAGWAN	0.92	5.0
1041	E2004	HIWAR	0.83	5.0	1041	E2132	SIRAS	0.84	3.0
1042	E2005	SIRAS	0.80	5.0	1042	E2133	SAGWAN	0.47	5.0
1043	E2006	SIRAS	0.99	6.0	1043	E2134	SHISHAM	0.7	5.0
1044	E2007	SIRAS	1.13	6.0	1044	E2135	SHISHAM	0.87	5.0
1045	E2016	GULMOHAR	0.97	6.0	1045	E2136	HIWAR	0.38	3.0
1046	E2017	PALAS	0.61	3.0	1046	E2145	SIRAS	0.81	4.0
1047	E2018	GULMOHAR	1.16	6.0	1047	E2146	SIRAS	0.85	4.0
1048	E2019	CHICHWA	1.70	6.0	1048	E2147	SAGWAN	0.72	6.0
1049	E2025	CHICHWA	0.82	6.0	1049	E2148	SAGWAN	0.8	6.0
1050	E2026	SHISHAM	0.62	5.0	1050	E2149	HIWAR	0.81	3.0
1051	E2027	SHISHAM	1.08	6.0	1051	E2150	BABUL	0.56	4.0
1052	E2032	CHICHWA	0.78	6.0	1052	E2151	BABUL	0.7	4.0
1053	E2033	SHISHAM	0.82	5.0	1053	E2152	PALAS	0.52	4.0
1054	E2034	SHISHAM	0.90	5.0	1054	E2153	SIRAS	0.56	4.0
1055	E2035	CHICHWA	0.80	6.0	1055	E2154	SHISHAM	0.85	6.0
1056	E2036	KARANJI	0.73	5.0	1056	E2155	SAGWAN	0.33	6.0
1057	E2043	CHICHWA	0.72	5.0	1057	E2156	HIWAR	0.67	4.0
1058	E2044	SHISHAM	0.89	5.0	1058	E2157	SAGWAN	2	7.0
1059	E2045	SHISHAM	0.55	4.0	1059	E2158	KARANJI	0.8	5.0
1060	E2046	SHISHAM	0.58	4.0	1060	E2159	KARANJI	0.68	5.0
1061	E2047	KARANJI	0.62	6.0	1061	E2166	KARANJI	0.72	6.0
1062	E2048	SHISHAM	0.52	4.0	1062	E2169A	SIRAS	0.93	5.0
1063	E2049	HIWAR	0.80	5.0	1063	E2170	KARANJI	0.52	5.0
1064	E2050	SHISHAM	0.62	5.0	1064	E2171	KARANJI	0.84	5.0
1065	E2051	SHISHAM	0.48	5.0	1065	E2176	SHISHAM	0.8	6.0
1066	E2056	SHISHAM	0.39	4.0	1066	E2177	SIRAS	0.95	6.0
1067	E2057	CHICHWA	0.22	3.0	1067	E2188	CHICHWA	1.18	6.0
1068	E2058	KARANJI	0.92	5.0	1068	E2189	SIRAS	0.97	6.0
1069	E2059	SHISHAM	0.82	5.0	1069	E2190	NEEM	0.47	5.0
1070	E2060	CHICHWA	0.67	5.0	1070	E2191	KARANJI	0.92	6.0
1071	E2061	PALAS	0.78	5.0	1071	E2192	SIRAS	1.09	5.0
1072	E2062	HIWAR	0.54	4.0	1072	E2193	SIRAS	0.56	5.0
1073	E2063	BOR	0.43	3.0	1073	E2199	CHICHWA	1.4	6.0

SN	TREE NO.	SPECIES	GIRTH IN M.	HEIGHT IN M.	SN	TREE NO.	SPECIES	GIRTH IN M.	HEIGHT IN M.
LEFT SIDE					RIGHT SIDE				
1074	E2064	SHISHAM	0.52	4.0	1074	E2200	CHICHWA	1.13	6.0
1075	E2065	CHICHWA	0.34	3.0	1075	E2201	SIRAS	0.6	6.0
1076	E2066	CHICHWA	0.28	3.0	1076	E2202	SIRAS	1.14	6.0
1077	E2075	NEEM	1.28	6.0	1077	E2218	SHISHAM	1.73	6.0
1078	E2076	BABUL	0.98	3.0	1078	E2219	CHICHWA	0.87	6.0
1079	E2077	BABUL	1.12	4.0	1079	E2220	CHICHWA	0.92	5.0
1080	E2080	PALAS	0.87	5.0	1080	E2222	CHICHWA	1.24	5.0
1081	E2081	CHICHWA	0.78	6.0	1081	E2223	SIRAS	0.7	5.0
1082	E2082	CHICHWA	1.28	6.0	1082	E2233	SHISHAM	0.93	6.0
1083	E2084	CHICHWA	0.92	5.0	1083	E2247	SHISHAM	0.81	5.0
1084	E2085	HIWAR	1.18	5.0	1084	E2260	CHICHWA	1.15	6.0
1085	E2086	SONA	0.95	4.0	1085	E2261	CHICHWA	0.75	6.0
1086	E2097	CHICHWA	0.67	4.0	1086	E2262	KARANJI	1.18	6.0
1087	E2098	HIWAR	0.50	4.0	1087	E2263	GULMOHAR	1.40	7.0
1088	E2099	CHICHWA	0.58	4.0	1088	E2264	KARANJI	0.75	4.0
1089	E2100	HIWAR	0.54	3.0	1089	E2268	CHICHWA	0.68	5.0
1090	E2101	PALAS	1.02	4.0	1090	E2269	CHICHWA	0.75	4.0
1091	E2102	PALAS	0.60	4.0	1091	E2270	CHICHWA	0.67	6.0
1092	E2103	NEEM	0.89	5.0	1092	E2271	CHICHWA	1.02	6.0
1093	E2104	CHICHWA	1.42	6.0	1093	E2272	CHICHWA	0.59	6.0
1094	E2105	PALAS	1.25	5.0	1094	E2287	BABUL	1.31	7.0
1095	E2116	CHICHWA	0.88	4.0	1095	E2288	CHICHWA	0.71	5.0
1096	E2117	GULMOHAR	0.61	6.0	1096	E2289	CHICHWA	1.06	6.0
1097	E2118	NEEM	0.92	5.0	1097	E2290	CHICHWA	0.45	5.0
1098	E2119	GULMOHAR	0.97	6.0	1098	E2291	BABUL	1.22	7.0
1099	E2120	NEEM	0.90	6.0	1099	E2292	BABUL	1.38	7.0
1100	E2121	GULMOHAR	1.16	6.0	1100	E2293	CHICHBILAI	0.61	6.0
1101	E2122	PALAS	0.87	3.0	1101	E2294	SIRAS	0.50	5.0
1102	E2123	SHISHAM	0.52	5.0	1102	E2295	CHICHWA	0.48	5.0
1103	E2124	SHISHAM	0.46	4.0	1103	E2296	CHICHWA	0.58	6.0
1104	E2130	SIRAS	0.94	6.0	1104	E2297	BABUL	1.87	7.0
1105	E2137	SHISHAM	1.02	6.0	1105	E2310	CHICHWA	0.57	6.0
1106	E2138	SHISHAM	0.42	4.0	1106	E2311	CHICHWA	0.75	5.0
1107	E2139	SHISHAM	0.48	4.0	1107	E2312	CHICHWA	0.62	6.0
1108	E2140	SHISHAM	0.52	5.0	1108	E2317	CHICHWA	0.45	6.0
1109	E2141	SHISHAM	0.34	5.0	1109	E2321	CHICHWA	0.52	6.0
1110	E2142	SHISHAM	0.57	5.0	1110	E2323	CHICHWA	0.35	5.0
1111	E2143	SHISHAM	0.51	4.0	1111	E2324	CHICHWA	0.37	5.0
1112	E2144	SHISHAM	0.73	5.0	1112	E2328	CHICHWA	0.43	5.0
1113	E2160	SHISHAM	0.37	4.0	1113	E2329	CHICHWA	0.36	5.0
1114	E2161	SHISHAM	1.48	6.0	1114	E2330	CHICHWA	0.36	5.0
1115	E2162	SHISHAM	0.32	3.0	1115	E2331	CHICHWA	0.42	5.0
1116	E2163	HIWAR	0.97	4.0	1116	E2332	CHICHWA	0.49	5.0
1117	E2164	SHISHAM	0.78	5.0	1117	E2347	CHICHWA	0.32	4.0
1118	E2165	SHISHAM	0.69	5.0	1118	E2348	CHICHWA	0.54	5.0
1119	E2167	HIWAR	0.64	5.0	1119	E2349	CHICHWA	0.44	5.0
1120	E2168	CHICHWA	0.50	4.0	1120	E2350	CHICHWA	0.41	5.0
1121	E2169	HIWAR	0.52	4.0	1121	E2351	CHICHWA	0.62	6.0
1122	E2172	CHICHWA	0.53	4.0	1122	E2352	CHICHWA	0.55	5.0

SN	TREE NO.	SPECIES	GIRTH IN M.	HEIGHT IN M.	SN	TREE NO.	SPECIES	GIRTH IN M.	HEIGHT IN M.
LEFT SIDE					RIGHT SIDE				
1123	E2173	HIWAR	0.63	4.0	1123	E2353	CHICHWA	0.46	6.0
1124	E2174	HIWAR	0.47	4.0	1124	E2357	CHICHWA	0.98	6.0
1125	E2175	SHISHAM	0.52	3.0	1125	E2358	PALAS	1.29	6.0
1126	E2178	SHISHAM	0.54	5.0	1126	E2359	CHICHWA	0.72	6.0
1127	E2179	CHICHWA	1.39	6.0	1127	E2360	SIMAR	0.67	5.0
1128	E2180	SHISHAM	0.40	4.0	1128	E2408	SIMAR	0.58	3.0
1129	E2181	SHISHAM	0.35	4.0	1129	E2409	CHICHWA	1.50	5.0
1130	E2182	SHISHAM	0.69	5.0	1130	E2410	PALAS	0.90	5.0
1131	E2183	SHISHAM	0.71	5.0	1131	E2411	CHICHWA	1.05	6.0
1132	E2184	SHISHAM	0.49	5.0	1132	E2412	UMBER	0.68	4.0
1133	E2185	SHISHAM	0.65	6.0	1133	E2413	CHICHWA	1.03	6.0
1134	E2186	PALAS	0.56	3.0	1134	E2414	CHICHWA	1.28	6.0
1135	E2187	SHISHAM	0.72	6.0	1135	E2415	CHICHWA	0.97	5.0
1136	E2194	SHISHAM	0.81	6.0	1136	E2416	CHICHWA	0.97	5.0
1137	E2195	SHISHAM	0.45	6.0	1137	E2422	CHICHWA	1.05	5.0
1138	E2196	SHISHAM	0.68	6.0	1138	E2423	CHICHWA	1.03	6.0
1139	E2197	CHICHWA	0.38	5.0	1139	E2424	SHISHAM	0.76	5.0
1140	E2198	CHICHWA	0.92	5.0	1140	E2425	CHICHWA	0.70	6.0
1141	E2203	SHISHAM	0.60	5.0	1141	E2426	CHICHWA	0.86	5.0
1142	E2204	CHICHWA	0.58	4.0	1142	E2427	CHICHWA	1.12	5.0
1143	E2205	SHISHAM	0.57	6.0	1143	E2428	CHICHWA	0.99	5.0
1144	E2206	SHISHAM	0.47	5.0	1144	E2429	CHICHWA	0.67	5.0
1145	E2207	SHISHAM	0.63	6.0	1145	E2437	SIRAS	0.33	4.0
1146	E2208	SHISHAM	0.66	5.0	1146	E2438	CHICHWA	0.72	6.0
1147	E2209	SHISHAM	0.42	5.0	1147	E2439	SIRAS	0.48	4.0
1148	E2210	SHISHAM	0.56	5.0	1148	E2440	SAGWAN	0.80	6.0
1149	E2211	SHISHAM	0.60	6.0	1149	E2441	CHICHWA	0.60	5.0
1150	E2212	SHISHAM	0.62	5.0	1150	E2442	CHICHWA	1.07	6.0
1151	E2213	CHICHWA	1.28	6.0	1151	E2443	SIMAR	1.13	7.0
1152	E2214	SHISHAM	0.75	6.0	1152	E2444	SIMAR	1.68	7.0
1153	E2215	SHISHAM	0.63	6.0	1153	E2445	SIRAS	0.75	6.0
1154	E2216	HIWAR	0.88	5.0	1154	E2446	CHICHWA	0.60	6.0
1155	E2217	SHISHAM	0.69	6.0	1155	E2447	SIRAS	0.60	6.0
1156	E2221	SHISHAM	0.67	5.0	1156	E2448	CHICHWA	0.58	5.0
1157	E2224	SHISHAM	0.93	4.0	1157	E2449	NEEM	0.72	6.0
1158	E2225	SHISHAM	0.55	4.0	1158	E2450	SAGWAN	0.61	7.0
1159	E2226	SHISHAM	0.88	6.0	1159	E2451	SAGWAN	0.62	7.0
1160	E2227	KARANJI	2.10	7.0	1160	E2452	CHICHWA	0.69	6.0
1161	E2228	SIRAS	0.88	6.0	1161	E2452A	SAGWAN	0.56	7.0
1162	E2229	SIRAS	0.90	6.0	1162	E2453	SHISHAM	0.75	6.0
1163	E2230	KARANJI	1.10	6.0	1163	E2454	SHISHAM	0.85	6.0
1164	E2231	SIRAS	0.78	5.0	1164	E2455	CHICHWA	0.72	6.0
1165	E2232	CHICHWA	1.20	6.0	1165	E2456	NEEM	0.87	6.0
1166	E2234	CHICHWA	1.27	5.0	1166	E2457	MANGO	1.03	5.0
1167	E2235	KARANJI	0.67	5.0	1167	E2489	SIRAS	0.7	5.0
1168	E2237	KARANJI	0.58	4.0	1168	E2490	CHICHWA	0.65	5.0
1169	E2238	KARANJI	0.84	5.0	1169	E2491	CHICHWA	0.4	5.0
1170	E2239	CHICHWA	0.81	4.0	1170	E2510	PAM	1.2	5.0
1171	E2240	CHICHWA	0.52	5.0	1171	E2511	PAM	1.17	5.0

SN	TREE NO.	SPECIES	GIRTH IN M.	HEIGHT IN M.	SN	TREE NO.	SPECIES	GIRTH IN M.	HEIGHT IN M.
LEFT SIDE					RIGHT SIDE				
1172	E2241	KARANJI	0.47	5.0	1172	E2512	NEEM	1.04	7.0
1173	E2242	CHICHWA	0.45	4.0	1173	E2513	BABUL	0.7	7.0
1174	E2243	CHICHWA	0.62	4.0	1174	E2514	CHICHWA	1.72	6.0
1175	E2244	CHICHWA	0.66	4.0	1175	E2515	CHICHWA	0.6	6.0
1176	E2245	KARANJI	0.98	6.0	1176	E2516	CHICHWA	0.53	5.0
1177	E2246	CHICHWA	0.82	6.0	1177	E2517	CHICHWA	0.45	5.0
1178	E2248	KARANJI	0.91	5.0	1178	E2518	CHICHWA	1.58	6.0
1179	E2249	CHICHWA	0.62	4.0	1179	E2519	CHICHWA	0.84	6.0
1180	E2250	KARANJI	0.85	5.0	1180	E2520	CHICHWA	0.99	6.0
1181	E2251	KARANJI	0.93	5.0	1181	E2521	CHICHWA	1.65	6.0
1182	E2252	KARANJI	0.78	5.0	1182	E2522	BABUL	0.93	6.0
1183	E2253	SHISHAM	0.89	6.0	1183	E2523	BABUL	2.43	7.0
1184	E2254	CHICHWA	0.66	5.0	1184	E2540	SIRAS	1.22	6.0
1185	E2255	CHICHWA	0.66	4.0	1185	E2541	SIRAS	0.92	6.0
1186	E2256	KARANJI	0.94	4.0	1186	E2542	SIRAS	1.06	6.0
1187	E2257	CHICHWA	1.29	6.0	1187	E2543	SIRAS	1.75	7.0
1188	E2258	KARANJI	0.82	4.0	1188	E2544	BABUL	1.44	6.0
1189	E2259	KARANJI	1.30	5.0	1189	E2545	BABUL	1.62	6.0
1190	E2265	KARANJI	0.67	5.0	1190	E2546	PALAS	0.75	5.0
1191	E2266	KARANJI	0.70	5.0	1191	E2549	PALAS	1.2	6.0
1192	E2267	CHICHWA	1.92	6.0	1192	E2550	MANGO	1.82	7.0
1193	E2273	KARANJI	0.75	5.0	1193	E2551	PALAS	0.51	4.0
1194	E2274	KARANJI	1.24	5.0	1194	E2552	PALAS	0.45	4.0
1195	E2275	KARANJI	0.68	4.0	1195	E2557	PALAS	0.6	3.0
1196	E2276	KARANJI	1.20	5.0	1196	E2560	SIRAS	0.52	4.0
1197	E2277	KARANJI	0.74	5.0	1197	E2561	PALAS	1.02	6.0
1198	E2278	KARANJI	1.22	5.0	1198	E2562	PALAS	1.28	6.0
1199	E2279	CHICHWA	1.92	6.0	1199	E2565	PALAS	0.97	6.0
1200	E2280	KARANJI	0.96	4.0	1200	E2566	SIMAR	0.8	6.0
1201	E2281	KARANJI	0.82	4.0	1201	E2569	PALAS	1	6.0
1202	E2282	KARANJI	0.65	4.0	1202	E2571	BABUL	1.27	6.0
1203	E2283	KARANJI	0.62	4.0	1203	E2576	PALAS	0.85	4.0
1204	E2284	CHICHWA	1.92	6.0	1204	E2582	PALAS	0.4	5.0
1205	E2285	CHICHWA	1.25	6.0	1205	E2583	HIWAR	0.76	5.0
1206	E2286	CHICHWA	0.68	5.0	1206	E2584	HIWAR	0.65	5.0
1207	E2298	CHICHWA	1.28	6.0	1207	E2585	PALAS	1.12	6.0
1208	E2299	CHICHWA	2.65	6.0	1208	E2586	SHISHAM	1.25	6.0
1209	E2300	PALAS	0.94	6.0	1209	E2587	NEEM	0.8	4.0
1210	E2301	SIRAS	1.47	7.0	1210	E2589	BABUL	0.88	5.0
1211	E2302	CHICHWA	0.74	6.0	1211	E2590	BABUL	0.94	5.0
1212	E2303	KARANJI	0.65	5.0	1212	E2593	BABUL	1.24	6.0
1213	E2304	PALAS	2.68	7.0	1213	E2594	BABUL	0.97	5.0
1214	E2305	CHICHWA	0.92	6.0	1214	E2596	BABUL	1.25	5.0
1215	E2306	GULMOHAR	1.42	6.0	1215	E2599	BABUL	1.23	6.0
1216	E2307	GULMOHAR	1.48	6.0	1216	E2604	BABUL	1.07	5.0
1217	E2308	GULMOHAR	0.95	6.0	1217	E2605	BABUL	0.78	5.0
1218	E2309	CHICHWA	2.60	7.0	1218	E2607	BABUL	1.18	6.0
1219	E2313	CHICHWA	0.58	4.0	1219	E2608	BABUL	1.08	6.0
1220	E2314	CHICHWA	0.97	6.0	1220	E2609	BABUL	0.8	5.0

SN	TREE NO.	SPECIES	GIRTH IN M.	HEIGHT IN M.	SN	TREE NO.	SPECIES	GIRTH IN M.	HEIGHT IN M.
LEFT SIDE					RIGHT SIDE				
1221	E2315	CHICHWA	1.65	7.0	1221	E2612	BABUL	1.36	6.0
1222	E2316	CHICHWA	1.78	7.0	1222	E2613	SHISHAM	0.78	5.0
1223	E2318	KARANJI	0.55	5.0	1223	E2614	KARANJI	0.68	5.0
1224	E2319	CHICHWA	0.56	5.0	1224	E2623	PALAS	0.54	5.0
1225	E2320	CHICHWA	0.43	5.0	1225	E2624	SAGWAN	0.6	6.0
1226	E2322	CHICHWA	1.07	6.0	1226	E2628	SAGWAN	0.55	6.0
1227	E2325	HIWAR	0.49	5.0	1227	E2630	PALAS	1.29	6.0
1228	E2326	CHICHWA	2.48	7.0	1228	E2634	PALAS	1.19	6.0
1229	E2327	GULMOHAR	1.38	7.0	1229	E2635	PALAS	0.5	5.0
1230	E2333	UMBER	1.18	5.0	1230	E2636	PALAS	0.98	3.0
1231	E2334	CHICHWA	1.92	7.0	1231	E2637	PALAS	1.05	6.0
1232	E2335	BABUL	0.82	6.0	1232	E2638	PALAS	0.9	6.0
1233	E2336	CHICHWA	0.45	5.0	1233	E2639	SAGWAN	0.75	7.0
1234	E2337	BABUL	0.30	5.0	1234	E2640	KARANJI	0.87	5.0
1235	E2338	CHICHWA	0.33	5.0	1235	E2641	NEEM	0.95	5.0
1236	E2339	BABUL	0.39	5.0	1236	E2643	SIMAR	0.6	5.0
1237	E2340	HIWAR	0.33	5.0	1237	E2644	NEEM	0.48	4.0
1238	E2341	CHICHWA	0.53	5.0	1238	E2645	SAGWAN	0.67	7.0
1239	E2342	SIRAS	0.37	5.0	1239	E2646	PALAS	0.62	6.0
1240	E2343	CHICHWA	0.70	6.0	1240	E2649	BABUL	1.55	6.0
1241	E2344	CHICHWA	0.35	5.0	1241	E2650	NEEM	0.7	4.0
1242	E2345	CHICHWA	0.78	6.0	1242	E2651	PALAS	0.7	6.0
1243	E2346	CHICHWA	0.76	6.0	1243	E2652	PALAS	0.78	6.0
1244	E2354	GULMOHAR	0.84	6.0	1244	E2653	PALAS	0.38	4.0
1245	E2355	CHICHWA	1.08	6.0	1245	E2654	SAGWAN	0.32	4.0
1246	E2356	SIMAR	0.70	6.0	1246	E2663	PALAS	0.55	4.0
1247	E2361	CHICHWA	1.22	6.0	1247	E2664	SAGWAN	0.52	5.0
1248	E2362	CHICHWA	1.62	6.0	1248	E2665	HIWAR	0.54	3.0
1249	E2363	CHICHWA	1.38	6.0	1249	E2666	NEEM	0.37	6.0
1250	E2364	CHICHWA	0.95	6.0	1250	E2667	SAGWAN	0.70	6.0
1251	E2365	CHICHWA	1.20	6.0	1251	E2668	BABUL	0.87	5.0
1252	E2366	CHICHWA	1.11	6.0	1252	E2669	MAIRUNG	1.28	5.0
1253	E2367	CHICHWA	1.82	7.0	1253	E2671	NEEM	0.80	5.0
1254	E2368	CHICHWA	1.85	7.0	1254	E2672	NEEM	1.32	6.0
1255	E2369	CHICHWA	0.55	4.0	1255	E2673	PALAS	1.28	5.0
1256	E2370	CHICHWA	0.94	6.0	1256	E2674	HIWAR	0.72	4.0
1257	E2371	CHICHWA	1.17	6.0	1257	E2675	HIWAR	0.65	4.0
1258	E2372	CHICHWA	1.10	7.0	1258	E2676	VAD	1.48	5.0
1259	E2373	PALAS	1.06	6.0	1259	E2680	SHISHAM	2.18	6.0
1260	E2374	CHICHWA	1.90	7.0	1260	E2681	VAD	2.37	6.0
1261	E2375	BABUL	0.79	5.0	1261	E2682	PALAS	0.45	3.0
1262	E2376	BABUL	0.79	5.0	1262	E2686	MAIRUNG	0.32	3.0
1263	E2377	CHICHWA	1.65	7.0	1263	E2687	BABUL	0.94	5.0
1264	E2378	CHICHWA	1.30	7.0	1264	E2691	HIWAR	0.90	5.0
1265	E2379	CHICHWA	1.50	7.0	1265	E2692	HIWAR	1.22	6.0
1266	E2380	CHICHWA	0.90	6.0	1266	E2693	HIWAR	0.75	4.0
1267	E2381	GULMOHAR	1.07	6.0	1267	E2698	PALAS	1.48	5.0
1268	E2382	BABUL	1.68	6.0	1268	E2699	MAIRUNG	1.80	5.0
1269	E2383	SHISHAM	0.85	5.0	1269	E2701	BABUL	1.27	5.0

SN	TREE NO.	SPECIES	GIRTH IN M.	HEIGHT IN M.	SN	TREE NO.	SPECIES	GIRTH IN M.	HEIGHT IN M.
LEFT SIDE					RIGHT SIDE				
1270	E2384	SHISHAM	0.68	5.0	1270	E2702	SHISHAM	0.42	3.0
1271	E2385	KARANJI	0.86	5.0	1271	E2703	HIWAR	1.00	5.0
1272	E2386	PALAS	0.94	6.0	1272	E2704	NEEM	0.86	5.0
1273	E2387	SIMAR	1.43	7.0	1273	E2705	BABUL	1.23	6.0
1274	E2388	SIMAR	0.87	6.0	1274	E2713	SIRAS	1.04	6.0
1275	E2389	KARANJI	0.76	5.0	1275	E2716	HIWAR	0.65	4.0
1276	E2390	KARANJI	0.50	5.0	1276	E2717	HIWAR	0.72	4.0
1277	E2391	KARANJI	1.16	5.0	1277	E2718	HIWAR	0.62	3.0
1278	E2392	KARANJI	0.92	6.0	1278	E2719	BABUL	1.40	6.0
1279	E2393	SIRAS	1.24	6.0	1279	E2720	BABUL	1.51	6.0
1280	E2394	SIRAS	0.88	6.0	1280	E2721	SIRAS	0.97	6.0
1281	E2395	SIRAS	1.32	7.0	1281	E2726	PALAS	0.52	3.0
1282	E2396	CHICHWA	0.80	5.0	1282	E2727	GULMOHAR	0.97	5.0
1283	E2397	CHICHWA	1.19	7.0	1283	E2730	PALAS	0.91	5.0
1284	E2398	SHISHAM	1.48	6.0	1284	E2731	GULMOHAR	0.43	3.0
1285	E2399	SHISHAM	1.06	7.0	1285	E2732	PALAS	0.78	4.0
1286	E2400	BABUL	0.83	6.0	1286	E2733	HIWAR	0.63	4.0
1287	E2401	BABUL	0.83	6.0	1287	E2734	HIWAR	0.71	4.0
1288	E2402	SHISHAM	0.91	6.0	1288	E2735	SAGWAN	1.26	6.0
1289	E2403	CHICHWA	0.94	6.0	1289	E2738	HIWAR	0.48	3.0
1290	E2404	CHICHWA	0.87	6.0	1290	E2745	PALAS	0.41	3.0
1291	E2405	HIWAR	0.84	5.0	1291	E2746	HIWAR	0.83	4.0
1292	E2406	BABUL	1.22	6.0	1292	E2747	NEEM	1.15	6.0
1293	E2407	KARANJI	1.56	6.0	1293	E2753	HIWAR	1.19	5.0
1294	E2417	SIMAR	0.58	6.0	1294	E2754	KARANJI	0.88	5.0
1295	E2418	CHICHWA	0.46	5.0	1295	E2755	NEEM	1.03	4.0
1296	E2419	SIMAR	0.40	5.0	1296	E2756	HIWAR	0.60	4.0
1297	E2420	SIMAR	0.42	5.0	1297	E2757	CHICHWA	0.62	4.0
1298	E2421	CHICHWA	0.81	5.0	1298	E2758	SIRAS	0.89	4.0
1299	E2430	CHICHWA	0.99	5.0	1299	E2759	HIWAR	0.72	4.0
1300	E2431	CHICHWA	0.49	5.0	1300	E2760	NEEM	0.72	5.0
1301	E2432	CHICHWA	0.58	4.0	1301	E2762	HIWAR	0.67	5.0
1302	E2433	CHICHWA	0.99	5.0	1302	E2763	SIMAR	1.05	6.0
1303	E2434	CHICHWA	0.51	4.0	1303	E2764	BABUL	1.18	6.0
1304	E2435	CHICHWA	0.50	4.0	1304	E2765	SIMAR	0.71	5.0
1305	E2436	CHICHWA	0.62	5.0	1305	E2766	SIMAR	0.42	5.0
1306	E2458	CHICHWA	0.65	5.0	1306	E2767	BABUL	1.17	6.0
1307	E2459	CHICHWA	0.54	6.0	1307	E2768	SIMAR	1.17	6.0
1308	E2460	CHICHWA	1.20	6.0	1308	E2773	JAMUN	1.02	6.0
1309	E2461	CHICHWA	1.98	6.0	1309	E2774	JAMUN	1.07	6.0
1310	E2462	SUBABUL	0.90	6.0	1310	E2775	JAMUN	0.95	6.0
1311	E2463	SHISHAM	0.78	5.0	1311	E2779	JAMUN	1.20	5.0
1312	E2464	CHICHWA	1.04	6.0	1312	E2780	JAMUN	0.95	5.0
1313	E2465	CHICHWA	0.83	6.0	1313	E2781	JAMUN	0.87	6.0
1314	E2466	CHICHWA	1.18	6.0	1314	E2782	JAMUN	0.58	4.0
1315	E2467	CHICHWA	0.90	5.0	1315	E2783	NEEM	0.59	5.0
1316	E2468	CHICHWA	1.04	6.0	1316	E2784	JAMUN	0.70	5.0
1317	E2469	SHISHAM	1.10	6.0	1317	E2785	JAMUN	1.12	6.0
1318	E2470	CHICHWA	1.30	6.0	1318	E2786	NEEM	0.94	3.0

SN	TREE NO.	SPECIES	GIRTH IN M.	HEIGHT IN M.	SN	TREE NO.	SPECIES	GIRTH IN M.	HEIGHT IN M.
LEFT SIDE					RIGHT SIDE				
1319	E2471	SIRAS	0.69	5.0	1319	E2787	JAMUN	1.20	5.0
1320	E2472	CHICHWA	0.75	6.0	1320	E2790	JAMUN	1.20	5.0
1321	E2473	CHICHWA	1.18	6.0	1321	E2791	JAMUN	1.17	5.0
1322	E2474	SIRAS	0.60	5.0	1322	E2792	JAMUN	1.10	6.0
1323	E2475	SIRAS	0.49	5.0	1323	E2794	JAMUN	1.07	6.0
1324	E2476	CHICHWA	1.32	5.0	1324	E2795	JAMUN	1.13	5.0
1325	E2477	CHICHWA	1.08	5.0	1325	E2797	JAMUN	1.34	5.0
1326	E2478	CHICHWA	0.80	6.0	1326	E2798	JAMUN	0.90	5.0
1327	E2479	CHICHWA	0.68	6.0	1327	E2799	JAMUN	0.98	4.0
1328	E2480	KARANJI	0.94	6.0	1328	E2805	JAMUN	1.60	6.0
1329	E2481	CHICHWA	1.04	6.0	1329	E2806	JAMUN	0.90	5.0
1330	E2482	CHICHWA	1.36	6.0	1330	E2807	JAMUN	0.97	5.0
1331	E2483	CHICHWA	0.95	5.0	1331	E2808	JAMUN	1.03	6.0
1332	E2484	CHICHWA	0.60	4.0	1332	E2809	JAMUN	2.17	6.0
1333	E2485	CHICHWA	1.08	6.0	1333	E2810	JAMUN	0.42	3.0
1334	E2486	SIRAS	1.80	6.0	1334	E2811	JAMUN	1.52	6.0
1335	E2487	SIRAS	0.65	5.0	1335	E2816	JAMUN	1.7	6.0
1336	E2488	KARANJI	1.60	7.0	1336	E2817	JAMUN	0.82	5.0
1337	E2492	SIMAR	0.68	5.0	1337	E2818	JAMUN	1.4	5.0
1338	E2493	PALAS	0.90	6.0	1338	E2819	JAMUN	0.94	5.0
1339	E2494	CHICHWA	0.75	4.0	1339	E2822	PALAS	0.97	4.0
1340	E2495	CHICHWA	0.41	5.0	1340	E2823	PALAS	0.61	3.0
1341	E2496	CHICHWA	0.84	5.0	1341	E2824	SHISHAM	1.95	6.0
1342	E2497	CHICHWA	0.37	5.0	1342	E2831	MAIRUNG	1.4	6.0
1343	E2498	CHICHWA	0.63	5.0	1343	E2833	MAIRUNG	1.15	6.0
1344	E2499	CHICHWA	0.39	5.0	1344	E2835	NEEM	0.96	4.0
1345	E2500	CHICHWA	0.46	5.0	1345	E2835A	GULMOHAR	0.38	3.0
1346	E2501	CHICHWA	0.60	5.0	1346	E2838	BABUL	0.67	5.0
1347	E2502	CHICHWA	1.40	6.0	1347	E2844	SIRAS	0.67	3.0
1348	E2503	CHICHWA	0.82	5.0	1348	E2845	CHICHWA	0.94	5.0
1349	E2504	CHICHWA	1.12	6.0	1349	E2846	NEEM	1.14	5.0
1350	E2505	CHICHWA	1.80	7.0	1350	E2847	CHICHWA	1.22	6.0
1351	E2506	BABUL	2.90	7.0	1351	E2852	GULMOHAR	1.8	7.0
1352	E2507	CHICHWA	1.70	7.0	1352	E2853	CHICHWA	0.83	6.0
1353	E2508	CHICHWA	1.18	6.0	1353	E2854	CHICHWA	1.34	6.0
1354	E2509	GULMOHAR	1.43	5.0	1354	E2855	SHISHAM	1.02	5.0
1355	E2524	MANGO	3.70	8.0	1355	E2856	SHISHAM	1.4	6.0
1356	E2525	NEEM	1.02	6.0	1356	E2857	NEEM	1.12	4.0
1357	E2526	SHISHAM	1.32	6.0	1357	E2858	BABUL	1.35	6.0
1358	E2527	CHICHWA	1.80	7.0	1358	E2859	CHICHWA	1.35	6.0
1359	E2528	BABUL	1.56	6.0	1359	E2860	SIMAR	0.54	4.0
1360	E2529	SIRAS	0.60	5.0	1360	E2861	CHICHWA	1.25	6.0
1361	E2530	SIRAS	2.18	7.0	1361	E2867	SIMAR	0.72	5.0
1362	E2531	BABUL	1.08	6.0	1362	E2870	CHICHWA	1.4	6.0
1363	E2532	CHICHWA	1.15	6.0	1363	E2871	HIWAR	0.52	4.0
1364	E2533	CHICHWA	1.50	6.0	1364	E2876	NEEM	0.93	5.0
1365	E2534	CHICHWA	1.28	6.0	1365	E2877	CHICHWA	0.95	5.0
1366	E2535	CHICHWA	1.64	6.0	1366	E2878	CHICHWA	1.05	4.0
1367	E2536	GULMOHAR	0.99	6.0	1367	E2879	NEEM	0.83	5.0

SN	TREE NO.	SPECIES	GIRTH IN M.	HEIGHT IN M.	SN	TREE NO.	SPECIES	GIRTH IN M.	HEIGHT IN M.
LEFT SIDE					RIGHT SIDE				
1368	E2537	SIRAS	1.70	7.0	1368	E2888	MAIRUNG	1.37	5.0
1369	E2538	BABUL	0.60	4.0	1369	E2889	NEEM	1.21	5.0
1370	E2539	BABUL	1.04	6.0	1370	E2892	PALAS	0.93	4.0
1371	E2547	MAIRUNG	1.27	6.0	1371	E2893	BOR	0.78	4.0
1372	E2548	CHICHBILAI	3.17	7.0	1372	E2913	BABUL	1.05	4.0
1373	E2553	BABUL	1.26	6.0	1373	E2914	BOR	0.38	3.0
1374	E2554	SIMAR	0.75	6.0	1374	E2915	CHICHBILAI	1.38	5.0
1375	E2555	UMBER	1.44	5.0	1375	E2920	BABUL	0.59	5.0
1376	E2556	SIMAR	1.05	6.0	1376	E2921	CHICHBILAI	0.99	4.0
1377	E2558	SIMAR	1.28	6.0	1377	E2922	CHICHWA	0.52	3.0
1378	E2559	SIMAR	0.54	6.0	1378	E2927	CHICHBILAI	0.52	4.0
1379	E2563	SIMAR	0.61	6.0	1379	E2928	NEEM	1.08	5.0
1380	E2564	BABUL	1.45	6.0	1380	E2929	BABUL	1.02	5.0
1381	E2567	PALAS	0.53	4.0	1381	E2933	BABUL	1.33	6.0
1382	E2568	BABUL	1.61	6.0	1382	E2939	BOR	1.55	5.0
1383	E2570	BABUL	1.54	6.0	1383	E2940	NEEM	1.12	5.0
1384	E2572	BABUL	1.36	6.0	1384	E2942	GULMOHAR	0.97	5.0
1385	E2573	SHISHAM	1.34	6.0	1385	E2943	GULMOHAR	2.24	6.0
1386	E2574	BABUL	1.26	6.0	1386	E2944	GULMOHAR	2.2	6.0
1387	E2575	SIMAR	1.40	7.0	1387	E2946	BABUL	1.13	5.0
1388	E2577	KARANJI	1.05	6.0	1388	E2947	GULMOHAR	0.96	5.0
1389	E2578	KARANJI	0.98	5.0	1389	E2948	GULMOHAR	0.95	5.0
1390	E2579	KARANJI	1.48	5.0	1390	E2949	GULMOHAR	1.42	6.0
1391	E2580	KARANJI	1.12	6.0	1391	E2950	GULMOHAR	1.68	6.0
1392	E2580A	KARANJI	1.00	5.0	1392	E2951	BABUL	1.34	5.0
1393	E2581	BABUL	0.91	5.0	1393	E2954	GULMOHAR	2.25	4.0
1394	E2588	VAD	5.20	6.0	1394	E2955	GULMOHAR	1.34	5.0
1395	E2591	BABUL	0.98	5.0	1395	E2956	BABUL	0.63	5.0
1396	E2592	NEEM	0.97	5.0	1396	E2957	GULMOHAR	1.44	6.0
1397	E2595	BABUL	1.13	5.0	1397	E2958	GULMOHAR	1.74	6.0
1398	E2597	PALAS	0.42	3.0	1398	E2959	GULMOHAR	0.9	5.0
1399	E2598	BABUL	1.05	6.0	1399	E2964	CHICHBILAI	1.82	6.0
1400	E2600	BABUL	0.56	4.0	1400	E2965	GULMOHAR	2.14	6.0
1401	E2601	NEEM	0.54	4.0	1401	E2966	AAJAN	0.91	3.0
1402	E2602	SAGWAN	0.71	4.0	1402	E2967	GULMOHAR	1.02	5.0
1403	E2603	KARANJI	1.12	6.0	1403	E2968	GULMOHAR	1.15	7.0
1404	E2606	BABUL	1.13	5.0	1404	E2971	GULMOHAR	1.68	6.0
1405	E2610	KARANJI	0.97	6.0	1405	E2972	CHICHBILAI	1	6.0
1406	E2611	BABUL	0.80	4.0	1406	E2973	CHICHBILAI	1.43	6.0
1407	E2615	SAGWAN	0.38	4.0	1407	E2974	GULMOHAR	1.71	7.0
1408	E2616	KARANJI	1.18	6.0	1408	E2983	GULMOHAR	0.83	5.0
1409	E2617	BABUL	1.18	5.0	1409	E2984	GULMOHAR	0.95	6.0
1410	E2618	KARANJI	0.89	4.0	1410	E2985	GULMOHAR	1.26	6.0
1411	E2619	CHICHWA	0.83	6.0	1411	E2986	GULMOHAR	1	5.0
1412	E2620	BABUL	1.14	6.0	1412	E2987	GULMOHAR	0.97	4.0
1413	E2621	CHICHWA	0.88	6.0	1413	E2988	CHICHBILAI	1.29	6.0
1414	E2622	BABUL	1.33	6.0	1414	E2989	GULMOHAR	1.14	6.0
1415	E2625	BABUL	1.20	6.0	1415	E2990	GULMOHAR	1.62	7.0
1416	E2626	BABUL	1.41	6.0	1416	E2991	GULMOHAR	1.04	6.0

SN	TREE NO.	SPECIES	GIRTH IN M.	HEIGHT IN M.	SN	TREE NO.	SPECIES	GIRTH IN M.	HEIGHT IN M.
LEFT SIDE					RIGHT SIDE				
1417	E2627	BABUL	1.83	6.0	1417	E2992	GULMOHAR	0.63	4.0
1418	E2629	PALAS	0.96	5.0	1418	E2993	GULMOHAR	1.32	5.0
1419	E2631	BABUL	1.03	6.0	1419	E2994	GULMOHAR	1.60	6.0
1420	E2632	GULMOHAR	0.99	5.0	1420	E2995	GULMOHAR	0.91	5.0
1421	E2633	BABUL	1.74	6.0	1421	E2996	CHICHBILAI	0.98	4.0
1422	E2642	NEEM	0.42	4.0	1422	E2997	GULMOHAR	2.36	6.0
1423	E2647	SAGWAN	0.65	6.0	1423	E2998	GULMOHAR	1.34	6.0
1424	E2648	SAGWAN	0.44	5.0	1424	E3001	CHICHBILAI	1.30	5.0
1425	E2655	NEEM	0.72	6.0	1425	E3002	GULMOHAR	0.92	6.0
1426	E2656	PALAS	0.67	5.0	1426	E3003	GULMOHAR	2.60	6.0
1427	E2657	SAGWAN	0.69	6.0	1427	E3004	CHICHBILAI	1.33	5.0
1428	E2658	SAGWAN	0.54	6.0	1428	E3005	GULMOHAR	1.38	5.0
1429	E2659	SAGWAN	0.47	6.0	1429	E3006	KARANJI	0.87	5.0
1430	E2660	BOR	0.52	4.0	1430	E3019	GULMOHAR	0.79	5.0
1431	E2661	SAGWAN	1.38	6.0	1431	E3020	CHICHBILAI	1.08	5.0
1432	E2662	MAIRUNG	1.12	7.0	1432	E3021	CHICHBILAI	0.93	4.0
1433	E2670	AAJAN	1.22	6.0	1433	E3022	BABUL	1.50	5.0
1434	E2677	MAIRUNG	1.25	6.0	1434	E3023	GULMOHAR	0.94	5.0
1435	E2678	BABUL	0.90	4.5	1435	E3051	CHAFA	0.70	2.5
1436	E2679	VAD	1.18	5.0	1436	E3052	CHICHBILAI	0.62	4.0
1437	E2683	BABUL	0.85	6.0	1437	E3053	CHAFA	0.40	3.0
1438	E2684	HIWAR	1.00	6.0	1438	E3054	SIMAR	1.08	5.0
1439	E2685	HIWAR	0.97	5.0	1439	E3055	CHICHWA	0.59	5.0
1440	E2688	HIWAR	0.74	4.0	1440	E3056	CHICHWA	0.82	6.0
1441	E2689	BABUL	1.28	6.0	1441	E3057	CHICHWA	0.70	4.0
1442	E2690	HIWAR	0.74	4.0	1442	E3058	CHICHWA	0.65	4.0
1443	E2694	HIWAR	0.84	4.0	1443	E3059	CHAFA	0.83	4.0
1444	E2695	HIWAR	0.75	4.0	1444	E3064	GULMOHAR	1.16	6.0
1445	E2696	NEEM	0.42	3.0	1445	E3065	CHICHWA	1.03	4.0
1446	E2697	HIWAR	0.52	3.0	1446	E3073	CHICHWA	1.12	5.0
1447	E2700	PALAS	1.26	6.0	1447	E3074	KARANJI	0.98	4.0
1448	E2706	MAIRUNG	2.20	6.0	1448	E3075	KARANJI	1.27	6.0
1449	E2707	BABUL	0.75	4.0	1449	E3076	CHICHWA	1.36	5.0
1450	E2708	HIWAR	0.79	4.0	1450	E3077	CHICHWA	1.12	5.0
1451	E2709	HIWAR	0.68	4.0	1451	E3078	GULMOHAR	1.28	5.0
1452	E2710	PALAS	0.40	4.0	1452	E3079	GULMOHAR	0.97	6.0
1453	E2711	PALAS	0.37	3.0	1453	E3081	BABUL	0.76	4.0
1454	E2712	HIWAR	0.78	4.0	1454	E3082	NEEM	0.97	3.0
1455	E2714	BABUL	0.45	3.0	1455	E3083	SHISHAM	0.89	4.0
1456	E2715	BABUL	1.34	5.0	1456	E3084	SHISHAM	0.72	3.0
1457	E2722	PALAS	1.28	4.0	1457	E3085	SHISHAM	0.49	4.0
1458	E2723	HIWAR	1.42	4.0	1458	E3086	SHISHAM	1.00	5.0
1459	E2724	PALAS	0.73	4.0	1459	E3087	CHICHWA	0.76	3.0
1460	E2725	SAGWAN	0.54	4.0	1460	E3088	CHICHWA	0.82	4.0
1461	E2728	HIWAR	0.67	4.0	1461	E3089	SHISHAM	0.38	4.0
1462	E2729	BABUL	1.50	6.0	1462	E3090	SHISHAM	0.60	3.0
1463	E2736	BABUL	1.56	5.5	1463	E3091	SHISHAM	0.78	5.0
1464	E2737	BABUL	1.52	5.0	1464	E3092	SHISHAM	0.60	5.0
1465	E2739	BABUL	0.98	4.0	1465	E3094	NEEM	0.63	5.0

SN	TREE NO.	SPECIES	GIRTH IN M.	HEIGHT IN M.	SN	TREE NO.	SPECIES	GIRTH IN M.	HEIGHT IN M.
LEFT SIDE					RIGHT SIDE				
1466	E2740	BABUL	1.10	5.0	1466	E3095	BOTTEL GREEN	0.74	6.0
1467	E2741	PALAS	1.76	6.0	1467	E3096	ASHOKA	0.39	5.0
1468	E2742	PALAS	1.64	5.0	1468	E3097	PAM	1.18	5.0
1469	E2743	PALAS	1.71	6.0	1469	E3098	BOTTEL GREEN	0.90	7.0
1470	E2744	PIPAL	0.72	5.0	1470	E3102	CHICHWA	0.75	4.0
1471	E2748	HIWAR	0.82	4.0	1471	E3103	CHICHBILAI	0.97	3.0
1472	E2749	PALAS	0.54	4.0	1472	E3104	CHICHWA	0.84	5.0
1473	E2750	PALAS	0.74	4.0	1473	E3106	SIRAS	1.67	6.0
1474	E2751	HIWAR	0.75	4.0	1474	E3107	BABUL	1.00	5.0
1475	E2752	PALAS	0.52	3.0	1475	E3108	CHICHWA	0.74	6.0
1476	E2761	KARANJI	0.87	3.0	1476	E3109	SIRAS	0.84	6.0
1477	E2769	NEEM	0.72	4.0	1477	E3110	CHICHWA	1.84	6.0
1478	E2770	BARGAT	4.27	6.0	1478	E3111	CHICHWA	1.11	5.0
1479	E2771	JAMUN	1.25	6.0	1479	E3115	CHICHWA	0.59	3.0
1480	E2772	JAMUN	1.03	6.0	1480	E3117	CHICHWA	0.98	5.0
1481	E2776	JAMUN	0.73	5.0	1481	E3118	CHICHWA	0.88	4.0
1482	E2777	JAMUN	1.20	5.0	1482	E3119	CHICHWA	0.45	4.0
1483	E2778	BOR	0.65	6.0	1483	E3120	CHICHWA	0.62	4.0
1484	E2788	JAMUN	1.18	6.0	1484	E3121	CHICHWA	1.62	5.0
1485	E2789	BABUL	1.08	6.0	1485	E3122	CHICHWA	0.60	4.0
1486	E2793	JAMUN	1.17	5.0	1486	E3131	CHICHWA	0.85	4.0
1487	E2796	JAMUN	1.17	5.0	1487	E3131A	CHICHWA	0.78	5.0
1488	E2800	JAMUN	1.37	6.0	1488	E3132	CHICHWA	0.68	5.0
1489	E2801	JAMUN	1.27	6.0	1489	E3133	BABUL	1.06	5.0
1490	E2802	BABUL	1.45	5.0	1490	E3137	CHICHWA	1.14	5.0
1491	E2803	JAMUN	1.13	5.0	1491	E3138	CHICHWA	1.00	4.0
1492	E2804	BOR	0.99	4.0	1492	E3140	BABUL	1.20	6.0
1493	E2812	JAMUN	1.36	5.0	1493	E3141	BABUL	0.95	5.0
1494	E2813	JAMUN	1.38	6.0	1494	E3142	CHICHWA	0.85	6.0
1495	E2814	SAGWAN	0.59	4.0	1495	E3143	CHICHWA	0.72	5.0
1496	E2815	JAMUN	1.00	5.0	1496	E3144	SUBABUL	0.9	7.0
1497	E2820	JAMUN	1.40	6.0	1497	E3145	CHICHWA	1.36	5.0
1498	E2821	GULMOHAR	1.02	4.0	1498	E3148	NEEM	0.65	5.0
1499	E2825	JAMUN	1.06	5.0	1499	E3152	BOR	0.42	3.0
1500	E2826	JAMUN	1.87	5.0	1500	E3155	CHICHWA	0.87	5.0
1501	E2827	BABUL	1.40	6.0	1501	E3157	CHICHWA	0.92	5.0
1502	E2828	HIWAR	0.90	6.0	1502	E3158	CHICHWA	1.06	4.0
1503	E2829	BABUL	0.78	4.0	1503	E3159	CHICHWA	0.89	5.0
1504	E2830	CHICHWA	1.05	5.0	1504	E3160	CHICHWA	0.72	5.0
1505	E2832	GULMOHAR	1.05	6.0	1505	E3163	BASS	2.92	7.0
1506	E2834	JAMUN	1.30	5.0	1506	E3164	CHICHWA	0.83	5.0
1507	E2836	SHISHAM	0.72	5.0	1507	E3169	BABUL	1.1	4.0
1508	E2837	MAIRUNG	1.62	6.0	1508	E3170	CHICHWA	0.54	4.0
1509	E2839	MAIRUNG	1.10	6.0	1509	E3171	CHICHWA	0.5	3.0
1510	E2840	MAIRUNG	1.60	6.0	1510	E3172	CHICHWA	0.38	3.0
1511	E2841	VAD	1.40	4.0	1511	E3173	BABUL	1.22	6.0
1512	E2842	MAIRUNG	1.47	4.0	1512	E3174	GULMOHAR	1.03	6.0
1513	E2843	NEEM	0.85	5.0	1513	E3175	GULMOHAR	0.92	5.0
1514	E2848	MAIRUNG	1.30	7.0	1514	E3176	GULMOHAR	0.58	6.0

SN	TREE NO.	SPECIES	GIRTH IN M.	HEIGHT IN M.	SN	TREE NO.	SPECIES	GIRTH IN M.	HEIGHT IN M.
LEFT SIDE					RIGHT SIDE				
1515	E2849	NEEM	0.92	4.0	1515	E3177	GULMOHAR	0.95	6.0
1516	E2850	NEEM	0.67	4.0	1516	E3178	CHICHWA	0.87	4.0
1517	E2851	KARANJI	0.90	5.0	1517	E3179	CHICHWA	1.02	5.0
1518	E2862	JUNGLI	0.65	4.0	1518	E3182	SIRAS	1.1	5.0
1519	E2863	CHICHWA	0.85	5.0	1519	E3183	SIRAS	0.65	3.0
1520	E2864	CHICHWA	0.83	5.0	1520	E3184	SIRAS	0.89	4.0
1521	E2865	CHICHWA	0.81	4.0	1521	E3185	NEEM	0.78	4.0
1522	E2866	CHICHWA	0.98	4.0	1522	E3186	BOR	0.55	4.0
1523	E2868	HIWAR	1.00	5.0	1523	E3187	GULMOHAR	0.81	5.0
1524	E2869	SAGWAN	1.02	5.0	1524	E3188	GULMOHAR	0.68	5.0
1525	E2872	CHICHWA	1.18	4.0	1525	E3189	GULMOHAR	0.65	4.0
1526	E2873	CHICHWA	0.73	4.0	1526	E3190	GULMOHAR	0.62	4.0
1527	E2874	KARANJI	0.70	3.0	1527	E3194	CHICHWA	0.97	5.0
1528	E2875	NEEM	1.00	4.0	1528	E3195	CHICHWA	1.02	6.0
1529	E2880	NEEM	1.04	5.0	1529	E3196	CHICHWA	1.36	6.0
1530	E2881	NEEM	1.21	4.0	1530	E3197	CHICHWA	1.28	5.0
1531	E2882	KARANJI	0.87	5.0	1531	E3198	CHICHWA	1.4	6.0
1532	E2883	KARANJI	0.90	5.0	1532	E3199	KARANJI	0.9	5.0
1533	E2884	KARANJI	1.24	6.0	1533	E3200	KARANJI	0.67	5.0
1534	E2885	KARANJI	1.14	5.0	1534	E3201	GULMOHAR	1.11	6.0
1535	E2887	BABUL	1.30	4.0	1535	E3202	GULMOHAR	0.8	5.0
1536	E2890	GULMOHAR	1.16	6.0	1536	E3203	GULMOHAR	1.02	6.0
1537	E2891	GULMOHAR	0.97	6.0	1537	E3204	CHICHWA	0.6	5.0
1538	E2894	SHISHAM	0.64	5.0	1538	E3205	CHICHWA	0.72	5.0
1539	E2895	SHISHAM	0.59	4.0	1539	E3206	SIRAS	0.73	5.0
1540	E2896	SHISHAM	0.52	5.0	1540	E3208	SIRAS	0.7	5.0
1541	E2897	CHICHWA	0.77	6.0	1541	E3210	SIRAS	0.59	5.0
1542	E2898	CHICHWA	0.48	5.0	1542	E3211	CHICHWA	0.98	6.0
1543	E2899	KARANJI	0.68	4.0	1543	E3212	CHICHWA	1	5.0
1544	E2900	CHICHWA	0.54	5.0	1544	E3213	CHICHWA	1.2	6.0
1545	E2901	NEEM	0.65	5.0	1545	E3214	CHICHWA	0.78	6.0
1546	E2902	GULMOHAR	1.16	6.0	1546	E3215	CHICHWA	0.9	6.0
1547	E2903	GULMOHAR	0.74	6.0	1547	E3216	CHICHWA	1.1	5.0
1548	E2904	GULMOHAR	1.05	6.0	1548	E3217	CHICHWA	1.02	5.0
1549	E2905	GULMOHAR	0.95	6.0	1549	E3218	CHICHWA	1.27	6.0
1550	E2906	GULMOHAR	0.52	4.0	1550	E3219	MANGO	3.3	7.0
1551	E2907	CHICHWA	0.50	4.0	1551	E3221	CHICHWA	1.02	6.0
1552	E2908	GULMOHAR	0.89	6.0	1552	E3222	BABUL	1	5.0
1553	E2909	GULMOHAR	0.56	5.0	1553	E3223	CHICHWA	1.22	6.0
1554	E2910	GULMOHAR	0.85	7.0	1554	E3224	BABUL	1.08	5.0
1555	E2911	GULMOHAR	0.95	6.0	1555	E3225	GULMOHAR	0.88	5.0
1556	E2912	GULMOHAR	1.20	7.0	1556	E3227	GULMOHAR	1.12	6.0
1557	E2916	GULMOHAR	0.92	5.0	1557	E3228	CHICHWA	0.98	6.0
1558	E2917	GULMOHAR	0.82	6.0	1558	E3229	CHICHWA	1	6.0
1559	E2918	GULMOHAR	0.98	3.0	1559	E3230	NEEM	0.72	5.0
1560	E2919	GULMOHAR	1.05	7.0	1560	E3231	CHICHWA	1.08	6.0
1561	E2923	SIMAR	0.70	6.0	1561	E3232	CHICHWA	0.52	4.0
1562	E2924	BABUL	1.19	5.0	1562	E3233	CHICHWA	1.02	6.0
1563	E2925	JAMUN	1.14	6.0	1563	E3234	CHICHWA	0.85	4.0

SN	TREE NO.	SPECIES	GIRTH IN M.	HEIGHT IN M.	SN	TREE NO.	SPECIES	GIRTH IN M.	HEIGHT IN M.
LEFT SIDE					RIGHT SIDE				
1564	E2926	JAMUN	1.42	5.0	1564	E3236	GULMOHAR	1.32	6.0
1565	E2930	BABUL	1.05	5.0	1565	E3239	GULMOHAR	1.08	6.0
1566	E2931	CHICHBILAI	1.25	6.0	1566	E3240	GULMOHAR	1.12	6.0
1567	E2932	CHICHBILAI	2.02	6.0	1567	E3241	GULMOHAR	0.96	4.0
1568	E2934	BABUL	0.95	6.0	1568	E3243	BABUL	2.52	6.0
1569	E2935	CHICHWA	0.84	6.0	1569	E3244	KARANJI	0.84	5.0
1570	E2936	GULMOHAR	0.99	5.0	1570	E3247	BABUL	0.8	4.0
1571	E2937	NEEM	1.40	6.0	1571	E3251	BABUL	0.68	6.0
1572	E2938	BABUL	1.26	5.0	1572	E3252	AAJAN	0.97	5.0
1573	E2941	BABUL	0.89	4.0	1573	E3257	NEEM	1.02	6.0
1574	E2945	SHISHAM	0.90	4.0	1574	E3261	SIRAS	0.8	5.0
1575	E2952	SHISHAM	0.42	4.0	1575	E3262	GULMOHAR	1.35	5.0
1576	E2953	SHISHAM	0.38	4.0	1576	E3265	GULMOHAR	1.8	6.0
1577	E2960	BABUL	1.10	5.0	1577	E3266	GULMOHAR	0.99	5.0
1578	E2961	BABUL	0.81	5.0	1578	E3267	GULMOHAR	0.93	6.0
1579	E2962	SIRAS	0.58	4.0	1579	E3268	GULMOHAR	0.85	6.0
1580	E2963	CHICHWA	0.49	4.0	1580	E3269	GULMOHAR	1.12	5.0
1581	E2969	SAGWAN	0.70	3.0	1581	E3271	GULMOHAR	0.80	6.0
1582	E2970	GULMOHAR	0.92	4.0	1582	E3273	GULMOHAR	1.18	6.0
1583	E2975	BABUL	1.61	7.0	1583	E3274	GULMOHAR	0.84	5.0
1584	E2976	BABUL	0.53	4.0	1584	E3275	HIWAR	0.58	4.0
1585	E2977	BABUL	1.25	5.0	1585	E3276	GULMOHAR	0.97	6.0
1586	E2978	HIWAR	0.75	3.0	1586	E3277	SHISHUM	0.58	4.0
1587	E2979	GULMOHAR	1.33	5.0	1587	E3278	PALAS	0.82	4.0
1588	E2980	GULMOHAR	1.08	5.0	1588	E3279	GULMOHAR	1.28	6.0
1589	E2981	GULMOHAR	0.89	6.0	1589	E3280	GULMOHAR	1.02	6.0
1590	E2982	GULMOHAR	0.96	4.0	1590	E3281	GULMOHAR	0.98	6.0
1591	E2999	GULMOHAR	0.95	5.0	1591	E3282	SHISHUM	0.45	4.0
1592	E3000	GULMOHAR	1.20	5.0	1592	E3282A	NEEM	0.38	4.0
1593	E3007	GULMOHAR	1.43	5.0	1593	E3284	HIWAR	0.55	3.0
1594	E3008	GULMOHAR	0.87	4.0	1594	E3285	BABUL	0.72	4.0
1595	E3009	GULMOHAR	1.02	5.0	1595	E3286	GULMOHAR	2.40	7.0
1596	E3010	GULMOHAR	1.02	6.0	1596	E3287	SHISHUM	0.46	4.0
1597	E3011	GULMOHAR	0.85	4.0	1597	E3288	SHISHUM	0.60	5.0
1598	E3012	GULMOHAR	1.20	5.0	1598	E3289	GULMOHAR	2.18	7.0
1599	E3013	PALAS	0.72	4.0	1599	E3290	GULMOHAR	1.20	6.0
1600	E3013A	PALAS	0.83	3.0	1600	E3292	GULMOHAR	1.10	6.0
1601	E3014	AAJAN	1.10	7.0	1601	E3293	GULMOHAR	0.91	5.0
1602	E3015	GULMOHAR	1.03	5.0	1602	E3294	GULMOHAR	1.00	5.0
1603	E3016	GULMOHAR	1.10	6.0	1603	E3296	GULMOHAR	0.98	6.0
1604	E3017	GULMOHAR	1.52	6.0	1604	E3301	GULMOHAR	1.02	6.0
1605	E3018	CHICHWA	0.98	4.0	1605	E3302	GULMOHAR	1.17	6.0
1606	E3024	GULMOHAR	1.10	6.0	1606	E3304	GULMOHAR	0.74	5.0
1607	E3025	GULMOHAR	1.42	6.0	1607	E3306	BABUL	1.00	5.0
1608	E3026	GULMOHAR	0.98	4.0	1608	E3307	BOR	0.85	4.0
1609	E3027	GULMOHAR	0.87	5.0	1609	E3310	SIRAS	1.12	4.0
1610	E3028	GULMOHAR	1.52	6.0	1610	E3312	CHICHWA	1.14	5.0
1611	E3029	AAJAN	1.32	7.0	1611	E3314	CHICHWA	1.27	6.0
1612	E3030	GULMOHAR	0.88	5.0	1612	E3315	CHICHWA	0.85	5.0

SN	TREE NO.	SPECIES	GIRTH IN M.	HEIGHT IN M.	SN	TREE NO.	SPECIES	GIRTH IN M.	HEIGHT IN M.
LEFT SIDE					RIGHT SIDE				
1613	E3031	GULMOHAR	0.62	3.0	1613	E3317	CHICHWA	1.36	6.0
1614	E3032	GULMOHAR	1.07	5.0	1614	E3320	CHICHWA	1.08	4.0
1615	E3033	GULMOHAR	1.60	6.0	1615	E3323	CHICHWA	1.26	6.0
1616	E3034	GULMOHAR	1.17	6.0	1616	E3324	SHISHUM	1.13	6.0
1617	E3035	GULMOHAR	0.90	5.0	1617	E3325	GULMOHAR	1.67	6.0
1618	E3036	GULMOHAR	1.37	6.0	1618	E3327	CHICHWA	1.07	6.0
1619	E3037	CHICHWA	1.48	6.0	1619	E3328	CHICHWA	1.46	6.0
1620	E3038	CHICHWA	0.89	6.0	1620	E3331	CHICHWA	0.88	5.0
1621	E3039	CHICHWA	0.78	4.0	1621	E3332	NEEM	0.62	3.0
1622	E3040	GULMOHAR	1.74	7.0	1622	E3333	GULMOHAR	1.42	6.0
1623	E3041	GULMOHAR	1.45	6.0	1623	E3335	JAMUN	1.11	4.0
1624	E3042	GULMOHAR	1.32	6.0	1624	E3337	GULMOHAR	1.73	6.0
1625	E3043	BABUL	1.07	6.0	1625	E3338	GULMOHAR	1.08	6.0
1626	E3044	CHAFA	0.98	5.0	1626	E3339	GULMOHAR	0.69	6.0
1627	E3045	BABUL	1.22	6.0	1627	E3340	CHICHWA	1.18	5.0
1628	E3046	BABUL	0.88	6.0	1628	E3341	JAMUN	0.52	4.0
1629	E3047	AAJAN	1.28	6.0	1629	E3345	SIRAS	1.18	5.0
1630	E3048	KARANJI	0.93	6.0	1630	E3356	CHICHWA	1.03	5.0
1631	E3049	KARANJI	1.08	6.0	1631	E3361	CHICHWA	0.86	5.0
1632	E3050	AAJAN	2.20	6.0	1632	E3365	SIRAS	1.75	6.0
1633	E3060	SHISHAM	1.25	6.0	1633	E3366	SIRAS	1.50	6.0
1634	E3061	BABUL	1.05	5.0	1634	E3367	GULMOHAR	0.92	5.0
1635	E3062	SIRAS	1.04	4.0	1635	E3368	SIRAS	0.97	5.0
1636	E3063	AAJAN	1.25	6.0	1636	E3369	BOR	0.62	3.0
1637	E3066	CHICHBILAI	1.10	4.0	1637	E3370	BABUL	0.59	4.0
1638	E3067	CHICHWA	0.97	5.0	1638	E3371	PALAS	0.85	4.0
1639	E3068	SHISHAM	1.12	5.0	1639	E3372	SIRAS	1.55	6.0
1640	E3069	SHISHAM	0.89	4.0	1640	E3373	GULMOHAR	2.06	5.0
1641	E3070	SHISHAM	0.52	5.0	1641	E3374	BOR	0.65	3.0
1642	E3071	SHISHAM	0.78	3.0					
1643	E3072	SHISHAM	0.67	5.0					
1644	E3080	CHICHWA	0.82	6.0					
1645	E3093	SIRAS	0.97	6.0					
1646	E3099	SHISHAM	0.85	5.0					
1647	E3100	SAGWAN	0.38	3.0					
1648	E3101	SAGWAN	0.78	4.0					
1649	E3105	KARANJI	0.87	4.0					
1650	E3112	CHICHWA	1.08	6.0					
1651	E3113	GULMOHAR	1.35	7.0					
1652	E3114	CHICHWA	1.20	6.0					
1653	E3116	CHICHWA	0.80	6.0					
1654	E3123	CHICHWA	0.88	5.0					
1655	E3124	CHICHWA	0.69	5.0					
1656	E3125	SIRAS	1.23	6.0					
1657	E3126	CHICHWA	0.82	5.0					
1658	E3127	SHISHAM	0.72	5.0					
1659	E3128	CHICHWA	0.80	5.0					
1660	**E3129**	**SIRAS**	**1.58**	**6.0**					
1661	E3130	SHISHAM	0.99	6.0					

SN	TREE NO.	SPECIES	GIRTH IN M.	HEIGHT IN M.	SN	TREE NO.	SPECIES	GIRTH IN M.	HEIGHT IN M.
LEFT SIDE					RIGHT SIDE				
1662	E3134	CHICHWA	1.40	5.0					
1663	E3135	GULMOHAR	1.38	6.0					
1664	E3136	CHICHWA	0.70	5.0					
1665	E3146	CHICHWA	0.84	6.0					
1666	E3147	GULMOHAR	2.08	7.0					
1667	E3149	GULMOHAR	1.52	6.0					
1668	E3150	GULMOHAR	1.27	6.0					
1669	E3151	GULMOHAR	0.90	5.0					
1670	E3152	CHICHWA	0.67	4.0					
1671	E3153	CHICHWA	0.52	3.0					
1672	E3154	CHICHWA	1.05	5.0					
1673	E3155	BABUL	0.92	5.0					
1674	E3156	BABUL	1.00	5.0					
1675	E3161	BABUL	0.76	5.0					
1676	E3162	GULMOHAR	1.43	8.0					
1677	E3165	GULMOHAR	0.97	5.0					
1678	E3166	CHICHWA	1.48	6.0					
1679	E3167	GULMOHAR	1.32	7.0					
1680	E3168	KARANJI	1.15	6.0					
1681	E3180	CHICHWA	1.05	6.0					
1682	E3181	GULMOHAR	1.30	7.0					
1683	E3191	GULMOHAR	1.08	7.0					
1684	E3192	GULMOHAR	1.52	7.0					
1685	E3193	CHICHWA	1.13	6.0					
1686	E3207	GULMOHAR	1.24	7.0					
1687	E3209	CHICHWA	1.10	6.0					
1688	E3220	MANGO	3.70	7.0					
1689	E3226	NEEM	0.57	4.0					
1690	E3235	CHICHWA	0.86	4.0					
1691	E3237	CHICHWA	0.75	4.0					
1692	E3238	CHICHWA	0.78	4.0					
1693	E3242	BABUL	1.70	4.0					
1694	E3245	BABUL	1.28	6.0					
1695	E3246	BABUL	1.42	6.0					
1696	E3248	CHICHWA	1.22	8.0					
1697	E3249	NEEM	0.67	5.0					
1698	E3250	GULMOHAR	1.28	7.0					
1699	E3253	BABUL	0.94	5.0					
1700	E3254	GULMOHAR	1.28	7.0					
1701	E3255	PALAS	1.28	8.0					
1702	E3256	GULMOHAR	0.87	5.0					
1703	E3258	GULMOHAR	1.30	6.0					
1704	E3259	GULMOHAR	1.32	7.0					
1705	E3260	GULMOHAR	1.40	7.0					
1706	E3263	BABUL	0.87	6.0					
1707	E3264	AAJAN	2.40	4.0					
1708	E3270	KARANJI	0.76	5.0					
1709	E3272	AAJAN	1.80	3.0					
1710	E3272A	CHICHWA	1.48	4.0					

SN	TREE NO.	SPECIES	GIRTH IN M.	HEIGHT IN M.	SN	TREE NO.	SPECIES	GIRTH IN M.	HEIGHT IN M.
LEFT SIDE					RIGHT SIDE				
1711	E3283	PALAS	0.49	4.0					
1712	E3291	SIRAS	0.94	4.0					
1713	E3295	GULMOHAR	1.86	7.0					
1714	E3297	CHICHWA	1.27	4.0					
1715	E3298	CHICHWA	0.85	4.0					
1716	E3299	GULMOHAR	1.32	6.0					
1717	E3300	CHICHWA	1.53	5.0					
1718	E3303	CHICHWA	1.12	4.0					
1719	E3305	CHICHWA	1.35	5.0					
1720	E3308	CHICHWA	0.97	5.0					
1721	E3309	CHICHWA	1.14	5.0					
1722	E3311	NEEM	0.92	3.0					
1723	E3313	JAMUN	0.82	5.0					
1724	E3316	CHICHWA	0.99	5.0					
1725	E3318	CHICHWA	1.10	5.0					
1726	E3319	CHICHWA	0.85	4.0					
1727	E3321	CHICHWA	1.50	5.0					
1728	E3322	NEEM	0.88	4.0					
1729	E3326	CHICHWA	1.45	6.0					
1730	E3329	CHICHWA	1.07	5.0					
1731	E3330	GULMOHAR	1.51	6.0					
1732	E3334	CHICHWA	1.45	6.0					
1733	E3336	CHICHWA	1.58	6.0					
1734	E3342	NILGIRI	2.14	8.0					
1735	E3343	BOTTEL GREEN	0.58	3.0					
1736	E3344	GULMOHAR	1.29	5.0					
1737	E3346	GULMOHAR	0.90	5.0					
1738	E3347	GULMOHAR	1.25	6.0					
1739	E3348	GULMOHAR	1.43	6.0					
1740	E3349	UMBER	1.65	6.0					
1741	E3350	GULMOHAR	1.80	7.0					
1742	E3351	GULMOHAR	1.28	5.0					
1743	E3352	UMBER	0.96	4.0					
1744	E3353	UMBER	1.40	5.0					
1745	E3354	NEEM	0.80	4.0					
1746	E3355	KARANJI	1.23	4.0					
1747	E3357	SIRAS	1.10	6.0					
1748	E3358	SIRAS	0.97	5.0					
1749	E3359	GULMOHAR	1.07	6.0					
1750	E3360	SIRAS	1.00	6.0					
1751	E3362	SIRAS	1.40	5.0					
1752	E3363	SIRAS	1.50	6.0					
1753	E3364	SIRAS	1.20	6.0					

ANNEXURE 5.2 LIST OF TREES IN CORRIDOR 2A

SN	TREE NO.	SPECIES	GIRTH	HEIGHT (m)	SN	TREE NO.	SPECIES	GIRTH	HEIGHT (m)
LEFT SIDE					RIGHT SIDE				
1	E553	BADAM	0.90	5M	1	E557	SUBABUL	1.52	15M
2	E554	NIM	0.70	7M	2	E558	KARANJI	1.62	14M
3	E555	PIPAL	2.75	14M	3	E559	SUBABUL	1.6	15M
4	E556	JAMUN	1.75	13M	4	E560	KARANJI	1.65	11M
5	E566	BABUL	1.50	8M	5	E561	DRY TREE	1.94	16M
6	E570	NIM	0.50	7M	6	E562	SUBABUL	1	14M
7	E571	BABUL	0.85	7M	7	E563	SUBABUL	2.65	15M
8	E572	BABUL	1.55	8M	8	E564	BABUL	0.68	8M
9	E573	UMAR	0.80	8M	9	E565	APTA	0.5	6M
10	E574	KARANJI	1.20	8M	10	E567	NIM	2.4	8M
11	E575	BABUL	0.80	7M	11	E568	BABUL	2.45	14M
12	E576	JAMUN	0.70	8M	12	E569	NIM	2.55	14M
13	E577	CHICHBILIY	1.37	14M	13	E594	JAMUN	0.8	6M
14	E578	NIM	1.00	12M	14	E600	BADAM	0.7	5M
15	E579	WAD	1.00	12M	15	E601	PIPAL	0.9	9M
16	E580	NIM	0.90	7M	16	E602	NIM	0.7	10M
17	E581	BABUL	0.95	7M	17	E603	PIPAL	1.2	12M
18	E582	KARANJI	1.30	14M	18	E611	KARANJI	1.3	12M
19	E583	NIM	1.30	15M	19	E614	BOR	0.8	7M
20	E584	KARANJI	0.90	10M	20	E615	BABUL	0.9	10M
21	E585	KARANJI	1.00	11M	21	E617	NIM	1.2	10M
22	E586	JAMUN	0.80	7M	22	E618	BADAM	1.3	11M
23	E587	APTA	0.70	8M	23	E619	BOR	0.8	12M
24	E588	NIM	0.90	7M	24	E623	PIPAL	0.7	10M
25	E589	NIM	0.80	8M	25	E624	PIPAL	1.2	12M
26	E590	UMAR	0.90	8M	26	E626	BABUL	0.8	7M
27	E591	MUNGNA	0.70	9M	27	E633	FORESHT TREE	0.8	7M
28	E592	KARANJI	1.30	10M	28	E635	NIM	0.7	12M
29	E593	BABUL	1.20	7M	29	E636	NIM	0.7	8M
30	E595	NIM	0.70	7M	30	E637	BADAM	1.3	10M
31	E596	IMLI	1.20	10M	31	E638	BOR	0.7	7M
32	E597	PIPAL	1.40	10M	32	E639	BOR	0.8	9M
33	E598	IMLI	1.30	12M	33	E643	NIM	1.3	10.0
34	E599	PIPAL	1.20	15M	34	E644	NIM	0.8	12M
35	E604	WAD	1.10	14M	35	E645	BABUL	1.2	9M
36	E605	BABUL	0.80	8M	36	E646	BABUL	1.3	11M
37	E606	NIM	0.70	10M	37	E650	PIPAL	0.9	12M
38	E607	BOR	0.80	11M	38	E651	FORESHT TREE	0.8	10M
39	E608	NIM	0.90	11M	39	E652	BABUL	0.7	9M
40	E609	NIM	0.80	10M	40	E653	BABUL	0.6	9M
41	E610	IMLI	1.20	10M	41	E654	BABUL	0.6	8M
42	E612	NIM	1.40	14M	42	E655	BABUL	0.8	10M
43	E613	WAD	0.90	6M	43	E656	NIM	0.9	12M
44	E616	WAD	0.90	13M	44	E661	NIM	1.2	14M
45	E620	NIM	0.70	12M	45	E662	NIM	1.1	10M
46	E621	NIM	1.20	14M	46	E663	NIM	1.3	11M
47	E622	BADAM	1.30	14M	47	E667	NIM	0.6	8M

SN	TREE NO.	SPECIES	GIRTH	HEIGHT (m)	SN	TREE NO.	SPECIES	GIRTH	HEIGHT (m)
LEFT SIDE					RIGHT SIDE				
48	E625	NIM	1.30	10M	48	E668	NIM	1.2	12M
49	E627	NIM	1.30	9M	49	E669	BABUL	1.3	12M
50	E628	IMLI	0.80	8M	50	E675	NIM	0.9	10M
51	E629	JAMUN	0.70	7M	51	E676	NIM	1.2	13M
52	E630	BABUL	0.80	10M	52	E677	NIM	0.9	10M
53	E631	UMAR	1.20	12M	53	E684	JAMUN	1.3	12M
54	E632	UMAR	1.10	10M	54	E685	JAMUN	1.3	11M
55	E634	PIPAL	1.30	12M	55	E691	NIM	0.9	14M
56	E640	NIM	1.20	9M	56	E692	NIM	0.9	13M
57	E641	BABUL	0.90	10M	57	E693	NIM	0.9	11M
58	E642	NIM	1.20	12M	58	E694	NIM	0.9	14M
59	E647	FORESHT TREE	1.20	12M	59	E696	NIM	1.3	11M
60	E648	PIPAL	0.80	10M	60	E699	NIM	0.9	11M
61	E649	BABUL	0.70	14M	61	E700	SISAM	0.7	7M
62	E657	NIM	1.20	10M	62	E701	SISAM	0.7	7M
63	E658	NIM	1.30	14M	63	E702	SISAM	0.7	7M
64	E659	NIM	0.70	8M	64	E703	SISAM	0.6	5M
65	E660	PIPAL	0.80	13M	65	E704	SISAM	0.7	6M
66	E664	PIPAL	0.90	9M	66	E705	SISAM	0.8	6M
67	E665	WAD	0.60	7M	67	E706	SISAM	0.7	6M
68	E666	PIPAL	1.30	11M	68	E707	NIM	1.3	11M
69	E670	SISAM	0.90	14M	69	E716	BABUL	0.7	10M
70	E671	SISAM	0.80	14M	70	E717	NIM	1.2	12M
71	E672	SISAM	0.90	12M	71	E722	JAMUN	0.9	14M
72	E673	NIM	1.30	15M	72	E723	NIM	1.2	13M
73	E674	NIM	0.80	11M	73	E724	NIM	1.3	13M
74	E678	WAD	1.3	15M	74	E727	PIPAL	1.2	14M
75	E679	PALAS	0.80	10M	75	E728	NIM	1.3	15M
76	E680	PALAS	0.70	10M	76	E730	NIM	0.9	9M
77	E681	PALAS	0.60	11M	77	E731	NIM	0.8	8M
78	E682	NIM	1.20	11M	78	E734	NIM	1.2	11M
79	E683	NIM	1.30	14M	79	E735	MANGO	0.9	14M
80	E686	KARANJI	0.90	8M	80	E736	NIM	1.2	9M
81	E687	KARANJI	0.90	11M	81	E739	NIM	0.9	11M
82	E688	BABUL	0.70	10M	82	E740	NIM	0.9	10M
83	E689	BABUL	0.70	9M	83	E741	KARANJI	1.1	12M
84	E690	BABUL	0.80	10M	84	E742	SISAM	1.2	11M
85	E695	BABUL	0.70	8M	85	E745	NIM	0.9	9M
86	E697	BABUL	0.70	8M	86	E746	NIM	1.2	12M
87	E698	BABUL	0.60	9M	87	E754	NIM	0.9	12M
88	E708	BABUL	0.70	7M	88	E755	BABUL	0.8	11M
89	E709	NIM	1.2	11M	89	E758	DRY TREE	1.1	3M
90	E710	PIPAL	0.9	11M	90	E761	NIM	1.1	13M
91	E711	ASHOKA	0.7	14M	91	E765	NIM	1.2	9M
92	E712	ASHOKA	0.7	14M	92	E766	NIM	1.3	8M
93	E713	ASHOKA	0.80	15M	93	E770	GULMOHAR	0.8	9M
94	E714	ASHOKA	0.70	13M	94	E776	PIPAL	0.9	10M
95	E715	ASHOKA	0.80	14M	95	E777	PIPAL	0.9	11M
96	E718	IMLI	1.30	12M	96	E778	NIM	0.6	6M

SN	TREE NO.	SPECIES	GIRTH	HEIGHT (m)	SN	TREE NO.	SPECIES	GIRTH	HEIGHT (m)
		LEFT SIDE					RIGHT SIDE		
97	E719	ASHOKA	0.90	11M	97	E779	NIM	0.7	10M
98	E720	ASHOKA	0.90	12M	98	E781	NIM	0.9	10M
99	E721	NIM	0.90	9M	99	E782	NIM	1.2	13M
100	E725	SISAM	1.20	10M	100	E783	NIM	1.2	14M
101	E726	SUBABUL	0.90	1OM	101	E784	PIPAL	0.5	4M
102	E729	NIM	1.20	18M	102	E785	BOR	0.6	5M
103	E732	NIM	0.90	10M	103	E789	DRY TREE	0.9	10M
104	E733	NIM	0.90	11M	104	E790	BOR	0.7	9M
105	E737	NIM	0.90	10M	105	E794	BABUL	0.7	8M
106	E738	KARANJI	0.80	9M	106	E795	NIM	1.2	11M
107	E743	NIM	0.90	8M	107	E795A	NIM	1.1	1OM
108	E744	NIM	0.80	9M	108	E798	NIM	0.7	9M
109	E747	NIM	1.20	14M	109	E799	NIM	1.3	14M
110	E748	NILGERI	0.70	16M	110	E801	NIM	0.8	9M
111	E749	KOKONAT	0.90	15M	111	E802	NIM	0.9	10M
112	E750	PALAS	0.90	13M	112	E806	NIM	0.9	10M
113	E751	IMLI	0.80	14M	113	E810	NIM	0.9	8M
114	E752	NIM	1.20	15M	114	E812	NIM	1.20	9M
115	E753	NIM	1.10	13M	115	E813	KARANJI	1.30	10M
116	E756	KARANJI	1.30	11M	116	E814	KARANJI	0.80	8M
117	E757	NIM	1.10	12M	117	E821	BABUL	1.20	9M
118	E759	NIM	1.10	10M	118	E822	BABUL	1.10	8M
119	E760	NIM	1.20	12M	119	E823	BABUL	1.30	11M
120	E762	NIM	0.90	11M	120	E824	KARANJI	1.10	9M
121	E763	BABUL	0.80	9M	121	E825	BABUL	1.20	10M
122	E764	NILAM	1.40	11M	122	E826	BABUL	0.90	8M
123	E767	NILAM	1.10	10M	123	E839	BABUL	1.30	5M
124	E768	ASHOKA	1.20	11M	124	E840	BABUL	0.90	4.5M
125	E769	ASHOKA	1.30	13M	125	E841	BABUL	1.20	8M
126	E771	NM	0.80	10M	126	E844	IMLI	1.90	8M
127	E772	NIM	0.90	11M	127	E845	BABUL	0.90	4M
128	E773	KUL	0.90	13M	128	E846	SUBABUL	1.35	12M
129	E774	MANGO	1.20	14M	129	E849	SUBABUL	0.95	14M
130	E775	DRY TREE	0.20	9M	130	E850	GULMOHAR	0.95	9M
131	E780	NIM	0.80	11M	131	E851	GULMOHAR	0.90	7M
132	E786	BABUL	0.90	10M	132	E852	SUBABUL	0.90	8M
133	E787	PIPAL	0.80	9M	133	E853	NIM	2.00	11M
134	E788	BABUL	1.20	11M	134	E857	SUBABUL	0.65	7M
135	E791	PIPAL	0.70	9M	135	E858	FORESHT TREE	0.60	3M
136	E792	PIPAL	0.90	9M	136	E866	KARANJI	1.00	15M
137	E793	BABUL	1.20	10M	137	E882	BABUL	1.30	13M
138	E796	NIM	1.20	10M	138	E883	BABUL	0.90	9M
139	E797	NIM	0.70	9M	139	E890	FORESHT TREE	0.80	14M
140	E800	NIM	0.70	4M	140	E892	BABUL	0.90	8M
141	E803	BABUL	0.70	9M	141	E893	SAGWAN	0.80	11M
142	E804	FORESHT TREE	0.80	8M	142	E902	SAGWAN	0.60	9M
143	E805	FORESHT TREE	0.80	9M	143	E903	BABUL	0.80	8M
144	E807	BABUL	0.70	5M	144	E904	BABUL	0.80	11M
145	E808	BABUL	0.50	4M	145	E905	BABUL	0.70	10M

SN	TREE NO.	SPECIES	GIRTH	HEIGHT (m)	SN	TREE NO.	SPECIES	GIRTH	HEIGHT (m)
LEFT SIDE					RIGHT SIDE				
146	E809	BABUL	0.50	4M	146	E906	BABUL	0.90	8M
147	E811	NIM	0.90	9M	147	E918	BABUL	0.60	8M
148	E815	BABUL	0.70	9M	148	E927	NIM	0.90	11M
149	E816	BABUL	0.60	4M	149	E928	NIM	0.60	9M
150	E817	BABUL	0.60	6M	150	E929	NIM	0.80	7M
151	E818	BABUL	0.60	7M	151	E935	KARANJI	0.60	4M
152	E819	BABUL	0.50	5M	152	E936	NILGERI	0.60	8M
153	E820	KARANJI	1.20	10M	153	E942	BABUL	1.30	14M
154	E827	NIM	0.80	11M	154	E943	BABUL	0.80	9M
155	E828	MANGO	0.75	4M	155	E979	NIM	1.20	12M
156	E829	SHOW	0.60	2M	156	E980	NIM	1.20	11M
157	E830	SHOW	0.60	2M	157	E996	BABUL	1.20	10M
158	E831	SHOW	0.60	2M	158	E1027	IMLI	1.10	11M
159	E832	SHOW	0.65	2.5M	159	E1028	NIM	1.20	10M
160	E833	SHOW	0.70	3M	160	E1029	SAGWAN	0.70	7M
161	E834	SHOW	0.60	3M	161	E1039	PIPAL	1.20	16M
162	E835	SHOW	0.63	2.5M	162	E1040	NIM	1.20	9M
163	E836	SHOW	0.67	2M	163	E1058	NIM	1.3	14M
164	E837	SHOW	0.71	2M	164	E1059	PIPAL	1.40	10M
165	E838	SHOW	0.75	2M	165	E1061	NIM	0.90	12M
166	E842	BABUL	0.90	7M	166	E1065	FORESHT TREE	0.60	10M
167	E843	BABUL	1.00	8M	167	E1066	NIM	0.90	11M
168	E847	SUBABUL	1.30	11M	168	E1073A	KARANJI	0.70	5M
169	E848	SUBABUL	0.80	9M	169	E1073B	KARANJI	0.90	7M
170	E854	NIM	0.70	7M	170	E1073C	KARANJI	0.70	8M
171	E855	SUBABUL	0.90	2M	171	E1073D	KARANJI	0.60	4M
172	E856	SUBABUL	0.70	4M	172	E1073E	KARANJI	0.90	6M
173	E859	SUBABUL	0.90	12M	173	E1073F	KARANJI	1.00	7M
174	E860	SUBABUL	1.20	14M	174	E1073G	KARANJI	0.60	5M
175	E861	SUBABUL	1.35	15M	175	E1073H	KARANJI	0.90	7M
176	E862	NIM	0.55	10M	176	E1073I	KARANJI	1.10	10M
177	E863	SUBABUL	0.90	8M	177	E1074	KARANJI	0.70	8M
178	E864	SUBABUL	1.00	14M	178	E1075	KARANJI	0.70	7M
179	E865	SUBABUL	1.15	14M	179	E1076	PIPAL	1.20	10M
180	E867	KARANJI	0.90	15M	180	E1077	KARANJI	0.90	9M
181	E868	BABUL	0.90	15M	181	E1078	PIPAL	0.90	10M
182	E869	BABUL	0.90	14M	182	E1082	KARANJI	1.20	12M
183	E870	NIM	1.30	13M	183	E1083	SHO TREE	0.60	7M
184	E871	NIM	1.20	13M	184	E1084	SHO TREE	0.70	6M
185	E872	BABUL	0.90	9M	185	E1085	SHO TREE	0.60	4M
186	E873	BABUL	0.80	10M	186	E1086	SHO TREE	0.70	5M
187	E874	NIM	1.20	15M	187	E1087	SHO TREE	0.70	3M
188	E875	KARANJI	1.30	14M	188	E1088	SHO TREE	0.80	4M
189	E876	KARANJI	1.20	14M	189	E1089	SHO TREE	0.70	6M
190	E877	WAD	0.70	6M	190	E1090	SHO TREE	0.80	5M
191	E878	PIPAL	0.80	9M	191	E1091	SHO TREE	0.80	4M
192	E879	NIM	1.20	12M	192	E1096	NIM	0.90	10M
193	E880	BABUL	1.20	12M	193	E1100	WAD	1.40	14M
194	E881	KARANJI	0.90	8M	194	E1101	PIPAL	1.30	13M

SN	TREE NO.	SPECIES	GIRTH	HEIGHT (m)	SN	TREE NO.	SPECIES	GIRTH	HEIGHT (m)
		LEFT SIDE					RIGHT SIDE		
195	E884	BABUL	0.80	8M	195	E1102	PIPAL	1.20	10M
196	E885	SAGWAN	0.80	10M	196	E1104	NIM	1.20	11M
197	E886	SAGWAN	0.90	11M	197	E1105	NIM	1.20	10M
198	E887	BABUL	1.20	11M	198	E1106	NIM	1.30	9M
199	E888	BABUL	0.90	10M	199	E1107	NIM	1.30	13M
200	E889	BABUL	1.10	12M	200	E1108	NIM	1.30	14M
201	E891	BABUL	0.90	7M	201	E1110	NIM	1.20	11M
202	E894	BABUL	0.70	8M	202	E1117	BABUL	0.70	8M
203	E895	BABUL	0.60	6M	203	E1118	NIM	0.90	8M
204	E896	BABUL	0.80	8M	204	E1119	NIM	0.70	7M
205	E897	BABUL	0.80	9M	205	E1120	NIM	1.20	11M
206	E898	NIM	1.20	9M	206	E1130	NIM	1.30	9M
207	E899	NIM	0.70	9M	207	E1131	DRY TREE	1.20	10M
208	E900	NIM	1.20	9M	208	E1132	SHO TREE	1.20	6M
209	E901	NIM	1.20	10M	209	E1133	SHO TREE	1.20	6M
210	E907	NIM	1.50	14M	210	E1134	SHO TREE	1.20	7M
211	E908	IMLI	0.70	10M	211	E1135	SHO TREE	1.20	7M
212	E909	IMLI	0.80	9M	212	E1136	SHO TREE	1.30	7M
213	E910	NIM	1.20	11M	213	E1137	SHO TREE	0.90	6M
214	E911	NIM	0.90	12M	214	E1138	SHO TREE	0.90	7M
215	E912	NIM	0.80	11M	215	E1151	NIM	0.70	7M
216	E913	BABUL	0.70	12M	216	E1152	BABUL	0.80	8M
217	E914	BABUL	0.80	8M	217	E1153	BABUL	0.80	7M
218	E915	BABUL	0.70	7M	218	E1154	NIM	0.80	8M
219	E916	BABUL	0.80	8M	219	E1155	NIM	0.70	7M
220	E917	BABUL	0.70	9M	220	E1155B	KADUNIM	2.30	13M
221	E919	FORESHT TREE	0.90	14M	221	E1157A	PIPAL	2.00	15M
222	E920	ASHOKA	0.70	13M	222	E1158	KADUNIM	1.40	14M
223	E921	BABUL	0.80	9M	223	E1159	KARANJI	0.90	10M
224	E922	NILGERI	0.80	15M	224	E1160	KARANJI	0.30	8M
225	E923	BABUL	0.80	11M	225	E1161	BELA	1.10	9M
226	E924	BABUL	0.70	11M	226	E1164	KARANJI	1.00	8M
227	E925	BABUL	0.60	9M	227	E1165	KARANJI	1.00	8M
228	E926	BABUL	0.80	12M	228	E1166	BELA	0.90	11M
229	E930	NIM	1.30	11M	229	E1166A	BELA	0.90	11M
230	E931	SAGWAN	0.60	8M	230	E1167	PIPAL	1.90	14M
231	E932	BABUL	0.90	10M	231	E1168	ASHOK	0.80	9M
232	E933	PIPAL	1.50	15M	232	E1168A	ASHOK	0.80	9M
233	E934	NIM	1.20	8M	233	E1169	SUBABUL	1.10	15M
234	E937	BABUL	0.60	8M	234	E1174	NILGERI	1.80	16M
235	E938	BABUL	0.70	9M	235	E1175	NILGERI	1.00	16M
236	E939	KARANJI	0.70	8M	236	E1176	KARANJI	1.00	12M
237	E940	IMLI	0.90	9M	237	E1179	PIPAL	1.10	14M
238	E941	NIM	1.20	10M	238	E1188	ASHOK	0.90	10M
239	E944	BABUL	0.70	8M	239	E1209	SUBABUL	0.80	13M
240	E945	NIM	1.20	14M	240	E1210	KADUNIM	0.90	9M
241	E946	BABUL	0.6	8M	241	E1211	KADUNIM	1.00	10M
242	E947	BABUL	0.6	9M	242	E1212	CHICHBIL	3.10	18M
243	E948	BABUL	0.60	10M	243	E1212A	CHICHBIL	3.10	18M

SN	TREE NO.	SPECIES	GIRTH	HEIGHT (m)	SN	TREE NO.	SPECIES	GIRTH	HEIGHT (m)
		LEFT SIDE					RIGHT SIDE		
244	E949	BABUL	0.60	7M	244	E1213	PIPAL	0.80	9M
245	E950	BABUL	0.60	8M	245	E1220	PIPAL	4.00	20M
246	E951	NIM	1.30	15M	246	E1231	SUBABUL	0.90	12M
247	E952	BABUL	1.2	13M	247	E1232	BABUL	0.70	10M
248	E953	UMAR	0.9	10M	248	E1233	BABUL	0.70	12M
249	E954	KARANJI	0.80	9M	249	E1234	NEEM	0.80	7.0
250	E955	BABUL	0.80	8M	250	E1235	NEEM	0.38	7.2
251	E956	BABUL	1.20	6M	251	E1237	GULMOHAR	1.00	7.0
252	E957	BABUL	1.30	10M	252	E1238	GULMOHAR	1.26	8.0
253	E958	NIM	0.90	9M	253	E1239	GULMOHAR	0.89	7.5
254	E959	KARANJI	0.60	10M	254	E1240	GULMOHAR	1.29	6.7
255	E960	KARANJI	0.60	10M	255	E1242	BABUL	0.77	4.0
256	E961	KARANJI	0.60	11M	256	E1243	BABUL	0.50	4.0
257	E962	BABUL	0.80	12M	257	E1244	BABUL	0.46	5.0
258	E963	BABUL	0.90	9M	258	E1245	BABUL	0.42	4.0
259	E964	NIM	1.20	14M	259	E1246	GULMOHAR	0.98	3.5
260	E965	BABUL	0.90	9M	260	E1247	NEEM	1.60	7.0
261	E966	BABUL	0.90	10M	261	E1248	GULMOHAR	0.76	6.0
262	E967	BABUL	0.80	9M	262	E1249	GULMOHAR	1.08	6.0
263	E968	BABUL	0.90	10M	263	E1250	GULMOHAR	0.97	7.0
264	E969	BABUL	0.70	9M	264	E1251	NEEM	1.03	8.0
265	E970	BABUL	1.20	12M	265	E1252	COCONUT	1.36	7.5
266	E971	BABUL	0.90	10M	266	E1254	NEEM	1.64	9.0
267	E972	BABUL	0.80	5M	267	E1255	CHICHBHILAI	1.04	5.0
268	E973	KARANJI	1.20	9M	268	E1256	CHICHBHILAI	1.78	6.0
269	E974	BABUL	0.70	5M	269	E1258	MAAYRUG	1.82	8.0
270	E975	NIM	1.50	12M	270	E1259	MAAYRUG	2.47	8.0
271	E976	BABUL	0.80	9M	271	E1260	CHICHWA	1.15	8.0
272	E977	KARANJI	0.80	8M	272	E1263	MAAYRUG	1.52	9.0
273	E978	KARANJI	0.60	8M	273	E1264	HIWAR	1.18	7.0
274	E981	BABUL	1.30	10M	274	E1270	PIPAL	0.75	7.0
275	E982	BABUL	1.20	12M	275	E1271	NEEM	1.68	8.5
276	E983	BABUL	0.90	9M	276	E1287	SITAFAL	0.65	4.0
277	E984	NIM	0.90	8M	277	E1288	NEEM	0.87	3.50
278	E985	BABUL	0.80	8M	278	E1289	CHICHWA	0.74	4.0
279	E986	BABUL	0.90	8M	279	E1290	JAM	0.71	4.0
280	E987	BABUL	0.90	9M	280	E1291	NEEM	1.32	5.0
281	E988	KARANJI	1.20	11M	281	E1296	SITAFAL	0.68	4.0
282	E989	KARANJI	0.80	7M	282	E1297	NEEM	1.65	6.0
283	E990	KARANJI	0.70	7M	283	E1298	BADAM	0.67	3.0
284	E991	KARANJI	0.90	9M	284	E1300	NEEM	1.28	5.0
285	E992	NIM	1.20	10M	285	E1301	PIPAL	3.08	4.0
286	E993	NIM	1.10	11M	286	E1305	NEEM	0.95	4.0
287	E994	BABUL	0.90	10M	287	E1306	CHICHWA	0.98	6.0
288	E995	BABUL	0.80	9M	288	E1310	ASHOKA	0.70	6.0
289	E997	BABUL	1.20	10M	289	E1311	ASHOKA	0.62	6.0
290	E998	BABUL	1.30	11M	290	E1323	PIPAL	0.58	5.0
291	E999	BABUL	0.90	8M	291	E1324	KARANJI	0.65	6.0
292	E1000	KARANJI	0.80	7M	292	E1325	BABUL	0.78	4.0

SN	TREE NO.	SPECIES	GIRTH	HEIGHT (m)	SN	TREE NO.	SPECIES	GIRTH	HEIGHT (m)
LEFT SIDE					RIGHT SIDE				
293	E1001	KARANJI	0.70	10M	293	E1326	KARANJI	0.55	5.0
294	E1002	NIM	0.60	7M	294	E1327	PIPAL	0.63	6.0
295	E1003	NIM	0.70	9M	295	E1328	BABUL	0.62	4.0
296	E1004	KARANJI	0.80	10M	296	E1329	BABUL	0.80	4.00
297	E1005	BABUL	1.20	10M	297	E1330	BABUL	0.47	6.0
298	E1006	BABUL	1.10	12M	298	E1331	BABUL	0.87	5.0
299	E1007	BABUL	1.30	11M	299	E1332	BABUL	1.47	4.0
300	E1008	BABUL	0.90	10M	300	E1333	BABUL	0.68	4.0
301	E1009	BABUL	0.90	9M	301	E1334	BABUL	0.82	4.0
302	E1010	BABUL	0.80	7M	302	E1335	BABUL	0.98	5.0
303	E1011	NIM	0.60	7M	303	E1336	BABUL	0.52	5.0
304	E1012	KARANJI	0.90	9M	304	E1337	BABUL	0.63	6.0
305	E1013	KARANJI	0.80	9M	305	E1338	BABUL	0.59	6.0
306	E1014	KARANJI	1.30	10M	306	E1339	BABUL	0.62	5.0
307	E1015	NIM	1.50	15M	307	E1340	KARANJI	0.54	5.0
308	E1016	NILGERI	0.90	14M	308	E1341	BABUL	0.72	5.0
309	E1017	BABUL	0.60	7M	309	E1342	BABUL	0.53	4.0
310	E1018	BABUL	0.70	6M	310	E1343	BABUL	0.47	4.0
311	E1019	BABUL	0.80	9M	311	E1344	BABUL	0.62	6.0
312	E1020	BABUL	0.60	8M	312	E1356	BABUL	0.55	6.0
313	E1021	KARANJI	0.80	8M	313	E1357	BABUL	0.45	5.0
314	E1022	KARANJI	0.80	7M	314	E1358	BABUL	0.65	5.0
315	E1023	BABUL	0.70	9M	315	E1359	SHIRUS	0.77	4.00
316	E1024	BABUL	0.90	9M	316	E1360	CHICHWA	1.27	6.0
317	E1025	BABUL	0.90	8M	317	E1361	BABUL	0.82	4.0
318	E1026	NIM	0.80	10M	318	E1362	BABUL	0.78	4.0
319	E1030	NIM	0.80	10M	319	E1363	BABUL	0.73	3.0
320	E1031	NIM	0.90	9M	320	E1364	BABUL	1.04	5.0
321	E1032	BABUL	0.70	9M	321	E1365	GULMOHAR	0.95	6.0
322	E1033	NIM	0.90	7M	322	E1366	NEEM	1.68	5.0
323	E1034	BABUL	0.90	8M	323	E1367	NEEM	1.38	4.0
324	E1035	ASHOKA	0.90	8M	324	E1370	BABUL	0.65	5.0
325	E1036	BANANA	0.80	4M	325	E1372	BABUL	1.50	5.0
326	E1037	FORESHT TREE	0.70	9M	326	E1373	KARANJI	0.97	4.0
327	E1038	FORESHT TREE	0.90	12M	327	E1395	BABUL	1.50	4.0
328	E1041	NIM	1.20	10M	328	E1396	BABUL	0.73	3.0
329	E1042	NIM	1.10	9M	329	E1397	SHIRAS	1.35	5.0
330	E1043	BABUL	0.90	8M	330	E1398	SHIRAS	1.4	5.0
331	E1044	BABUL	0.80	9M	331	E1414	SHIRAS	1.52	5.0
332	E1045	BABUL	0.80	8M	332	E1415	BABUL	1.3	4.0
333	E1046	KARANJI	0.90	9M	333	E1416	SHIRAS	1.05	5.0
334	E1047	KARANJI	0.90	8M	334	E1417	SHIRAS	0.86	5.0
335	E1048	NIM	1.20	11M	335	E1418	GULMOHAR	4.13	4.0
336	E1049	NIM	1.10	11M	336	E1419	CHICHWA	0.42	5.0
337	E1050	NIM	1.20	10M	337	E1420	SHIRAS	0.86	5.0
338	E1051	BABUL	0.80	8M	338	E1421	SHIRAS	0.74	6.0
339	E1052	NIM	0.90	10M	339	E1422	BAAS	2.2	4.0
340	E1053	NIM	1.20	10M	340	E1423	BAAS	3.04	4.0
341	E1054	NIM	1.50	12M	341	E1424	BAAS	2.47	4.0

SN	TREE NO.	SPECIES	GIRTH	HEIGHT (m)	SN	TREE NO.	SPECIES	GIRTH	HEIGHT (m)
LEFT SIDE					RIGHT SIDE				
342	E1055	NIM	1.50	15M	342	E1436	BABUL	0.52	3.0
343	E1056	NIM	1.20	13M	343	E1437	CHICHWA	0.55	3.0
344	E1057	NIM	0.90	13M	344	E1438	CHICHWA	0.67	4.0
345	E1060	NIM	1.30	14M	345	E1455	BABUL	0.62	5.0
346	E1062	NIM	0.90	12M	346	E1456	BABUL	0.65	5.0
347	E1063	FORESHT TREE	0.80	9M	347	E1457	BOR	0.78	3.0
348	E1064	FORESHT TREE	0.90	10M	348	E1467	CHICHWA	0.75	5.0
349	E1067	NIM	0.90	12M	349	E1468	CHICHWA	0.98	4.0
350	E1068	NIM	1.20	13M	350	E1469	CHICHWA	0.8	4.0
351	E1069	NIM	1.10	10M	351	E1470	CHICHWA	0.37	3.0
352	E1070	FORESHT TREE	1.20	12M	352	E1471	SUBABUL	0.53	6.0
353	E1071	KARANJI	0.90	10M	353	E1481	BABUL	1.22	5.0
354	E1072	JAMUN	1.30	14M	354	E1482	BABUL	1.18	5.0
355	E1073	FORESHT TREE	0.90	6M	355	E1483	NEEM	4.62	4.0
356	E1079	NIM	1.20	13M	356	E1509	BABUL	0.96	5.0
357	E1080	NIM	1.10	14M	357	E1510	SUBABUL	0.88	7.0
358	E1081	NIM	0.90	11M	358	E1511	SUBABUL	1.42	7.0
359	E1092	NIM	1.20	6M	359	E1512	SUBABUL	1.26	6.0
360	E1093	NIM	1.30	12M	360	E1513	CHICHWA	1.05	5.0
361	E1094	NIM	1.10	11M	361	E1514	CHICHWA	1.25	5.0
362	E1095	NIM	0.90	9M	362	E1515	SIMAR	0.92	6.0
363	E1097	NIM	1.20	12M	363	E1516	SUBABUL	0.96	7.0
364	E1098	PIPAL	1.30	13M	364	E1517	SHISHUM	1.22	5.0
365	E1099	FORESHT TREE	0.90	9M	365	E1518	SUBABUL	1.11	7.0
366	E1103	NIM	0.90	9M	366	E1519	SUBABUL	1.57	6.0
367	E1109	ASHOKA	0.90	8M	367	E1520	CHICHWA	0.78	5.0
368	E1111	NIM	0.80	6M	368	E1521	CHICHWA	1	4.0
369	E1112	JAMUN	0.80	7M	369	E1522	CHICHWA	0.92	4.0
370	E1113	BABUL	0.50	10M	370	E1523	CHICHWA	1.72	5.0
371	E1114	BABUL	0.80	8M	371	E1524	SHIRAS	0.56	6.0
372	E1115	NIM	0.80	8M	372	E1542	GODHAN	2.53	7.0
373	E1116	NIM	0.90	9M	373	E1543	NEEM	3.33	4.0
374	E1121	NIM	0.80	7M	374	E1544	SAGWAN	1.28	7.0
375	E1122	NIM	0.70	6M	375	E1577	BAMBOO	1.28	7.0
376	E1123	SHO TREE	1.20	8M	376	E1578	GULMOHAR	0.47	6.0
377	E1124	SHO TREE	1.20	7M	377	E1579	NEEM	4.02	4.0
378	E1125	SHO TREE	1.30	7M	378	E1580	BOR	0.97	3.0
379	E1126	NIM	0.70	6M	379	E1581	NEEM	3.14	5.0
380	E1127	NIM	0.70	7M	380	E1582	NEEM	4.87	5.0
381	E1128	MANGO	0.70	4M	381	E1584	BABUL	1.1	6.0
382	E1129	BABUL	0.80	8M	382	E1585	BABUL	1.17	6.0
383	E1139	HARSHNK	0.80	7M	383	E1586	NEEM	4.58	5.0
384	E1140	HARSHNK	0.80	8M	384	E1587	BABUL	0.9	5.0
385	E1141	HARSHNK	0.70	7M	385	E1588	BABUL	1.12	4.0
386	E1142	HARSHNK	0.70	7M	386	E1589	BABUL	1.42	4.0
387	E1143	HARSHNK	0.70	6M	387	E1590	BABUL	0.88	5.0
388	E1144	HARSHNK	0.80	7M	388	E1593	BABUL	0.48	3.0
389	E1145	NIM	0.90	7M	389	E1594	BABUL	0.72	4.0
390	E1146	NIM	0.90	8M	390	E1595	SAGWAN	1.18	6.0

SN	TREE NO.	SPECIES	GIRTH	HEIGHT (m)	SN	TREE NO.	SPECIES	GIRTH	HEIGHT (m)
LEFT SIDE					RIGHT SIDE				
391	E1147	PIPAL	0.80	7M	391	E1596	SAGWAN	0.42	4.0
392	E1148	KARANJI	0.80	8M	392	E1597	SAGWAN	0.54	5.0
393	E1149	KARANJI	0.70	7M	393	E1598	SAGWAN	0.62	5.0
394	E1150	NIM	0.60	5M	394	E1599	SAGWAN	0.37	4.0
395	E1155A	KADUNIM	1.30	13M	395	E1600	SAGWAN	0.58	4.0
396	E1156	KADUNIM	1.00	11M	396	E1601	SAGWAN	0.58	4.0
397	E1157	PIPAL	2.00	15M	397	E1602	SAGWAN	1.12	7.0
399	E1162	SUBABUL	0.50	9M	399	E1605	BABUL	1.16	5.0
400	E1163	WAD	1.30	10M	400	E1606	BABUL	1.07	5.0
401	E1170	PIPAL	2.10	20M	401	E1607	SAGWAN	0.62	6.0
402	E1171	BOR	1.10	9M	402	E1608	BABUL	1.03	4.0
403	E1172	PIPAL	1.3	16M	403	E1619	SAGWAN	1.12	7.0
404	E1173	BABUL	1.10	11M	404	E1620	SAGWAN	0.54	7.0
405	E1177	SUBABUL	1.40	13M	405	E1621	SAGWAN	0.52	3.0
406	E1178	SHO TREE	0.20	6M	406	E1622	SAGWAN	0.69	5.0
407	E1180	MANGO	0.30	5M	407	E1623	SAGWAN	0.68	5.0
408	E1181	SUBABUL	1.50	14M	408	E1624	BABUL	0.77	6.0
409	E1182	SHO TREE	0.90	14M	409	E1625	SAGWAN	0.48	4.0
410	E1183	KADUNIM	0.80	12M	410	E1626	BABUL	0.75	6.0
411	E1184	ASHOK	0.20	8M	411	E1627	SAGWAN	0.62	5.0
412	E1185	ASHOK	0.90	10M	412	E1628	SAGWAN	0.72	5.0
413	E1186	ASHOK	0.60	11M	413	E1629	SAGWAN	0.88	6.0
414	E1187	ASHOK	0.80	10M	414	E1630	SAGWAN	0.52	4.0
415	E1189	BADAM	0.50	9M	415	E1631	SAGWAN	0.68	6.0
416	E1190	KADUNIM	1.00	11M	416	E1632	SAGWAN	0.74	6.0
417	E1191	ASHOK	1.10	9M	417	E1633	SAGWAN	0.8	6.0
418	E1192	ASHOK	0.4	11M	418	E1634	SAGWAN	1.28	7.0
419	E1193	ASHOK	0.9	9M	419	E1648	KARANJI	0.8	8.0
420	E1194	BADAM	0.5	8M	420	E1649	KARANJI	0.32	4.0
421	E1195	ASHOK	1.6	14M	421	E1650	BABUL	0.62	6.0
422	E1196	KARANJI	1.90	15M	422	E1651	SAGWAN	0.51	5.0
423	E1197	BADAM	1.00	13M	423	E1652	SAGWAN	0.56	6.0
424	E1198	KADUNIM	1.30	14M	424	E1653	SAGWAN	0.64	7.5
425	E1199	SUBABUL	0.60	9M	425	E1654	SAGWAN	0.64	6.0
426	E1200	KADUNIM	1.20	13M	426	E1655	SAGWAN	0.55	7.0
427	E1201	SETU	0.50	5M	427	E1656	SAGWAN	0.7	7.0
428	E1202	BADAM	0.40	11M	428	E1657	CHICHWA	0.62	6.0
429	E1203	KADUNIM	1.00	12M	429	E1658	BABUL	0.42	5.0
430	E1204	PIPAL	2.30	17M	430	E1659	HIWAR	0.68	6.0
431	E1205	BADAM	1.10	14M	431	E1660	SAGWAN	0.47	7.0
432	E1206	PIPAL	0.60	9M	432	E1661	BABUL	0.87	7.0
433	E1207	KADUNIM	0.90	11M	433	E1662	SAGWAN	0.92	8.0
434	E1208	KARANJI	0.60	12M	434	E1663	SAGWAN	0.98	8.0
435	E1214	NILGERI	1.00	20M	435	E1664	SAGWAN	0.54	7.0
436	E1215	SUBABUL	0.70	10M	436	E1665	BABUL	0.65	5.0
437	E1216	SUBABUL	0.80	13M	437	E1666	BABUL	1.41	7.5
438	E1217	SUBABUL	0.90	14M	438	E1667	BABUL	1.45	8.0
439	E1218	SUBABUL	1.00	13M	439	E1668	BABUL	1.37	7.0
440	E1219	PIPAL	1.60	19M	440	E1669	BABUL	0.98	7.0

SN	TREE NO.	SPECIES	GIRTH	HEIGHT (m)	SN	TREE NO.	SPECIES	GIRTH	HEIGHT (m)
LEFT SIDE					RIGHT SIDE				
441	E1221	SUBABUL	0.50	10M	441	E1670	BABUL	1.65	8.0
442	E1222	NILGERI	0.80	10M	442	E1671	KARANJI	0.45	6.0
443	E1223	KADUNIM	1.00	11M	443	E1672	BABUL	0.51	6.0
444	E1224	NILGERI	0.90	15M	444	E1673	BABUL	0.68	6.0
445	E1225	SUBABUL	0.80	15M	445	E1682	SAGWAN	0.88	8.0
446	E1226	SUBABUL	0.90	16M	446	E1683	HIWAR	1.12	7.0
447	E1227	KADUNIM	0.80	10M	447	E1684	BABUL	1.04	7.0
448	E1228	NILGERI	1.20	20M	448	E1685	SAGWAN	0.83	8.0
449	E1229	PIPAL	1.00	13M	449	E1686	BABUL	0.90	7.0
450	E1230	SUBABUL	0.90	10M	450	E1687	BABUL	0.77	7.0
451	E1230	SUBABUL	0.90	10M	451	E1688	BABUL	0.59	6.0
452	E1236	MUNGNA	1.80	8.0	452	E1689	BABUL	0.62	5.0
453	E1241	MUNGNA	0.62	4.0	453	E1690	BABUL	0.64	7.0
454	E1253	MUNGNA	1.38	4.0	454	E1691	BABUL	0.68	7.0
455	E1257	COCONUT	0.62	3.0	455	E1692	SAGWAN	0.57	8.0
456	E1261	MAAYRUG	1.50	9.0	456	E1693	SAGWAN	0.56	7.0
457	E1262	BABUL	1.12	6.0	457	E1694	KARANJI	0.85	7.0
458	E1265	BABUL	0.92	6.0	458	E1695	BABUL	0.55	6.0
459	E1266	BABUL	0.50	7.0	459	E1696	BABUL	0.84	7.0
460	E1267	BABUL	0.65	7.0	460	E1697	SAGWAN	1.02	9.5
461	E1268	SHIRAS	0.62	7.0	461	E1698	SAGWAN	0.67	9.0
462	E1269	SHIRAS	0.87	7.5	462	E1699	SAGWAN	0.67	9.0
463	E1272	SHIRAS	0.76	6.0	463	E1700	SAGWAN	0.67	9.0
464	E1273	SHIRAS	0.69	6.0	464	E1701	SAGWAN	0.48	8.0
465	E1274	SHIRAS	0.55	5.0	465	E1702	SAGWAN	0.42	9.0
466	E1275	SHIRAS	0.59	5.0	466	E1703	SIMAR	0.56	9.0
467	E1276	PIPAL	0.57	4.0	467	E1704	SAGWAN	0.52	7.0
468	E1277	KARANJI	0.57	6.0	468	E1705	SAGWAN	0.42	7.0
469	E1278	BABUL	0.84	4.0	469	E1706	SAGWAN	0.55	8.0
470	E1279	BABUL	0.72	4.0	470	E1707	KARANJI	1.48	9.0
471	E1280	BABUL	0.62	5.0	471	E1708	SAGWAN	0.68	8.0
472	E1281	CHICHWA	0.98	6.0	472	E1709	SAGWAN	0.99	9.0
473	E1282	CHICHWA	1.31	6.0	473	E1710	SIMAR	0.57	9.0
474	E1283	CHICHWA	1.20	4.0	474	E1711	SAGWAN	0.96	9.0
475	E1284	SHISHUM	1.38	5.0	475	E1712	SAGWAN	0.65	3.0
476	E1285	SHIRAS	1.20	6.0	476	E1713	SAGWAN	0.90	8.5
477	E1286	NEEM	0.47	4.0	477	E1714	SAGWAN	0.77	8.0
478	E1292	NEEM	1.32	6.0	478	E1715	SAGWAN	0.72	9.0
479	E1293	CHICHWA	1.28	6.0	479	E1716	KARANJI	0.68	6.0
480	E1294	NEEM	1.43	6.0	480	E1717	SAGWAN	1.25	8.0
481	E1295	KARANJI	0.84	6.0	481	E1718	NEEM	0.55	4.0
482	E1299	SIMAR	0.88	5.0	482	E1719	SAGWAN	0.62	8.0
483	E1302	KARANJI	0.68	5.0	483	E1720	SAGWAN	0.95	8.5
484	E1303	CHICHWA	0.75	3.0	484	E1721	SAG	0.96	8.0
485	E1304	NEEM	4.62	4.0	485	E1722	KARANJI	1.48	5.8
486	E1307	NEEM	1.32	5.0	486	E1723	SAGWAN	0.90	5.0
487	E1308	NEEM	1.12	5.0	487	E1724	SAG	0.56	7.0
488	E1309	NEEM	4.80	7.0	488	E1725	SAG	1.43	8.0
489	E1312	NEEM	1.38	6.0	489	E1726	SAG	0.82	7.5

SN	TREE NO.	SPECIES	GIRTH	HEIGHT (m)	SN	TREE NO.	SPECIES	GIRTH	HEIGHT (m)
LEFT SIDE					RIGHT SIDE				
490	E1313	NEEM	1.32	5.0	490	E1727	BABUL	0.67	7.0
491	E1314	KARANJI	0.90	6.0	491	E1728	SAG	1.15	7.5
492	E1315	KARANJI	0.58	5.0	492	E1729	SAG	0.88	7.5
493	E1316	NEEM	1.23	6.0	493	E1730	SIMAR	2.24	8.2
494	E1317	CHICHWA	0.91	6.0	494	E1731	MAAYRUG	0.88	8.5
495	E1318	CHICHWA	0.58	4.0	495	E1732	BABUL	1.02	7.0
496	E1319	BOR	1.27	5.0	496	E1733	SAG	0.84	7.0
497	E1320	HIWAR	0.60	6.0	497	E1734	SAG	1.15	7.8
498	E1321	PALAS	0.90	3.0	498	E1735	SAG	0.99	8.0
499	E1322	BOR	1.26	4.0	499	E1736	SAG	1.42	8.0
500	E1345	HIWAR	1.55	6.0	500	E1737	SAG	0.58	8.0
501	E1346	NEEM	0.73	6.0	501	E1738	SAG	0.82	8.2
502	E1347	CHICHWA	0.32	4.0	502	E1739	KARANJI	0.89	6.0
503	E1348	CHICHWA	0.52	6.0	503	E1740	BABUL	1.10	5.0
504	E1349	KARANJI	1.02	6.0	504	E1741	KARANJI	0.75	8.0
505	E1350	SHISHUM	1.32	6.0	505	E1742	BABUL	1.03	7.5
506	E1351	KARANJI	1.32	4.0	506	E1743	SAGWAN	1.16	8.5
507	E1352	CHICHWA	1.14	5.0	507	E1744	SAGWAN	1.42	8.0
508	E1353	CHICHWA	1.28	6.0	508	E1745	CHICHWA	0.58	6.0
509	E1354	KARANJI	1.33	6.0	509	E1746	NEEM	1.70	8.0
510	E1355	GODHAN	1.20	7.0	510	E1747	SAGWAN	1.12	8.0
511	E1368	BABUL	0.72	5.0	511	E1748	SAGWAN	0.48	8.0
512	E1369	BABUL	0.45	5.0	512	E1749	BABUL	0.98	5.0
513	E1371	SHIRAS	0.60	4.0	513	E1750	SAGWAN	0.95	8.0
514	E1374	SHIRAS	1.24	5.0	514	E1751	BABUL	0.89	7.0
515	E1375	SHIRAS	2.20	6.0	515	E1752	MAAYRUG	1.08	9.0
516	E1376	SHIRAS	0.88	6.0	516	E1753	SAGWAN	0.90	8.5
517	E1377	SHIRAS	0.90	6.0	517	E1754	SAGWAN	1.14	8.0
518	E1378	GULMOHAR	1.90	6.0	518	E1776	CHICHWA	1.88	6.0
519	E1379	GULMOHAR	2.56	7.0	519	E1777	CHICHWA	1.27	5.0
520	E1380	GULMOHAR	1.05	7.0	520	E1778	CHICHWA	0.53	5.0
521	E1381	CHICHWA	1.24	5.0	521	E1779	CHICHWA	0.48	6.0
522	E1382	CHICHWA	1.42	5.0	522	E1780	CHICHWA	1.10	6.0
523	E1383	CHICHWA	1.12	4.0	523	E1781	CHICHWA	0.62	6.0
524	E1384	CHICHWA	0.85	4.0	524	E1782	CHICHWA	0.95	6.0
525	E1385	CHICHWA	1.60	6.0	525	E1783	SHIRAS	1.57	7.0
526	E1386	CHICHWA	1.08	6.0	526	E1784	CHICHBHILAI	1.43	8.0
527	E1387	GULMOHAR	1.23	6.0	527	E1785	CHICHBHILAI	1.27	8.0
528	E1388	GULMOHAR	0.85	5.0	528	E1786	SAGWAN	0.62	8.0
529	E1389	GULMOHAR	1.32	5.0	529	E1787	SAGWAN	0.85	9.0
530	E1390	SHIRAS	1.48	6.0	530	E1788	SAGWAN	1.08	8.5
531	E1391	CHICHWA	1.22	5.0	531	E1789	SAGWAN	1.08	7.5
532	E1392	CHICHWA	1.41	5.0	532	E1790	SAGWAN	0.87	8.0
533	E1393	GULMOHAR	1.17	3.0	533	E1805	NEEM	3.11	8.0
534	E1394	SHIRAS	0.93	4.0	534	E1806	SAGWAN	0.91	7.0
535	E1399	SHIRAS	0.99	5.0	535	E1807	SAGWAN	0.53	6.0
536	E1400	BABUL	1.46	4.0	536	E1810	KARANJI	1.07	5.0
537	E1401	BABUL	0.92	4.0	537	E1811	MAAYRUG	1.43	8.5
538	E1402	CHICHWA	0.72	3.0	538	E1812	SAGWAN	0.75	6.8

SN	TREE NO.	SPECIES	GIRTH	HEIGHT (m)	SN	TREE NO.	SPECIES	GIRTH	HEIGHT (m)
LEFT SIDE					RIGHT SIDE				
539	E1403	CHICHWA	0.81	4.0	539	E1813	CHICHWA	0.82	5.0
540	E1404	CHICHWA	0.85	4.0	540	E1814	CHICHWA	0.92	6.0
541	E1405	CHICHWA	0.85	5.0	541	E1815	SAGWAN	0.43	5.0
542	E1406	CHICHWA	0.81	5.0	542	E1816	MAAYRUG	1.32	7.0
543	E1407	BOR	0.62	3.0	543	E1817	SAGWAN	0.50	5.0
544	E1408	BOR	0.52	3.0	544	E1818	SAGWAN	0.65	4.5
545	E1409	BAMBU	3.98	7.0	545	E1819	SAGWAN	0.38	4.5
546	E1410	NEEM	0.67	4.0	546	E1820	MAAYRUG	1.41	8.0
547	E1411	BAMBU	2.22	7.0	547	E1821	SAGWAN	0.60	3.0
548	E1412	NEEM	1.04	5.0	548	E1822	SAGWAN	0.75	3.5
549	E1413	NEEM	0.93	4.0	549	E1823	NEEM	1.09	5.5
550	E1425	NEEM	0.98	3.0	550	E1824	NEEM	1.20	5.5
551	E1426	CHICHWA	1.52	5.0	551	E1825	KARANJI	1.25	5.0
552	E1427	CHICHWA	0.60	4.0	552	E1826	KARANJI	1.38	6.5
553	E1428	CHICHWA	0.78	5.0	553	E1827	NEEM	0.80	6.0
554	E1429	PALAS	0.55	3.0	554	E1828	NEEM	0.82	5.8
555	E1430	KARANJI	0.81	6.0	555	E1829	CHICHBHILAI	0.67	5.0
556	E1431	COCONUT	0.58	7.0	556	E1830	CHICHBHILAI	0.75	5.0
557	E1432	SITAFAL	0.73	4.0					
558	E1433	BABUL	0.49	5.0					
559	E1434	PALAS	0.59	3.0					
560	E1435	SUBABUL	1.26	7.0					
561	E1439	NEEM	1.35	5.0					
562	E1440	SHIRAS	0.82	5.0					
563	E1441	CHICHWA	0.78	3.0					
564	E1442	CHICHWA	0.99	4.0					
565	E1443	SHIRAS	1.00	5.0					
566	E1444	CHICHWA	0.92	4.0					
567	E1445	CHICHWA	0.8	4.0					
568	E1446	CHICHWA	0.78	3.0					
569	E1447	CHICHWA	1.14	4.0					
570	E1448	BAMBU	3.45	7.0					
571	E1449	BAMBU	2.45	7					
572	E1450	SHIRAS	0.97	5.0					
573	E1451	NEEM	0.94	5.0					
574	E1452	SHIRU	0.73	3.0					
575	E1453	SIMAR	0.37	6.0					
576	E1454	SIMAR	0.54	6.0					
577	E1458	SIMAR	0.50	6.0					
578	E1459	NEEM	0.79	5.0					
579	E1460	NEEM	0.75	5.0					
580	E1461	GULMOHAR	1.63	6.0					
581	E1462	CHICHWA	1.06	5					
582	E1463	SIMAR	0.60	6.0					
583	E1464	PALAS	1.08	5.0					
584	E1465	CHICHWA	0.57	4.0					
585	E1466	CHICHWA	1.98	4.0					
586	E1472	GULMOHAR	0.90	6.0					
587	E1473	GULMOHAR	0.94	6.0					

SN	TREE NO.	SPECIES	GIRTH	HEIGHT (m)	SN	TREE NO.	SPECIES	GIRTH	HEIGHT (m)
LEFT SIDE					RIGHT SIDE				
588	E1474	GULMOHAR	0.54	5.0					
589	E1475	GULMOHAR	1.02	6.0					
590	E1476	GULMOHAR	1.28	6.0					
591	E1477	GULMOHAR	1.30	6.0					
592	E1478	GULMOHAR	0.95	5.0					
593	E1479	GULMOHAR	1.32	6.0					
594	E1480	GULMOHAR	1.00	6.0					
595	E1484	SHIRAS	0.92	4.0					
596	E1485	GULMOHAR	0.81	5.0					
597	E1486	GULMOHAR	1.28	6.0					
598	E1487	GULMOHAR	1.60	6.0					
599	E1488	GULMOHAR	0.75	5.0					
600	E1489	NEEM	0.67	4.0					
601	E1490	GULMOHAR	1.00	6.0					
602	E1491	GULMOHAR	0.90	6.0					
603	E1492	NEEM	2.52	7.0					
604	E1493	KARANJI	0.42	3.0					
605	E1494	KARANJI	0.38	4.0					
606	E1495	CHICHWA	0.32	3.0					
607	E1496	CHICHWA	1.04	5.0					
608	E1497	CHICHWA	1.30	4.0					
609	E1498	CHICHWA	0.95	4.0					
610	E1499	CHICHWA	1.40	5.0					
611	E1500	KARANJI	1.02	6.0					
612	E1501	KARANJI	0.95	6.0					
613	E1502	KARANJI	1.28	5.0					
614	E1503	CHICHWA	1.33	6.0					
615	E1504	CHICHWA	0.37	6.0					
616	E1505	KARANJI	0.88	5.0					
617	E1506	KARANJI	0.89	5.0					
618	E1507	GULMOHAR	1.85	6.0					
619	E1508	CHICHWA	1.07	5.0					
620	E1525	SIMAR	0.55	6.0					
621	E1526	NEEM	2.48	5.0					
622	E1527	SAGWAN	2.02	7.0					
623	E1528	NEEM	0.89	4.0					
624	E1529	CHICHWA	0.85	5.0					
625	E1530	KARANJI	0.65	5.0					
626	E1531	SAGWAN	1.03	7.0					
627	E1532	SAGWAN	0.92	5.0					
628	E1533	CHICHWA	0.87	4.0					
629	E1534	CHICHWA	0.85	4.0					
630	E1535	CHICHWA	0.82	4.0					
631	E1536	CHICHWA	0.72	5.0					
632	E1537	CHICHWA	0.91	5.0					
633	E1538	NEEM	0.91	4.0					
634	E1539	SHIRUS	0.75	5.0					
635	E1540	KARANJI	1.35	6.0					
636	E1541	CHICHWA	1.04	5.0					

SN	TREE NO.	SPECIES	GIRTH	HEIGHT (m)	SN	TREE NO.	SPECIES	GIRTH	HEIGHT (m)
		LEFT SIDE					RIGHT SIDE		
637	E1545	NEEM	2.94	6.0					
638	E1546	SHIRAS	0.80	4.0					
639	E1547	GULMOHAR	1.23	6.0					
640	E1548	GULMOHAR	1.27	6.0					
641	E1549	GULMOHAR	0.67	4.0					
642	E1550	NEEM	0.59	3.0					
643	E1551	GULMOHAR	1.00	6.0					
644	E1552	SHIRAS	0.86	5.0					
645	E1553	NEEM	0.30	4.0					
646	E1554	KARANJI	1.12	5.0					
647	E1555	KARANJI	0.76	4.0					
648	E1556	SHIRAS	1.18	5.0					
649	E1557	KARANJI	0.96	4.0					
650	E1558	SIMAR	0.98	6.0					
651	E1559	GULMOHAR	1.41	6.0					
652	**E1560**	**CHICHWA**	**0.72**	**4.0**					
653	E1561	CHICHWA	0.98	4.0					
654	E1562	KARANJI	0.45	5.0					
655	E1563	KARANJI	2.50	7.0					
656	E1564	CHICHWA	0.65	5.0					
657	E1565	CHICHWA	1.03	5.0					
658	E1566	CHICHWA	0.50	4.0					
659	E1567	CHICHWA	0.68	4.0					
660	E1568	GULMOHAR	1.17	6.0					
661	E1569	BOR	0.76	5.0					
662	E1570	GULMOHAR	1.35	6.0					
663	E1571	CHICHWA	0.93	5.0					
664	E1572	GULMOHAR	1.42	7.0					
665	E1573	CHICHWA	0.90	5.0					
666	E1574	BAAS	4.22	7.0					
667	E1575	SUBABUL	0.47	6.0					
668	E1576	NEEM	3.46	6.0					
669	E1583	NEEM	3.20	6.0					
670	E1591	CHICHWA	1.88	6.0					
671	E1592	CHICHWA	1.47	6.0					
672	E1603	CHICHWA	0.80	5.0					
673	E1604	ASHOKA	0.85	6.0					
674	E1609	ASHOKA	0.72	6.0					
675	E1610	SAGWAN	0.45	5.0					
676	E1611	SAGWAN	0.92	5.0					
677	E1612	SAGWAN	0.68	6.0					
678	E1613	NEEM	1.28	4.0					
679	E1614	SAGWAN	0.50	6.0					
680	E1615	SAGWAN	0.54	5.0					
681	E1616	SAGWAN	0.43	5.0					
682	E1617	SIMAR	0.48	6.0					
683	E1618	SAGWAN	0.62	4.0					
684	E1635	SAGWAN	0.55	4.0					
685	E1637	SAG	0.32	6.0					

SN	TREE NO.	SPECIES	GIRTH	HEIGHT (m)	SN	TREE NO.	SPECIES	GIRTH	HEIGHT (m)
LEFT SIDE					RIGHT SIDE				
686	E1638	SAG	0.48	6.0					
687	E1639	SAG	0.43	5.0					
688	E1640	MAAYRUG	1.28	5.0					
689	E1641	NEEM	0.87	7.5					
690	E1642	NEEM	0.62	7.5					
691	E1643	KARANJI	1.70	5.0					
692	E1644	SAGWAN	0.52	7.0					
693	E1645	SAGWAN	0.45	7.0					
694	E1646	SAGWAN	0.52	6.0					
695	E1647	NEEM	0.58	7.0					
696	E1674	NEEM	1.52	8.0					
697	E1675	ASHOKA	0.52	7.0					
698	E1676	CHICHWA	0.47	6.0					
699	E1677	ASHOKA	0.42	7.0					
700	E1678	ASHOKA	0.57	7.0					
701	E1679	ASHOKA	0.57	8.0					
702	E1680	ASHOKA	0.62	6.0					
703	E1681	ASHOKA	0.55	6.0					
704	E1755	CHINCH	2.28	8.5					
705	E1756	CHINCH	1.48	9.0					
706	E1757	CHINCH	1.70	9.0					
707	E1758	CHINCH	1.70	8.8					
708	E1759	CHINCH	1.55	9.0					
709	E1760	KARANJI	2.25	7.0					
710	E1761	NEEM	1.35	7.0					
711	E1762	PIPAL	2.54	8.0					
712	E1763	SUBABUL	1.52	6.0					
713	E1764	NEEM	1.23	6.0					
714	E1765	KARANJI	0.60	4.0					
715	E1766	MANGO	1.55	6.5					
716	E1767	CHICHWA	0.48	3.0					
717	E1768	SAGWAN	1.60	7.0					
718	E1769	SAGWAN	0.84	7.5					
719	E1770	SAGWAN	0.80	7.0					
720	E1771	SAGWAN	0.77	6.7					
721	E1772	SAGWAN	0.95	7.0					
722	E1773	SAGWAN	0.94	8.0					
723	E1774	SAGWAN	0.78	8.0					
724	E1775	SAGWAN	0.75	7.0					
725	E1791	SAGWAN	1.52	8.0					
726	E1792	SAGWAN	0.58	3.0					
727	E1793	SAGWAN	0.69	6.0					
728	E1794	SAGWAN	0.88	7.5					
729	E1795	SAGWAN	0.59	6.0					
730	E1796	NEEM	1.64	7.0					
731	E1797	SAGWAN	0.64	7.0					
732	E1798	SAGWAN	0.58	6.5					
733	E1799	SAGWAN	0.98	7.0					
734	E1800	SAGWAN	0.99	7.5					

SN	TREE NO.	SPECIES	GIRTH	HEIGHT (m)	SN	TREE NO.	SPECIES	GIRTH	HEIGHT (m)
LEFT SIDE					RIGHT SIDE				
735	E1801	SAGWAN	0.65	6.0					
736	E1802	SAGWAN	0.95	7.0					
737	E1803	SAGWAN	1.00	0.7					
738	E1804	SAGWAN	0.77	7.0					
739	E1808	SAGWAN	0.87	7.0					
740	E1809	SAGWAN	0.52	7.0					
741	E1831	SAGWAN	0.78	6.0					
742	E1832	SAGWAN	1.1	8.0					
743	E1833	SHIRAS	1.24	7.8					
744	E1834	CHICHWA	1.6	8.2					
745	E1835	SHIRAS	1.65	8.0					
746	E1836	CHINCH	2.88						
747	E1837	CHICHWA	1.20	7.8					
748	E1838	CHINCH	1.32	8.0					
749	E1839	CHICHWA	1.22	7.5					
750	E1840	BABUL	1.52	7.0					
751	E1841	BABUL	1.43	7.0					
752	E1842	KARANJI	1.12	6.0					
753	E1843	KARANJI	0.97	6.0					

ANNEXURE 5.3 LIST OF TREES IN CORRIDOR 3A

SN	TREE NO.	SPECIES	GIRTH IN M.	HEIGHT IN M.	SN	TREE NO.	SPECIES	GIRTH IN M.	HEIGHT IN M.
LEFT SIDE					RIGHT SIDE				
1	E-222	NEEM	1.00	10.0	1	E-221	NEEM	1.2	9.0
2	E-224	NEEM	2.10	8.0	2	E-223	NEEM	1.2	9.0
3	E-227	NEEM	2.00	9.0	3	E-225	NEEM	2.9	9.0
4	E-227A	UNKNOWN	0.50	9.0	4	E-225A	UNKNOWN	1.3	9.0
5	E-231	MAHARUK	0.40	8.0	5	E-226	NEEM	2.1	8.0
6	E-232	NEEM	0.70	7.0	6	E-228	NEEM	1.5	9.0
7	E-237	NEEM	0.80	5.0	7	E-229	UMBER	0.7	6.0
8	E-238	MAHARUK	0.90	7.0	8	E-229A	UNKNOWN	0.8	6.0
9	E-239	SUBABUL	0.80	6.0	9	E-230	UMBER	0.6	7.0
10	E-240	NEEM	0.90	8.0	10	E-233	UMBER	0.8	6.0
11	E-241	SHEWANGA	0.40	7.0	11	E-234	UMBER	0.8	6.0
12	E-242	SUBABUL	0.90	9.0	12	E-235	MAHARUK	0.7	6.0
13	E-262	CHINCH	3.40	10.0	13	E-236	MAHARUK	0.9	8.0
14	E-264	NEEM	0.50	8.0	14	E-243	GULMOHAR	0.8	8.0
15	E-265	NEEM	0.30	5.0	15	E-244	GULMOHAR	0.7	9.0
16	E-266	NEEM	0.50	6.0	16	E-245	SUKHA PED	0.6	5.0
17	E-267	NEEM	0.60	7.0	17	E-246	SUKHA PED	0.6	5.0
18	E-278	NEEM	0.30	4.0	18	E-247	GULMOHAR	0.7	6.0
19	E-279	SUBABUL	0.80	7.0	19	E-248	UMBER	0.6	7.0
20	E-280	NEEM	0.60	8.0	20	E-249	SUKHA PED	0.7	6.0
21	E-281	NEEM	0.70	9.0	21	E-250	UMBER	0.3	4.0
22	E-282	NEEM	0.50	4.0	22	E-251	UMBER	0.8	7.0

SN	TREE NO.	SPECIES	GIRTH IN M.	HEIGHT IN M.	SN	TREE NO.	SPECIES	GIRTH IN M.	HEIGHT IN M.
LEFT SIDE					RIGHT SIDE				
23	E-284	NEEM	1.00	8.0	23	E-252	UMBER	0.8	7.0
24	E-285	DEVBABUL	0.80	7.0	24	E-253	UMBER	0.9	8.0
25	E-286	NEEM	0.90	7.0	25	E-254	UMBER	0.8	9.0
26	E-289	PIMPAL	0.60	8.0	26	E-255	UMBER	0.7	8.0
27	E-290	NEEM	0.90	8.0	27	E-256	AANJAN	0.9	10.0
28	E-292	NEEM	0.90	8.0	28	E-257	KARANJI	0.8	9.0
29	E-296	GULMOHAR	0.40	6.0	29	E-258	BABUL	0.8	8.0
30	E-297	NEEM	1.10	6.0	30	E-259	PIMPAL	2.2	9.0
31	E-302	NEEM	1.90	9.0	31	E-260	WAD	3	11.0
32	E-303	NEEM	1.60	8.0	32	E-261	KARANJI	0.9	4.0
33	E-308	NEEM	1.90	7.0	33	E-263	NEEM	0.9	10.0
34	E-315	NEEM	0.50	6.0	34	E-268	NEEM	0.7	8.0
35	E-316	NEEM	0.60	6.0	35	E-269	NEEM	0.6	8.0
36	E-325	NEEM	0.80	7.0	36	E-270	NEEM	0.5	7.0
37	E-331	NEEM	0.90	7.0	37	E-271	NEEM	0.5	6.0
38	E-332	NEEM	0.80	8.0	38	E-272	UMBER	0.6	8.0
39	E-333	NEEM	0.50	7.0	39	E-273	NEEM	0.7	7.0
40	E-334	NEEM	0.70	7.0	40	E-274	NEEM	0.7	8.0
41	E-335	NEEM	0.90	8.0	41	E-275	UMBER	0.6	7.0
42	E-336	PIMPAL	1.00	8.0	42	E-276	UMBER	0.5	8.0
43	E-338	NEEM	0.60	5.0	43	E-277	UMBER	0.7	8.0
44	E-340	PIMPAL	2.00	8.0	44	E-283	UMBER	0.6	6.0
45	E-341	NEEM	0.60	5.0	45	E-287	NEEM	2.1	12.0
46	E-342	NEEM	0.60	6.0	46	E-288	NEEM	1.9	9.0
47	E-343	NEEM	0.50	5.0	47	E-291	NEEM	2	9.0
48	E-343A	UNKNOWN	0.70	6.0	48	E-293	KARAI	1	8.0
49	E-343B	UNKNOWN	0.60	7.0	49	E-294	NEEM	0.9	8.0
50	E-343C	UNKNOWN	0.50	5.0	50	E-295	NEEM	0.8	7.0
51	E-343D	UNKNOWN	0.70	5.0	51	E-298	NEEM	1.2	7.0
52	E-343E	UNKNOWN	0.80	7.0	52	E-299	KARANJI	0.7	6.0
53	E-344	CHINCHWA	0.90	8.0	53	E-300	KARANJI	0.5	6.0
54	E-345	SUBABUL	0.40	4.0	54	E-301	KARANJI	0.6	6.0
55	E-346	CHINCHWA	0.60	5.0	55	E-304	NEEM	2	8.0
56	E-351	SUBABUL	0.60	7.0	56	E-305	KARAI	0.6	8.0
57	E-356	CHINCHWA	0.70	9.0	57	E-306	KARAI	0.4	5.0
58	E-361	SUBABUL	0.70	9.0	58	E-307	KARAI	0.5	5.0
59	E-362	SUBABUL	0.60	8.0	59	E-309	KARAI	0.4	6.0
60	E-364	NEEM	0.60	7.0	60	E-310	KARAI	0.7	7.0
61	E-364A	UNKNOWN	0.70	6.0	61	E-311	PIMPAL	0.8	10.0
62	E-364B	UNKNOWN	0.60	5.0	62	E-312	PIMPAL	0.6	8.0
63	E-364C	UNKNOWN	0.70	6.0	63	E-313	PIMPAL	0.6	8.0
64	E-364D	UNKNOWN	0.50	7.0	64	E-314	NEEM	0.7	7.0
65	E-364E	UNKNOWN	0.70	6.0	65	E-317	NEEM	0.9	7.0
66	E-364F	UNKNOWN	0.70	5.0	66	E-318	KARAI	0.6	8.0
67	E-364G	UNKNOWN	0.70	5.0	67	E-319	KARAI	0.6	8.0

SN	TREE NO.	SPECIES	GIRTH IN M.	HEIGHT IN M.	SN	TREE NO.	SPECIES	GIRTH IN M.	HEIGHT IN M.
LEFT SIDE					RIGHT SIDE				
68	E-369	NEEM	0.80	6.0	68	E-320	KARAI	0.4	5.0
69	E-369A	UNKNOWN	0.80	6.0	69	E-321	KARAI	0.3	4.0
70	E-369B	UNKNOWN	0.80	6.0	70	E-322	PIMPAL	0.5	5.0
71	E-369C	UNKNOWN	0.70	6.0	71	E-323	NEEM	0.7	6.0
72	E-369D	UNKNOWN	0.80	6.0	72	E-324	SHEWANGA	0.6	7.0
73	E-369E	UNKNOWN	0.60	6.0	73	E-326	KARAI	0.6	5.0
74	E-369F	UNKNOWN	0.50	6.0	74	E-327	DEVBABUL	0.5	5.0
75	E-369G	UNKNOWN	0.6	6.0	75	E-328	KARAI	0.6	6.0
76	E-371	CHINCHWA	0.50	6.0	76	E-329	KARAI	0.6	6.0
77	E-374	CHINCHWA	0.90	8.0	77	E-330	KARAI	0.4	5.0
78	E-375	SUBABUL	0.40	4.0	78	E-337	CHINCHWA	0.4	6.0
79	E-376	CHINCHWA	0.60	5.0	79	E-339	KARAI	0.6	6.0
80	E-377	SUBABUL	0.60	7.0	80	E-347	GULMOHAR	0.6	6.0
81	E-378	CHINCHWA	0.70	9.0	81	E-348	GULMOHAR	0.6	6.0
82	E-385	SUBABUL	0.70	9.0	82	E-349	GULMOHAR	0.6	6.0
83	E-386	SUBABUL	0.60	8.0	83	E-350	GULMOHAR	0.5	6.0
84	E-387	NEEM	0.60	7.0	84	E-352	DEVBABUL	0.5	6.0
85	E-388	UNKNOWN	0.70	6.0	85	E-353	DEVBABUL	0.6	7.0
86	E-389	UNKNOWN	0.60	5.0	86	E-354	DEVBABUL	0.7	6.0
87	E-390	UNKNOWN	0.70	6.0	87	E-355	DEVBABUL	0.6	7.0
88	E-391	UNKNOWN	0.50	7.0	88	E-357	GULMOHAR	0.8	6.0
89	E-392	UNKNOWN	0.70	6.0	89	E-358	GULMOHAR	0.9	6.0
90	E-393	GULMOHAR	0.8	6.0	90	E-359	GULMOHAR	0.9	7.0
91	E-394	GULMOHAR	0.9	6.0	91	E-360	GULMOHAR	0.5	7.0
92	E-395	GULMOHAR	0.9	7.0	92	E-363	NEEM	0.6	6.0
93	E-396	GULMOHAR	0.5	7.0	93	E-365	GULMOHAR	0.7	7.0
94	E-397	CHINCHWA	0.60	5.0	94	E-366	SUBABUL	0.7	6.0
95	E-401	SUBABUL	0.60	7.0	95	E-367	NEEM	0.7	9.0
96	E-402	CHINCHWA	0.70	9.0	96	E-368	NEEM	0.8	8.0
97	E-403	SUBABUL	0.70	9.0	97	E-368A	UNKNOWN	0.7	7.0
98	E-404	SUBABUL	0.70	9.0	98	E-370	NEEM	0.8	6.0
99	E405	BADAM	0.53	5.0	99	E-370A	UNKNOWN	0.7	7.0
100	E406	NEEM	0.58	6.0	100	E-370B	UNKNOWN	0.8	6.0
101	E406A	NEEM	0.63	5.0	101	E-370C	UNKNOWN	0.8	6.0
102	E407	NEEM	1.16	7.0	102	E-372	GULMOHAR	0.5	8.0
103	E408	BABUL	1.30	7.0	103	E-373	NEEM	0.9	9.0
104	E409	NEEM	0.48	6.0	104	E-379	UNKNOWN	0.7	7.0
105	E410	NEEM	1.02	5.0	105	E-380	UNKNOWN	0.8	6.0
106	E412	KARANJI	0.68	5.0	106	E-381	UNKNOWN	0.8	6.0
107	E413	SIRAS	1.40	7.0	107	E-382	DEVBABUL	0.7	6.0
108	E416	SIRAS	0.29	6.0	108	E-383	DEVBABUL	0.6	7.0
109	E417	PIPAL S	1.09	5.0	109	E-384	GULMOHAR	0.8	6.0
110	E418	SIRAS	0.29	6.0	110	E-398	GULMOHAR	0.9	6.0
111	E419	SIRAS	0.87	6.0	111	E-399	GULMOHAR	0.9	7.0
112	E420	NEEM	0.97	6.0	112	E-400	GULMOHAR	0.5	7.0
113	E421	SIRAS	2.08	6.0	113	E-405	UNKNOWN	0.8	6.0
114	E422	KARANJI	2.30	6.0	114	E-406	UNKNOWN	0.8	6.0
115	E424	KARANJI	1.02	6.0	115	E404	NEEM	0.92	4.0
116	E425	KARANJI	0.94	5.0	116	E411	NEEM	0.89	4.0

SN	TREE NO.	SPECIES	GIRTH IN M.	HEIGHT IN M.	SN	TREE NO.	SPECIES	GIRTH IN M.	HEIGHT IN M.
LEFT SIDE					RIGHT SIDE				
117	E426	KARANJI	0.92	5.0	117	E414	NEEM	0.58	4.0
118	E427	KARANJI	1.08	6.0	118	E415	CHIKU	0.98	5.0
119	E427A	NEEM	0.60	6.0	119	E423	NEEM	0.80	6.0
120	E431	KARANJI	0.94	6.0	120	E428	NEEM	0.58	4.0
121	E434	NEEM	1.51	7.0	121	E429	KARANJI	0.72	6.0
122	E439	KARANJI	1.07	4.0	122	E430	NEEM	0.80	6.0
123	E440	KARANJI	1.09	2.0	123	E432	KARANJI	0.72	4.0
124	E442	KARANJI	1.13	6.0	124	E433	PIPAL	3.14	8.0
125	E443	SIRAS	0.75	5.0	125	E435	PIPAL	2.45	7.0
126	E444	BABUL	0.42	6.0	126	E436	PIPAL	3.14	8.0
127	E449	SIRAS	0.60	4.0	127	E437	PIPAL	2.90	7.0
128	E450	WAD	1.82	6.0	128	E438	GULMOHAR	1.18	6.0
129	E460	SIRAS	0.89	6.0	129	E441	BADAM	0.38	6.0
130	E462	SIRAS	0.72	5.0	130	E445	SIRAS	0.90	2.0
131	E464	ASHOKA	0.41	5.0	131	E446	SIRAS	0.97	4.0
132	E465	NEEM	1.62	6.0	132	E447	BABUL	0.82	3.0
133	E466	UMARI	1.11	6.0	133	E448	PIPAL	1.33	6.0
134	E467	ASHOKA	0.36	6.0	134	E451	NEEM	0.57	4.0
135	E473	BABUL	0.38	5.0	135	E452	CHICHWA	0.89	5.0
136	E474	CHICHBILAI	2.36	6.0	136	E453	CHICHWA	1.12	6.0
137	E478	NEEM	1.53	5.0	137	E454	CHICHWA	0.90	6.0
138	E479	KARANJI	0.91	6.0	138	E455	NEELGIRI	1.43	8.0
139	E480	KARANJI	0.97	6.0	139	E456	HIWAR	0.20	2.0
140	E480A	KARANJI	0.71	5.0	140	E457	BADAM	0.37	6.0
141	E482	GULMOHAR	1.52	7.0	141	E458	HIWAR	1.62	7.0
142	E483	KARANJI	0.71	5.0	142	E459	NEEM	1.86	7.0
143	E488	BABUL	1.19	6.0	143	E461	NEEM	1.11	6.0
144	E489	NEEM	0.82	5.0	144	E463	CHINCH	2.18	7.0
145	E490	BABUL	0.87	6.0	145	E468	NEEM	1.11	6.0
146	E491	SIRAS	1.06	6.0	146	E469	CHINCH	1.78	7.0
147	E495	BABUL	0.87	6.0	147	E470	NEEM	1.67	7.0
148	E496	BOR	1.00	5.0	148	E471	CHICHBILAI	2.38	6.0
149	E497	NEEM	1.02	6.0	149	E472	CHICHBILAI	1.83	7.0
150	E498	NEEM	0.98	5.0	150	E475	NEEM	1.25	6.0
151	E499	GULMOHAR	0.50	4.0	151	E476	VAD	0.39	3.0
152	E500	NEEM	0.87	6.0	152	E477	NEEM	0.87	6.0
153	E501	NEEM	0.84	6.0	153	E481	PADAS	0.82	6.0
154	E502	BABUL	0.68	5.0	154	E484	NEEM	1.25	6.0
155	E503	BOR	0.57	4.0	155	E485	BADAM	0.37	4.0
156	E504	NEEM	0.94	6.0	156	E486	NEEM	2.63	6.0
157	E506	BABUL	0.58	6.0	157	E487	SUBABUL	1.18	6.0
158	E507	BABUL	0.82	6.0	158	E492	KARANJI	0.38	5.0
159	E508	NEEM	1.47	6.0	159	E493	NEEM	1.65	7.0
160	E509	BABUL	0.49	6.0	160	E494	SUBABUL	0.65	6.0
161	E510	NEEM	1.02	7.0	161	E505	PALAS	1.02	6.0
162	E511	BABUL	0.82	6.0	162	E522	PIPAL	0.45	3.0
163	E512	SIRAS	1.10	5.0	163	E529	NEEM	1.10	6.0
164	E513	SIRAS	0.60	5.0	164	E560	GULMOHAR	0.51	6.0
165	E514	JAMUN	0.80	4.0	165	E561	CHINCH	3.20	7.0

SN	TREE NO.	SPECIES	GIRTH IN M.	HEIGHT IN M.	SN	TREE NO.	SPECIES	GIRTH IN M.	HEIGHT IN M.
LEFT SIDE					RIGHT SIDE				
166	E515	NEEM	0.60	4.0	166	E562	GULMOHAR	1.08	6.0
167	E516	CHCHWA	0.98	3.0	167	E563	MAYRUNG	1.89	7.0
168	E517	NEELGIRI	1.85	8.0	168	E564	CHINCH	3.20	7.0
169	E518	SHISHUM	1.10	7.0	169	E565	COCONUT	1.22	9.0
170	E519	SIRAS	1.00	6.0	170	E566	COCONUT	1.00	5.0
171	E520	NEELGIRI	1.48	7.0	171	E567	CHINCH	0.92	5.0
172	E521	ASHOKA	0.92	6.0	172	E568	GULMOHAR	1.08	6.0
173	E523	ASHOKA	1.22	6.0	173	E569	GULMOHAR	1.00	6.0
174	E524	NEELGIRI	1.70	8.0	174	E580	MANGO	1.55	6.0
175	E525	ASHOKA	0.72	5.0	175	E581	MAYRUNG	0.98	5.0
176	E526	ASHOKA	0.60	5.0	176	E582	VAD	0.50	4.0
177	E527	SIRAS	1.28	7.0	177	E583	PIPAL	0.40	3.0
178	E528	GULMOHAR	1.38	7.0	178	E584	PAM	1.70	8.0
179	E530	NEEM	1.54	6.0	179	E585	NEEM	0.67	4.0
180	E531	NEEM	0.90	4.0	180	E586	JAMUN	1.09	6.0
181	E532	VAD	2.78	6.0	181	E587	JAMUN	0.75	5.0
182	E533	NEEM	0.55	4.0	182	E588	PAM	1.27	5.0
183	E534	NEEM	1.35	6.0	183	E589	MANGO	1.53	7.0
184	E535	MAIRUM	1.00	6.0	184	E628	PAM	1.27	5.0
185	E536	CHICHWA	0.60	3.0	185	E629	CHICHWA	0.97	6.0
186	E537	CHICHWA	0.92	4.0	186	E630	CHICHWA	0.97	6.0
187	E538	CHICHWA	1.51	7.0	187	E631	KARANJI	1.23	6.0
188	E539	BABUL	1.45	5.0	188	E646	BABUL	2.32	7.0
189	E540	BABUL	0.69	4.0	189	E647	CHICHWA	1.09	6.0
190	E541	NEEM	0.75	3.0	190	E652	CHICHWA	0.92	5.0
191	E542	NEEM	0.58	3.0	191	E655	BABUL	1.38	5.0
192	E543	BOR	0.62	4.0	192	E656	CHICHWA	1.25	6.0
193	E544	NEEM	0.67	4.0	193	E657	KARANJI	0.52	4.0
194	E545	KARANJI	0.43	3.0	194	E657A	KARANJI	0.38	3.0
195	E546	KARANJI	0.52	3.0	195	E659	CHICHWA	1.17	6.0
196	E547	UMBAR	1.45	7.0	196	E661	CHICHWA	1.22	6.0
197	E548	NEEM	1.32	6.0	197	E663	CHICHWA	1.10	5.0
198	E549	MAIRUM	1.03	6.0	198	E664	CHICHWA	1.03	4.0
199	E550	MAIRUM	0.92	6.0	199	E666	SHRIRUS	1.13	5.0
200	E551	NEEM	0.60	4.0	200	E675	NEEM	1.12	7.0
201	E552	NEEM	0.47	3.0	201	E676	SHIRUS	0.97	6.0
202	E553	NEEM	0.87	5.0	202	E677	NEEM	0.93	6.0
203	E554	BADAM	1.10	5.0	203	E681	NEEM	0.92	6.0
204	E555	MAIRUM	0.69	6.0	204	E683	NEEM	0.63	5.0
205	E556	MAIRUM	1.28	6.0	205	E685	NEEM	1.32	6.0
206	E557	CHINCHA	1.05	6.5	206	E687	NEEM	0.83	6.0
207	E558	NEEM	1.65	6.0	207	E688	NEEM	0.71	6.0
208	E559	BARGAD	2.10	7.0	208	E689	NEEM	1.37	6.0
209	E570	CHINCHA	3.20	8.0	209	E690	PADAS	0.98	6.0
210	E571	NEEM	1.48	7.0	210	E691	BABUL	0.75	6.0
211	E572	NEEM	1.00	6.0	211	E691A	BABUL	0.70	6.0
212	E573	COCONUT	1.30	8.0	212	E692	PADAS	1.28	4.0
213	E574	NEEM	1.00	6.0	213	E693	GULMOHAR	0.93	4.0
214	E575	BABUL	1.16	6.0	214	E694	BADAM	0.45	4.0

SN	TREE NO.	SPECIES	GIRTH IN M.	HEIGHT IN M.	SN	TREE NO.	SPECIES	GIRTH IN M.	HEIGHT IN M.
LEFT SIDE					RIGHT SIDE				
215	E576	BABUL	1.22	6.0	215	E695	BADAM	0.71	6.0
216	E577	BABUL	1.30	6.0	216	E697	BABUL	0.92	5.0
217	E578	NEEM	1.24	6.0	217	E698	NEEM	0.99	5.0
218	E579	GULMOHAR	1.20	6.0	218	E699	CHICHWA	1.32	4.0
219	E590	NEEM	0.72	4.0	219	E801	GULMOHAR	0.52	7.0
220	E591	NEEM	0.75	4.0	220	E802	RAMFAD	0.90	4.0
221	E592	NEEM	1.62	6.0	221	E803	PAM	1.32	6.0
222	E593	SHIRUS	0.98	6.0	222	E804	PAM	1.50	6.0
223	E594	NEEM	0.47	4.0	223	E805	PAM	0.98	7.0
224	E595	KARANJI	1.45	6.0	224	E806	PAM	1.40	7.0
225	E596	SHIRUS	1.41	6.0	225	E809	NEEM	0.52	4.0
226	E597	NEEM	1.54	7.0	226	E810	NEEM	0.48	3.0
227	E598	BABUL	1.60	6.0	227	E813	NEEM	0.83	5.0
228	E599	GULMOHAR	0.58	5.0	228	E814	MUGNAAHENGA	0.75	4.0
229	E600	BABUL	0.42	4.0	229	E816	NEEM	0.81	6.0
230	E601	SHIRUS	1.70	6.0	230	E818	NEEM	2.10	7.0
231	E602	BABUL	0.92	6.0	231	E819	PIPAL	1.21	5.0
232	E603	BABUL	0.58	5.0	232	E824	KARANJI	0.48	3.0
233	E604	ASHOKA	0.63	4.0	233	E832	PIPAL	1.24	6.0
234	E605	BABUL	0.72	5.0	234	E833	NEEM	2.10	7.0
235	E606	BABUL	1.22	6.0	235	E837	KARANJI	0.48	3.0
236	E607	BARGAD	1.58	6.0	236	E839	BABUL	0.72	5.0
237	E608	BABUL	1.80	6.0	237	E840	SUBABUL	0.68	4.0
238	E609	CHICHWA	0.45	5.0	238	E847	NEEM	4.08	7.0
239	E610	CHICHWA	0.72	6.0	239	E848	BABUL	0.72	5.0
240	E611	CHICHWA	0.57	6.0	240	E851	BABUL	0.87	5.0
241	E612	CHICHWA	0.62	6.0	241	E852	SUBABUL	0.68	4.0
242	E613	CHICHWA	0.55	5.0	242	E853	BOR	0.59	4.0
243	E614	SHIRUS	0.65	6.0	243	E854	SHIRUS	0.80	5.0
244	E615	SHIRUS	1.70	7.0	244	E858	GULMOHAR	0.33	5.0
245	E616	SHIRUS	0.87	6.0	245	E859	GULMOHAR	0.48	5.0
246	E617	SHIRUS	0.84	5.0	246	E860	GULMOHAR	0.60	5.00
247	E618	SHIRUS	0.87	5	247	E861	BABUL	1.02	6.0
248	E619	SHIRUS	0.7	6.0	248	E862	BOR	0.70	5.0
249	E620	SHIRUS	0.75	6.0	249	E863	HIWAR	0.75	5.0
250	E621	SHIRUS	1.36	7.0	250	E864	NEEM	0.60	4.0
251	E622	NEEM	6.52	6.0	251	E865	NEEM	0.32	3.0
252	E623	KARANJI	1.27	4.0	252	E866	WAD	2.32	6.0
253	E624	KARANJI	1.02	6.0	253	E867	NEEM	0.46	5.0
254	E625	CHICHWA	1.35	7.0	254	E868	NEEM	0.30	4.0
255	E626	CHICHWA	1.72	9.0	255	E869	NEEM	0.48	6.0
256	E627	NEEM	1.07	6.0	256	E870	NEEM	0.38	5.0
257	E632	SHIRUS	0.49	5	257	E871	NEEM	0.45	5.0
258	E633	SHIRUS	0.68	6.0	258	E872	NEEM	0.62	6.0
259	E634	SHIRUS	0.79	5.0	259	E873	NEEM	0.38	5.0
260	E635	CHICHWA	0.88	6.0	260	E874	NEEM	0.75	5.0
261	E636	CHICHWA	0.95	5.0	261	E875	SHIRUS	0.70	5.0
262	E637	CHICHWA	0.94	6.0	262	E876	WAD	0.78	4.0
263	E638	CHICHWA	0.75	6.0	263	E877	NEEM	0.58	4.0

SN	TREE NO.	SPECIES	GIRTH IN M.	HEIGHT IN M.	SN	TREE NO.	SPECIES	GIRTH IN M.	HEIGHT IN M.
LEFT SIDE					RIGHT SIDE				
264	E639	CHICHWA	0.81	5.0	264	E878	NEEM	0.80	5.0
265	E640	CHICHWA	0.92	6.0	265	E879	SUBABUL	0.65	6.0
266	E641	CHICHWA	1.40	6.0	266	E880	MAYRUNG	0.84	5.0
267	E642	CHICHWA	1.03	6.0					
268	E643	SHIRUS	0.82	6.0					
269	E644	SHIRUS	0.65	5.0					
270	E645	SHIRUS	0.82	6.0					
271	E648	PIPAL S	1.22	4.0					
272	E649	PIPAL S	1.00	4.0					
273	E650	PIPAL S	0.73	4.0					
274	E651	CHICHWA	0.76	4.0					
275	E653	MUN_SHENGA	0.77	4.0					
276	E654	SHIRUS	1.48	5.0					
277	E658	SHIRUS	5.00	6.0					
278	E660	CHICHWA	0.62	6.0					
279	E662	CHICHWA	1.32	5.0					
280	E665	BOR	1.47	5.0					
281	E667	CHICHWA	1.15	6.0					
282	E668	CHICHWA	1.23	6.0					
283	E669	CHICHWA	1.10	6.0					
284	E670	CHICHWA	0.73	5.0					
285	E671	CHICHWA	1.29	5.0					
286	E672	BADAM	0.38	3.0					
287	E673	PAM	1.08	7.0					
288	E674	NEEM	0.80	5.0					
289	E678	NEEM	1.15	7.0					
290	E679	BABUL	1.30	5.0					
291	E680	SHISHWA	1.80	6.0					
292	E682	NEEM	1.21	6.0					
293	E684	NEEM	0.99	5.0					
294	E686	NEEM	1.64	6.0					
295	E696	GULMOHAR	0.82	6.0					
296	E800	MAYRUNG	1.02	5.0					
297	E807	PADAS	0.67	5.0					
298	E808	NEEM	0.96	7.0					
299	E811	NEEM	0.74	3.0					
300	E812	KARANJI	0.30	2.0					
301	E815	SHIRUS	0.35	3.0					
302	E817	SHIRUS	0.37	3.0					
303	E820	CHICHWA	0.48	3.0					
304	E821	CHICHWA	0.50	4.0					
305	E822	CHICHWA	0.53	4.0					
306	E823	CHICHWA	0.32	3.0					
307	E825	CHICHWA	0.48	3.0					
308	E826	SHIRUS	0.49	3.0					
309	E827	CHICHWA	0.50	4.0					
310	E828	NEEM	0.45	4.0					
311	E829	WAD	0.90	5.0					
312	E830	NEEM	0.54	5.0					

SN	TREE NO.	SPECIES	GIRTH IN M.	HEIGHT IN M.	SN	TREE NO.	SPECIES	GIRTH IN M.	HEIGHT IN M.
LEFT SIDE					RIGHT SIDE				
313	E831	BABUL	0.62	5.0					
314	E834	BABUL	0.42	3.0					
315	E835	KARANJI	1.65	5.0					
316	E836	PIPAL	1.65	3.0					
317	E838	HIWAR	1.28	4.0					
318	E841	MUN_SHENGA	0.95	4.0					
319	E842	KARANJI	0.55	4.0					
320	E843	KARANJI	0.62	4.0					
321	E844	KARANJI	0.78	3.0					
322	E845	KARANJI	0.70	5.0					
323	E846	BABUL	1.05	6.0					
324	E849	ASHOKA	0.75	6.0					
325	E850	GULMOHAR	0.59	5.0					
326	E855	CHICHWA	0.92	5.0					
327	E856	KARANJI	0.73	6.0					

ANNEXURE 5.4 LIST OF TREES IN CORRIDOR 4A

SN	TREE NO.	SPECIES	GIRTH IN M.	HEIGHT IN M.	SN	TREE NO.	SPECIES	GIRTH IN M.	HEIGHT IN M.
LEFT SIDE					RIGHT SIDE				
1	E427	PIPAL	1.30	10.0	1	E426	SHOW TREE	1.5	7.0
2	E428	SHOW TREE	0.80	9.0	2	E429	NEEM	0.3	4.0
3	E428A	UNKNOWN	0.80	8.0	3	E430	NEEM	0.15	2.0
4	E428B	UNKNOWN	1.00	9.0	4	E431	SUBABHUL	1	7.0
5	E428C	UNKNOWN	1.00	8.0	5	E432	CHINCH	2	12.0
6	E428D	UNKNOWN	1.00	8.0	6	E433	SUBABHUL	1.3	8.0
7	E428E	UNKNOWN	1.00	9.0	7	E434	CHINCH	2	10.0
8	E428F	UNKNOWN	0.90	8.0	8	E434A	UNKNOWN	2	8.0
9	E439	PIPAL	1.90	8.0	9	E435	AAPTA	0.6	3.0
10	E439A	PIPAL	1.90	8.0	10	E436	ASHOKA	0.9	6.0
11	E439B	PIPAL	1.90	8.0	11	E437	WAD	3.2	8.0
12	E439C	PIPAL	1.90	8.0	12	E438	CHINCH	1	5.0
13	E440	NEEM	0.90	6.0	13	E438A	UNKNOWN	1	4.5
14	E441	SHOW TREE	0.90	6.0	14	E438B	UNKNOWN	0.9	4.5
15	E442	NEEM	5.00	15.0	15	E438C	UNKNOWN	0.9	4.5
16	E443	PIPAL	1.70	10.0	16	E445	PIPAL	4.6	7.0
17	E444	PIPAL	0.95	5.0	17	E446	NEEM	1.3	12.0
18	E444A	UNKNOWN	0.90	5.0	18	E447	RITHA	1.9	5.0
19	E448	KARANJI	0.70	7.0	19	E451	RITHA	2.4	8.0
20	E449	IMLI	4.70	9.0	20	E452	ASHOKA	1.9	3.0
21	E450	PIPAL	3.50	10.0	21	E453	UMBAR	0.9	3.0
22	E450A	UNKNOWN	4.00	9.0	22	E455	NEEM	2.2	7.0
23	E454	WAD	4.20	9.0	23	E456	JUNGLI BADAM	0.9	8.0
24	E459	NEEM	1.60	15.0	24	E457	NEEM	1.3	9.0
25	E461	SHOW TREE	1.90	15.0	25	E458	RITHA	0.85	3.5
26	E462	SHOW TREE	2.30	10.0	26	E460	SUKHA PED	1.2	2.0
27	E468	NEEM	1.90	7.0	27	E463	WAD	1.2	7.0
28	E469	NEEM	2.00	6.0	28	E464	NEEM	1	6.0

SN	TREE NO.	SPECIES	GIRTH IN M.	HEIGHT IN M.	SN	TREE NO.	SPECIES	GIRTH IN M.	HEIGHT IN M.
LEFT SIDE					RIGHT SIDE				
29	E470	GULMOHAR	1.20	10.0	29	E465	NILGIRI	3	11.0
30	E471	NEEM	1.00	5.0	30	E466	NILGIRI	1.9	15.0
31	E472	NEEM	0.95	7.0	31	E467	NILGIRI	1.95	15.0
32	E473	NEEM	0.80	5.0	32	E474	NILGIRI	1.95	14.0
33	E476	WAD	0.90	5.0	33	E475	NILGIRI	1.8	16.0
34	E476A	UNKNOWN	0.70	4.5	34	E477	BABHUL	1.1	6.0
35	E476B	UNKNOWN	0.70	4.5	35	E478	BABHUL	0.95	3.0
36	E476C	UNKNOWN	0.70	5.0	36	E479	BABHUL	1.3	6.0
37	E476D	UNKNOWN	0.90	4.5	37	E480	ASHOKA	0.6	5.0
38	E476E	UNKNOWN	0.70	4.0	38	E481	NILGIRI	0.9	7.0
39	E476F	UNKNOWN	0.90	4.0	39	E487C	UNKNOWN	0.9	7.0
40	E476G	UNKNOWN	0.90	4.0	40	E487D	UNKNOWN	0.9	6.0
41	E482	SUKHA PED	0.95	6.0	41	E489	SUKHA PED	0.9	5.5
42	E483	NEEM	1.30	9.0	42	E493	NEEM	1.3	4.5
43	E484	NEEM	1.45	8.0	43	E494	SISAM	2.1	10.0
44	E485	NEEM	1.70	8.0	44	E497	SUBABHUL	0.8	2.5
45	E486	BABHALI	2.40	7.0	45	E498	SUBABHUL	0.82	2.5
46	E487	BABHALI	2.80	7.0	46	E499	SISAM	1.7	8.5
47	E487A	UNKNOWN	2.50	7.0	47	E500	SISAM	1.5	8.5
48	E487B	UNKNOWN	2.50	7.0	48	E501	ASHOKA	0.8	7.5
49	E488	PIPAL	1.05	4.0	49	E502	ASHOKA	1.6	8.0
50	E490	NEEM	0.86	4.0	50	E503	SHOW TREE	0.6	3.5
51	E491	PIPAL	0.82	3.5	51	E504	ASHOKA	1.3	4.4
52	E492	PIPAL	1.30	6.5	52	E505	NEEM	3.5	8.5
53	E495	PIPAL	1.30	6.0	53	E506	ASHOKA	1	7.0
54	E496	PIPAL	0.40	3.5	54	E507	NEEM	1.4	6.0
55	E509	SUBABHUL	1.60	4.5	55	E508	SHOW TREE	0.9	3.5
56	E510	NEEM	0.70	5.0	56	E511	MUNGNA	2.3	8.5
57	E513	SUBABHUL	0.60	5.0	57	E512	MUNGNA	1.8	8.5
58	E514	NEEM	0.50	5.5	58	E518	NEEM	1.4	6.0
59	E515	MUNGNA	0.30	3.0	59	E522	SUKHA PED	1.6	5.5
60	E516	MUNGNA	0.30	3.0	60	E525	MUNGNA	1.3	5.0
61	E517	NEEM	0.30	3.0	61	E526	MUNGNA	1.4	5.0
62	E519	NEEM	0.30	3.0	62	E527	NEEM	0.9	4.5
63	E520	MUNGNA	0.30	3.0	63	E528	PIPAL	1.5	6.0
64	E521	CHICHBULAI	1.70	8.5	64	E529	NEEM	1	6.5
65	E523	SISAM	1.10	5.0	65	E536	CHICHBULAI	0.7	5.0
66	E524	NEEM	1.30	5.5	66	E537	JAMUN	0.9	5.5
67	E530	NEEM	0.40	4.5	67	E538	SUKHA PED	0.8	4.5
68	E531	NEEM	1.10	5.5	68	E539	MUNGNA	0.9	4.5
69	E532	JAMUN	0.70	5.5	69	E540	CHICHBULAI	1.1	5.0
70	E533	NEEM	1.40	5.5	70	E541	MUNGNA	0.9	5.0
71	E534	SUKHA PED	0.90	4.4	71	E542	MUNGNA	0.9	4.5
72	E535	SUKHA PED	1.00	5.0	72	E543	KARANJI	0.3	5.5
73	E545	ASHOKA	0.70	6.5	73	E544	PIPAL	0.8	5.5
74	E546	ASHOKA	0.60	6.0	74	E554	PIPAL	0.8	5.5
75	E547	ASHOKA	0.7	6.5	75	E557	ASHOKA	0.6	6.0
76	E548	ASHOKA	0.50	5.0	76	E558	ASHOKA	0.7	6.5
77	E549	ASHOKA	0.80	6.5	77	E559	ASHOKA	0.5	5.0
78	E550	SISAM	1.40	6.5	78	E569	ASHOKA	0.8	6.5
79	E551	TEAK	1.50	7.0	79	E570	NEEM	1.3	5.5
80	E552	NEEM	1.40	8.0	80	E571	NEEM	0.4	4.5
81	E553	NEEM	1.40	8.0	81	E572	NEEM	1.1	5.5
82	E555	ASHOKA	0.70	6.5	82	E573	NEEM	1.3	5.5
83	E556	ASHOKA	0.60	6.0	83	E574	NEEM	0.4	4.5

SN	TREE NO.	SPECIES	GIRTH IN M.	HEIGHT IN M.	SN	TREE NO.	SPECIES	GIRTH IN M.	HEIGHT IN M.
LEFT SIDE					RIGHT SIDE				
84	E560	ASHOKA	0.70	6.5	84	E582	NEEM	1.1	5.5
85	E561	ASHOKA	0.50	5.0	85	E583	NEEM	1.1	5.5
86	E562	ASHOKA	0.80	6.5	86	E575	PIPAL	0.40	3.2
87	E564	ASHOKA	0.60	6.0	87	E577	CHICHWA	0.38	3.0
88	E565	ASHOKA	0.70	6.5	88	E579	UMBER	0.92	5.0
89	E566	ASHOKA	0.50	5.0	89	E591	VAD	1.70	6.0
90	E567	ASHOKA	0.80	6.5	90	E603	BABUL	0.78	5.0
91	E568	NEEM	1.30	5.5	91	E607	BADAM	1.02	5.0
92	E575	NEEM	0.40	4.5	92	E622	CHICHWA	1.00	4.0
93	E576	NEEM	1.10	5.5	93	E623	NO NAME	1.00	4.0
94	E577	SUKHA PED	0.90	4.4	94	E624	GULMOHAR	1.02	5.0
95	E578	SUKHA PED	1.00	5.0	95	E626	JAMUN	0.98	6.0
96	E579	ASHOKA	0.70	6.5	96	E627	GULMOHAR	0.62	7.0
97	E580	ASHOKA	0.60	6.0	97	E628	BADAM	1.48	6.0
98	E581	ASHOKA	0.70	6.5	98	E637	NEEM	1.44	6.0
99	E584	NEEM	1.40	6.0	99	E638	ASHOKA	0.81	7.0
100	E585	SHOW TREE	0.90	3.5	100	E639	CHICHWA	0.62	5.0
101	E586	MUNGNA	2.30	8.5	101	E641	ASHOKA	0.55	6.0
102	E587	NEEM	1.40	6.0	102	E643	NEEM	1.16	6.0
103	E588	SHOW TREE	0.90	3.5					
104	E589	MUNGNA	2.30	8.5					
105	E590	ASHOKA	0.70	6.5					
106	E574	NEEM	0.72	6.0					
107	E576	CHICHWA	0.62	3.5					
108	E578	CHICHWA	0.60	3.0					
109	E580	SAGWAN	0.74	4.0					
110	E581	SAGWAN	0.65	4.0					
111	E582	SAGWAN	0.89	4.0					
112	E583	SAGWAN	0.55	4.0					
113	E584	SAGWAN	1.22	4.0					
114	E585	SAGWAN	0.92	5.0					
115	E586	BABUL	1.12	5.0					
116	E587	BABUL	1.38	4.0					
117	E588	GULMOHAR	0.32	3.0					
118	E589	BABUL	0.68	4.0					
119	E590	HIWAR	0.47	3.0					
120	E590A	CHICHWA	0.40	3.0					
121	E592	NEEM	0.72	5.0					
122	E593	CHICHWA	0.65	5.0					
123	E594	CHICHWA	0.45	4.0					
124	E595	CHICHWA	0.68	6.0					
125	E596	CHICHWA	1.28	6.0					
126	E597	BOR	0.75	4.0					
127	E598	SIRAS	0.62	5.0					
128	E599	CHICHWA	0.60	5.0					
129	E600	CHICHWA	0.60	5.0					
130	E601	CHICHWA	0.68	4.0					
131	E602	CHICHWA	0.52	4.0					
132	E604	SIMAR	0.75	4.0					
133	E605	SIMAR	0.82	5.0					
134	E606	SIMAR	1.00	6.0					
135	E608	CHICHWA	0.87	5.0					
136	E609	SUBABUL	0.92	7.0					
137	E610	SHISHUM	0.67	5.0					
138	E611	CHICHWA	0.52	4.0					

SN	TREE NO.	SPECIES	GIRTH IN M.	HEIGHT IN M.	SN	TREE NO.	SPECIES	GIRTH IN M.	HEIGHT IN M.
LEFT SIDE					RIGHT SIDE				
139	E612	CHICHWA	0.37	4.0					
140	E613	CHICHWA	0.30	5.0					
141	E614	CHICHWA	0.85	5.0					
142	E615	CHICHWA	0.70	6.0					
143	E616	CHICHWA	0.90	6.0					
144	E617	CHICHWA	0.35	5.0					
145	E618	CHICHWA	0.62	6.0					
146	E619	CHICHWA	0.36	4.5					
147	E620	SAGWAN	0.52	5.0					
148	E621	SAGWAN	1.02	5.0					
149	E629	KARANJI	0.72	4.0					
150	E630	SAGWAN	0.68	5.0					
151	E631	SHISHUM	0.85	5.0					
152	E632	BABUL	0.60	4.0					
153	E633	BABUL	1.28	6.0					
154	E634	CHICHWA	0.58	4.0					
155	E635	CHICHWA	0.62	4.0					
156	E636	CHICHWA	0.57	4.0					
157	E636A	SAGWAN	0.78	5.0					
158	E636B	SAGWAN	0.72	5.0					
159	E640	NEEM	0.42	3.0					
160	E642	BABUL	1.08	4.0					
161	E644	CHICHWA	0.79	5.0					

ANNEXURE 5.5 LIST OF TREES IN CORRIDOR 5

SN	TREE NO.	SPECIES	GIRTH IN M.	HEIGHT IN M.	SN	TREE NO.	SPECIES	GIRTH IN M.	HEIGHT IN M.
LEFT SIDE					RIGHT SIDE				
1	E 1	NEEM	0.90	8.0	1	E 3	BADAM	0.8	10.0
2	E 2	JAMBHUL	0.70	8.0	2	E 4	BADAM	0.8	10.0
3	E 5	BADAM	0.60	7.0	3	E 8	JAMBHUL	2.2	12.0
4	E 6	WAD	0.50	6.0	4	E 13	GULMOHAR	2.2	14.0
5	E 7	PIMPAL	0.40	5.0	5	E 14	GULMOHAR	2	13.0
6	E 9	APATA	1.10	8.0	6	E 16	SISAM	0.7	8.0
7	E 10	APATA	0.80	10.0	7	E 17	NEEM	1.2	7.0
8	E 11	GULMOHAR	1.70	13.0	8	E 20	GULMOHAR	2.7	12.0
9	E 12	SUBABHUL	2.10	13.0	9	E 21	BABARI	0.6	7.0
10	E 15	GULMOHAR	3.00	12.0	10	E 22	BABARI	0.4	6.0
11	E 18	SISAM	0.50	10.0	11	E 23	BABARI	0.6	6.0
12	E 19	DRY TREE	0.70	8.0	12	E 24	GULMOHAR	2.3	13.0
13	E 25	SISAM	0.70	7.0	13	E30	SISAM	0.6	4.0
14	E 26	SISAM	0.40	5.0	14	E31	BABARI	0.7	7.0
15	E 27	GULMOHAR	0.60	8.0	15	E38	BABUL	0.9	6.0
16	E28	NEEM	0.70	7.0	16	E39	SISAM	1.4	8.0
17	E29	NEEM	0.60	7.0	17	E40	GULMOHAR	0.11	7.0
18	E32	SAAGWAN	0.60	5.0	18	E41	NEEM	0.7	6.0
19	E33	SISAM	0.80	6.0	19	E42	ASHOKA	0.4	7.0
20	E34	SISAM	1.30	10.0	20	E43	ASHOKA	0.3	5.0
21	E35	SISAM	1.20	6.0	21	E44	ASHOKA	0.2	4.0

SN	TREE NO.	SPECIES	GIRTH IN M.	HEIGHT IN M.	SN	TREE NO.	SPECIES	GIRTH IN M.	HEIGHT IN M.
LEFT SIDE					RIGHT SIDE				
22	E36	SISAM	0.90	4.0	22	E45	ASHOKA	0.6	7.0
23	E37	SISAM	0.30	4.0	23	E46	NEEM	1.1	6.0
24	E47	BABUL	1.20	7.0	24	E54	UNKNOWN	1.2	10.0
25	E48	GULMOHAR	1.70	7.0	25	E55	BABUL	0.11	9.0
26	E49	DHUDI CHE JHAD	2.10	8.0	26	E56	GULMOHAR	1.1	7.0
27	E50	BABUL	2.10	8.0	27	E57	GULMOHAR	2.5	13.0
28	E51	GULMOHAR	0.50	7.0	28	E63	GULMOHAR	0.7	7.0
29	E52	GULMOHAR	1.50	8.0	29	E64	GULMOHAR	1.9	10.0
30	E53	GULMOHAR	1.20	8.0	30	E65	GULMOHAR	2	15.0
31	E58	SISAM	1.90	10.0	31	E66	GULMOHAR	2	15.0
32	E59	KARANJEE	2.50	13.0	32	E67	GULMOHAR	1.1	9.0
33	E60	KARANJEE	2.30	15.0	33	E68	GULMOHAR	1.9	15.0
34	E61	SISAM	1.10	12.0	34	E69	SISAM	1.3	13.0
35	E62	KARANJEE	2.00	13.0	35	E70	GULMOHAR	1.4	10.0
36	E77	BABUL	1.40	9.0	36	E71	GULMOHAR	1.5	12.0
37	E78	GULMOHAR	1.30	8.0	37	E72	GULMOHAR	1.6	9.0
38	E79	SISAM	1.60	7.0	38	E73	SISAM	1.8	7.0
39	E80	GULMOHAR	2.20	12.0	39	E74	GULMOHAR	1.1	9.0
40	E82	SISAM	1.09	9.0	40	E75	GULMOHAR	1	8.0
41	E84	UMBER	1.10	10.0	41	E76	NEEM	1.2	8.0
42	E88	SISAM	1.10	5.0	42	E81	BABARI	1.1	8.0
43	E91	BABUL	0.11	7.0	43	E83	SISAM	1.8	12.0
44	E96	SISAM	0.80	5.0	44	E85	UNKNOWN	1.8	6.0
45	E96A	SISAM	1.00	5.0	45	E86	SISAM	1.6	7.0
46	E100	GULMOHAR	1.60	6.0	46	E87	BABUL	1.2	10.0
47	E101	GULMOHAR	1.60	7.0	47	E89	SISAM	1.7	6.0
48	E105	SUBABHUL	1.20	9.0	48	E90	SISAM	1.4	6.0
49	E106	SUBABHUL	1.90	9.0	49	E92	SISAM	1.9	7.0
50	E107	CHICHWA	1.70	12.0	50	E93	SISAM	1.6	6.0
51	E108	SISAM	1.80	8.0	51	E94	WAD	4.2	8.0
52	E109	CHICHWA	1.80	8.0	52	E95	NEEM	0.1	7.0
53	E111	CHHINAR	0.70	7.0	53	E97	SISAM	1.11	7.0
54	E112	GULMOHAR	1.00	8.0	54	E98	NEEM	1.11	12.0
55	E117	SISAM	0.90	4.1	55	E99	NEEM	1.2	12.0
56	E118	SISAM	1.10	5.0	56	E102	ROHAN	1.2	10.0
57	E123	MAYRUK	0.90	5.0	57	E103	NEEM	0.8	8.0
58	E125	MAYRUK	0.50	3.0	58	E104	GULMOHAR	0.9	6.0
59	E128	KARANJEE	0.90	3.0	59	E110	GULMOHAR	0.7	4.0
60	E129	PIMPAL	2.80	12.0	60	E113	CHICHABILAI	1	9.0
61	E130	PIMPAL	2.00	12.0	61	E114	GULMOHAR	0.9	10.0
62	E131	KARANJEE	2.20	10.0	62	E115	NEEM	0.8	6.0
63	E141	SISAM	2.10	11.0	63	E116	NEEM	0.7	5.0
64	E143	KARANJEE	2.00	6.0	64	E119	SUBABHUL	1	6.0
65	E145	KARANJEE	2.50	12.0	65	E120	NEEM	0.9	6.0
66	E146	UNKNOWN	2.10	7.0	66	E121	SUBABHUL	0.5	3.0
67	E147	UMARI	3.10	12.0	67	E122	DEV BABUL	0.9	6.0
68	E148	CHICHWA	3.10	15.0	68	E124	SUBABHUL	1	6.0
69	E149	KARANJEE	2.20	13.0	69	E126	UMBAR	2	18.0
70	E151	SISAM	2.30	9.0	70	E127	SISAM	2	10.0
71	E152	SISAM	2.40	10.0	71	E127A			
72	E153	SISAM	2.50	13.0	72	E127B			
73	E159	KARANJEE	1.30	7.0	73	E127C			
74	E160	KARANJEE	0.60	4.0	74	E132	KARANJEE	0.9	5.0
75	E161	BABUL	2	9.0	75	E133	NEEM	3.2	12.1
76	E162	CHICHWA	3.10	15.0	76	E134	KARANJEE	0.9	5.2

SN	TREE NO.	SPECIES	GIRTH IN M.	HEIGHT IN M.	SN	TREE NO.	SPECIES	GIRTH IN M.	HEIGHT IN M.
LEFT SIDE					RIGHT SIDE				
77	E163	SISAM	3.00	13.0	77	E135	KARANJEE	1	7.0
78	E174	CHICHWA	2.90	12.0	78	E136	KARANJEE	0.6	4.0
79	E175	SHEMDI	1.50	10.0	79	E137	NEEM	2.9	12.0
80	E179	PARAS	0.60	9.0	80	E138	KARAI	1	13.0
81	E181	UMBER	2.10	8.0	81	E139	KARANJEE	1.2	6.0
82	E186	KARANJEE	2.80	12.0	82	E140	SISAM	2.3	12.0
83	E187	DEVBABUL	0.80	7.0	83	E142	MAYRUK	2	10.0
84	E188	BABUL	1.00	9.0	84	E144	UMBAR	0.6	5.0
85	E189	DEVBABUL	1.30	10.0	85	E150	SISAM	2.4	14.0
86	E190	UMBER	0.90	7.0	86	E154	SISAM	2.9	12.0
87	E191	UMBER	0.90	8.0	87	E155	CHICHWA	3.2	13.0
88	E192	DEVBABUL	0.80	7.0	88	E156	CHICHWA	2.1	10.0
89	E193	UMBER	0.90	9.0	89	E157	UMARI	3.1	15.0
90	E194	DEVBABUL	1	7.0	90	E158	WAD	5.2	15.0
91	E195	UMBER	2.3	12.0	91	E164	NEEM	1.1	12.0
92	E196	PIMPAL	1.1	12.0	92	E165	UMBAR	0.7	9.0
93	E198	DEVBABUL	2.5	11.0	93	E166	UMBAR	0.9	11.0
94	E198A				94	E167	SUBABHUL	1.9	14.0
95	E200	SAAGVAN	0.90	7.0	95	E168	SISAM	2.4	14.0
96	E202	DEVBABUL	1.30	7.0	96	E169	KAAD SAVAN	1.5	9.0
97	E206	UMBER	0.90	9.0	97	E170	KARANJEE	1.7	8.0
98	E209	UMBER	0.80	9.0	98	E171	DEV BABUL	2.2	6.0
99	E214	SUBABHUL	2.10	14.0	99	E172	APATA	1.8	9.0
100	E215	TEMBHRI	0.90	6.0	100	E173	SONA JHAD	1.2	7.0
101	E216	PIMPAL	1.90	6.0	101	E176	NEEM	0.9	6.5
102	E221	SHOW	0.20	1.5	102	E177	KARANJEE	2.5	7.8
103	E222	SHOW	0.20	1.5	103	E178	KARANJEE	2.3	4.0
104	E223	SHOW	0.20	1.5	104	E180	SISAM	2.3	9.0
105	E224	SHOW	0.20	1.5	105	E182	UMBER	1.7	9.0
106	E 227	SHOW	0.20	1.5	106	E183	NEEM	1.6	10.0
107	E 228	SHOW	0.22	1.5	107	E184	UMBER	2.3	11.0
108	E 229	BABUL	0.80	3.0	108	E185	CHICHWA	0.4	6.0
109	E 229A	SHOW	0.35	1.8	109	E197	KARANJEE	0.9	9.0
110	E 230	SHOW	0.15	3.0	110	E199	KARANJEE	2	9.0
111	E 230A	SHOW	0.25	3.0	111	E199A			
112	E 231	SHOW	0.15	1.5	112	E201	CHICHWA	1	7.0
113	232	SHOW	0.23	1.5	113	E203	KARANJEE	1.5	5.0
114	E 233	PIPAL	0.35	3.0	114	E204	CHICHWA	3.1	15.0
115	E 234	SUBABUL	0.38	3.0	115	E205	CHICHWA	3.10	14.0
116	E 235	KARANJEE	0.10	12.0	116	E207	BOR	0.70	7.0
117	E 236	KARANJEE	0.10	12.0	117	E208	SISAM	1.10	6.0
118	E 238	SHOW	0.35	1.5	118	E210	PIMPAL	2.50	11.0
119	E 241	SHOW	0.33	1.5	119	E211	UMBER	1.60	9.0
120	E 242	SHOW	0.30	1.5	120	E212	UMBER	1.60	10.0
121	E 243	SHOW	0.25	1.5	121	E213	UMBER	1.20	10.0
122	E 244	SHOW	0.50	1.5	122	E217	SISAM	1.20	7.0
123	E 245	SHOW	0.35	1.5	123	E218	PIMPAL	2.50	10.0
124	E 246	SHOW	0.35	1.5	124	E219	PIMPAL	2.40	10.0
125	E 247	SHOW	0.15	1.5	125	E220	PIMPAL	0.50	6.0
126	E 248	SHOW	0.35	1.5	126	E225	SHOW	0.30	10.0
127	E68	PIPAL	1.20	6.0	127	E226	SHOW	0.30	10.0
128	E69	UMAR	1.00	7.0	128	E227	SHOW	0.30	10.0
129	E70	NIM	0.30	5.0	129	E 249	WAD	0.35	10.0
130	E71	PIPAL	0.80	4.0	130	E 250	SHOW	0.30	10.0
131	E72	CHICHBULAI	0.40	7.0	131	E 251	SHOW	0.36	12.0

SN	TREE NO.	SPECIES	GIRTH IN M.	HEIGHT IN M.	SN	TREE NO.	SPECIES	GIRTH IN M.	HEIGHT IN M.
LEFT SIDE					RIGHT SIDE				
132	E73	CHICHBULAI	0.35	6.0	132	E 252	PIPAL	0.60	14.0
133	E280	NIM	0.60	10.0	133	E 253	NIM	0.30	13.0
					134	E 254	WAD	0.35	8.0
					135	E 255	SHOW	0.40	7.0
					136	E 256	UMAR	0.45	12.0
					137	E 257	KARNJI	0.25	7.0
					138	E 258	COCONT	0.40	6.0
					139	E 259	COCONT	0.35	6.0
					140	E 260	UMAR	0.50	13.0
					141	E 261	NIM	0.80	4.0
					142	E 262	PIPAL	0.35	7.0
					143	E 263	SHOW	0.30	6.0
					144	E 264	SHOW	0.35	8.0
					145	E 265	SHOW	0.30	7.0
					146	E266	SHOW	0.35	8.0
					147	E267	SHOW	0.30	7.0
					148	E274	BADAM	0.25	10.0
					149	E275	PIPAL	0.70	9.0
					150	E276	PIPAL	0.65	7.0
					151	E277	SAGWAN	0.40	4.0
					152	E278	SHOW	0.10	2.0
					153	E279	SHOW	0.35	10.0

Chapter – 6
STATION PLANNING

6. STATION PLANNING

6.1. STATION PLANNING - BASED ON SITE CONDITIONS

The proposed rail based mass transit system corridors have been planned to serve major passenger catchment areas/ destinations and to enable convenient integration with other modes of transport. Stations vary in complexity along the route and have been located by an interactive process influenced by ridership forecasts, existing major settlements, major roads, interchange requirements with other modes of transport, station spacing, alignment, utilities, traffic and pedestrian requirements, station spacing, etc. The stations locations along with their chainages and inter-station distance are presented in **Table 6.1**.

TABLE 6.1: INTER-STATION DISTANCE AND TYPE OF PROPOSED STATIONS

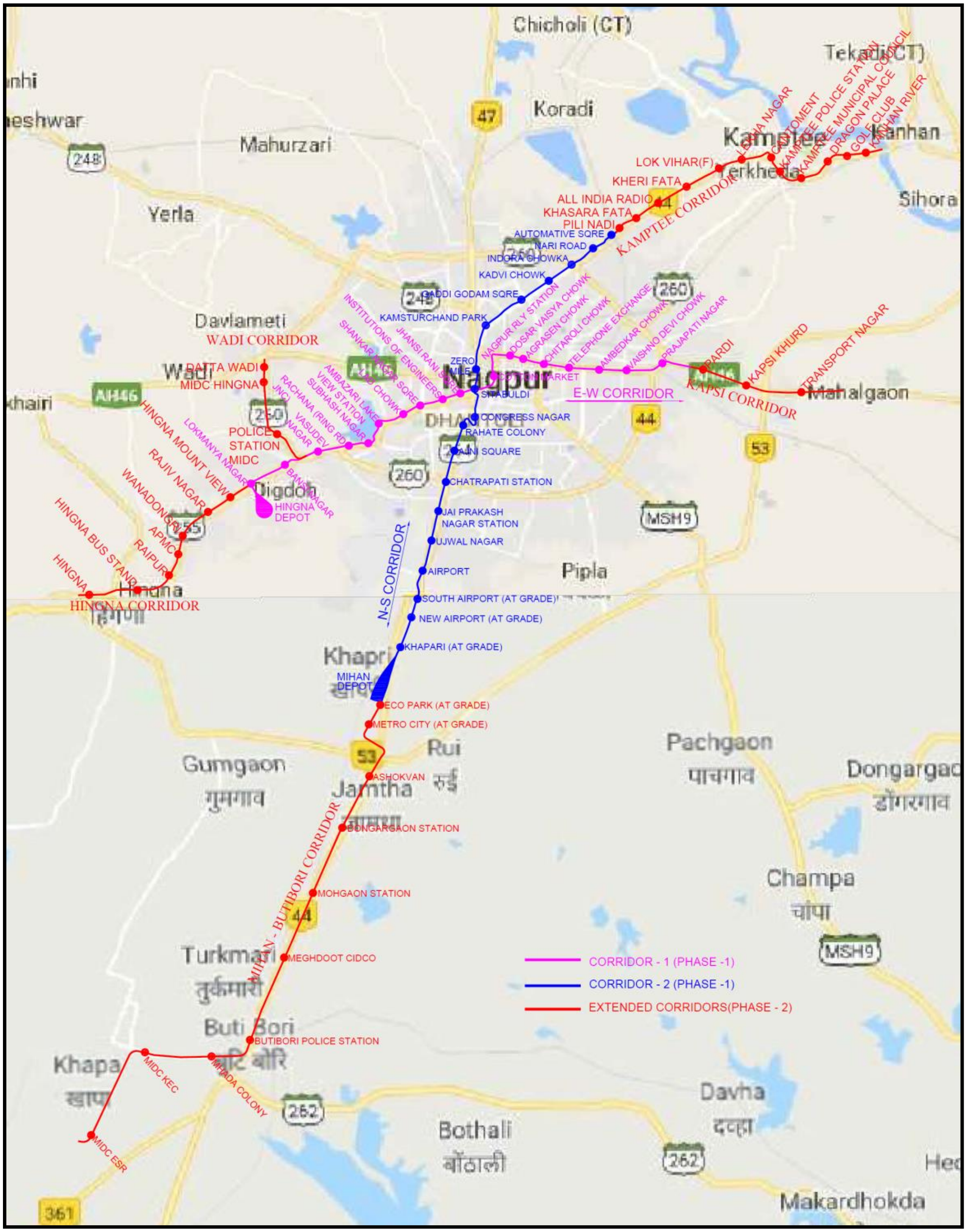
SN	Station Name	Chainages (m)	Inter-station Distance (m)	Cumulative Distance (m)	Elevated/ Underground
	Corridor-1A: MIHAN to MIDC ESR				
1	ECO Park Station	20462	-	0	At grade
2	Metro City Station	21057	595	595	At grade
3	Ashokvan	23843	2786	3381	Elevated
4	Dongargaon	26693	2850	6231	Elevated
5	Mohgaon	29878	3185	9416	Elevated
6	Meghdoot CIDCO	32802	2924	12340	Elevated
7	Butibori Police Station	33540	738	13078	Elevated
8	MHADA Colony	34233	693	13771	Elevated
9	MIDC KEC	37360	3127	16898	Elevated
10	MIDC ESR	38352	992	17890	Elevated
	Corridor-2A: Automotive Square to Kanhan River				
1	Pili Nadi	-1409	-	0	Elevated
2	Khasara Fata	-2286	877	877	Elevated
3	All India Radio	-3314	1028	1905	Elevated
4	Khairi Fata	-5250	1936	3841	Elevated
5	Lok Vihar	-6176	926	4767	Elevated

SN	Station Name	Chainages (m)	Inter-station Distance (m)	Cumulative Distance (m)	Elevated/ Underground
6	Lekha Nagar	-7199	1023	5790	Elevated
7	Cantonment	-8681	1482	6850	Elevated
8	Kamptee Police Station	-9410	729	8001	Elevated
9	Kamptee Municipal Council	-10225	815	8816	Elevated
10	Dragon Palace	-11196	971	9787	Elevated
11	Golf Club	-12468	1272	11059	Elevated
12	Kanhan River	-13324	856	11915	Elevated
	Corridor-3A: Lokmanya Nagar to Hingna				
1	Hingna Mount View	18761	-	0	Elevated
2	Rajiv Nagar	19607	846	846	Elevated
3	Wanadongri	21006	1399	2245	Elevated
4	APMC	21715	709	2954	Elevated
5	Raipur	22823	1108	4062	Elevated
6	Hingna Bus Station	23625	802	4864	Elevated
7	Hingna	24532	907	5771	Elevated
	Corridor-4A: Prajapati Nagar to Transport Nagar				
1	Pardi	-1365	-	0	Elevated
2	Kapsi Khurd	-3200	1835	1835	Elevated
3	Transport Nagar	-5026	1826	3661	Elevated
	Corridor-5: Vasudev Nagar to Dattawadi				
1	Police Station MIDC	16831	-	0	Elevated
2	MIDC Hingna	19162	2331	2331	Elevated
3	Dattawadi	19838	676	3007	Elevated

6.1.1 Station Area Characteristics

The catchment areas for all stations, issues and concerns, potential improvements of Phase 2 metro corridors are summarized below:

FIGURE 6.1: NAGPUR METRO CORRIDORS WITH PHASE 2 EXTENSION



CORRIDOR-1A: MIHAN TO MIDC ESR

1. Ashokvan

This is the first station of the proposed corridor. It is an elevated station near Suretech Hospital. The catchment area of station are Monfort School, Suretech Hospital, Jamtha, Jari etc.

Issues & Concerns	Potential for Improvements
• Lack of footpaths resulting in pedestrian spillover on road • On-street parking causes reduction in efficient roadway width	• Dedicated pedestrian friendly facilities like footpath • Parking areas and dedicated bays for pick up/ drop facilities

Proposed location for the station

Approach road at the location

Surrounding areas near location

Lack of footpath near location

2. Dongargaon

This is the 2nd station of the proposed extended metro corridor. The elevated station has the catchment area of Dongargaon, Vijay College, Ghuti, Sirul etc.

Issues & Concerns	Potential for Improvements
• Lack of footpaths resulting in pedestrian spillover on road • On-street parking causes reduction in efficient roadway width	• Dedicated pedestrian friendly facilities like footpath • Parking areas and dedicated bays for pick up/ drop facilities

Approach road at the location

Proposed location for the station

Surrounding areas near location

Approach road showing road & median

3. Mohgaon

This is the 3rd station of the proposed Extended Corridor. The catchment area of this elevated station are Mohgaon Basti, Bothali etc.

Issues & Concerns	Potential for Improvements
• Lack of footpaths resulting in pedestrian spillover on road • On-street parking causes reduction in efficient roadway width	• Dedicated pedestrian friendly facilities like footpath • Parking areas and dedicated bays for pick up/ drop facilities


Proposed location for the station


Approach road at the location


Road and median near location


Surrounding areas near location

4. Meghdoot CIDCO

This is the 4th station of the proposed extended metro corridor. It is an elevated station near Samrat Bar Restaurant and A K Garrage. The catchment area of station are Maruti Nagar, Satgaon, Borkhedi etc.

Issues & Concerns	Potential for Improvements
• Lack of footpaths resulting in pedestrian spillover on road • On-street parking causes reduction in efficient roadway width	• Dedicated pedestrian friendly facilities like footpath • Parking areas and dedicated bays for pick up/ drop facilities

	
Proposed location for the station	Approach road at the location
	
Surrounding areas near location	Lack of footpath on approach road

5. Butibori Police Station

This is the 5th station of the proposed extended metro corridor. It is an elevated station near Jijamata Primary Jr. College on aforesaid corridor. The catchment area of station are Godawary Nagar, Jijamata College etc.

Issues & Concerns	Potential for Improvements
• Lack of footpaths resulting in pedestrian spillover on road • On-street parking causes reduction in efficient roadway width	• Dedicated pedestrian friendly facilities like footpath • Parking areas and dedicated bays for pick up/ drop facilities

Proposed location for the station

Lack of footpath on approach road

Surrounding areas near location

Surrounding areas near location

6. MHADA Colony

This is the 6th station of the proposed extended metro corridor. It is an elevated station near MHADA Colony. The catchment area of station are Satgaon, Butibori Bus Stop etc.

Issues & Concerns	Potential for Improvements
• Lack of footpaths resulting in pedestrian spillover on road • On-street parking causes reduction in efficient roadway width	• Dedicated pedestrian friendly facilities like footpath • Parking areas and dedicated bays for pick up/ drop facilities

	
Proposed location for the station	Approach road at the location
	
Surrounding areas near location	Surrounding areas near location

7. MIDC KEC

This is the 7th station of the proposed extended metro corridor. It is an elevated station near Goyal Dhatu Udyog Pvt. Ltd on aforesaid corridor. The catchment area of station are Tembhari, Kinhi, Sukali etc.

Issues & Concerns	Potential for Improvements
• Lack of footpaths resulting in pedestrian spillover on road • On-street parking causes reduction in efficient roadway width	• Dedicated pedestrian friendly facilities like footpath • Parking areas and dedicated bays for pick up/ drop facilities

Proposed location for the station

Approach road at the location

Lack of footpath on approach road

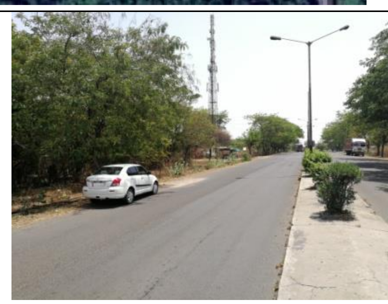
Surrounding areas near location

8. MIDC ESR

This is the last station of the proposed extended metro corridor. It is an elevated station near Orange City Weldmesh. The catchment area of station are Tembhari, Weldmesh, Sukali etc.

Issues & Concerns	Potential for Improvements
• Lack of footpaths resulting in pedestrian spillover on road • On-street parking causes reduction in efficient roadway width	• Dedicated pedestrian friendly facilities like footpath • Parking areas and dedicated bays for pick up/ drop facilities

Proposed location for the station



Approach road at the location

Surrounding areas near location

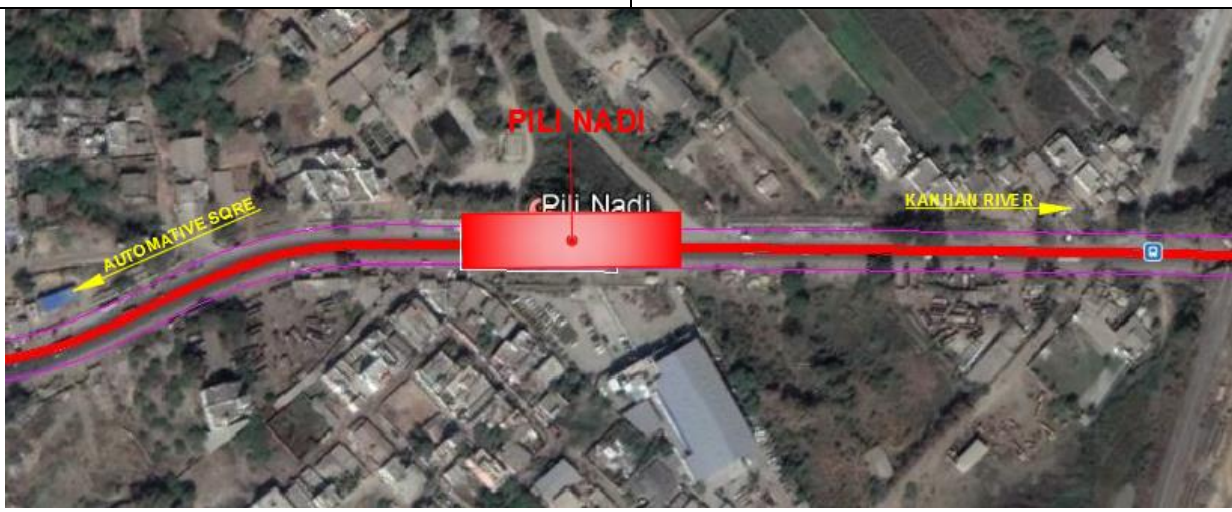
Lack of footpath near approach road

CORRIDOR-2A: AUTOMOTIVE SQUARE TO KANHAN RIVER

1. Pili Nadi

Pili Nadi is the first station of aforesaid extended Corridor. It is an elevated station near Chevrolet Car Show Room on NH-7.

Issues & Concerns	Potential for Improvements
• Lack of pedestrians facilities/footpath. • Lack of PT/IPT stops and dedicated bays for Buses and Auto affect the connectivity of the location.	• Parking areas and dedicated bays for pick up/ drop facilities for PT/IPT. • Dedicated pedestrian friendly facilities like footpath and cycle tracks.



Proposed location for the Station

Approach Road near proposed Station

Surrounding areas near Location

Approach Road and Surrounding Areas

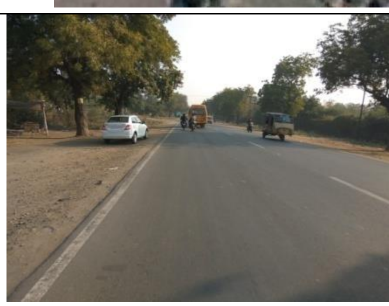
2. Khasara Fata

Khasara Fata is second station of the proposed Corridor. It is an elevated station on NH 7. The main passengers catchment areas include Khasara.

Issues & Concerns	Potential for Improvements
• Lack of pedestrians facilities/footpath. • Lack of PT/IPT stops and dedicated bays for Buses and Auto affect the connectivity of the location	• Parking areas and dedicated bays for pick up/ drop facilities for PT/IPT • Dedicated pedestrian friendly facilities like footpath and cycle tracks

	
Proposed location of the station	Proposed location & approach road
	
Surrounding areas near location	Lack of footpath on approach road

3. All India Radio

<table>
<tr><td colspan="2">This is the third station of the proposed extended Corridor. It is an elevated station near MSEB Upkendra Mandal on NH 7.</td></tr>
<tr><th>Issues & Concerns</th><th>Potential for Improvements</th></tr>
<tr><td>• Lack of pedestrians facilities/footpath.
• PT/IPT stops do not have dedicated bays which causes reduction of carriageway</td><td>• Parking areas and dedicated bays for pick up/ drop facilities
• Planning of dispersal facilities through feeder modes will cater to a larger catchment.</td></tr>
<tr><td colspan="2">
</td></tr>
<tr><td></td><td></td></tr>
<tr><td>Location of proposed station</td><td>Approach road near the proposed station</td></tr>
<tr><td></td><td></td></tr>
<tr><td>Lack of footpath on approach road</td><td>Surrounding areas near location</td></tr>
</table>

4. Khairi Fata

<table>
<tr><td colspan="2">This is the fourth station of the proposed extended Corridor. It is an elevated station near Maruti Suzuki Automotive Manufacturing on NH 7 serving nearby Khairi village.</td></tr>
<tr><td>Issues & Concerns</td><td>Potential for Improvements</td></tr>
<tr><td>• Lack of footpaths resulting in pedestrian spillover on road
• On-street parking causes reduction in efficient roadway width</td><td>• Dedicated pedestrian friendly facilities like footpath
• Parking areas and dedicated bays for pick up/ drop facilities</td></tr>
<tr><td colspan="2">
</td></tr>
<tr><td></td><td></td></tr>
<tr><td>Proposed location for the station</td><td>Approach road near the proposed station</td></tr>
<tr><td></td><td></td></tr>
<tr><td>Surrounding areas near location</td><td>Surrounding areas near location</td></tr>
</table>

5. Lok Vihar

Lok Vihar is the fifth station of the proposed Extended Metro Corridor. It is an elevated station near Raj Royal Lawn on NH 7 catering to the surrounding areas.

Issues & Concerns	Potential for Improvements
• Lack of footpaths resulting in pedestrian spillover on road further adding to pedestrian vehicular conflict • PT/IPT stops do not have dedicated bays which causes reduction of carriageway	• Dedicated bays for pick up/ drop facilities for IPT • Parking areas and dedicated bays for pick up/ drop facilities

Lack of Pedestrian Facility

Approach Road nearthe proposed Station

Surrounding areas near Location

Lack of footpath on approach Road

6. Lekha Nagar

This is the sixth station of the proposed Extended Metro Corridor. The catchment area of this elevated station are Raksha Manglya Awas and Lekha Nagar.

Issues & Concerns	**Potential for Improvements**
• Lack of pedestrians facilities results in pedestrian vehicular conflict • Lack of PT/IPT stops and dedicated bays for Buses and Auto affect the connectivity of the location • Pedestrian Safety is a concern	• Parking areas and dedicated bays for pick up/ drop facilities for PT/IPT • Dedicated pedestrian friendly facilities like footpath and cycle tracks

Proposed location for the station

Approach road near the proposed Station

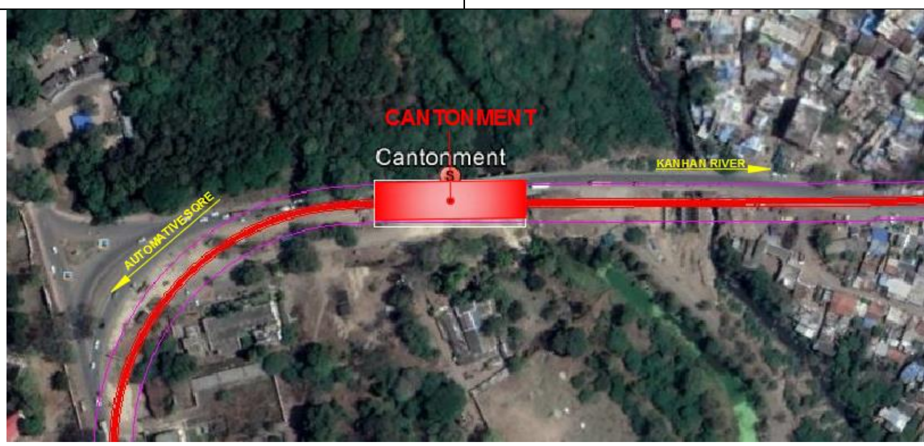
Approach Road & Surrounding

Approach Road & Surrounding

7. Cantonment

This is the seventh station of the proposed Extended Metro Corridor. It is an elevated station and the main catchment area of this station is Kamptee Cantonment area.

Issues & Concerns	Potential for Improvements
• Lack of pedestrians facilities results in pedestrian vehicular conflict • Lack of PT/IPT stops and dedicated bays for Buses and Auto affect the connectivity of the location • Pedestrian Safety is a concern	• Parking areas and dedicated bays for pick up/ drop facilities. • Planning of dispersal facilities through feeder modes will cater to a larger catchment. • Dedicated pedestrian facilities like footpath and cycle tracks.



Proposed location of the station

Proposed location from other side

Surrounding areas near location

Surrounding areas near location

8. Kamptee Police Station

This is the eighth station of the proposed Extended Metro Corridor. It is an elevated station near Kamptee Police station on NH-7. The catchment area of this station are nearby areas along Old Kamptee Road and Kalamna Road etc.

Issues & Concerns	Potential for Improvements
• Lack of pedestrians facilities resulting in pedestrian spillover on road • On-street parking causes reduction in efficient roadway width • PT/IPT stops do not have dedicated bays which causes reduction of carriageway	• Dedicated NMT friendly facilities • Parking areas and dedicated bays for pick up/ drop facilities • Planning of dispersal facilities through feeder modes will cater to a larger catchment.

Location of proposed station

Approach road near the proposed station

Surrounding areas near location

Vehicular movement near proposed station

9. Kamptee Municipal Council

This is the ninth station of the proposed Extended Metro Corridor. It is an elevated station near Tehsil Office and Nagar Parisad Office, Kamptee on NH-7. The catchment area of this station are Nagar Parisad, Tehsil, Government Hospital and surrounding areas etc.

Issues & Concerns	**Potential for Improvements**
• Lack of footpaths resulting in pedestrian spillover on road • On-street parking causes reduction in efficient roadway width • PT/IPT stops do not have dedicated bays which causes reduction of carriageway	• Dedicated pedestrian friendly facilities like footpath • Parking areas and dedicated bays for pick up/ drop facilities • Planning of dispersal facilities through feeder modes will cater to a larger catchment and help maximize ridership of the proposed system

Proposed location for the station

Approach road near the proposed station

Surrounding areas near location

Vehicular movement near proposed station

10. Dragon Palace

This is the tenth station of the proposed Extended Metro Corridor. It is an elevated station near Dada Saheb Kumbhare and Children Park on NH-7. The main catchment area include Dr. Ambedkar Sanskrutik Bhavan, Buddha Vihar etc.

Issues & Concerns	Potential for Improvements
• Lack of footpaths resulting in pedestrian spillover on road further adding to pedestrian vehicular conflict • PT/IPT stops do not have dedicated bays which causes reduction of carriageway • Encroachments and On-street parking due to adjacent land uses causes reduction in efficient roadway width	• Dedicated bays for pick up/ drop facilities for IPT • Continuous encroachment free footpath facilities • Proper parking areas and dedicated bays for pick up/ drop facilities

Approach road near the proposed station

Proposed location for the station

Surrounding area near location

Approach road and surrounding area

11. Golf Club

<table>
<tr><td colspan="2">This is the eleventh station of the proposed Extended Metro Corridor. It is an elevated station near Cantonment area.</td></tr>
<tr><td>Issues & Concerns</td><td>Potential for Improvements</td></tr>
<tr><td>• Lack of pedestrians facilities results in pedestrian vehicular conflict
• Lack of PT/IPT stops and dedicated bays for Buses and Auto affect the connectivity of the location
• Pedestrian Safety is a concern</td><td>• Proper parking areas and dedicated bays for pick up/ drop facilities for PT/IPT
• Dedicated pedestrian friendly facilities like footpath and cycle tracks</td></tr>
<tr><td colspan="2">
</td></tr>
<tr><td></td><td></td></tr>
<tr><td>Proposed location for the Station</td><td>Existing are anear the proposed Station</td></tr>
<tr><td></td><td></td></tr>
<tr><td>Existing surrounding areas</td><td>Surrounding area near station</td></tr>
</table>

12. Kanhan River

This is the 12th station of the proposed Metro Corridor. It is an elevated off the road station near Kanhan river. The catchment area basically across the river from Kanhan, Dr. BR Ambedkar Nagar, Tukaram Nagar, Dattaji Nagar and Shiv Nagar.

Issues & Concerns	Potential for Improvements
• Lack of NMT facilities like footpath and cycle tracks results in pedestrian spillover on road • On-street parking causes reduction in efficient roadway width • PT/IPT stops do not have dedicated bays which causes congestion at carriageway	• Parking areas and dedicated bays for pick up/ drop facilities • Planning of dispersal facilities through feeder modes will cater to a larger catchment. • Dedicated pedestrian facilities like footpath and cycle tracks

Proposed location of the station

Proposed location & approach road

Surrounding area near proposed station

Surrounding area near proposed station

CORRIDOR-3A: LOKMANYA NAGAR TO HINGNA

1. Hingna Mount View

This is the first station of the proposed extended metro corridor. It is an elevated station near Vrundavan Residency Boys Hostel. The catchment area of station are Amar Nagar, MIDC, Lokmanya Nagar etc.

Issues & Concerns	Potential for Improvements
• Lack of pedestrians facilities results in pedestrian vehicular conflict. Lack of PT/IPT stops and dedicated bays for Buses and Auto affect the connectivity of the location.	• Parking areas and dedicated bays for pick up/ drop facilities for PT/IPT.

Proposed location ofthestation

Approach road nearthe proposed station

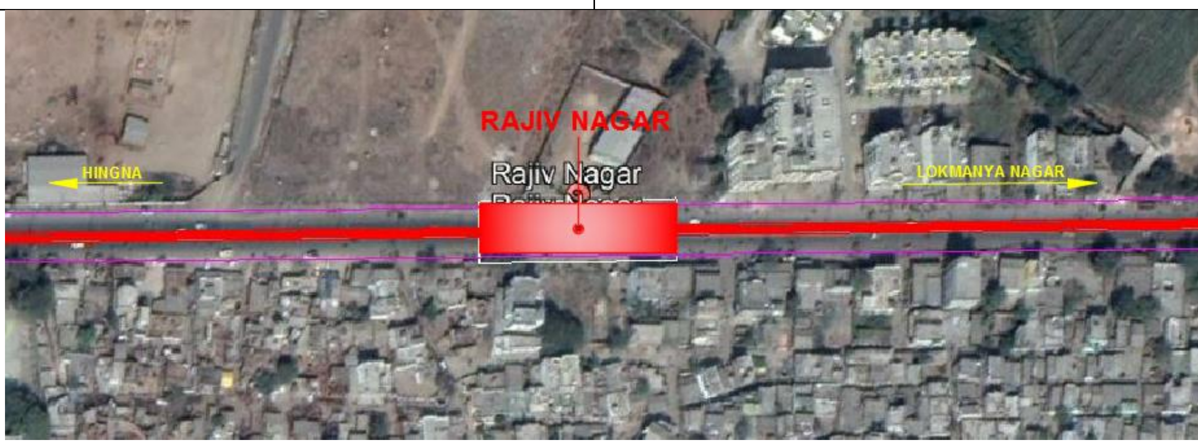
Surrounding areas near proposed station

Surrounding areas near proposed station

2. Rajiv Nagar

This is the second station of the proposed Extended Metro Corridor. It is an elevated station near Nilkamal Apartment on Hingna Extension corridor. The catchment area of station are Rajiv Nagar, Nildoh etc.

Issues & Concerns	Potential for Improvements
• Lack of NMT facilities like footpath and cycle tracks results in pedestrian spillover on road. • PT/IPT stops do not have dedicated bays which causes congestion at carriageway.	• Parking areas and dedicated bays for pick up/ drop facilities. • Planning of dispersal facilities through feeder modes will cater to a larger catchment.



Proposed location of thestation

Proposed location & approach road

Surrounding area of proposed location

Lack of footpath on approach road

3. Wanadongri

This is the third station of the proposed Extended Metro Corridor. It is an elevated station near Wanadongri area on Hingna Extension Corridor. The catchment area of station are Wanadongri, Lakshmi Nagar etc.

Issues & Concerns	**Potential for Improvements**
• Lack of pedestrians facilities resulting in pedestrian spillover on road • On-street parking causes reduction in efficient roadway width • PT/IPT stops do not have dedicated bays which causes reduction of carriageway	• Dedicated NMT friendly facilities • Parking areas and dedicated bays for pick up/ drop facilities • Planning of dispersal facilities through feeder modes will cater to a larger catchment.

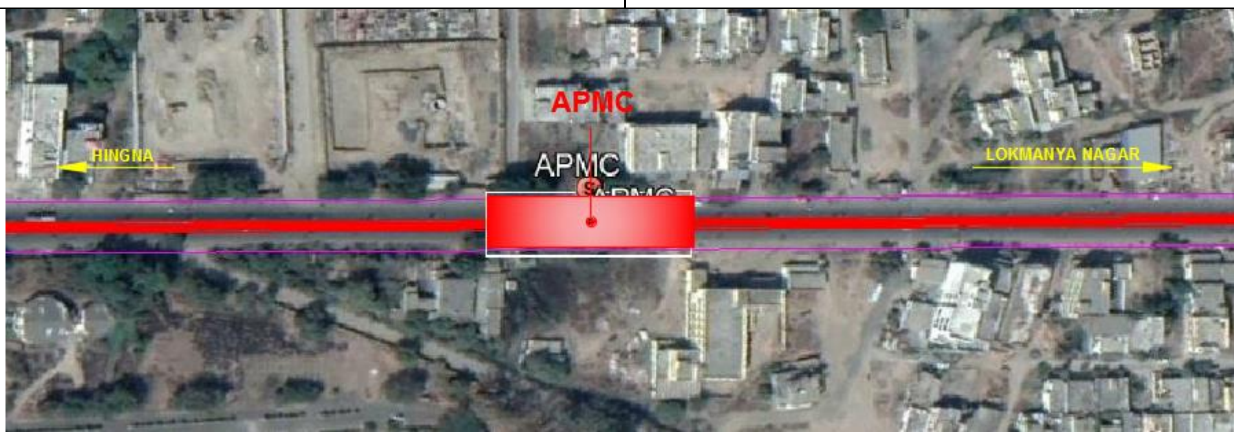
Location of proposed station

Surrounding area near location

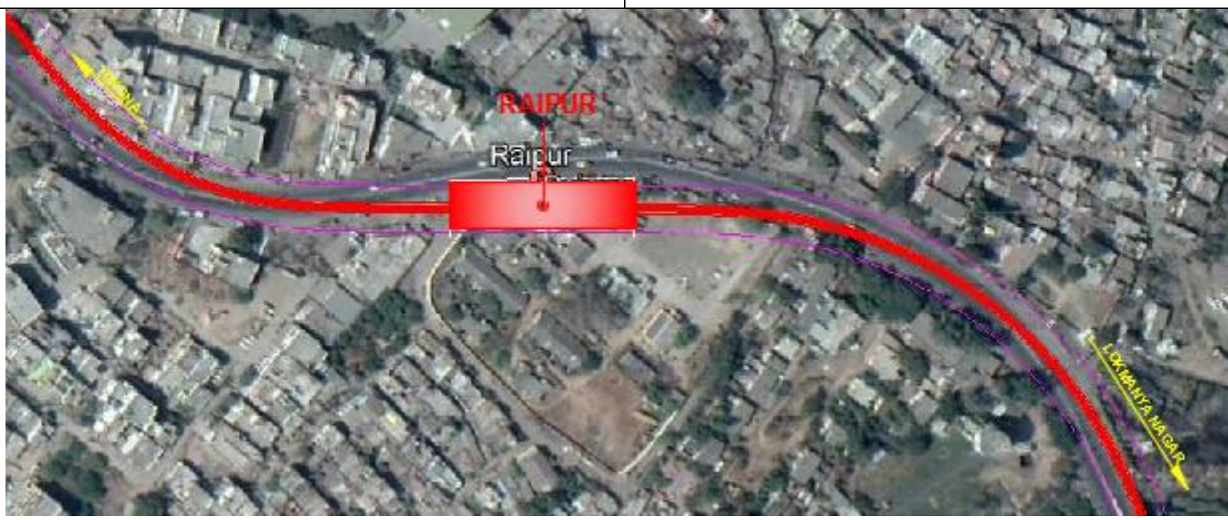
Lack of footpath on approach road

Approach road nearthe proposed station

4. APMC

<table>
<tr><td colspan="2">This is the fourth station of the proposed extension. It is an elevated station near Krushi Utpan Bazar Samiti Market (APMC) on Hingna Extension corridor with catchment area of APMC, Mahajanwadi etc.</td></tr>
<tr><td>Issues & Concerns</td><td>Potential for Improvements</td></tr>
<tr><td>• Lack of footpaths resulting in pedestrian spillover on road.
• Lack of parking and pick up/drop facilities.</td><td>• Dedicated pedestrian friendly facilities like footpath.
• Parking areas and dedicated bays for pick up/ drop facilities.</td></tr>
<tr><td colspan="2"></td></tr>
<tr><td></td><td></td></tr>
<tr><td>Proposed location of the station</td><td>Surrounding area near the location</td></tr>
<tr><td></td><td></td></tr>
<tr><td>Approach road at proposed location</td><td>Lack of footpath near location</td></tr>
</table>

5. Raipur

<table>
<tr><td colspan="2">This is the 5th station on the extension. It is an elevated station near Hingna Police Station. The catchment area of station include Raipur Bazar etc.</td></tr>
<tr><td>Issues & Concerns</td><td>Potential for Improvements</td></tr>
<tr><td>Lack of footpaths resulting in pedestrian spillover on road.
On-street parking causes reduction in efficient roadway width.</td><td>Dedicated pedestrian friendly facilities like footpath.
Parking areas and dedicated bays for pick up/ drop facilities.</td></tr>
<tr><td colspan="2">
</td></tr>
<tr><td></td><td></td></tr>
<tr><td>Proposed location for the station</td><td>Approach road near location</td></tr>
<tr><td></td><td></td></tr>
<tr><td>Surrounding areas near location</td><td>Surrounding areas showing parking</td></tr>
</table>

6. Hingna Bus Station

This is the 6th station of proposed extended metro corridor. It is an elevated station near Nagar Panchayat Commercial Complex. The catchment area of station are Jogeshwarpuri, Kanolibara, Hingna Bus Station etc.

Issues & Concerns	**Potential for Improvements**
• Lack of footpaths resulting in pedestrian spillover on road • On-street parking causes reduction in efficient roadway width	• Dedicated pedestrian friendly facilities like footpath • Parking areas and dedicated bays for pick up/ drop facilities

	
Proposed location for the station	Approach road near location
	
Lack of parking shown at location	Surrounding areas near location

7. Hingna

This is the last station of the proposed extended metro corridor. It is an elevated station near Vijayvinkar Society. The catchment area of station are Dhangarpura, Hingna Rural Hospital etc.

Issues & Concerns	Potential for Improvements
• Lack of footpaths resulting in pedestrian spillover on road • On-street parking causes reduction in efficient roadway width	• Dedicated pedestrian friendly facilities like footpath • Parking areas and dedicated bays for pick up/ drop facilities

Proposed location for the station

Lack of footpath shown at location

Approach road near location

Surrounding areas near location

CORRIDOR-4A: PRAJAPATI NAGAR TO TRANSPORT NAGAR

1. Pardi

This is the first station of the proposed extension. It is an elevated station near Prakash Krushi Mahavidhyalaya. The catchment area of station are Navin Nagar, Bhawani Nagar, Mahajanpura etc.

Issues & Concerns	Potential for Improvements
• Lack of footpaths resulting in pedestrian spillover on road • On-street parking causes reduction in efficient roadway width	• Dedicated pedestrian friendly facilities like footpath • Parking areas and dedicated bays for pick up/ drop facilities

	
Lack of footpath near location	Approach road at the location
	
Surrounding areas near location	Proposed location for the station

2. Kapsi Khurd

This is the 2nd station of the proposed extended corridor. It is an elevated station near Bihar Bengal Carriers. The catchment area are Navin Nagar, Kapsi Khurd, Ghar Sansar Nagar etc.

Issues & Concerns	Potential for Improvements
• Lack of footpaths resulting in pedestrian spillover on road • On-street parking causes reduction in efficient roadway width	• Dedicated pedestrian friendly facilities like footpath • Parking areas and dedicated bays for pick up/ drop facilities

Proposed location for the station

Approach roadnear location

Surrounding areas near location

Lack of footpath near approach road

3. Transport Nagar

This is the last station of the proposed extended corridor. It is an elevated station near Transport Nagar Approach Road and near Bharat Petrol pump. The catchment area of station are Transport Nagar, Kapsi , Asoli etc.

Issues & Concerns	Potential for Improvements
• Lack of footpaths resulting in pedestrian spillover on road • On-street parking causes reduction in efficient roadway width	• Dedicated pedestrian friendly facilities like footpath • Parking areas and dedicated bays for pick up/ drop facilities

Proposed location for the station

Lack of footpath near location

Surrounding areas near location

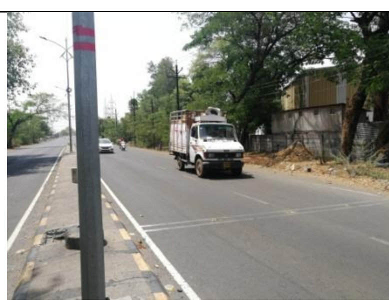
Approach road at the location

CORRIDOR-5: VASUDEV NAGAR TO DATTAWADI

1. Police Station MIDC

This is the first station of the proposed extension. It is an elevated station near MIDC Post Office and Bank of Maharashtra. The catchment area includes G H Raisoni Group of Institutions, Post Office and various surrounding industrial buildings etc.

Issues & Concerns	Potential for Improvements
• Lack of footpaths resulting in pedestrian spillover on road • On-street parking causes reduction in efficient roadway width	• Dedicated pedestrian friendly facilities like footpath • Parking areas and dedicated bays for pick up/ drop facilities

	
Proposed location for the station	Approach road showing median
	
Surrounding areas near location	Lack of footpath shown near location

2. MIDC Hingna

<table>
<tr><td colspan="2">This is the 2nd station of the proposed extended metro corridor. It is an elevated station near Rama Entertainment and Munich Motors. The catchment area of this station are various nearby automobile workshops, Pardsinga etc.</td></tr>
<tr><th>Issues & Concerns</th><th>Potential for Improvements</th></tr>
<tr><td>• Lack of footpaths resulting in pedestrian spillover on road.
• On-street parking causes reduction in efficient roadway width.</td><td>• Dedicated pedestrian friendly facilities like footpath.
• Parking areas and dedicated bays for pick up/ drop facilities.</td></tr>
<tr><td colspan="2">
</td></tr>
<tr><td></td><td></td></tr>
<tr><td>Proposed location for the station</td><td>Surrounding areas near location</td></tr>
<tr><td></td><td></td></tr>
<tr><td>Lack of footpath near location</td><td>Approach road near location</td></tr>
</table>

3. Dattawadi

<table>
<tr><td colspan="2">This is the last station of proposed extended corridor. It is an elevated station near Hotel Rahul Palace. The catchment area of station is various MIDC sectors located nearby, Dattawadi Bus stop and surrounding areas near MIDC Wadi T-Point.</td></tr>
<tr><td>Issues & Concerns</td><td>Potential for Improvements</td></tr>
<tr><td>• Lack of footpaths resulting in pedestrian spillover on road
• On-street parking causes reduction in efficient roadway width</td><td>• Dedicated pedestrian friendly facilities like footpath
• Parking areas and dedicated bays for pick up/ drop facilities</td></tr>
<tr><td colspan="2"></td></tr>
<tr><td></td><td></td></tr>
<tr><td>Proposed location for the station</td><td>Lack of footpath near location</td></tr>
<tr><td></td><td></td></tr>
<tr><td>Surrounding areas near location</td><td>Proposed road and location</td></tr>
</table>

6.1.2 Station Planning

a. Planning Parameters

NBC (National Building Code) & NFPA 130 (Standard for Fixed Guide way Transit and Passenger Rail Systems) shall be used for station designing & planning.

b. Station Planning – Coverage

The station planning will be determined by the following factors:

- Operational requirements in the use of side platforms in elevated stations.
- Station entry/exit location requirements
- Utilities such as firefighting systems, ventilation, water requirements
- Structural requirements
- Flexibility in design to allow stations to respond to site specific requirements

The essential quality in a good station layout is the provision of adequate space for efficient movement of passengers between ground level entrances on to the trains and vice versa in the most direct, simple and logical way.

c. Salient Features of a Typical Station

Station entrances provide the link between station concourse and the surrounding streets and their location must reflect the separate constraints of both. Station entrances are located with particular reference to passenger catchment points and also cater for inter modal interchange which includes buses, IPTs, pick/drop by private mode etc. Important criteria that have been applied in the development of station planning include:

- Sizing of Station Passenger Facilities
- Stipulated Design Standards
- Emergency Evacuation
- Passenger circulation, comfort, ease of use, safety and security
- Operational accommodation (Back of House Areas)
- Electrical and Mechanical Plant and Equipment space requirements

Concourse forms the interface between streets and the platform. This is where all the passenger amenities are provided.

Office accommodation, operational areas and plant room space are provided in the non-public areas of the station.

The platform level has been designed for adequate assembly space for passengers for both normal operating conditions and a recognized abnormal scenario (emergency).

The location of DG set, Bore Well Pump House, Underground / overhead tank, chiller plant and Pump Houses are preferably proposed to be located in one area at ground level wherever possible.

d. Planning Norms & Standards

Station Design is dependent on the peak hour traffic load for each station. The platform length is planned for 3 cars/train. The total evacuation time for the movement of all passengers in an emergency from platform level to the point of safety does not exceed 4.0 minutes (as per "NFPA 130" Guidelines) in the stations. The station planning is also in compliance to the "Guidelines and Space Standards for Barrier Free Built Environment for Disabled and Elderly persons" published by the Ministry of Urban Affairs and Employment India in 1998.

e. Entry/Exit

Entrances to stations have adequate capacity to satisfy predicted passenger flows and emergency evacuation requirement. The position of entrances is determined by the juxtaposition of building location of roadway footpath width, space availability and flow directions of passenger traffic.

The numbers and width of staircases/ escalators are determined by checking the capacity/available width against peak passenger flows rates for both normal and emergency conditions such as delayed train service, fire etc.

f. Concourse Planning Standards

The arrangement of the concourse is assessed on a station-by-station basis and is determined by site constraints and passenger access requirements. The stations are divided into public and non-public areas (those areas where access is restricted). The public areas are further subdivided into paid and unpaid areas. The concourse contains automatic fare collection system (AFC) in a manner that divides the concourse into two distinct areas called Paid and Unpaid areas. The 'unpaid area' is where passengers gain access to the system, obtain travel information and purchase tickets. On passing through the ticket gates, the passenger enters the 'paid area', which includes access to the platforms. The concourse is planned in such a way that maximum surveillance can be achieved by the ticket hall supervisor over ticket machines, automatic fare collection (AFC) gates, stairs and escalators. Ticket machines and AFC gates are positioned to minimize cross flows of passengers and provide adequate circulation space. Sufficient space for queuing and passenger flow has been proposed in front of the ticketing counters and AFCs gates. The “Non Public Areas” comprise of the Back of House (BOH) areas. The BOH areas consists of System Rooms, Operations, Staff Facilities, Water Supply and Drainage System and Miscellaneous requirements. Passenger handling facilities comprise of stairs/escalators, lifts, ticketing counters/automatic ticket vending machines and ticket gates required to process the peak traffic from street to platform and vice-versa. These facilities are provided in the concourse and they also act as a medium to transfer between Paid and Unpaid areas (these facilities also enable evacuation of the station under emergency conditions, within a set safe time limit). Uniform number of these facilities has been provided for system wide uniformity, although the requirement of the facilities actually varies from station to station based on the peak hour passenger load.

g. Operational Rooms for Public Use

Ticketing Gates

The ticketing system shall be simple, easy to use/operate, and maintain, easy on accounting facilities, capable of issuing single/multiple journey tickets, amenable for quick fare changes and requiring less man power. The requirement of the number of gates is based on the peak hour passenger traffic at the station. Uniform space has been provided at all stations where gates can be installed in the unpaid area of the concourse. Ticketing gates provides a means of transfer between paid and unpaid area of the concourse. Ticketing gates’ requirement has been calculated taking the gate capacity as 28 persons per minute per gate (85% of the Maximum Practical Capacity which is taken as 35 persons per minute per gate). In the design year output capacity of 35 passengers is assumed because of passenger’s familiarity with the system. At least two ticketing gates are provided at any elevated station.

- The gate design will depend upon;

- Check in and checkout (distance fare): implying bi-directional gates
- Fare media: smart card, magnetic or paper ticket.
- The most popular gates are with sliding glass panels (“pavel” design)
- Special gates are designed for;
- Widened ticket gates for Disabled persons access,
- Customers with luggage,
- Customers with strollers

The total number of gates also includes one service gate, one emergency exit door in case of breakdown, one separate gate for disabled in Elevated stations.

Ticket Counters and Ticket Vending Machines (TVMS)

It is proposed to deploy manual ticket issuing counters in the beginning of the operation of the line. At a later stage, automatic TVMs would be used, for which space provision will be made at the concourse. The number of TVMs required is governed by the peak hour passenger traffic, the fare policy and the ticketing. Depending on the composition of monthly pass/smart card users and single ticket users, the number of TVMs could change. Adequate provision has been kept at the stations for the TVM and Ticket counters in the unpaid area of the concourse and is suitably located for the ease of usability of the passengers. As a general thumb rule, it is proposed to provide 5 to 7 TVM's for stations with high traffic and 2 to 5 TVM's for other stations (**Figure 6.2**)

FIGURE 6.2: TICKET VENDING MACHINES AT STATIONS

Shinjuku Station - Tokyo

MTR Wall Mounted TVM – Paris

Ticket Office

The number of Ticket Offices is determined by the passenger traffic and the operation policy. A minimum of 2 ticket office per station in the stations with high traffic, and 1 ticket office per station in the stations with low traffic have been planned (**Figure 6.3**)

FIGURE 6.3: TICKET OFFICE AT STATIONS

h. Platform Planning Standards

The length of the Platform is 77.5meter. This allows for the length of 3 car train and a stopping tolerance for the rail corridor Platforms. The nominal platform width measured from the platform edge to any continuous (longer than 2000 mm) fixed structure shall be a minimum of 3000 mm. The minimum distance from the platform edge to any isolated obstruction e.g. columns, shall be 2500 mm (an isolated obstruction shall not be longer than 2000 mm). This clearance shall be maintained for safety reasons, irrespective of passenger flows. The platform width greater than the minimum may be required at stations with large passenger flows. The platform edge shall have a safety margin of 600 mm wide with a non-slip surface and a yellow warning strip of 100 mm wide of contrasting texture. The platform ends shall be provided with a 1200 mm wide security gate and be installed with a Pressure Mat Alarm system.

Platform widths Calculation:

The platform width shall be determined by the peak minute flow, allowing for two missed headways. The crush load is taken as the sectional load between two stations. For an island platform, the area between the boundaries of the two platforms is included in the calculation.

The process to derive the platform width calculations are detailed below:

Disruption of time of service = Two missed headways

Peak Minute Peak Direction Boarding = Peak hour Peak direction boarding/50. The peak minute flow taken in the calculations is assumed to be 20% higher from the average minute flow as derived from the hourly passenger volume. This takes into account the peaking minute during the peak hour flow of the passengers.

Platform congregation during disrupted time of service: Peak minute Peak direction boarding X Disrupted Time

Platform Width = {Platform congregation during disrupted time of service + Train Sectional Load} X 0.2/Platform length

(0.2 sq. m/person has been taken as the platforms are planned for a minimum Level of Service)

Markings on the platform and ramps to assist and control the flow of passengers for boarding and alighting with a step free access from/to the trains shall be provided. Tactile Markings shall also be provided for guiding paths and warning strips for vision impaired persons to ease the travel for Persons with Disabilities. The built platforms shall also provide for bright colour contrast for low vision persons; large lettering and information displays and digital signage; lifts with lowered control panel with Braille and raised control buttons and auditory signals, wide doors and grip rails on the sidewalls of the elevator car; resting areas for senior citizens and disabled persons; well-lit platform corridors along with public announcement system. Inside the coaches, there will be designated spaces for wheelchair users, audio announcement with dynamic display and sensory door closing mechanisms. Space occupied by stairs, escalators, structure, seating, platform supervisor's accommodation etc. is not be included as part of the platform area. Platforms shall have a clear head room of at least 3000 mm to structures and platform signs to a width of at least 2000 mm from the platform edge over their entire length. Suspended signs, fittings, and fixtures shall have a minimum clearance of 2100 mm above finished floor.

i. Emergency Evacuation Standards

The Requirement is to evacuate people from a station platform to the point of safety, initially the next level below or above and then on to street level without hindrance.

The principles to be followed are:-

The maximum distance on the platform to a point at which means of egress route leaves the platform shall not exceed 100 m. The provision in the station layouts from the remote point on the platform to an exit route has been kept within 50 meter.

The time required walking from the farthest point on a platform to the escalator or stair landing is considered to be half a minute. Walking speed as per NFPA 130 has been taken as 37.8 meter/minute.

A Check shall be made to ensure that sufficient capacity exists at the level to which passengers are evacuated as being a place of ultimate safety so that people can move freely away from stairs and escalators as they arrive. The emergency is assumed to be occurring in one direction of travel only at any given point of time.

For ensuring adequacy of platform area, stair widths and requirement of additional emergency evacuation stairs, a maximum accumulation of passengers in the station has been considered to be comprising waiting passengers at the platform (including two missed headways) and section load (or full train load if the section load exceeds a full train load) expected to be evacuated from the peak direction at the station in case of an emergency. Also, waiting passengers congregated during this disrupted time of service (two missed headways) in the off-peak direction to be added in the evacuation from the platform to concourse in case of underground stations and concourse to ground in both underground as well as elevated stations.

j. Operational Rooms (BOH Areas)

Back of House (BOH) areas comprise of "Public" and “Non Public Areas”. The BOH areas consist of System Rooms, Operations, staff facilities, Water Supply and Drainage System and Miscellaneous requirements.

Some of the areas and their functions are detailed below:

Station Control Room

The station control room is required to control and monitor the stations’ equipments (fire-fighting systems, ventilation, etc.). It is generally located in the concourse of each station. It is recommended that the operator can easily access any part of the station from this office. This room is fitted with a dialog box for passenger information.

Ticket Office

The Ticket Office can also be used to inform passengers. If the main Ticket Office is located next to the Station master control room, it will be fitted with a self-closing door between these two rooms. The room will require special protection (as armored glass, metal doors, etc.).

TVM back-store room

For security reasons, the Ticket Vending Machines should be equipped with a back store room. The TVM back-store room is preferably located near the Ticket Counters.

Security/Police Room

This room is located in each station and is used by the security staff. It is preferable that this room is located at the concourse, in the public operation area allowing watching over the public. This room could be fitted with specific equipments in relation to the role of security staff.

Water Storage

The Design of the Water tank is based upon the assumption of 35 liter/person for raw and treated water. The capacity of the Water Tank is provided as 50 cum approximately(as per NBC 2016) for each elevated station and that for the UG station, it is taken as 2 lakh liters. However, when commercial areas are present within metro stations, firefighting facilities shall need augmentation as per NBC 2016.

k. Escalator Design

The following regulations and standards shall form the basis for the design of escalator system.

- American National Standard Institute (ANSI)
- American Society of testing Materials (ASTM)
- International Electro technical Commissions (IEC)
- Indian Standard (IS)

- European Norm (EN)
- National Electrical manufacturers Association (NEMA)
- National Fire Protection Association (NFPA)
- Underwriters Laboratories, Inc. (UL)

Design Criteria

The escalators will be heavy duty “public” service escalators capable of operating safely, smoothly and continuously in either direction, for a period of not less than 20 hours per day, seven days per week, (except special holiday which may be operated 24 hours a day) within the environmental conditions prevailing within the well way and at the location where the escalators are installed. The maximum allowable passenger load of each step should not be less than load equivalent of three 65 kg person per step. The escalators will be equipped with energy saving system. Speed of escalators will be in the range of 0.6-0.75 m/s for normal operation. The energy saving system will reduce speed of escalators to standby speed mode of 0.20 m/s during low traffic hour. The number of flat steps at the upper landing should be in proportion to the vertical rise of the escalator. For 6.1 m to 18.3 m rise, minimum four flat steps should be provided and for a rise up to 6.1 m manufacturers’ standards should be used (2-3 flat steps).The design of the escalators which act as emergency stairways should meet all the criteria requirements in NFPA 130. The design of the escalators will be such that they can be used as fixed staircases under a condition of power failure, activation of stop button or activation by safety/protection devices. When the escalators are stationed, no slipping, jerking, sliding and vibration should occur. Escalators will be equipped with protective barriers, where necessary.

Interfacing requirements:

The following escalators interface will be monitored by the SCADA and abnormal conditions will be alarmed:

- Incoming power lines healthy.
- Direction status.
- Running
- Fault
- Emergency

- Elevator Requirements
- Standards, Codes and Regulations

I. Elevator Design

The following regulations and standards will form the basis for the design of elevator system.

- American National Standard Institute (ANSI)
- American Society of testing Materials (ASTM)
- International Electro technical Commissions (IEC)
- Indian Standard (IS)
- European Norm (EN)
- National Electrical manufacturers Association (NEMA)
- National Fire Protection Association (NFPA)
- Underwriters Laboratories, Inc. (UL)

Design Criteria

Lifts will be of the goods/passenger public service type and rated at minimum 180 starts per hour. Lifts will be of proven technology and designed to have low energy consumption, low operational costs and will provide environment friendly passenger service. Lifts will be rope traction type capable of operating safely and smoothly without jerking under all loading conditions, for a period of not less than 20 hours per day (except special holiday which may be operated 24 hours a day), seven days per week within the environmental conditions prevailing within the hoist-way and at the location where the elevators are installed. Lift will be capable of carrying minimum loading of 750 kg, and may be sized for comfortably taking an injured person on a stretcher with room for the stretcher bearers to place the stretcher in the lift without difficulty. The design of the lift will take into consideration fire prevention, elimination of dust and dirt traps, and easy access for cleaning and routine maintenance. The drive machine, its associated machinery and all necessary control equipment of lifts at stations will be installed within the lift shaft without any lift machine room. Intercom will be provided inside the lift car to communicate with the Station Operation Room of the station where lifts are installed. The leveling accuracy at the landing served, under no load and full load condition in either up and down direction, will be made within + 5 mm. The speed of lift will be capable of reaching the uppermost discharge point in not more than one minute. The time will be calculated from the time the doors are fully closed at the lowest discharge point to the time that they begin to open at the uppermost discharge point. The minimum speed will be not less than 1.0 m/s irrespective of the travel distance. Lifts will be equipped with facilities for physically challenged people, in accordance with the relevant standards.

Interfacing Requirements:

The following shall be monitored by the SCADA and abnormal conditions will be alarmed:

- Incoming power lines healthy.
- Direction status.
- Running
- Fault
- Emergency Status.

m. Stairs Requirements

- A central handrail is provided where stair width is 4.5 m or more.
- Risers per flight: 3 minimum, 12 maximum
- All Steps in a flight of Stairs have the same dimensions
- Tread width : 300mm; Rise : 150mm
- Length of intermediate landing: lesser of 2m or width of stairs
- Handrail: 0.9m high, 50mm diameter, 45mm clearance to wall.
- Step noses will be rounded and color contrasted
- Minimum Stair width for assembly building: 2000mm

n. Commercial Areas for Retail Shops/Kiosks/ATM's

Retail shops in the stations could provide additional financial income. The expected level of passenger traffic in the stations provides great potential for a high commercial value for the retail shops. Here the station area is small so such Kiosk/shops may me provided outside the station where parking provision exist.

o. Roof and Elevations

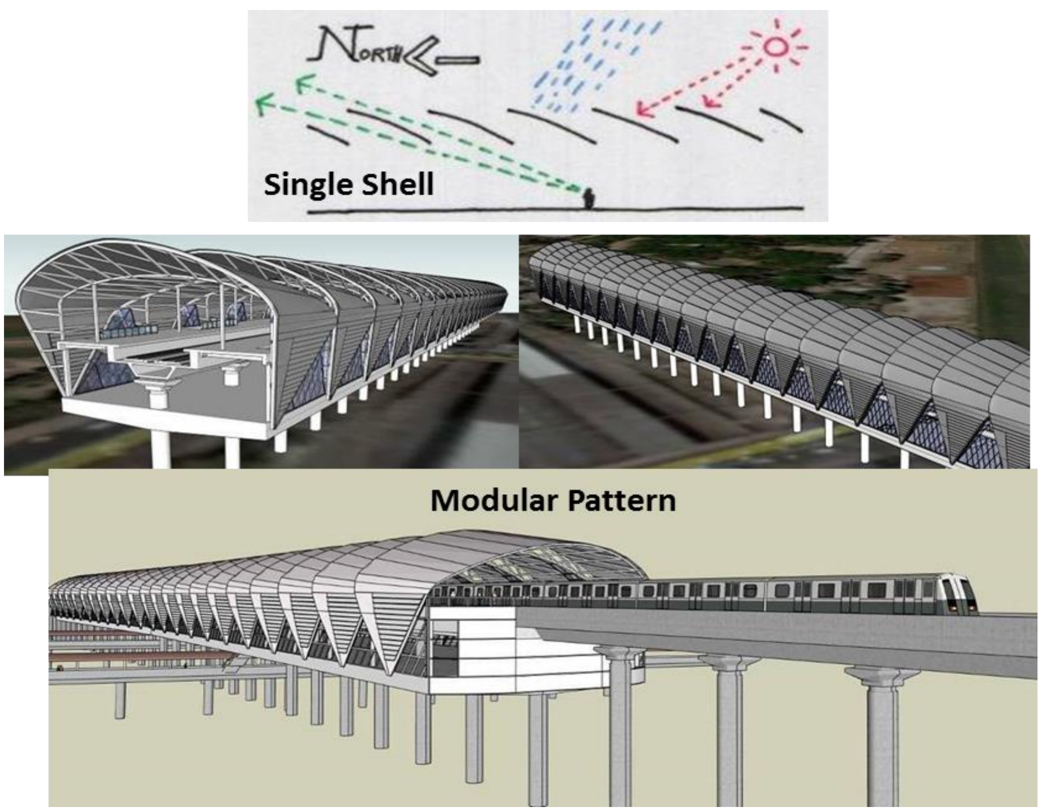
The roof is the most visible part of the station from the surroundings. At approximately 18 to 26 m height, the roof will be the iconic signature of the station identity. It has to reflect the modern and contemporary values of the new line, while being human scaled and properly sized to offer visual comfort for users.

Two types of roof (**Figure 6.4**) concept for elevated stations are proposed;

The single shell: A set of triangle modules of 15 m span, slightly inclined on the top, and chasing the soft northern light, while being closed to the south side, to protect from the sunlight and harsh shower of monsoon season.

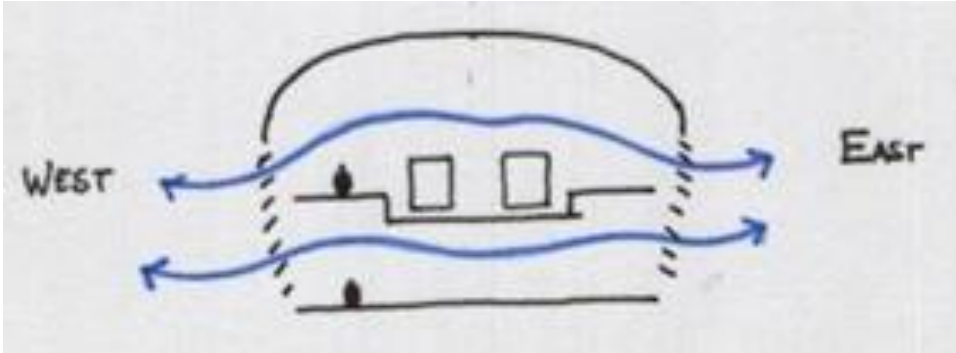
In addition, the modular pattern could be easily adapted to the curvy layout of many of elevated structures.

FIGURE 6.4: ROOF TYPES

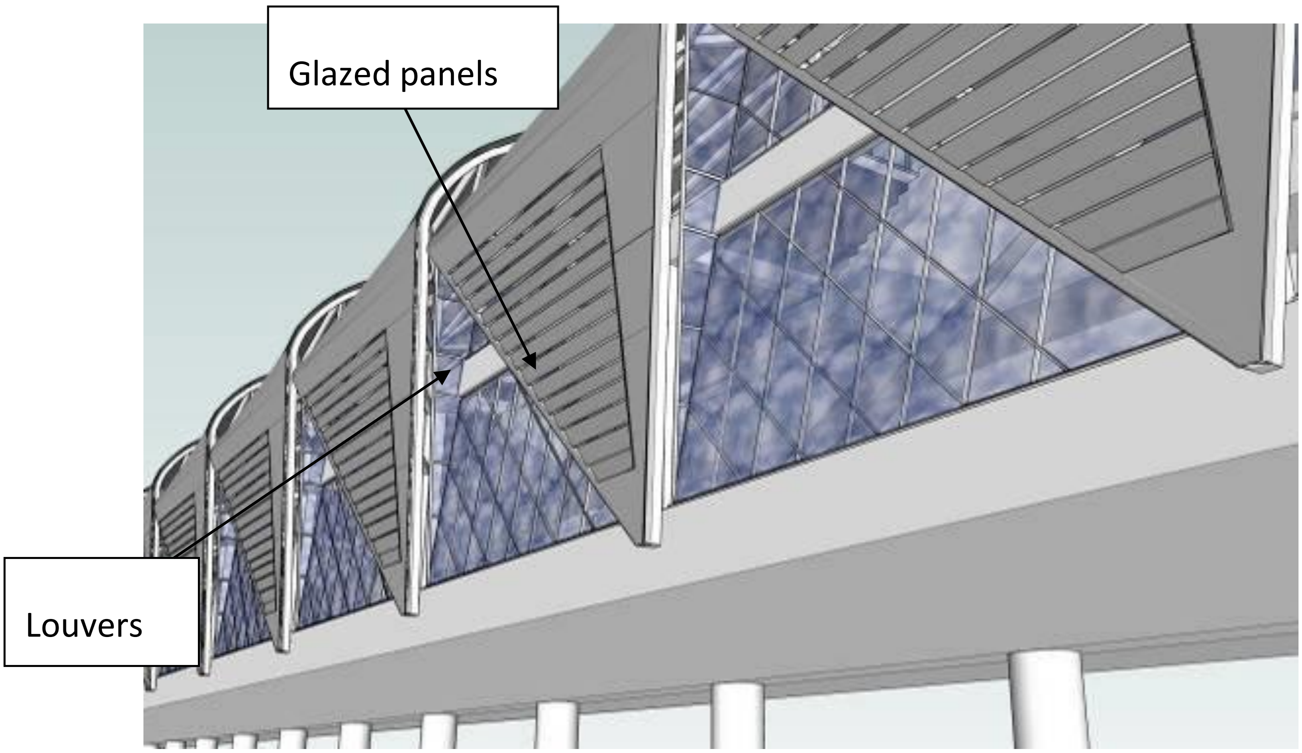


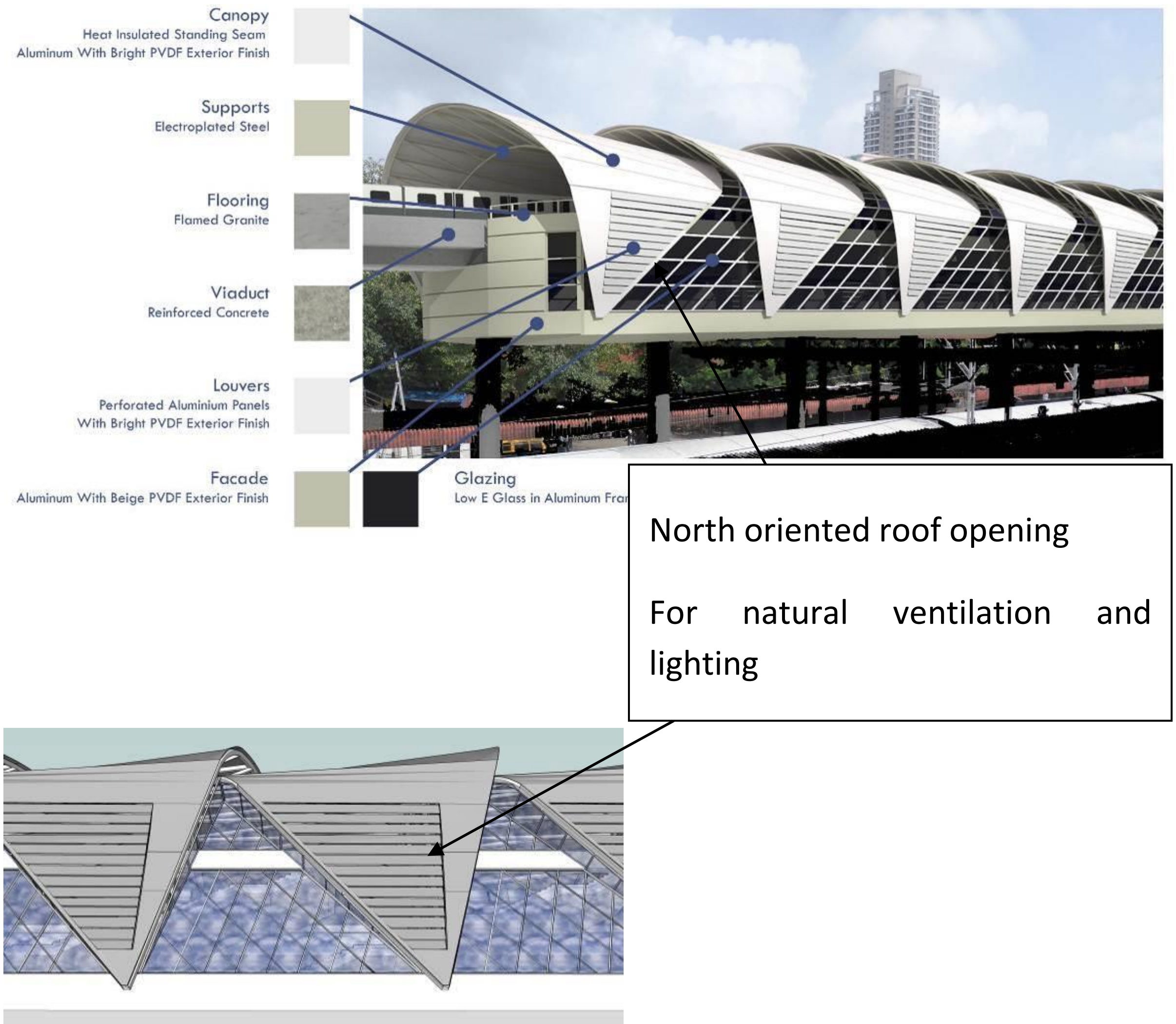
Natural ventilation on platforms and concourse area is ensured through louvers embodied in the lateral side of each module.

FIGURE 6.5: LOUVERS FOR VENTILATION



In the spare space between two modules, a glazed façade could be erected to protect laterally from the elements. Further detailing during implementation can improve some of the opacity of the glazed panels to the natural light and air flows.





p. PLANNING OF METRO STATIONS

The conceptual station planning are the adaptations of the typical stations finalized keeping in view the projected traffic, station requirements, site conditions, minimum land acquisition, method of construction and overall cost optimization. Since land is at a premium throughout the corridor, the process of reconciling the land that is actually required for the station development has had a major influence upon the design process and important elements of the stations such as entry/exits, concourse, platforms etc. have been designed and marked for each station to overcome land acquisition problems. But, wherever the vacant land parcels have not been found available, land acquisition has been proposed for placing the necessary utilities/facilities. The most important design consideration is to provide a safe and comfortable environment to passengers during both normal and emergency operation.

The stations have been provided with an internal environment suitable for a world class Light Rail system by incorporating the experience of international best practices. The stations have been planned in such a way that they are easily operated, maintained and can be upgraded in future. Accommodation for staff and plant rooms is provided at both platform and concourse levels within areas that are entirely separate from the public access. The internal arrangement for the stations is evolved in such a way that Back of House accommodation is organized, so that the rooms of a similar operational use are placed along a common corridor and plant accommodation is clearly distinct from habitable rooms.

The detailed descriptions for the elevated station typology are detailed in subsequent section.

Typical Elevated Station: 79m x 20.85m Cantilevered Structure

The size of the elevated station has been kept as 79m x 20.85m. The stations are generally located on the road median. Total length of the station is 79m. All the stations are two-level stations. The passenger areas on concourse level are concentrated in the middle of the station, with staircases, escalators & elevators leading from either side of the road. The width of the station is 20.85m. It is planned to be a cantilevered structure thereby keeping flexibility for provision of a wider carriageway in future below the concourse with central median. Passenger facilities like ticketing, information, etc. as well as operational areas are provided at the concourse level. Typically, the concourse is divided into public and non-public zones. The non-public zone or the restricted zone contains station operational areas such as Station Control Room, UPS &battery room, signaling equipment room, communication equipment room, auxiliary substations, security room etc. The public zone is further divided into paid and unpaid areas.

Since the station is generally in the middle of the road, minimum vertical clearance of 5.5m has been provided under the concourse. Concourse floor level is about 8.59m above the road. Consequently, platforms are at a level of about 14.89m from the road.

With respect to its spatial quality, an elevated MRT structure makes a great impact on the viewer as compared to an at-grade station. The positive dimension of this impact has been accentuated to enhance the acceptability of an elevated station and the above ground section of tracks. Structures that afford maximum transparency and are light looking have been envisaged. A slim and ultra-modern concrete form is proposed, as they would look both compatible and modern high-rise environment as well as the lesser-built, low-rise developments along some parts of the corridor.

In this type, minimum 2.5m wide staircase is provided on either side of the platform along with one escalator on each side of the platform. Provision of 1 lift has been proposed both sides. Platform roofs that can invariably make a structure look heavy; have been proposed to be of steel frame with aluminium cladding to achieve a light look. Platforms would be protected from the elements by providing an overhang of the roof and sidewalls would be avoided, thereby enhancing the transparent character of the station building. The rest of the station structure is supported on a single column, which lies unobtrusively on the central verge. The room schedule for this typology is given in **Table 6.2**

TABLE 6.2: ROOM SCHEDULE FOR ELEVATED STATION (79MX20.85M)

Sl. No.	Room Name	Room Size (m)		Area Provided (Sq.m)
1	Station Control Room	7.13	6.45	46.00
2	Excess Fare Office	2.58	2.58	6.66
3	Ticket Office-1	5.93	3.22	19.00
4	Ticket Office-2	6.60	3.18	20.99
5	Signaling Equipment Room	12.64	5.00	63.20
6	Telecom Equipment Room	10.01	4.40	44.10
7	Auxiliary Substation, Electrical & DB Room, D G Room, Sump Room & AC Compressor	VARIES	VARIES	323
8	UPS Room	10.01	5.30	53.10
9	Store Room	4.55	4.40	20
10	Paid Area	VARIES	VARIES	1231
11	Unpaid	VARIES	VARIES	1392
12	Security Room	3.00	4.00	12.00
13	Toilet Female	3.23	6.81	22.00
14	Toilets Male	3.23	6.81	22.00
15	PWD Toilet	3.64	1.65	6
16	Platform A			535

Sl. No.	Room Name	Room Size (m)		Area Provided (Sq.m)
17	Platform B			535

Station Details for Corridors of Nagpur Metro Phase-2 are presented in **Table 6.3**

TABLE 6.3: DETAILS OF STATION

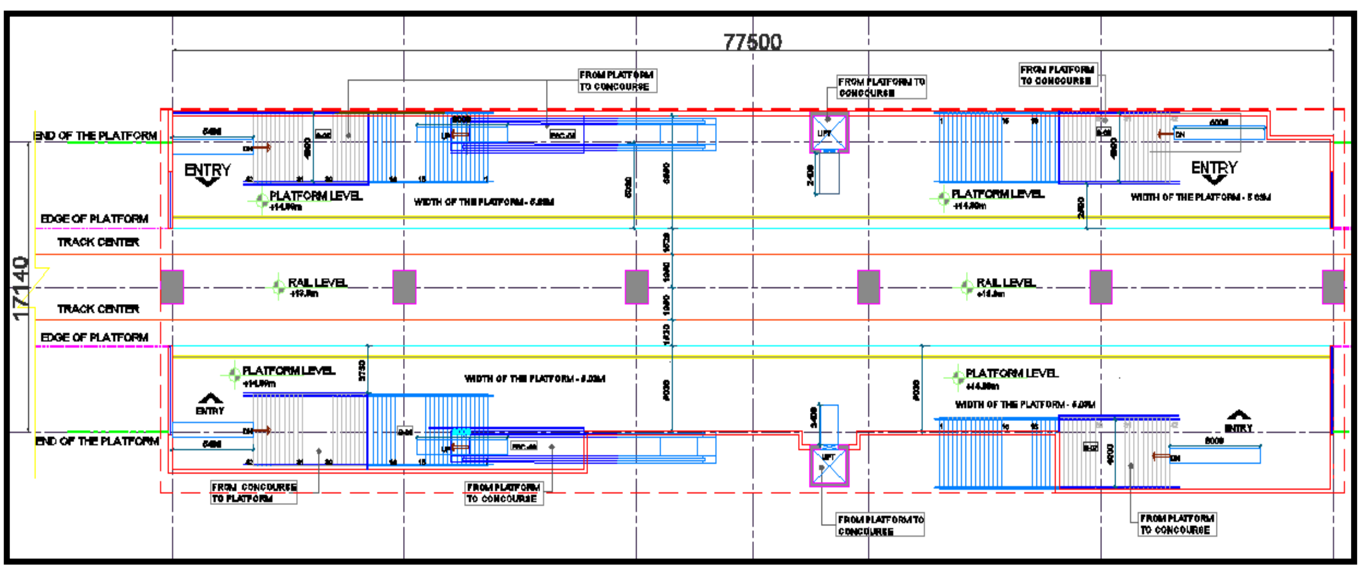
Sl. No.	Name of station	Chainages (m)	Distance from previous station (m)	Platform type	Station type	No. of Escalators	No. of Lifts
Corridor-1A: MIHAN to MIDC ESR Corridor							
1	ECO Park Station	20462	-	SIDE	At grade	-	-
2	Metro City Station	21057	595	SIDE	At grade	-	-
3	Ashokvan	23843	2786	SIDE	Elevated	4	4
4	Dongargaon	26693	2850	SIDE	Elevated	4	4
5	Mohgaon	29878	3185	SIDE	Elevated	4	4
6	Meghdoot CIDCO	32802	2924	SIDE	Elevated	4	4
7	Butibori Police Station	33540	738	SIDE	Elevated	4	4
8	MHADA Colony	34233	693	SIDE	Elevated	4	4
9	MIDC KEC	37360	3127	SIDE	Elevated	4	4
10	MIDC ESR	38352	992	SIDE	Elevated	4	4
Corridor-2A: Automotive square to Kanhan River							
1	Pili Nadi	-1409	-	SIDE	Elevated	4	4
2	Khasara Fata	-2286	877	SIDE	Elevated	4	4
3	All India Radio	-3314	1028	SIDE	Elevated	4	4
4	Khairi Fata	-5250	1936	SIDE	Elevated	4	4
5	Lok Vihar	-6176	926	SIDE	Elevated	4	4
6	Lekha Nagar	-7199	1023	SIDE	Elevated	4	4
7	Cantonment	-8681	1482	SIDE	Elevated	4	4
8	Kamptee Police Station	-9410	729	SIDE	Elevated	4	4
9	Kamptee Municipal Council	-10225	815	SIDE	Elevated	4	4
10	Dragon Palace	-11196	971	SIDE	Elevated	4	4
11	Golf Club	-12468	1272	SIDE	Elevated	4	4
12	Kanhan River	-13324	856	SIDE	Elevated	4	4
1	Pili Nadi	-1409	-	SIDE	Elevated	4	4
Corridor-3A: Lokmanya Nagar to Hingna							

Sl. No.	Name of station	Chainages (m)	Distance from previous station (m)	Platform type	Station type	No. of Escalators	No. of Lifts
1	Hingna Mount View	18761	-	SIDE	Elevated	4	4
2	Rajiv Nagar	19607	846	SIDE	Elevated	4	4
3	Wanadongri	21006	1399	SIDE	Elevated	4	4
4	APMC	21715	709	SIDE	Elevated	4	4
5	Raipur	22823	1108	SIDE	Elevated	3	3
6	Hingna Bus Station	23625	802	SIDE	Elevated	4	4
7	Hingna	24504	879	SIDE	Elevated	4	4
Corridor-4A: Prajapati Nagar to Transport Nagar							
1	Pardi	-1365	-	SIDE	Elevated	4	4
2	Kapsi Khurd	-3200	1835	SIDE	Elevated	4	4
3	Transport Nagar	-5026	1826	SIDE	Elevated	4	4
Corridor-5: Vasudev Nagar to Dattawadi							
1	Police Station MIDC	16831	-	SIDE	Elevated	4	4
2	MIDC Hingna	19162	2331	SIDE	Elevated	4	4
3	Dattawadi	19838	676	SIDE	Elevated	4	4

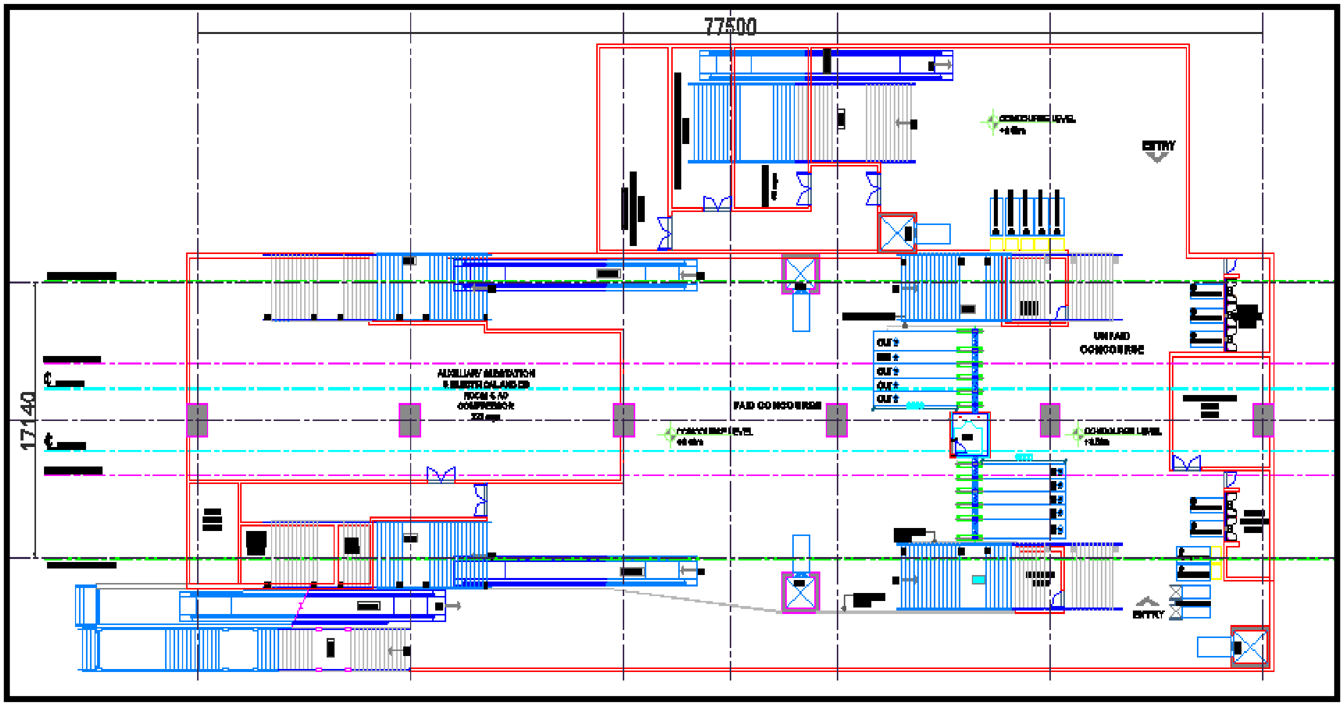
6.1.3 Typical Elevated Station

A typical elevation station of Nagpur Metro Phase-2 is presented in **Figure 6.6**.

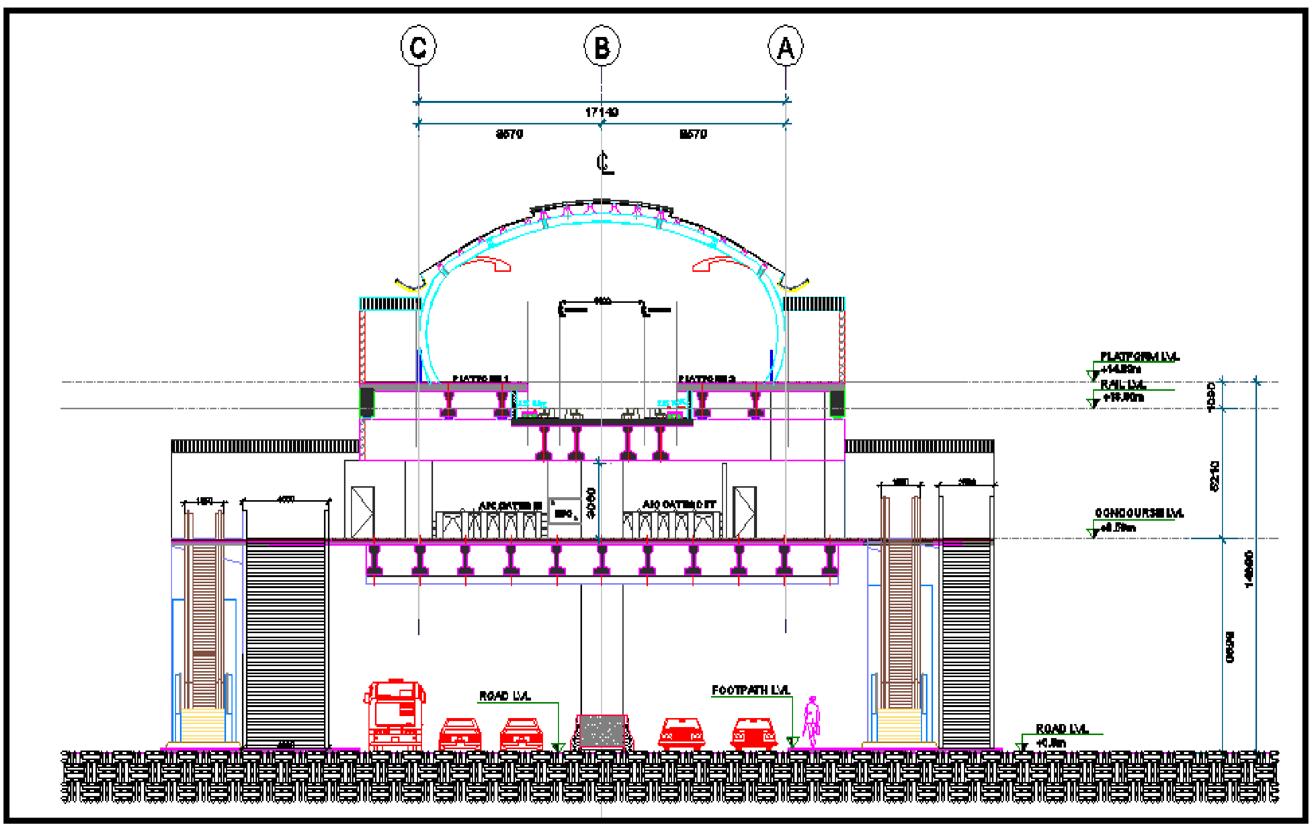
FIGURE 6.6: TYPICAL ELEVATED STATION



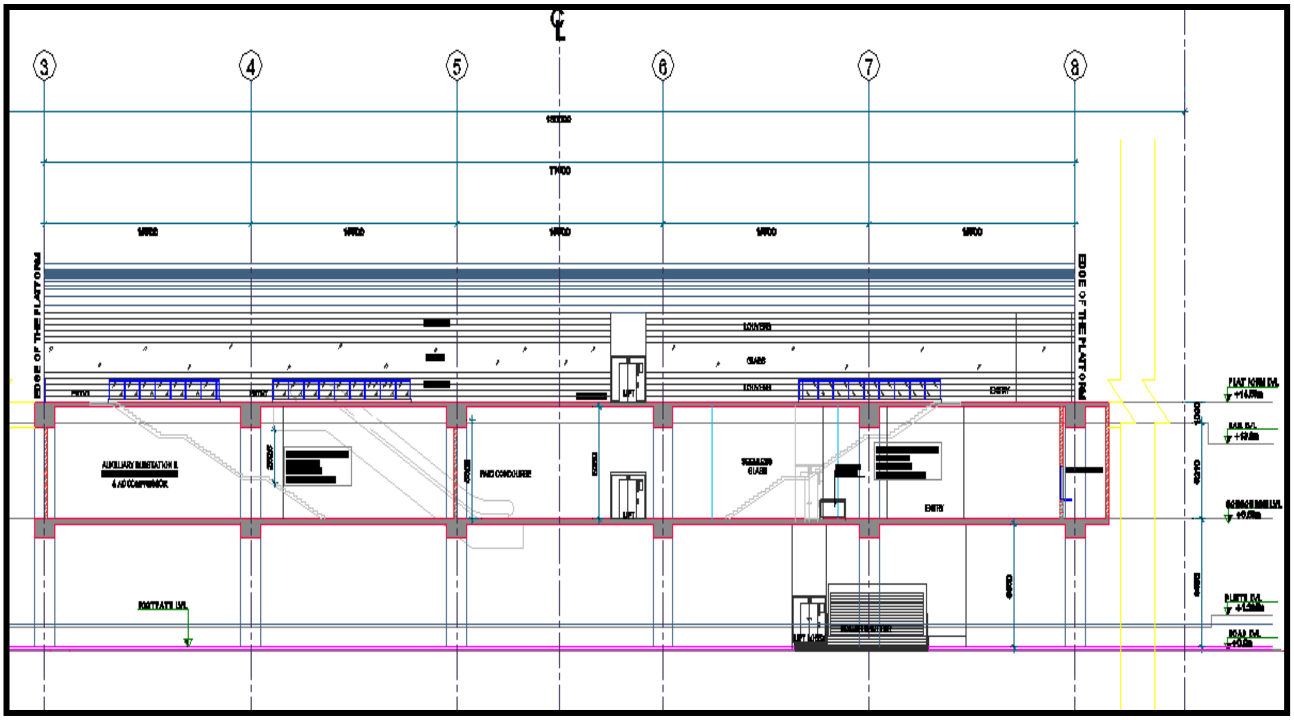
PLATFORM LEVEL PLAN



CONCOURSE LEVEL PLAN



CROSS SECTION

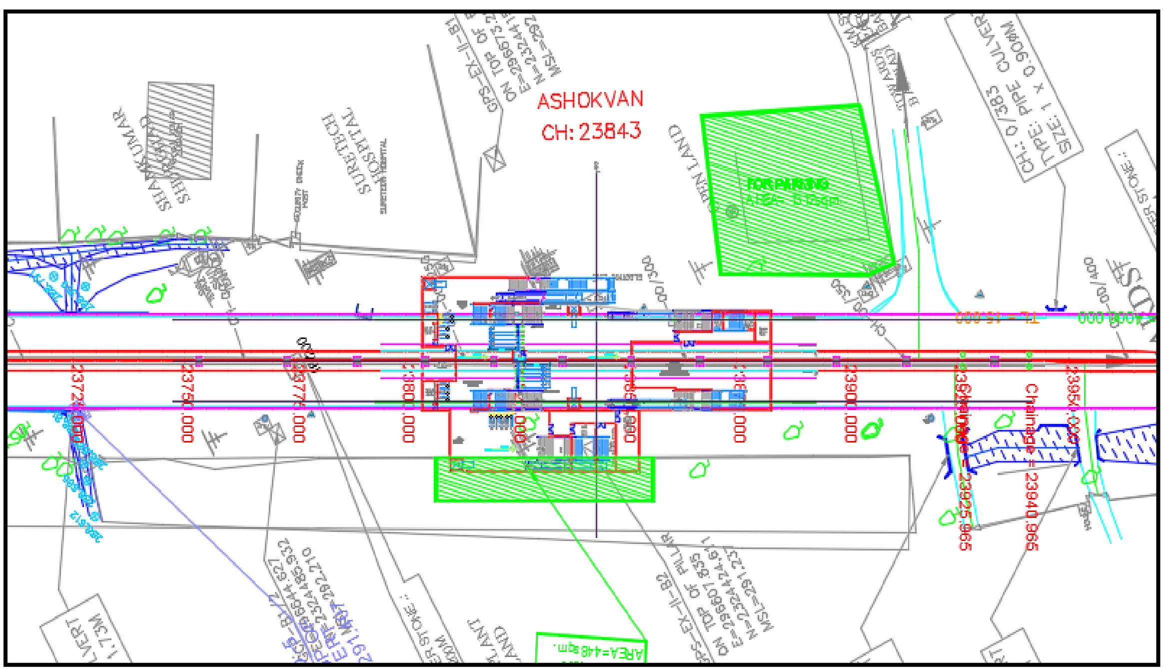


LONG SECTION

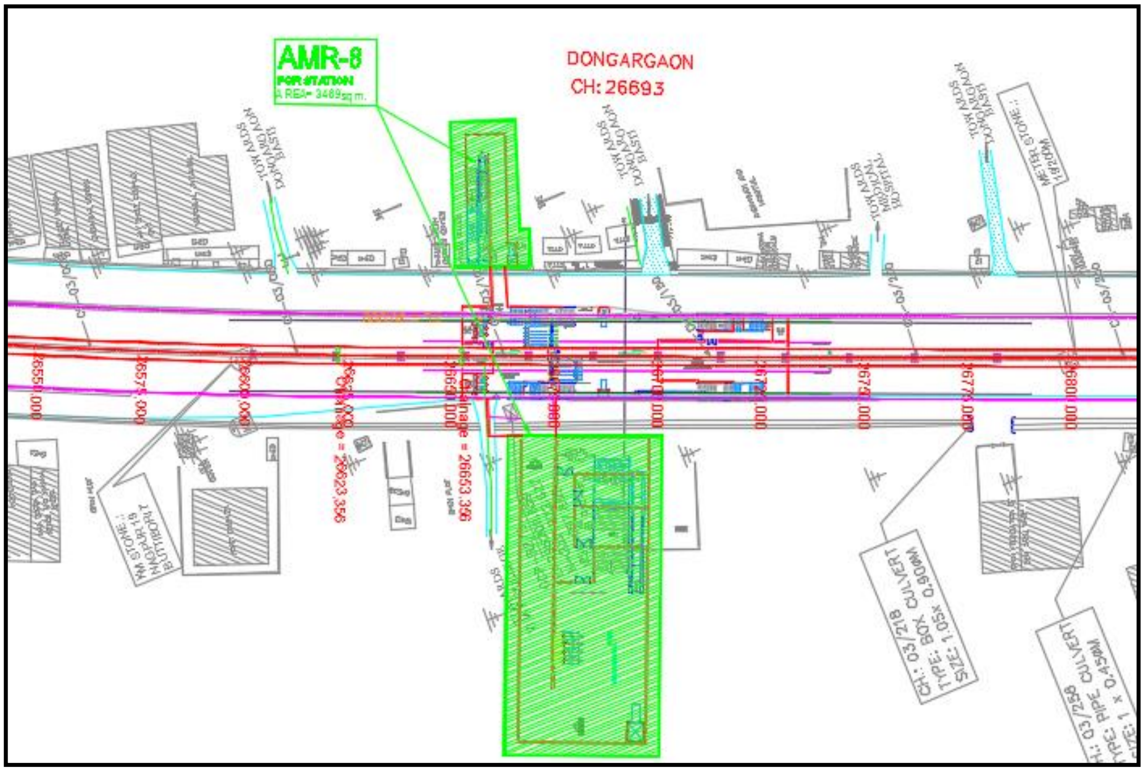
6.1.4 Stations on Site

Corridor-1A: MIHAN to MIDC ESR

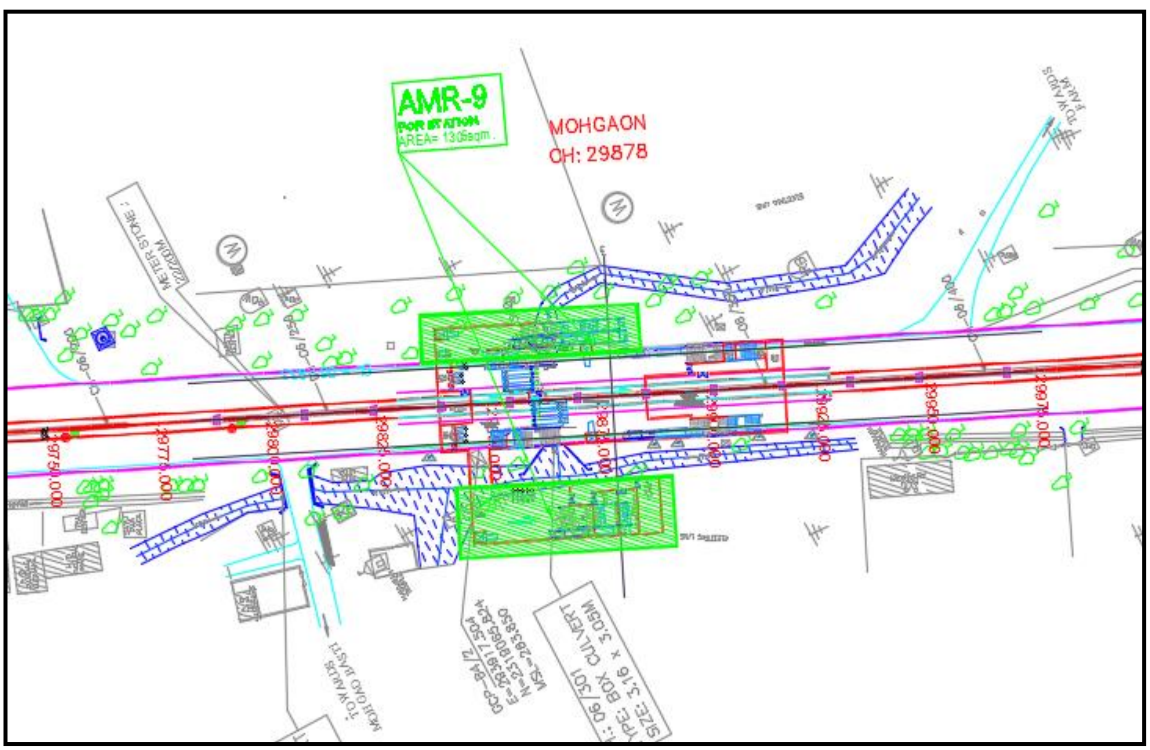
ASHOKVAN



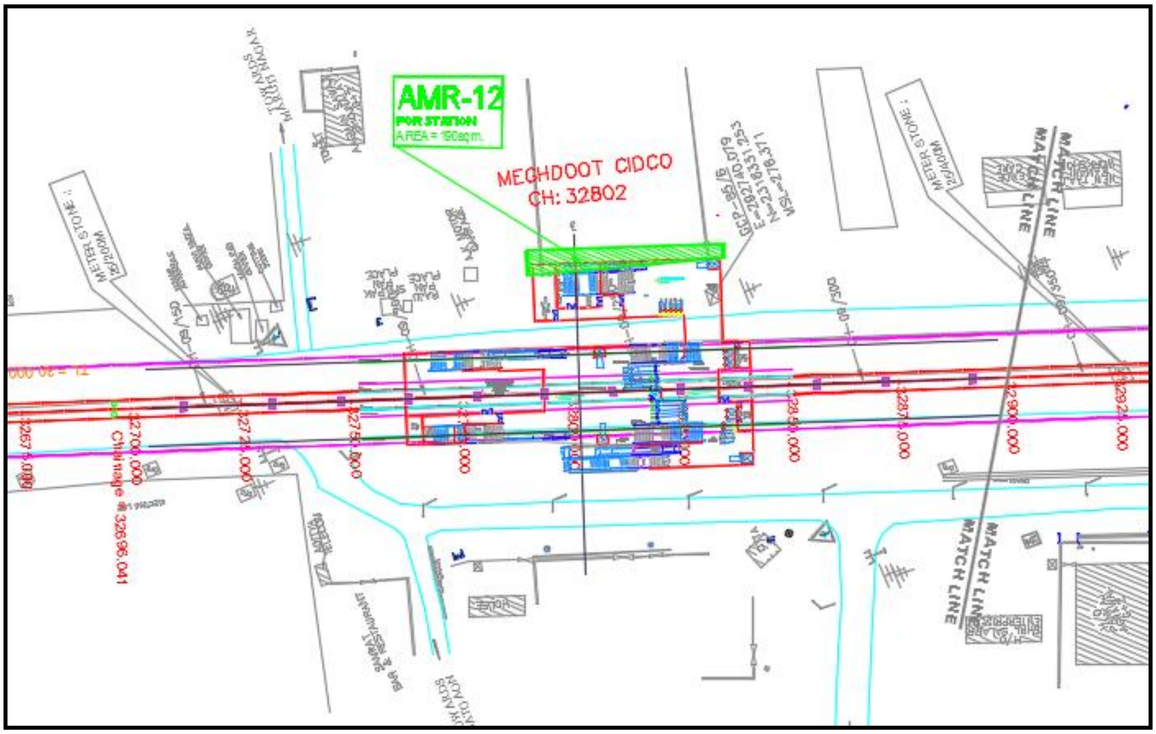
DONGARGAON



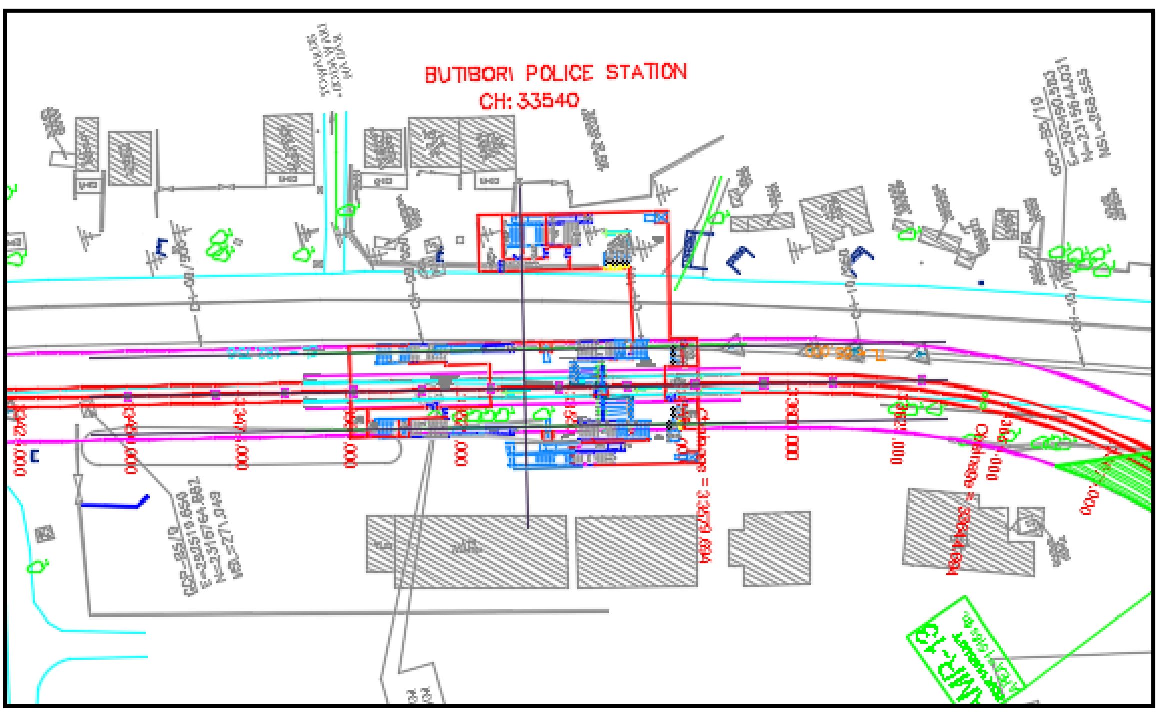
MOHGAON



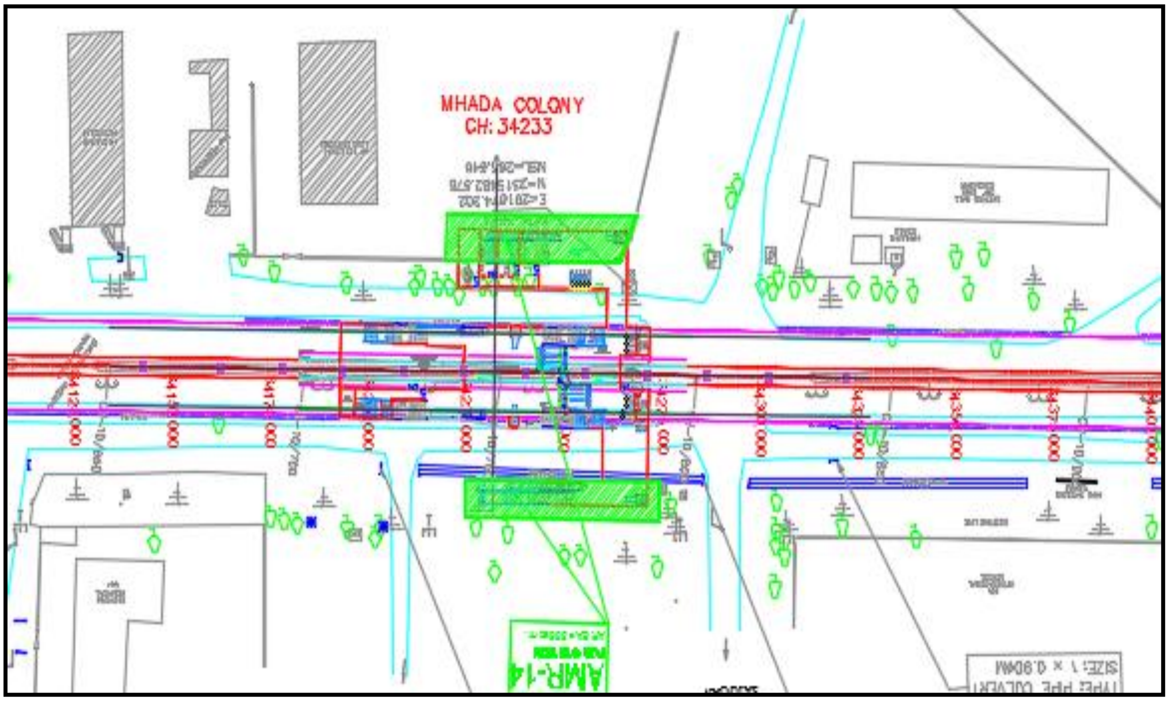
MEGHDOOT CIDCO



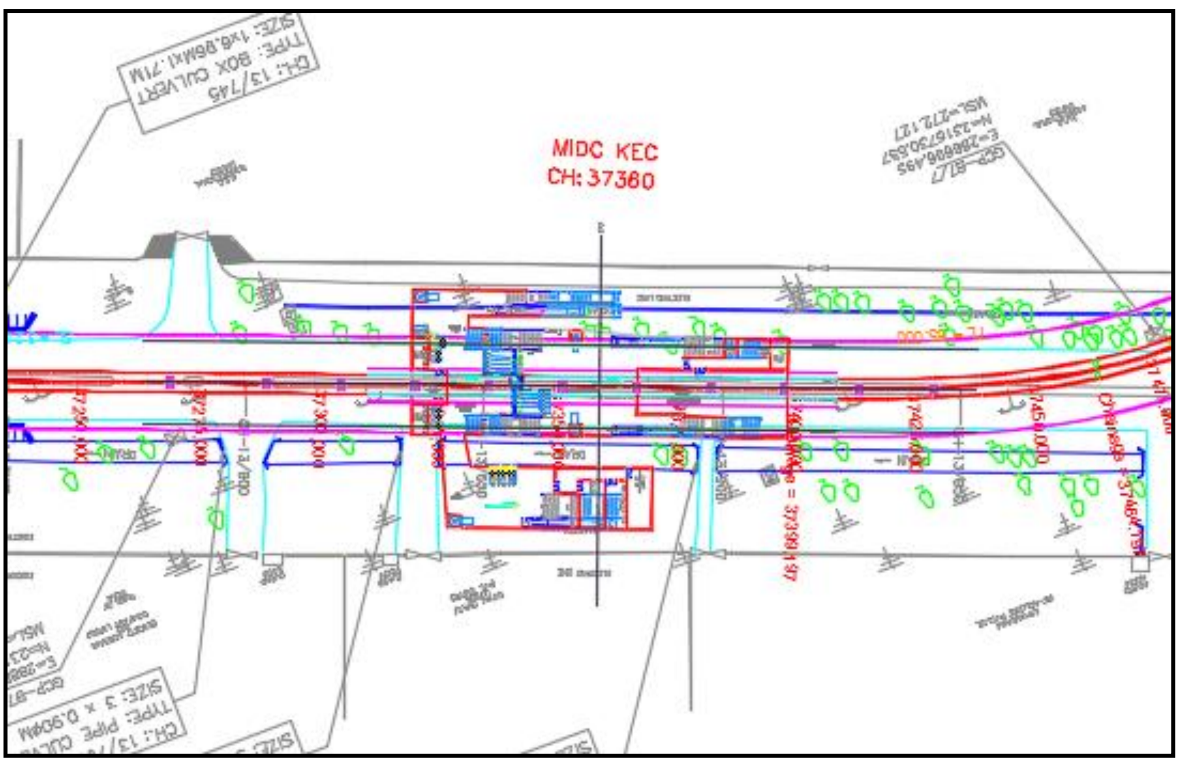
BUTIBORI POLICE STATION



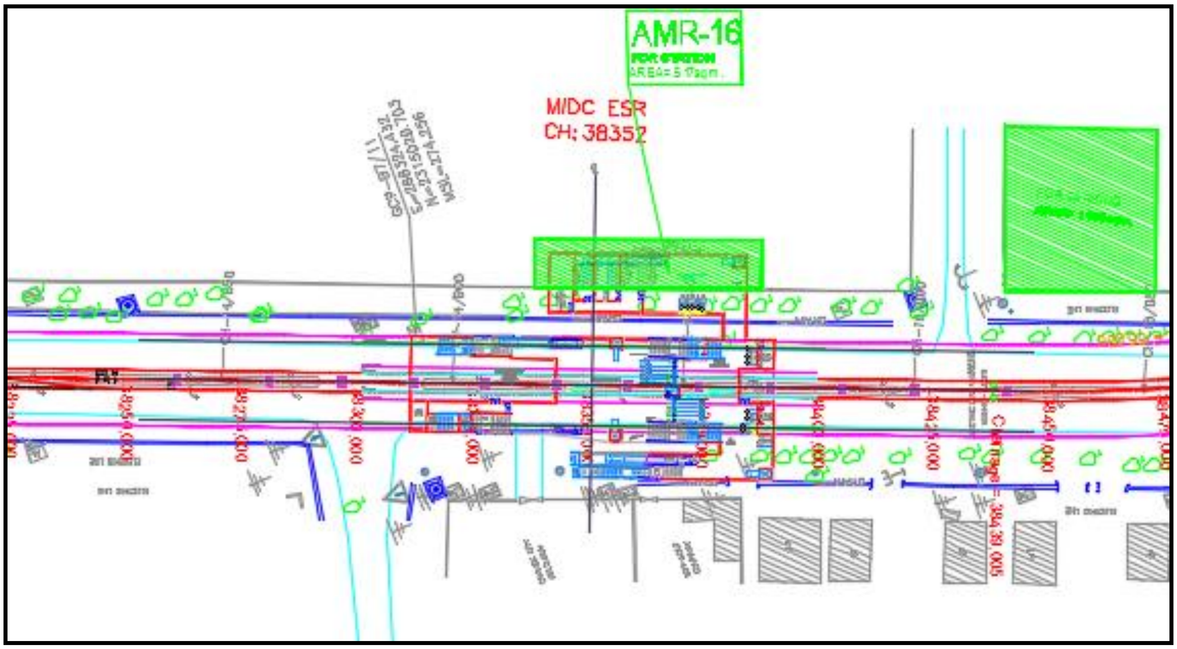
MHADA COLONY



MIDC KEC

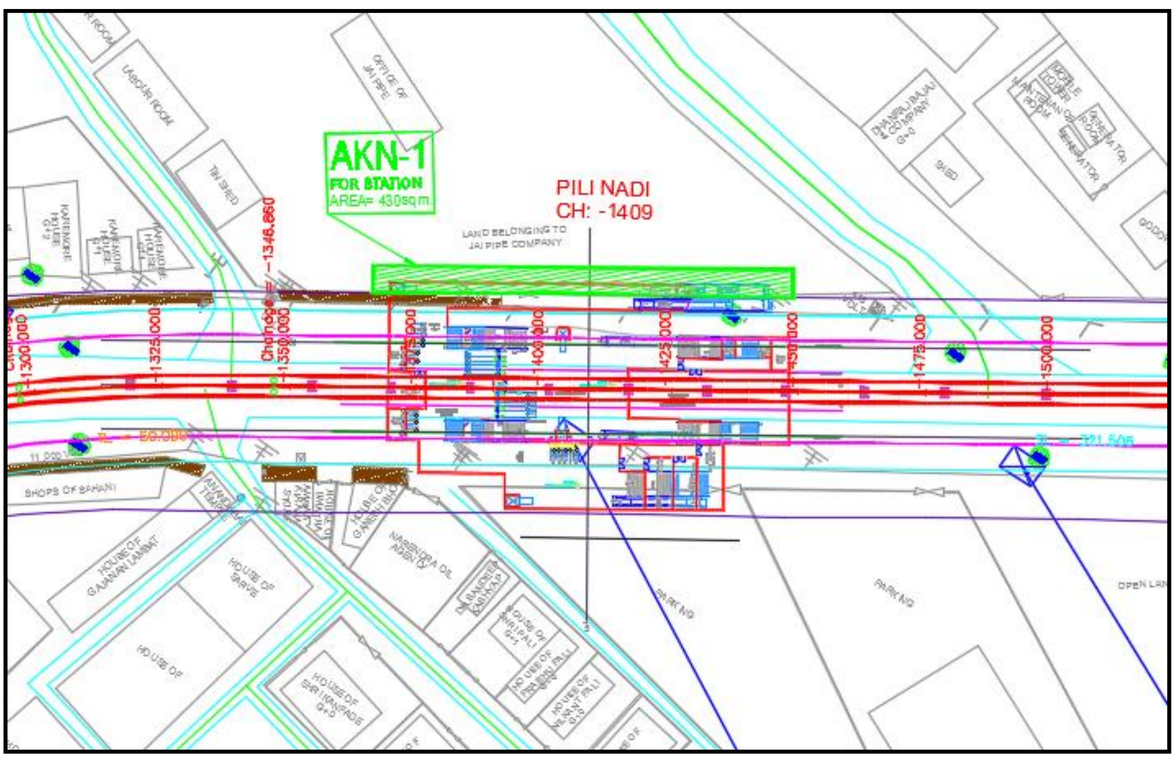


MIDC ESR

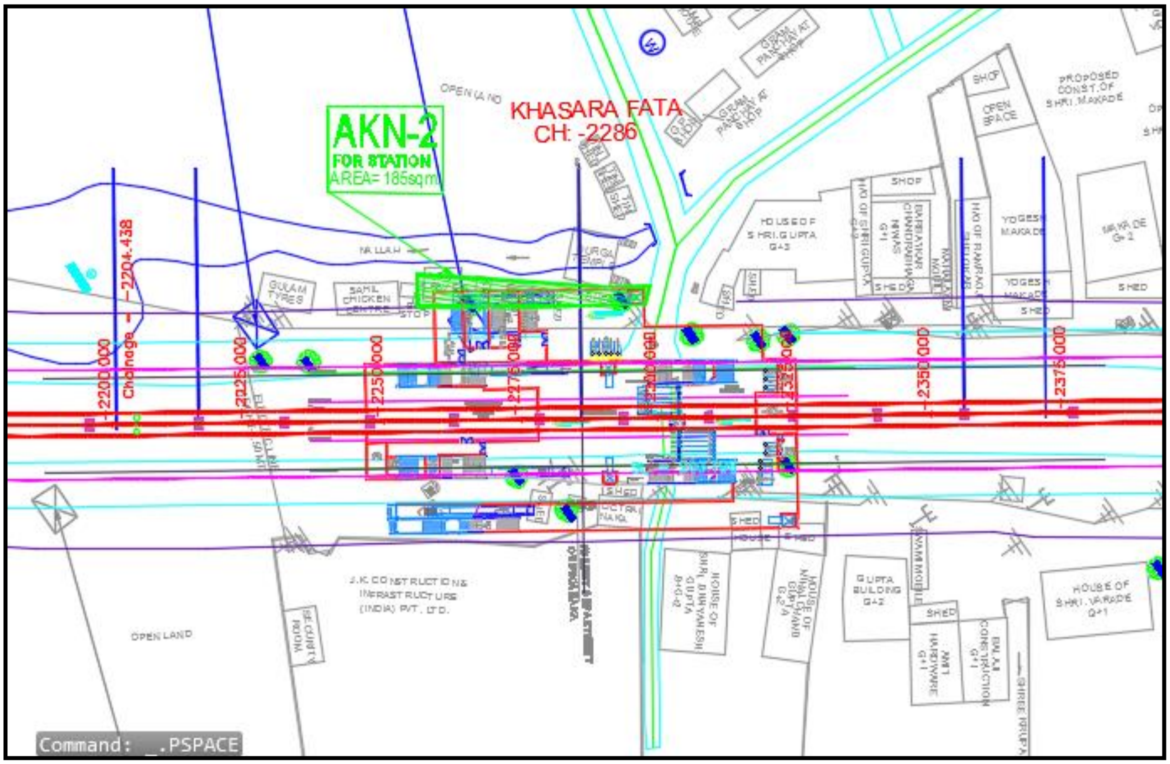


Corridor-2A: Automotive Square to Kanhan River

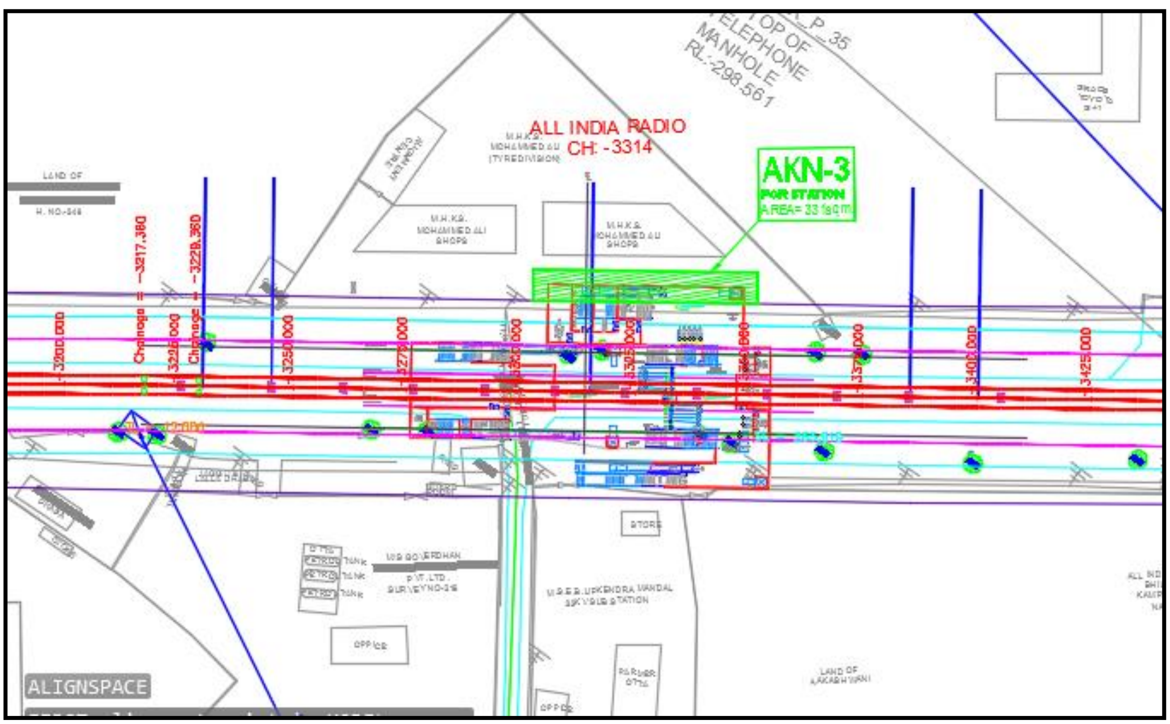
PILI NADI



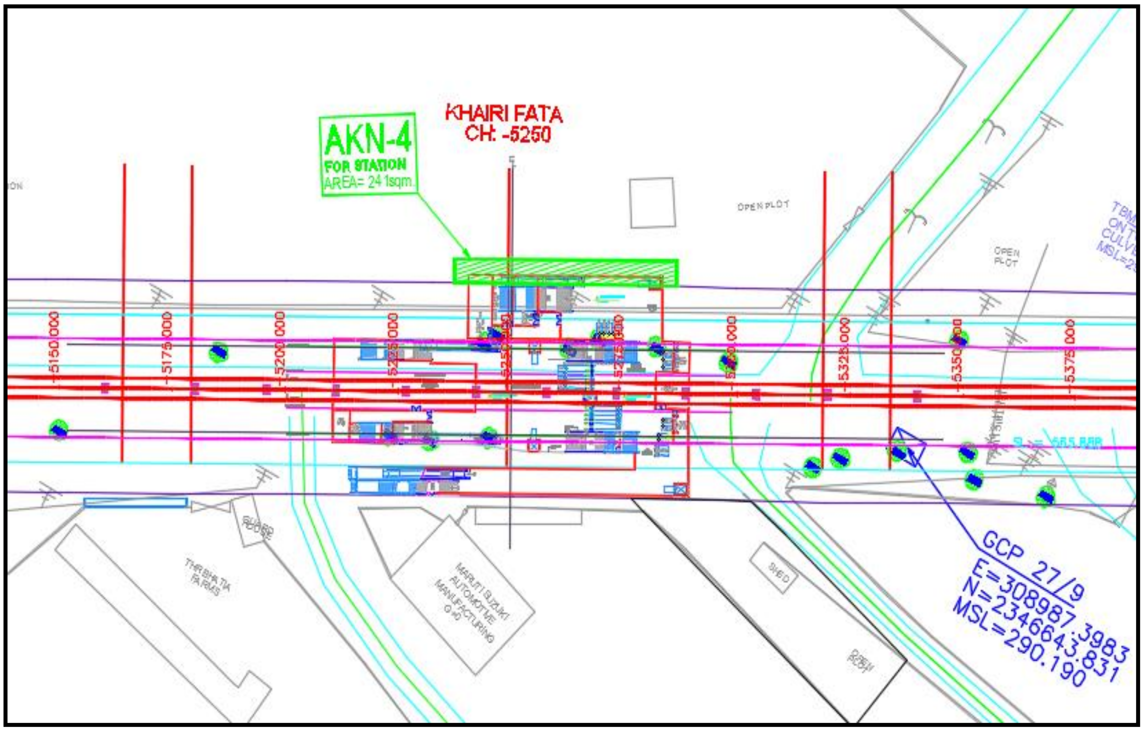
KHASARA FATA



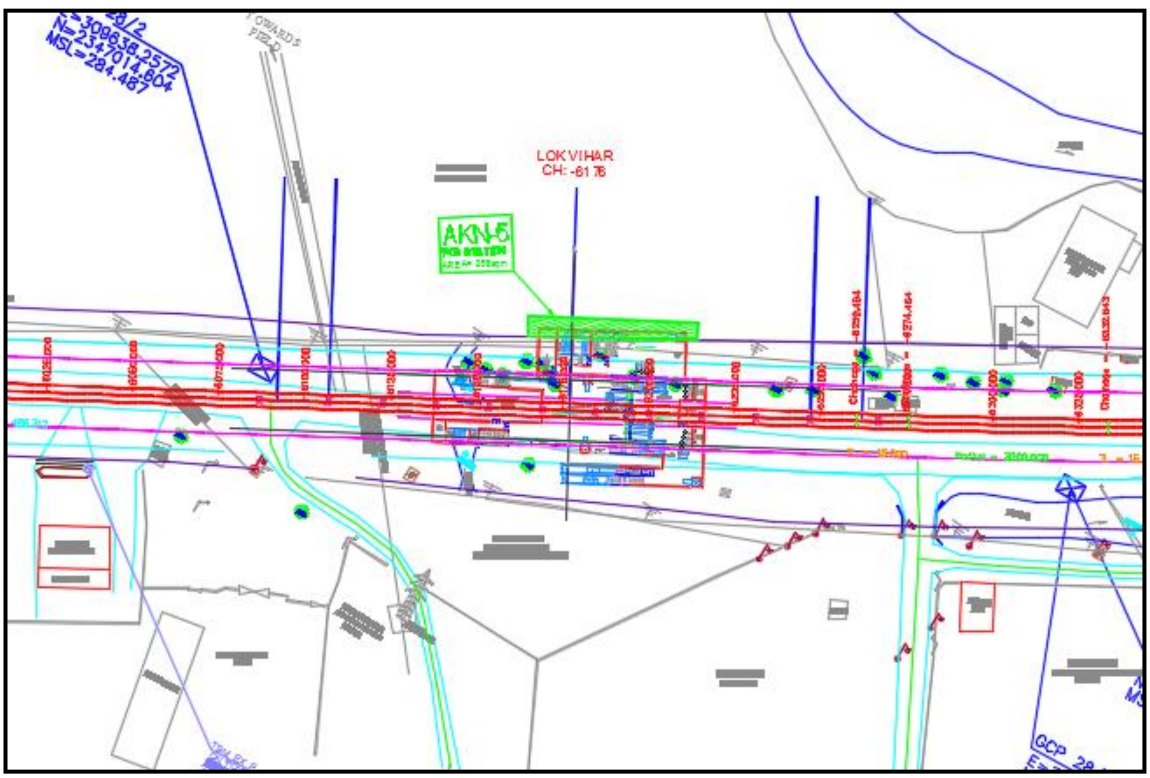
ALL INDIA RADIO



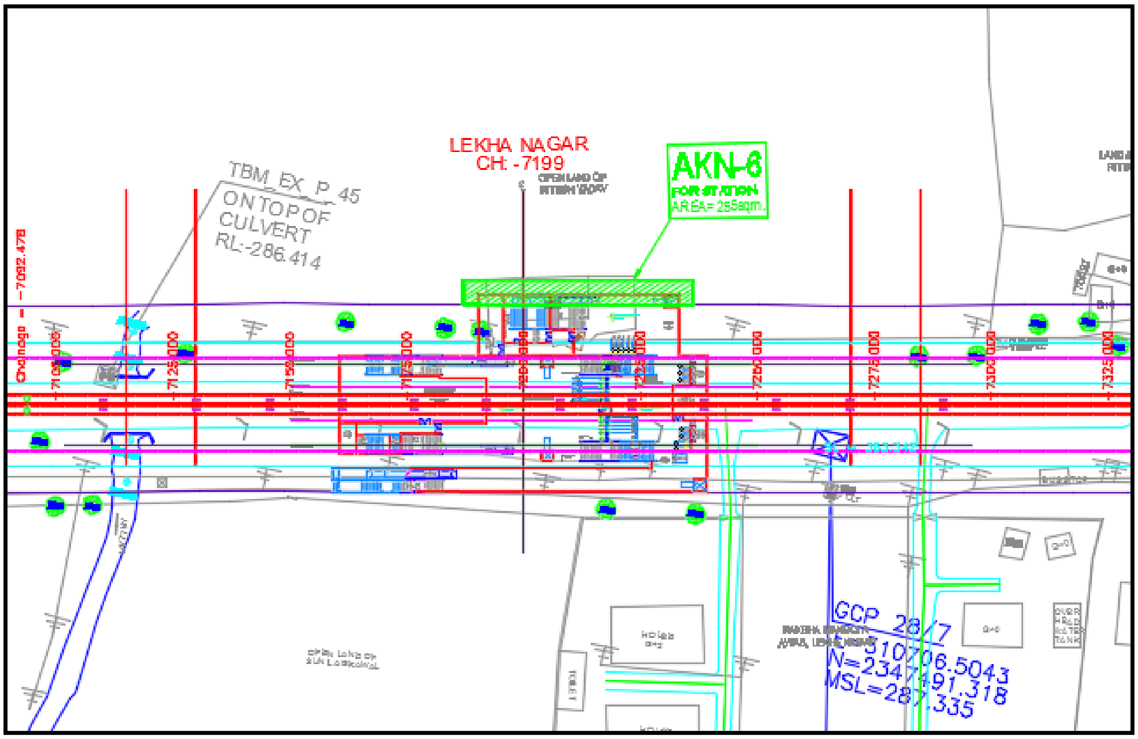
KHAIRI FATA



LOK VIHAR



LEKHA NAGAR



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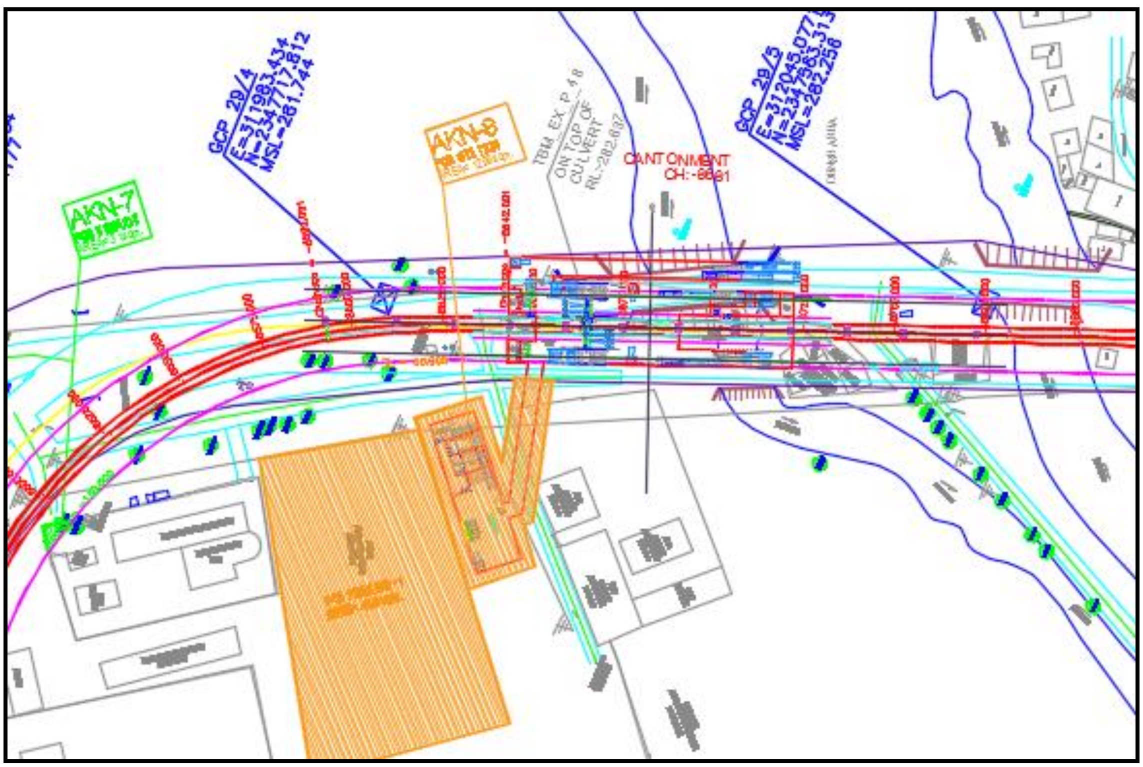
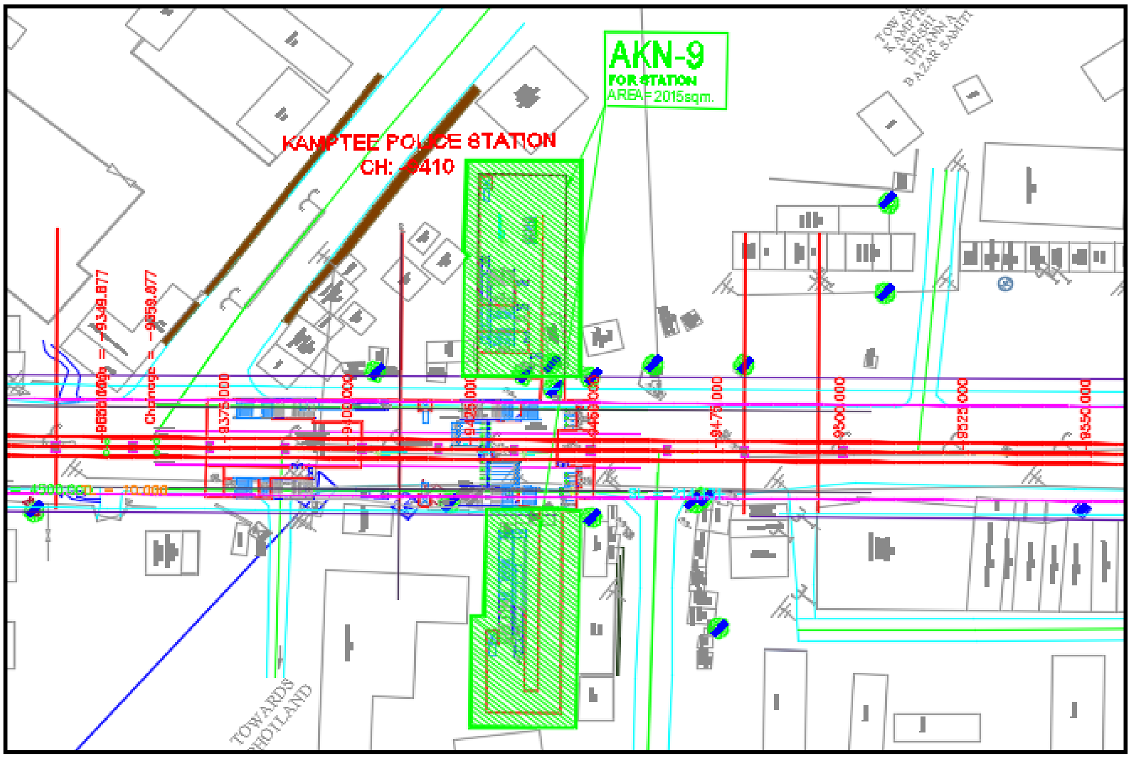
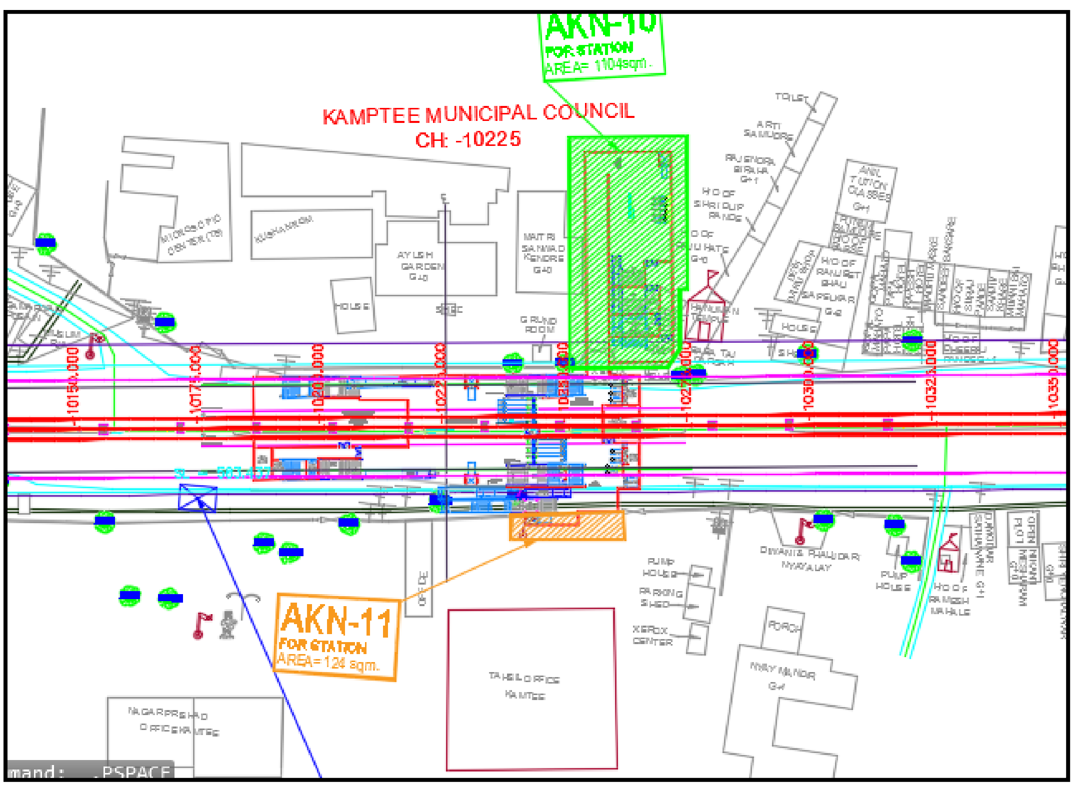


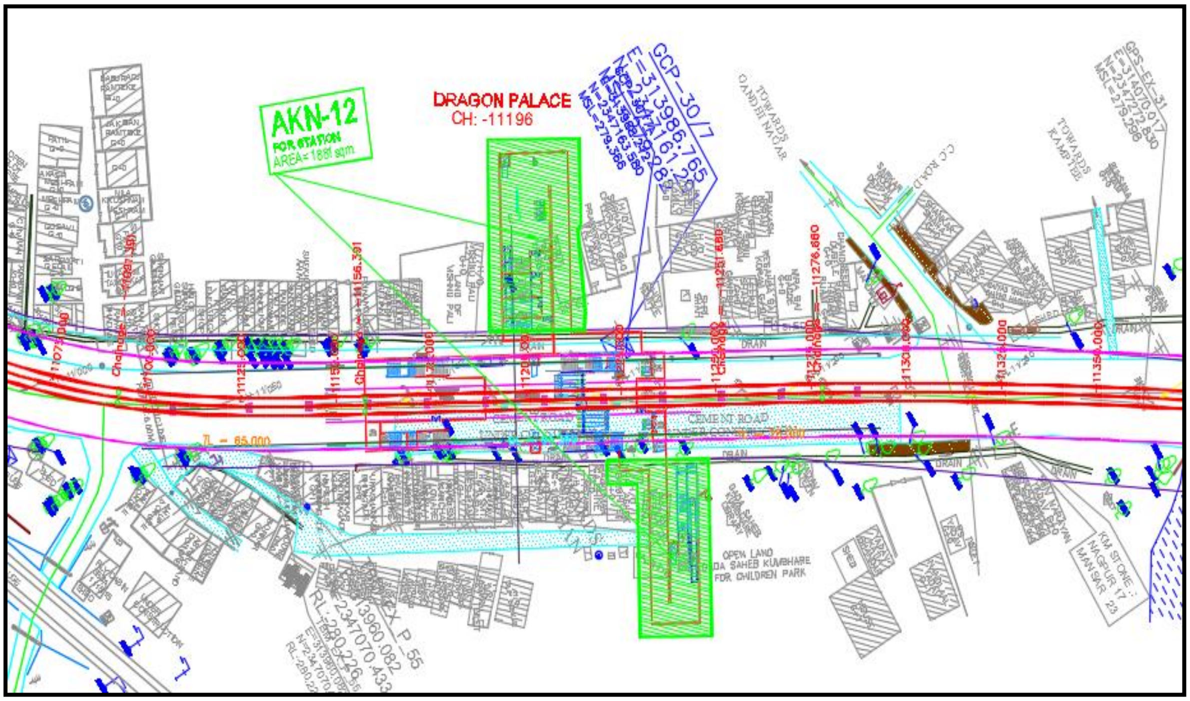
KAMPTEE POLICE STATION



KAMPTEE MUNICIPAL COUNCIL

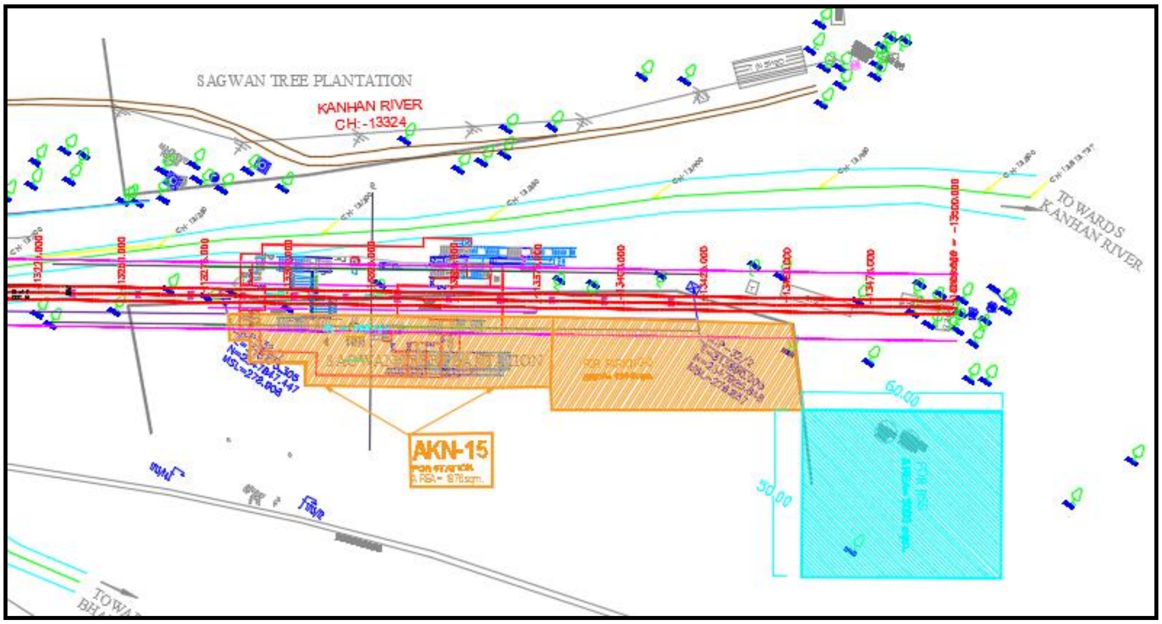


DRAGON PALACE



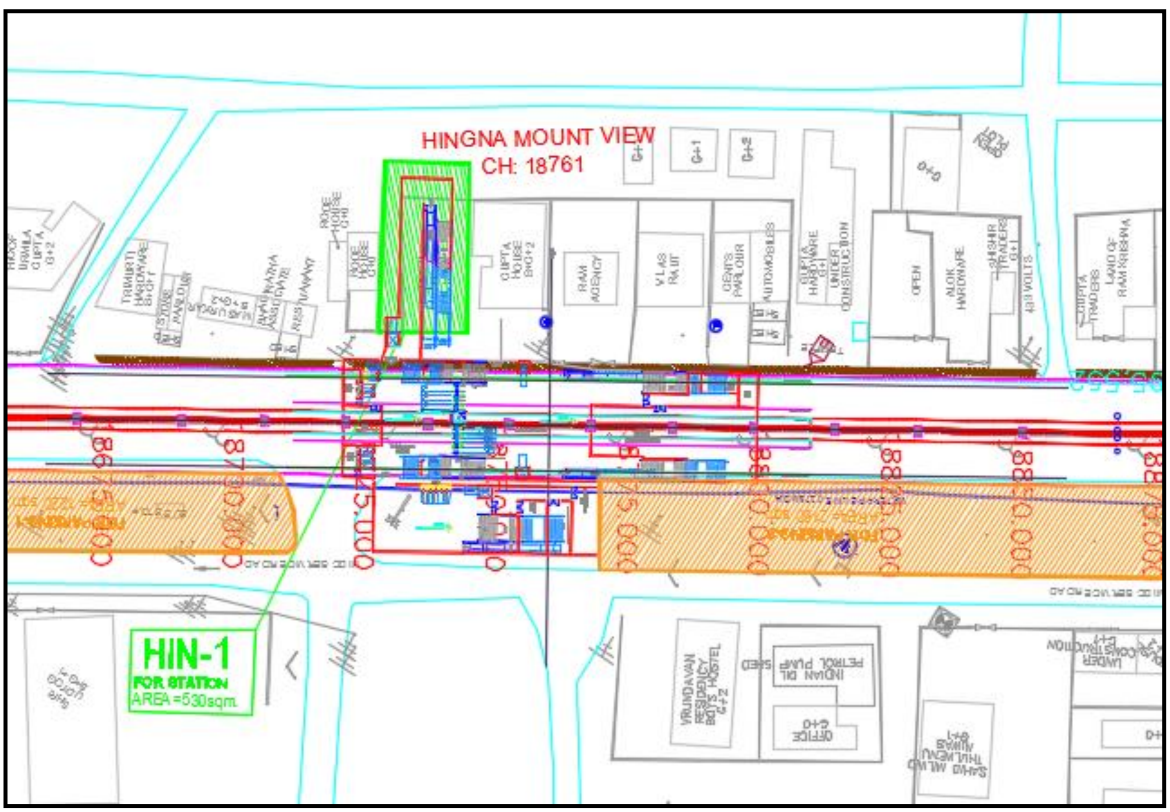
GOLF CLUB

KANHAN RIVER

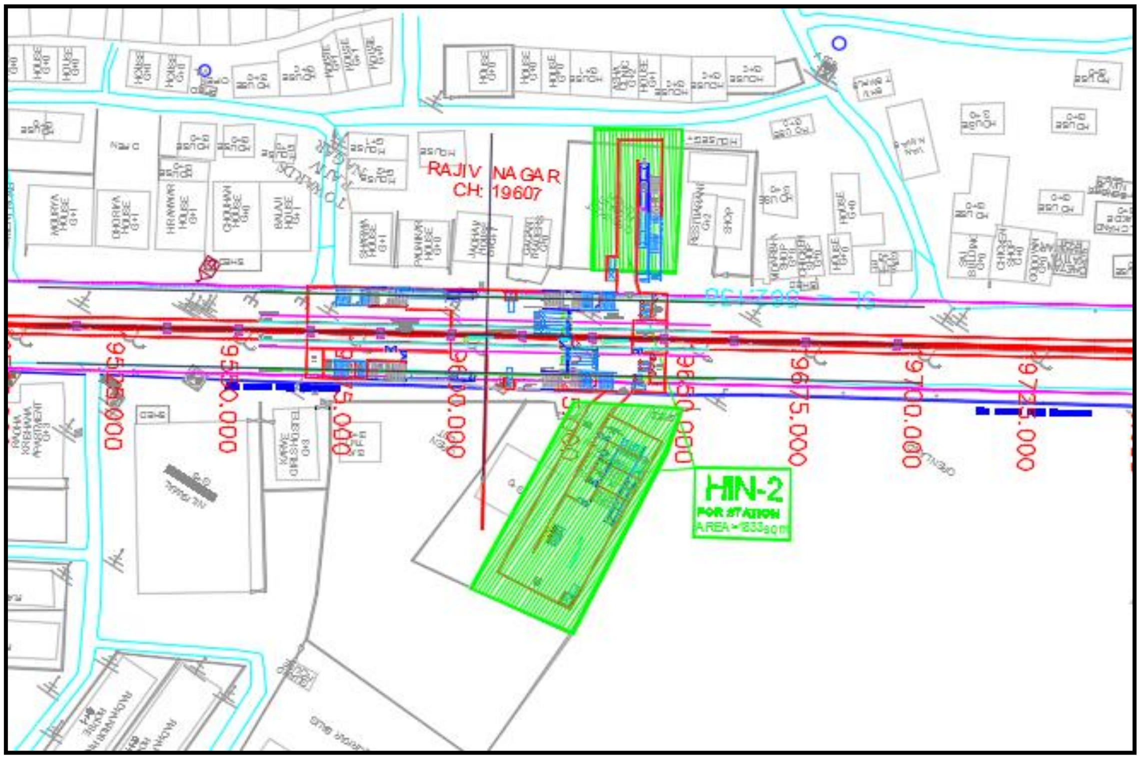


Corridor-3A: Lokmanya Nagar to Hingna

HINGNA MOUNT VIEW



RAJIV NAGAR



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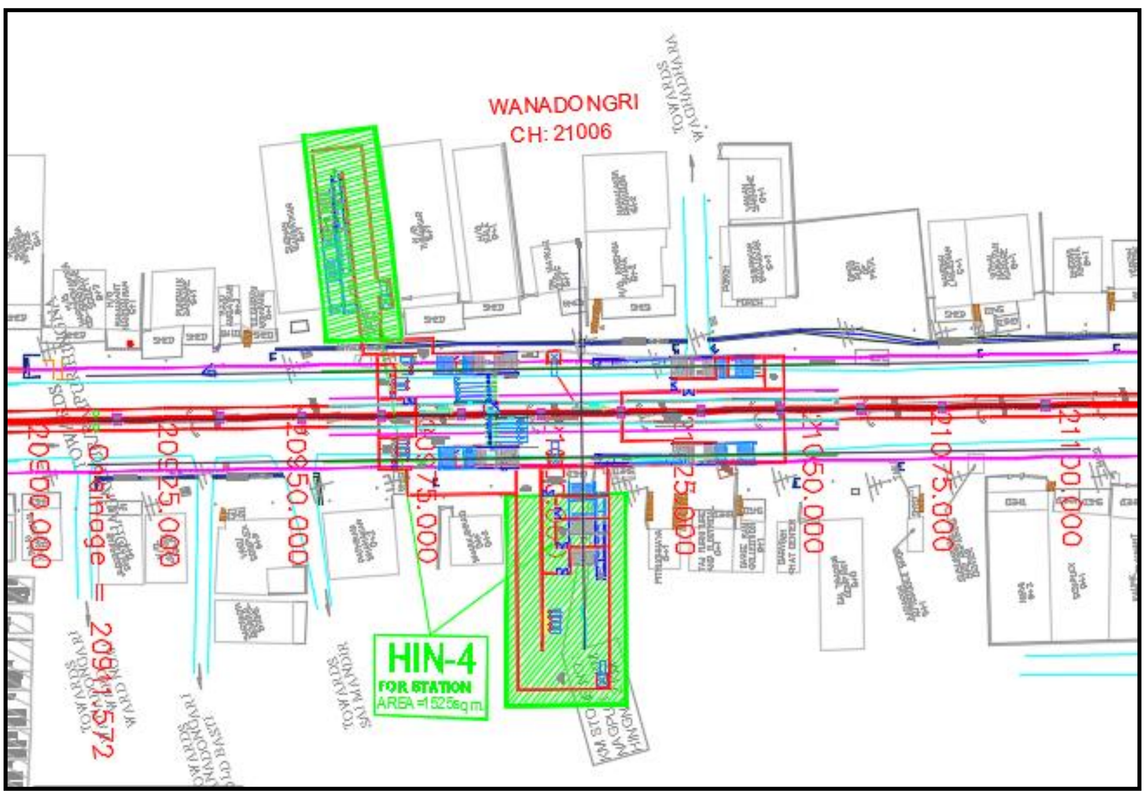

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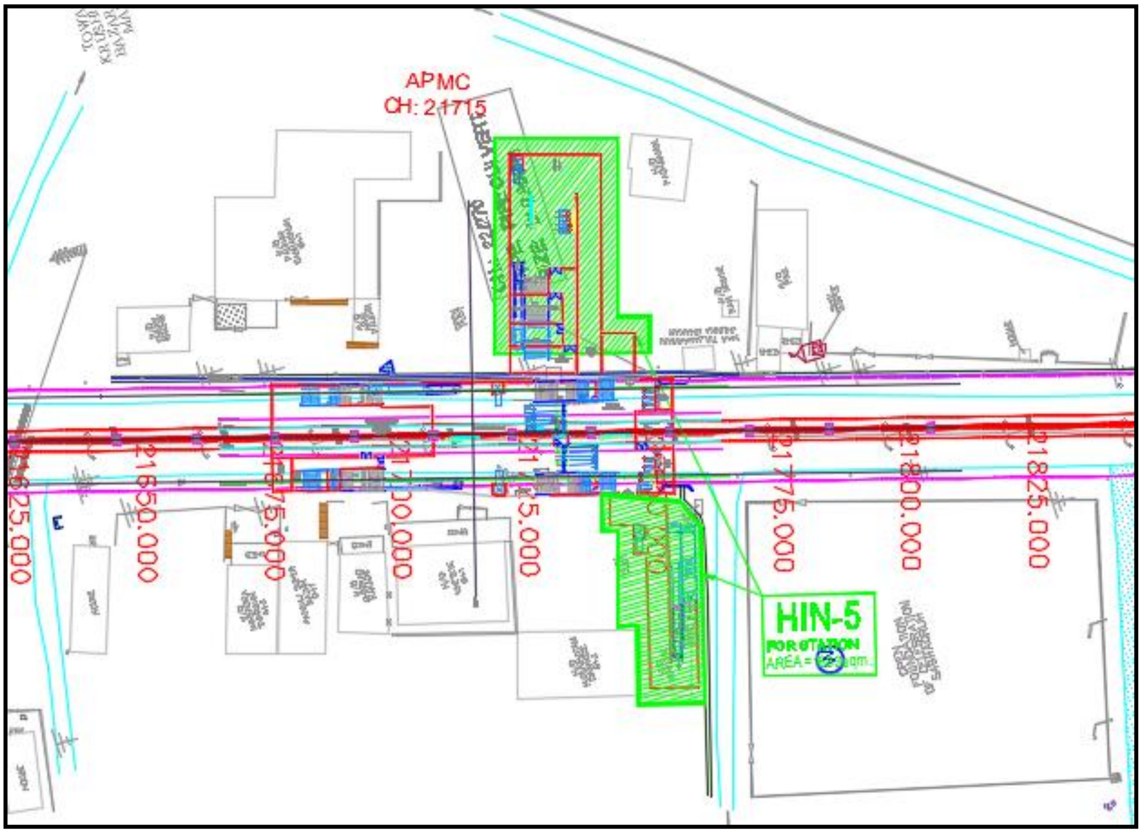
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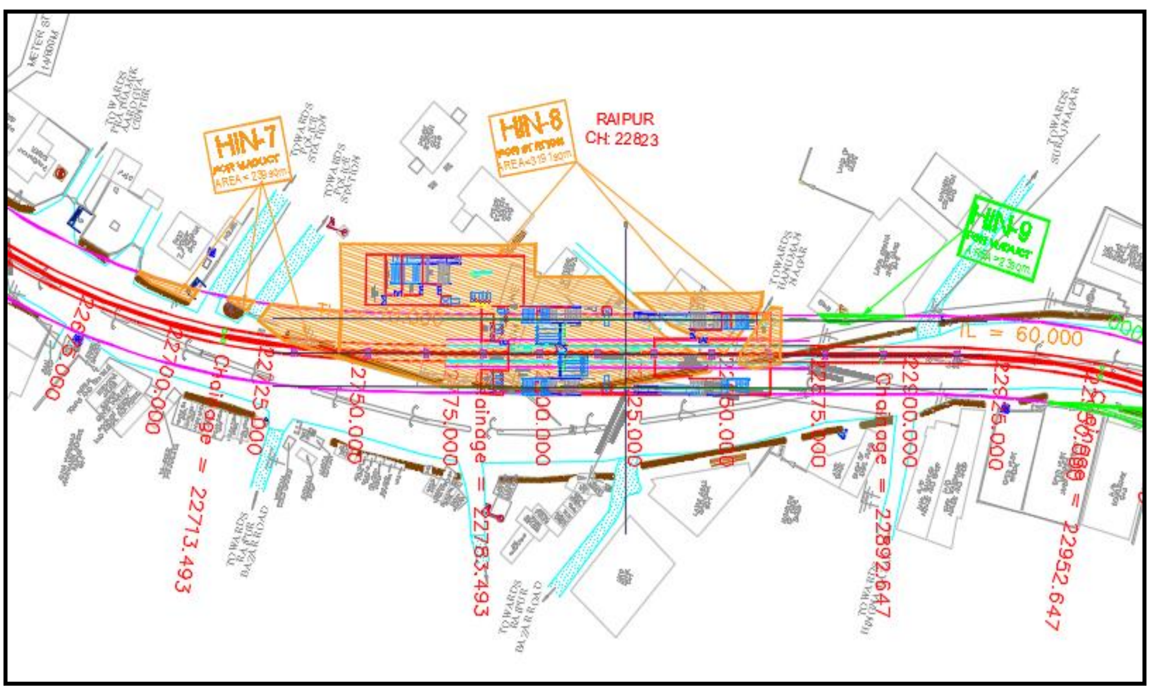
HIN-5
FOR STATION
21650.000
21800.000
21825.000

RAIPUR


RAIPUR
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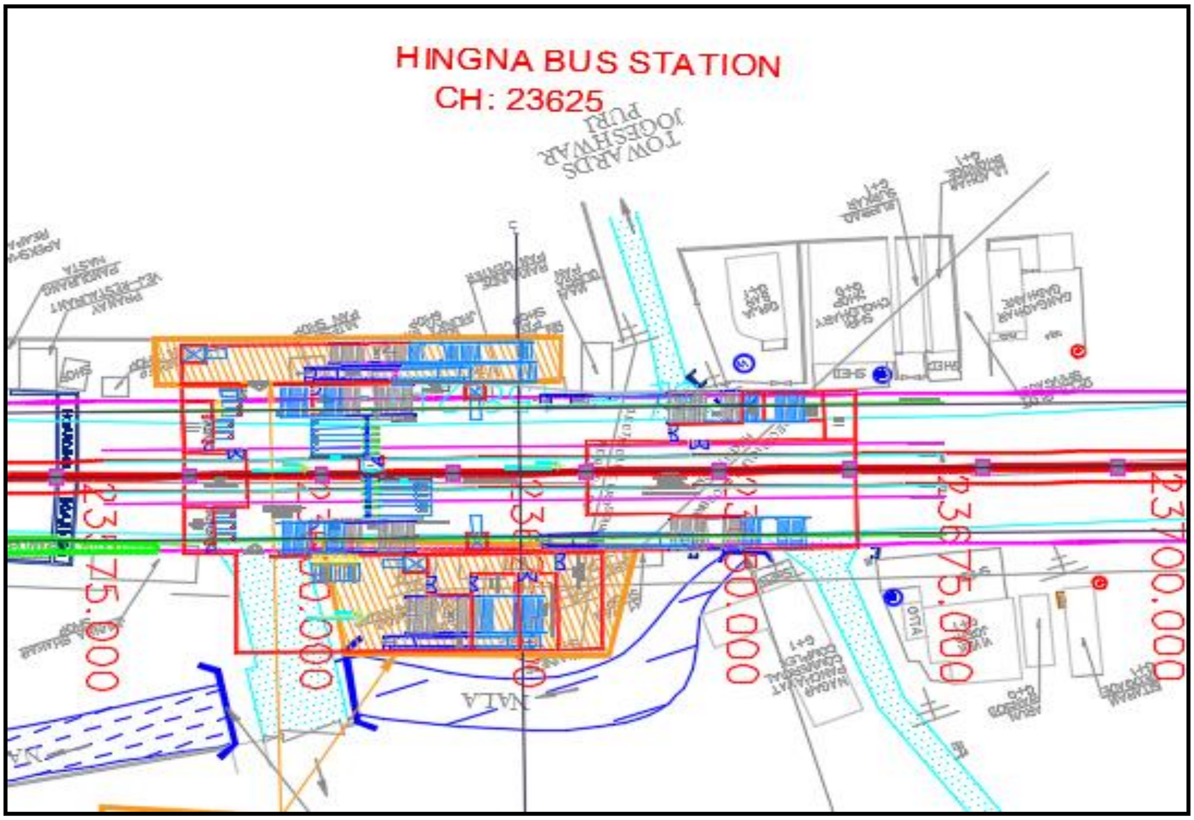
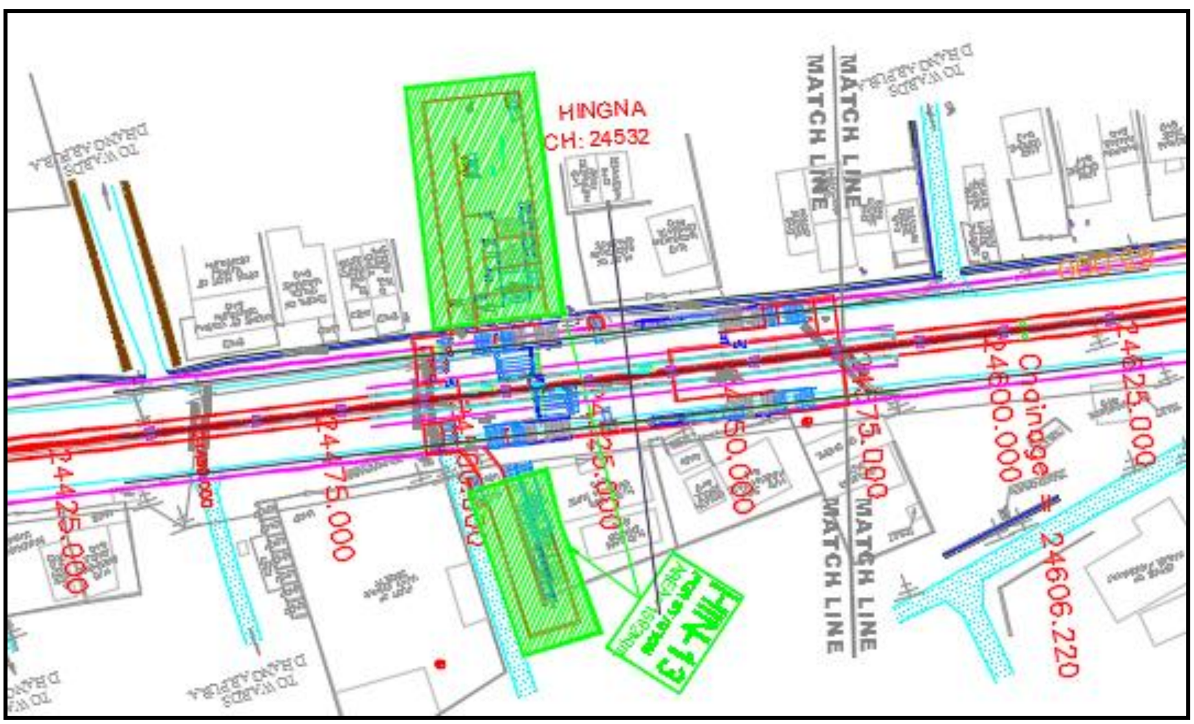
HIN-7
FOR VIADUCT
HIN-8
FOR STATION
HIN-9
FOR VIADUCT
IL = 60.000
Chainage = 22713.493
Chainage = 22892.647
22952.647

HINGNA BUS STATION

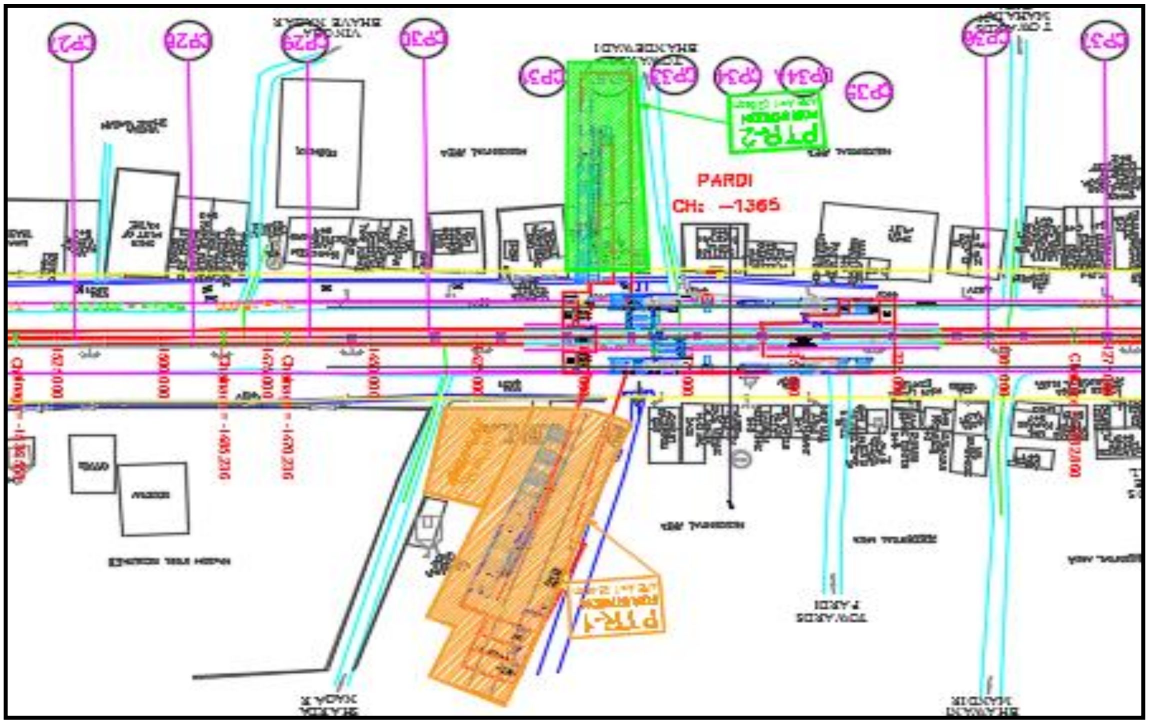


HINGNA

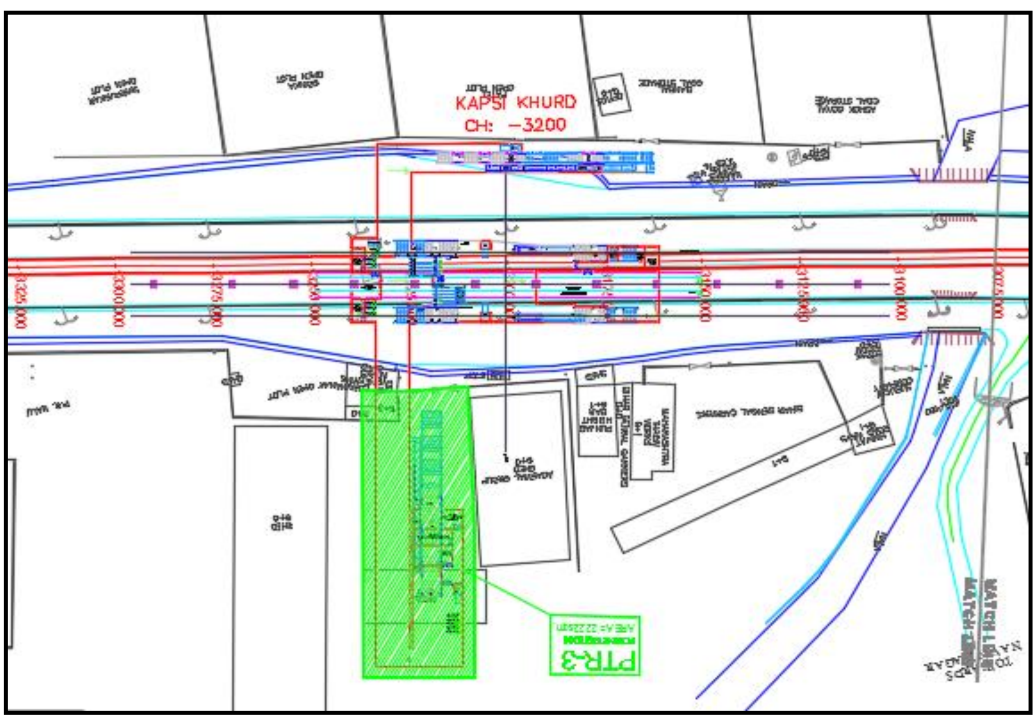


Corridor-4A: Prajapati Nagar to Transport Nagar

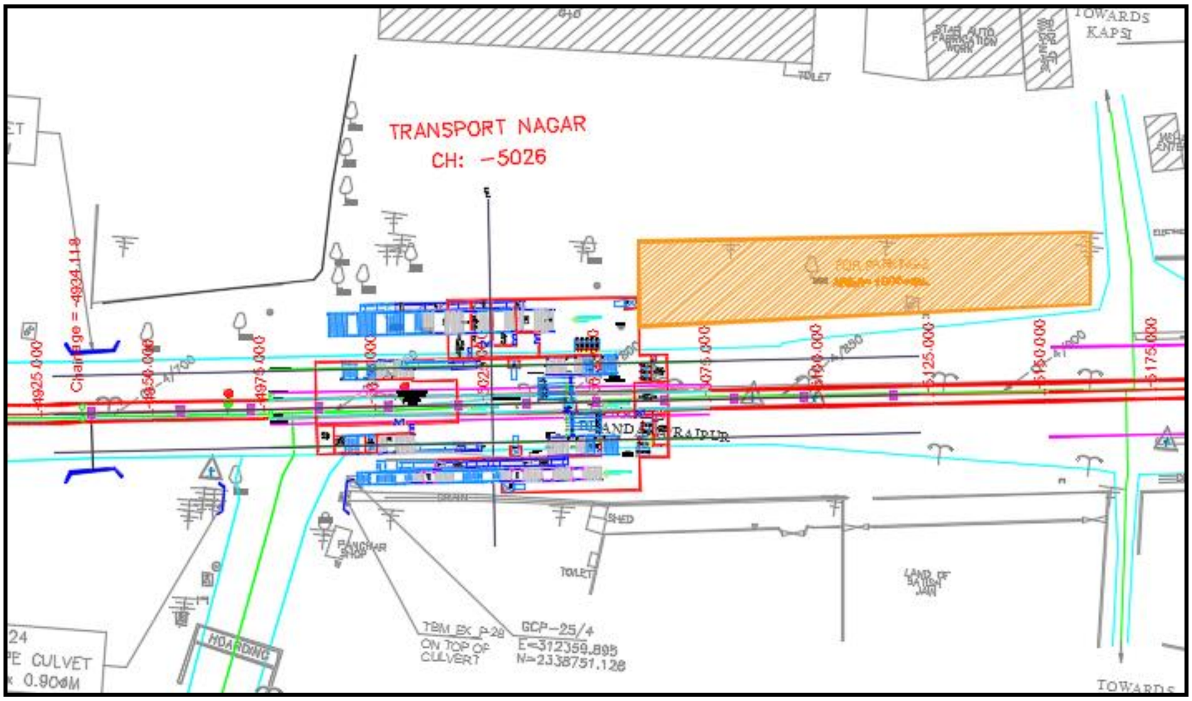
PARDI



KAPSI KHURD

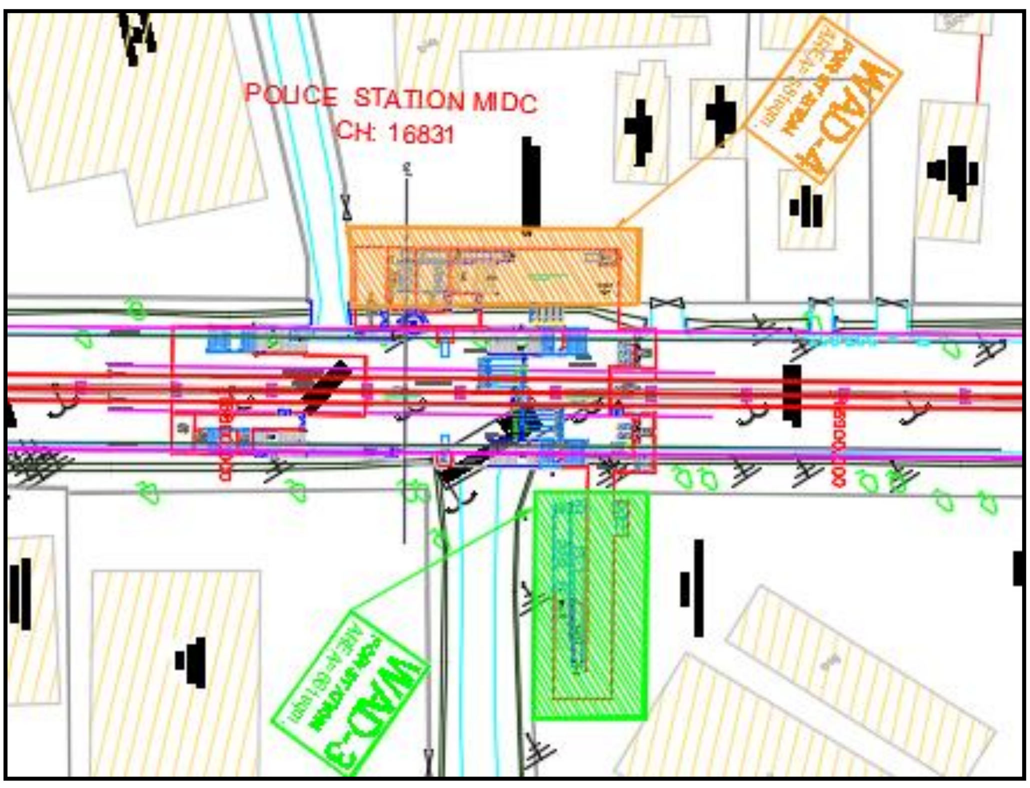


TRANSPORT NAGAR

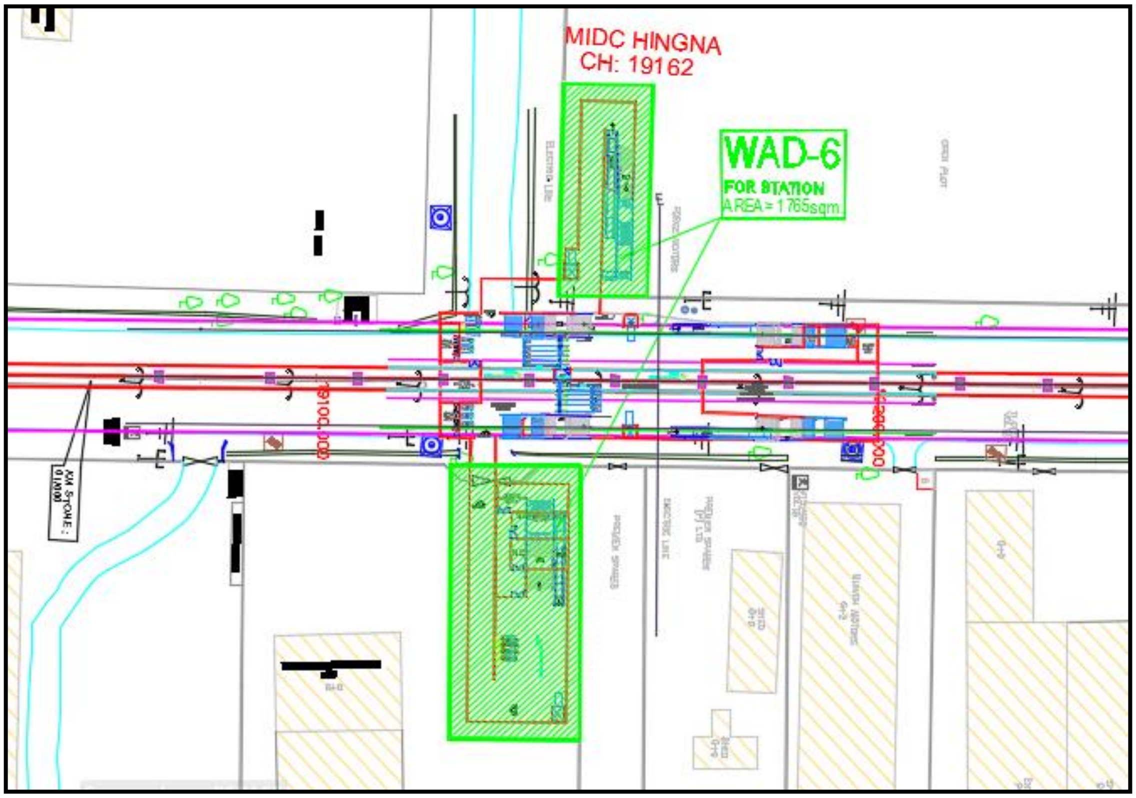


Corridor-5: Vasudev Nagar to Dattawadi

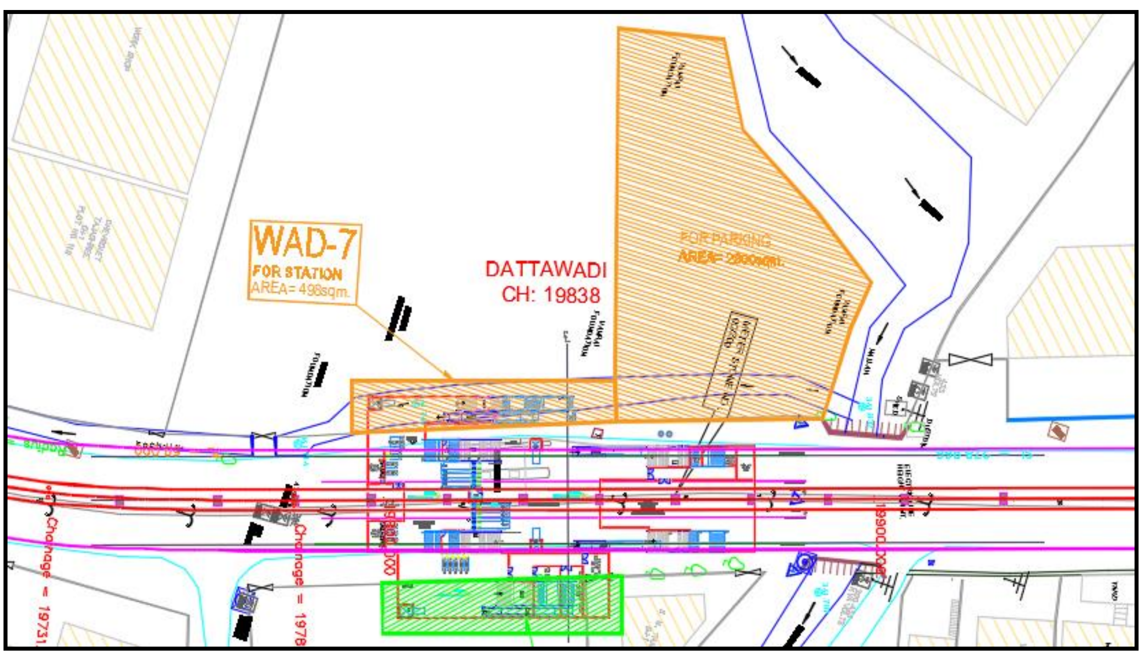
POLICE STATION MIDC



MIDC HINGNA



DATTAWADI



6.2. STATION AREA PLANNING FOR NON-MOTORIZED VEHICLE AND PEDESTRIANS FACILITIES

The following pedestrian facilities and non-motorized vehicles facilities have been planned near the station influence area.

The circulating area adjoining the station building is proposed to be properly designed to ensure rapid/efficient dispersal of passengers, avoiding conflict between pedestrians and vehicular traffic.

The station entry/exit has been planned keeping in view the major growth centers/activity areas. The entry/exit has been designed to integrate the station with existing/ proposed bus stops/bus bays, pick-drop zones and IPT services within walking distance.

Pick and drop zones and bays for feeder modes like buses, IPT have been proposed near the station.

Dedicated linkages have been proposed like subways, skywalks, covered walkways etc. at interchange stations which reduces the passenger travel time and pedestrian load on the roads.

All the footpaths in the metro station influence zone have been planned to be upgraded to desired level of comfort and also proposed new within the stations vicinity areas. The existing road shoulder areas and service lanes also have been augmented/ strengthened in the design wherever possible to utilize the complete ROW to cater to the future traffic volume

A minimum of 1.8m wide footpath has been proposed on the local roads whereas a continuous footpath of 2 m width on the major roads to provide accessibility to people on wheel chairs.

The vendors if any on the footpaths shall be removed and desired accessibility to metro stations will be provided.

Junctions and intersections have been proposed with proper pedestrian crossings. In the design, table top crossings has been proposed wherever possible, otherwise ramps with gentle slope ranging from 1:5-1:7 have been designed for pedestrians

FIGURE 6.7: PEDESTRIAN FACILITIES PROVIDED NEAR THE PROPOSED STATIONS

Table top crossing for pedestrians

Ramp from footpath to carriageway for easy movement

Footpath and Cycle Track Facilities

Footpath for Pedestrian Movement

For non-motorized vehicles like bicycle, rickshaw etc. separated NMV lane have been planned within the station influence area for smooth circulation based on the availability of land.

The design has been incorporated with a 2-m continuous strip of cycle track on both sides of the road around stations in accordance to available RoW.

The cycle track will be differentiated by colour, markings and material for uninterrupted movement.

FIGURE 6.8: NMT FACILITIES AT STATION AREA

Cyclist friendly junction design

Lane Marking for Cyclists

6.3. ACCESSIBILITY FOR DIFFERENTLY ABLED

Space Standards for Barrier Free Built Environment for Disabled and Elderly Persons-1998 and revised in 2013 by Ministry of Home and Urban Affairs and other international best practices have been considered.

User-friendly mass transport system can ensure accessibility to persons with differently abled, people travelling with small children or carrying luggage and the elderly persons. The following measures will be considered while planning of metro stations for such persons:

A metro route map in Braille/raised numbers shall be maintained at the enquiry/ticketing window. In each car, there shall be an announcement and provision of a visual display of the names of stations en route.

Tactile Guiding Paver (Line-Type) and Tactile Warning Paver (Dot-Type) shall be installed from station entry upto the platform boarding/alighting place for visual impaired persons wherever is needed.

At least one of the ticket gates shall allow a wheelchair user through and have a continuous line of guiding paver for people with visual impairments.

Public dealing counters (Information or help desks) shall be close to the terminal entrance, and highly visible. They shall be clearly identified and accessible to both those who use wheelchairs and those who stand.

Staircase, lift and ramp shall be planned for persons with learning differently abled, intellectual differently abled, and elderly persons. Location shall be clearly visible from the pedestrian route. Lifts shall have both visual and audible floor level indicators.

In emergency situations, audible alarms with 'voice instructions' Non-auditory alarms (visual or sensory) to alert persons with hearing impairments should be installed at visible locations in all areas that the passengers may use (including toilet areas, etc.).

Figure 6.9 shows various differently abled features as proposed in the station.

FIGURE 6.9: VARIOUS DIFFERENTLY ABLED FEATURES IN/AROUND STATIONS

Tactile Guiding Tiles for Wayfinding

Station Entry symbols for all users

Signage for accessible washroom

Way finding signage

6.4. PARKING ON STATIONS

Dedicated parking provision for station are key factors in determining success of a Metro system. Parking provisions along pedestrian facilities like footpath and feeder systems would encourage more commuters to use the transit system who could safely park their vehicles at the nearest station, walk to the station or rely on feeder connectivity. The tentative station wise parking facility area for personal vehicles and bicycle as planned along both corridors is presented in **Table 6.4.**

TABLE 6.4: DETAILS OF PARKING FOR NAGPUR PH-2 CORRIDORS

S. No.	Station/Location	Parking Area in Sqm
Corridor-1A : MIHAN to MIDC ESR		
1	Ashokvan	1312
2	MIDC ESR	1155
Corridor-2A : Automotive Square to Kanhan River		
1	Cantonment	4413
2	Kanhan River	2200
Corridor-3A : Lokmanya Nagar to Hingna		
1	Hingna Mount View	2000
2	Hingna	614
Corridor-4A : Prajapati Nagar to Transport Nagar		
1	Pardi	460
2	Transport Nagar	1800
Corridor-5 : Vasudev Nagar to Dattawadi		
1	Dattawadi	2900

Various modes of transportation like feeder buses, auto rickshaw/taxi and bicycles can provide first mile as well as last mile connectivity other than walking to the station. For catchment area of about 0.5km -1 km from the proposed network, commuter can easily access it by walk. People residing in the next 1 km can reach the station by cycles, 2-Wheeler and auto-rickshaws. Areas beyond the 2-km catchment will require regular feeder bus services to reach the metro station. Adequate arrangements have been provided for receiving and dispatch of PT/ IPT at all stations. Parking for these stations have been already located in the alignment plan.

Chapter – 7
INTER-MODAL INTEGRATION

7. INTERMODAL INTEGRATION

7.1. INTERMODAL INTEGRATION WITH EXISTING MODES

The concept of inter-modal integration with the modes is to provide last mile connectivity to the commuters residing/working in the MRTS influence zone. The MoHUA has also laid down policy guidelines to include this important aspect of last mile connectivity in the DPRs for the MRTS systems. This connectivity is expected to be achieved through proper access to the MRTS stations by city buses, intermediate public transport (auto rickshaws and cycle rickshaws) and pedestrian facilities etc.

Inter-modal integration explores the coordinated use of two or more modes of transport for efficient, speedy, safe, pleasant and comfortable movement of passengers in urban areas. It provides convenient and economical connection of various modes to make complete journey from origin to destination.

The inter-modal integration with existing modes have been planned at MRTS stations for efficient passenger movement. The proposals have been formulated for facilitating traffic dispersal and circulation facilities based on the following considerations:

- Dedicated linkages have been proposed like subways, skywalks, covered walkways etc. up to existing bays which will reduce the passenger travel time and pedestrian load on the roads.

- Availability of total carriageway and footpath widths required to cater to the proposed traffic volumes to be augmented through strengthening of road shoulder areas and relocation of vendors/hawkers, on-street parking and all encroachments from the service/ access roads.

- Designated space for embarking and disembarking for vehicular traffic (pick-drop zones) and existing modes like Buses, IPTs and NMT have been proposed.

- Proper design of circulation area has been planned to adjoin the station building to ensure rapid/ efficient dispersal of the passengers and avoiding conflicts between pedestrian and vehicular traffic.

  Based on above, intermodal integration plans for stations of Nagpur Metro Phase 2 have been prepared and presented in **Annexure 7.1**.

7.2. FEEDER SERVICES PLANNING AT STATIONS

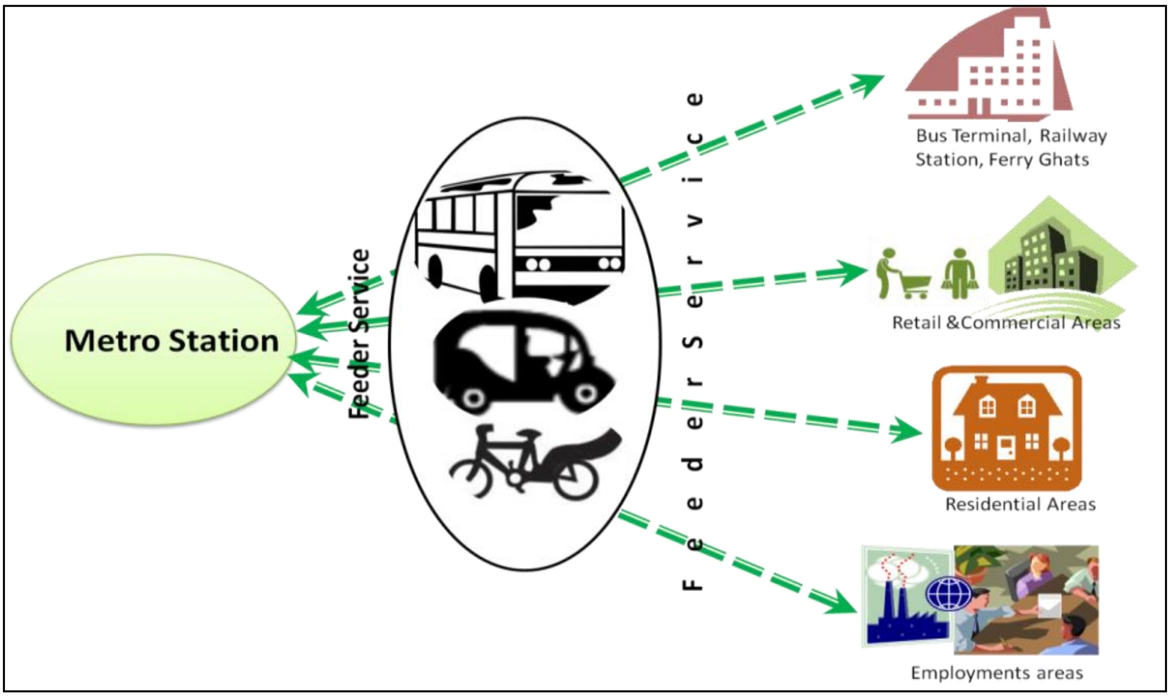
7.2.1. Feeder Modes

The planning of seamless transport integration facilities at the influence zones of various MRTS stations is of utmost importance. Feeder services to the proposed MRTS network are essential for convenient and quick transfer of passengers. As all commuters will not be living within walking distance of the proposed network, proper planning for feeder services will be necessary.

Various modes of transportation like feeder buses, auto rickshaw/taxi and bicycles can provide first mile as well as last mile connectivity to the MRTS station. For catchment area of about 0.5 -1 km from the proposed network, commuter can easily access it by walk. People residing in the next 1 km can reach the station by cycles, 2-wheeler and cycle / auto-rickshaws. Areas beyond the 2-km catchment will require feeder buses to reach MRTS station.

The feeder service facilities are proposed at MRTS stations to connect the trip generation/ attraction areas in the influencing zones. **Figure 7.1** shows the concept of provision of feeder services to a MRTS system. The facilities of footpaths, feeder buses and bicycles (bike sharing) have been planned for peak hour passenger demand.

FIGURE 7.1: CONCEPT OF FEEDER SERVICES AT MRTS STATION



7.2.2. Feeder Bus Service

The feeder buses shall be of high quality, ultra-modern and customer oriented that can deliver fast, comfortable and cost-effective urban mobility. Easy-to-board (low floor), attractive and environmentally friendly mini buses with air conditioning having capacity of 35 (seating + standing)(for minibuses) are proposed for feeder system.

The facilities of feeder buses have been estimated for peak hours of various horizon years 2024, 2031 and 2041. Boarding/alighting at metro stations have been used to determine the bus fleet requirement. Boarding/alighting at metro stations in various horizon years is given in chapter 3. Modal split of access modes have been assumed to assess the bus fleet and bicycles requirement. The assumed modal split is shown in **Table 7.1.** The fleets required along MRTS corridors are presented in **Table 7.1.** The total number of buses required are 133, 158 and 193 in the year 2024, 2031 and 2041 respectively. The feeder route planning has been identified at almost all stations as presented in **Figure 7.2.** Total 30 feeder routes have been planned for Phase II Metro corridors. The proposed feeder routes have also been integrated with the nearby metro stations of Phase I.

TABLE 7.1: ASSUMED MODAL SPLIT

Mode	Assumed Modal Split
Car	5%
2W	15%
Auto	30%
Bus	30%
Cycle	20%

7.2.3. Public Bicycle Sharing Service

This service will be provided for the passengers for 1 km to 2 km of the MRTS stations influence area. A bicycle sharing system is the service in which bicycles are made available for free and shared use to MRTS passengers on a short-term basis. The main purpose is to allow passengers to depart or arrive at MRTS stations. The requirement of bicycles along the MRTS corridors is estimated and is presented in **Table 7.3.**

TABLE 7.2: FEEDER BUS FLEET REQUIREMENT FOR NAGPUR METRO PH II

S. No.	Metro Station	Route No.	Route	Length (in Km)	Reqd No. of Buses in Peak Hour		
					2024	2031	2041
Corridor - 1A: Mihan to MIDC ESR							
1	Ashok Van	R1	Jamtha to Harihar Nagar	4.8	2	2	3
		R2	Ashok Van to Airport	8	2	3	4
2	Dongargaon	R1	Dongargaon to Sukli	6	3	4	4
		R2	Dongargaon to Ukhali	7.9	4	5	5
3	Meghdoot CIDCO - Butibori Police Station	R1	Turkmari to Butibori Raiway Station	6	3	3	4
4	MHADA Colony	R1	Satgaon to Gopalpur	5.6	2	3	4
5	MIDC KEC - MIDC ESR	R1	Morarji Textile to Rui Khairi	8.4	3	3	4
		R2	MIDC KEC to Pipri	8.4	3	3	4
Corridor -2A: Automotive Square to Kanhan River							
1	Pili Nadi	R1	Pili Nadi - Ashok Nagar	6.6	7	8	8
2	Khasara Fata - All India Radio	R1	Kawatha to Kalmana	12.3	10	12	12
3	Khairi Fata	R1	Khairy to Bhushan Nagar	5	3	3	4
4	Lekha Nagar	R1	Lekha Nagar - Waregaon	6.3	5	6	7
5	Kamptee Cantonment - Police Station	R1	Cantonment to Belena Nagar	6.7	7	7	8
		R2	Cantonment to Gautam Nagar	4	4	5	6
6	Kamptee Municipal Council - Dragon Palace	R1	Golf Club to Gautam Nagar	6	2	2	3
7	Golf Club - Kanhan River	R1	Kanhan River to Warada	8.3	2	3	4
Corridor - 3A: Lokmanya Nagar to Hingna							
1	Mount View - Rajiv Nagar	R1	Nagalwadi to Wagdara	9.5	8	9	11
		R2	Lokmanya Nagar to Nildoh	6	6	6	8
2	Wanadongri	R1	Nildoh - Teacher's Colony	5	2	2	2
3	APMC	R1	APMC to Wagdara	6.2	3	7	8
4	Raipur - Hingna Bus Station	R1	Raipur to Mondha	5	2	2	3
Corridor - 4A: Prajapati Nagar to Transport Nagar							
1	Pardi	R1	Bharatwada to Ambedkar Nagar	11.3	7	8	11
		R2	Pardi to Dighori Chowk	7.5	5	6	8
2	Kapsi Khurd	R1	Ghar Sansar Nagar toTarodi BK	8.8	3	3	4
3	Transport Nagar	R1	Tarodi BK to Lihigaon	9.4	4	6	6
Corridor - 5: Vasudev Nagar to Dattawadi							
1	Duttawadi Station	R1	Lava to Sitabuldi	12	6	7	8
		R2	Duttawadi to Zero Mile	12	6	7	8
		R3	Duttawadi to Lava	9.8	6	7	8
2	MIDC Hingna	R1	MIDC Hingna - Surabardi	6.7	6	7	8
3	Police station MIDC	R1	Police Station MIDC - Ordnance factory	12	8	10	14
Total					**133**	**158**	**193**

FIGURE 7.2: PROPOSED FEEDER ROUTE MAP ALONG PH II CORRIDORS

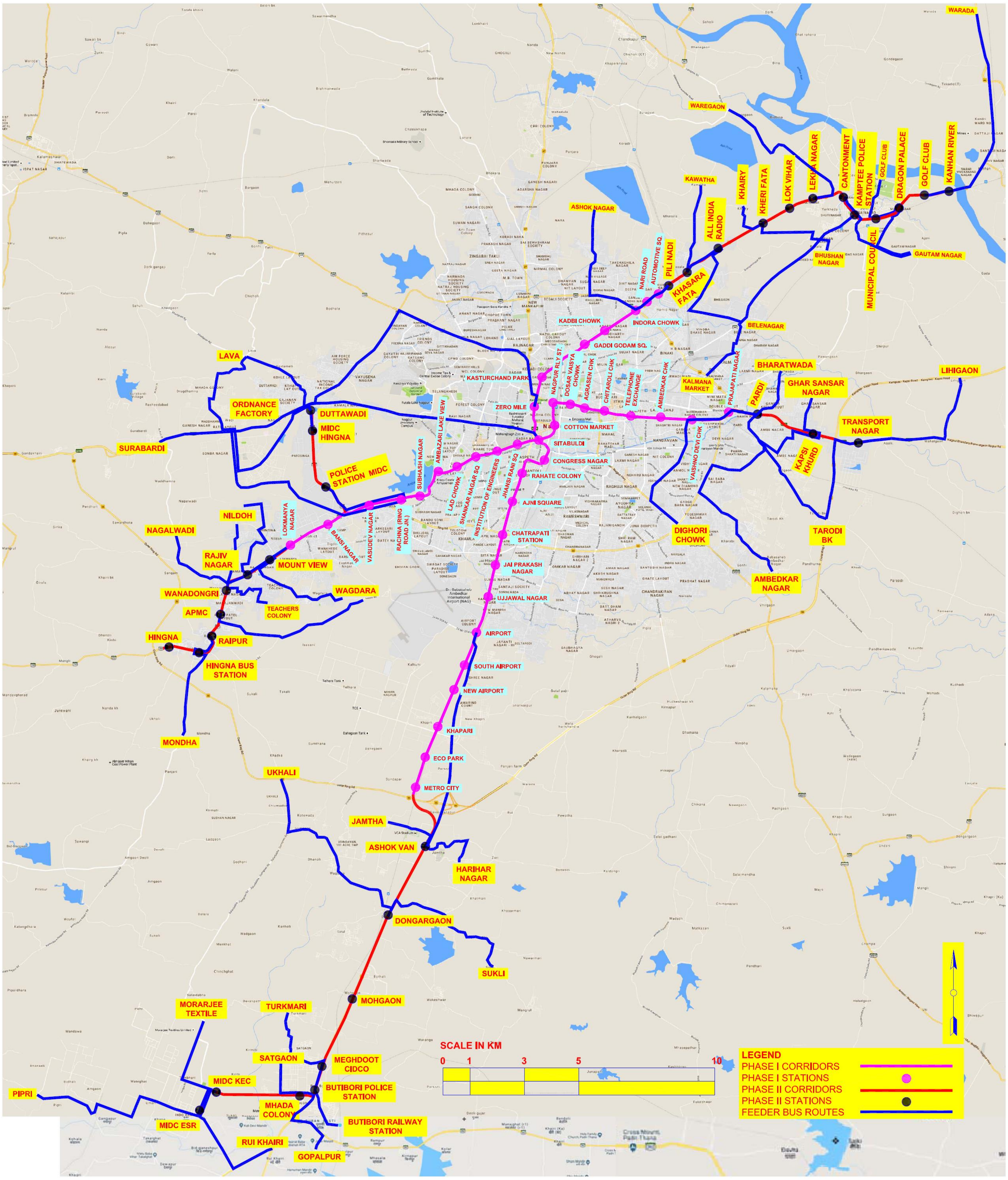


TABLE 7.3: BICYCLE SHARING SCHEME FOR MRTS CORRIDORS

S. No.	Metro Station	Reqd No. of Bicycles in Peak Hour		
		2024	2031	2041
Corridor - 1A: Mihan to MIDC ESR				
1	Ashok Van	19	21	37
2	Dongargaon	37	40	50
3	Meghdoot CIDCO - Butibori Police Station	17	19	26
4	MHADA Colony	14	19	24
5	MIDC KEC - MIDC ESR	6	9	12
Corridor -2A: Automotive Square to Kanhan River				
1	Pili Nadi	44	47	50
2	Khasara Fata - All India Radio	32	34	39
3	Khairi Fata	19	19	22
4	Lekha Nagar	31	32	38
5	Kamptee Cantonment - Police Station	72	78	92
6	Kamptee Municipal Council - Dragon Palace	8	9	10
7	Golf Club - Kanhan River	4	5	7
Corridor - 3A: Lokmanya Nagar to Hingna				
1	Mount View - Rajiv Nagar	72	84	97
2	Wanadongri	3	5	6
3	APMC	11	38	47
4	Raipur - Hingna Bus Station	8	15	16
Corridor - 4A: Prajapati Nagar to Transport Nagar				
1	Pardi	54	57	80
2	Kapsi Khurd	11	12	15
3	Transport Nagar	16	21	24
Corridor - 5: Vasudev Nagar to Dattawadi				
1	Duttawadi Station	60	67	80
2	MIDC Hingna	33	37	43
3	Police station MIDC	30	34	68
Total		**602**	**699**	**884**

7.3. PHYSICAL INFRASTRUCTURE REQUIREMENT FOR INTERMODAL INTEGRATION

Physical infrastructure facilities have been planned to facilitate easy transfer of commuters between different modes of transport. Seamless mobility is proposed to remain connected between different transport modes i.e. MRTS, city bus system, IPT, NMT and private modes i.e. cars, two wheelers etc.

- Demarcations of designated bus bays have been proposed with proper shelter near station entry/ exits by utilizing road shoulder areas.

- Demarcations of planned IPT/private pick and drop facilities, wherever land is available have been proposed. Most of the passengers use IPT / taxis for short distances.

- Relocation of vendors/hawkers and removal of all encroachments from the station precinct.

- Off – street parking lots be identified to avoid on-street parking

- Continuous, encroachment free and well-maintained footpaths of 1.8-3 m width have been proposed near station areas.

- Proper road markings, Zebra crossings, & table top crossings have been provided near the station influence area.

The physical infrastructure requirement for intermodal integration facilities and passenger traffic dispersal at all stations along the MRTS corridors have been proposed on the basis of availability of land and suitably incorporated in station plans.

In case of skywalks and subways, the following facilities may be suggested for differently abled and senior citizens:

- Footbridge ramps with appropriate resting places/ landings
- Within the subway, a handrail set 850mm-900mm above the walking surface should be provided.
- To assist visually impaired people, tactile paving/ tiles and a colour contrast should be provided at the top and bottom of the flight of steps and these areas should be well lit.
- Elevator/lift should be provided on both the entrances/exits and should have minimum internal dimensions of 1400mm x 1400mm.
- All Lifts to have Braille buttons and audio announcement systems.

7.4. RECOMMENDATIONS FOR INSTITUTIONAL, PHYSICAL, FARE, OPERATIONAL AND TECHNOLOGY INTEGRATION

Some of the essential features of an integrated multi-modal urban transport system are the physical integration of public transport services, fares, ticketing, infrastructure provision, management, pricing, and integration of transport authorities.

7.4.1. Physical Integration

Physical integration refers to the provision of jointly used transport facilities & equipment to provide seamless mobility. Integration of physical space, network planning and physical infrastructure have been planned to facilitate easy transfer of commuters between MRTS, city bus system, feeder bus system, IPT, NMT and private modes i.e. cars, two wheelers etc.

Augmentation of carriageway and footpath in station vicinity to cater to traffic volumes has been proposed through strengthening of road shoulder and relocation of vendors/hawkers, on-street parking and all encroachments.

7.4.2. Operational Integration

This involves application of management techniques to optimize the allocation of transit resources and coordinate services. The techniques/principles of network integration include:

- Coordinated Routing and Scheduling- in which high-capacity, such as MRTS system is considered as trunk system and buses act as feeder to the MRTS. Accordingly, the integrated route network may be planned by generating feeder bus routes for selected MRTS station.
- Rationalization of redundant services - wasteful duplication of transit service by competing systems may be eliminated and resources redeployed to reduce headways on existing routes and extend services into new areas.
- Network coordination and access- in which access facilities may be provided for non-motorized transport (pedestrians and cyclists) and private transport to support and enhance the public transport operations, to achieve overall network integration.

The service integration takes into account all modes implying the services will be complementary to each other with in the station area.

7.4.3. Fare Integration

The basic principle behind fare integration is that one ticket provides access to all modes of transport even when managed by different operators. Choice of fare structure is a very important part of public transport planning. It directly influences operators' revenue. At its simplest, integration of fares, allows a person to make a journey that involves transfers (within or between different transport modes) with a single ticket that is valid for the complete journey, modes being buses, trains, MRTS, taxis, parking, etc. The major benefits of fare integration are as follows:

- It encourages people to use public transport by simplifying the transfer between transport modes and by increasing the efficiency of the services
- Provides a common ticket across the modes
- Improves the experience of seamless mobility

Smartcard ticketing systems enable commuters to carry one durable card for use on all transit modes. A single multipurpose ticket makes using multiple transport modes much simpler and less time consuming. In turn, this facilitates the multimodal travel behaviour that is encouraged by operators and transport planners. In this regard, smartcard ticketing is proposed facilitating a genuinely seamless multimodal transport system in Nagpur city.

7.4.4. Information Integration

Creating the possibility to get information about the entire journey and not having to enquire at different sources. To take an informed decision during travel, real-time access to information is of strategic importance.

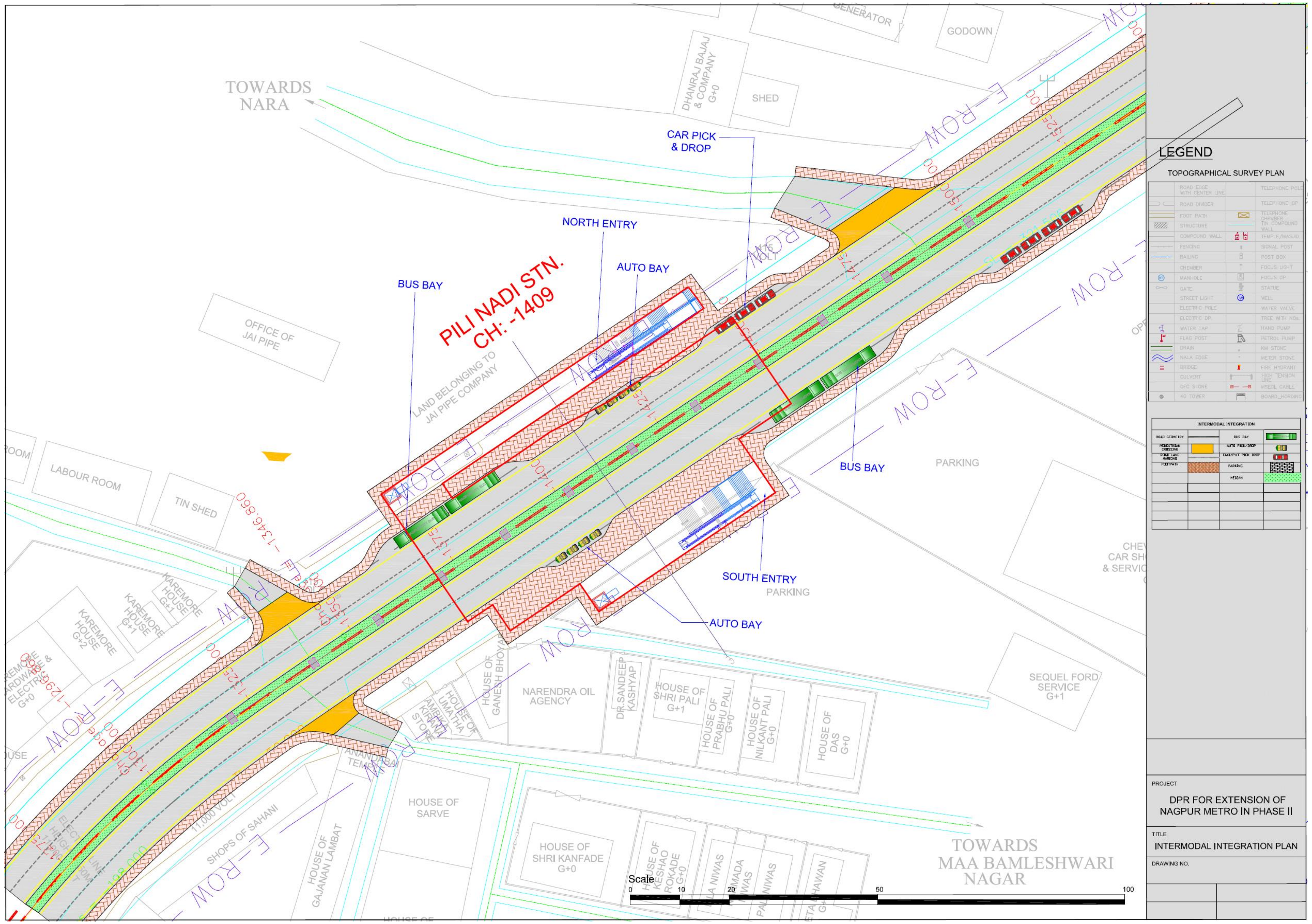
Information integration deals with the Information on routes, schedules, fares, and transfer points for all transit modes and services throughout the urban area, which is provided by a centralized source. Information services include route maps, timetables, fare schedules, and promotion materials, uniform street signs and vehicle identification, display at stops, transfer points and major stations, and telephone inquiry answering service. Providing integrated information during journey before and in between is important, to make them attractive. Information integration for all transit modes in the city is proposed for the MRTS network.

7.4.5. Institutional Integration

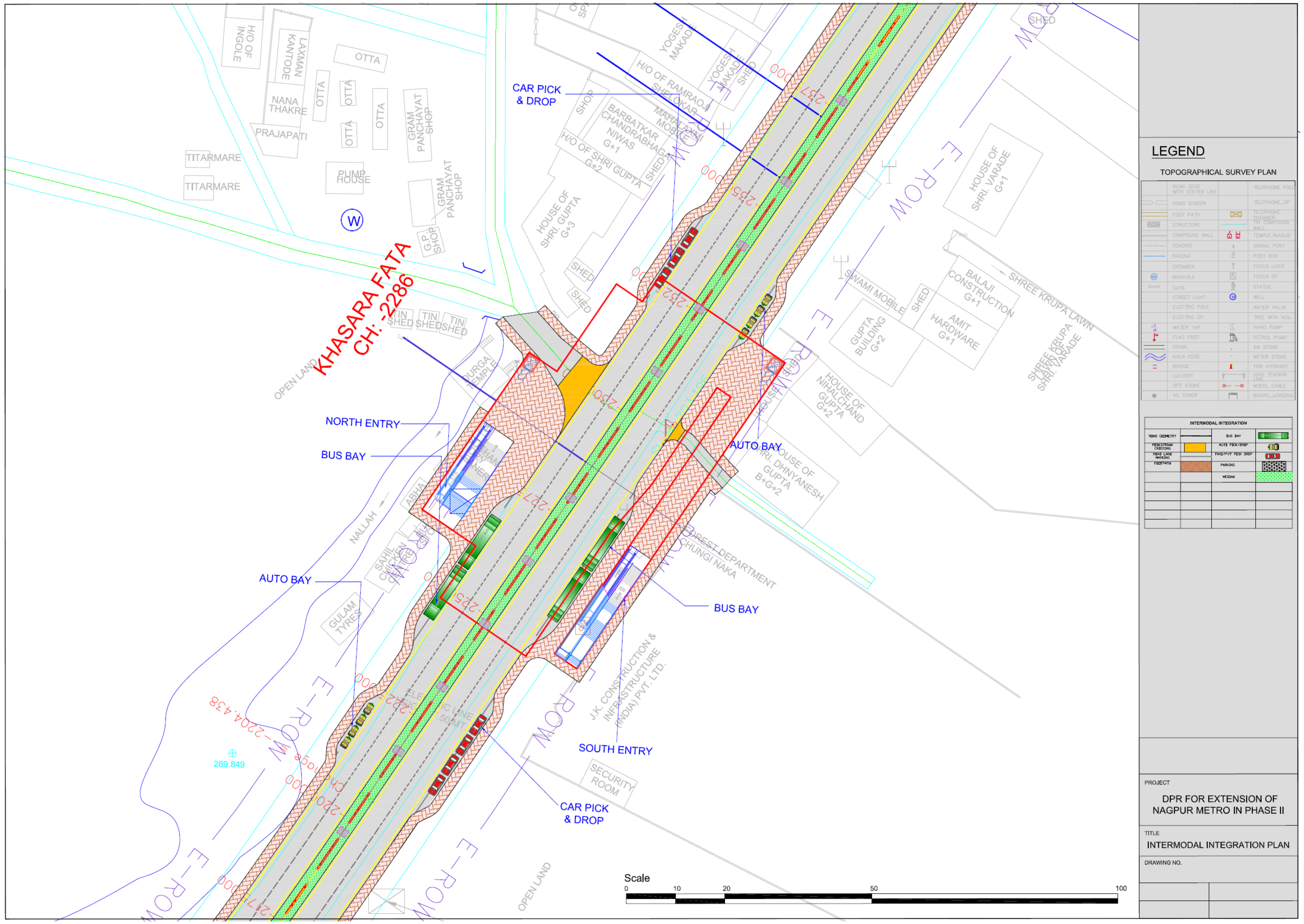
City growth strategies are usually guided by documents like land use plans, development plans and master plans etc. and the urban transport models are determined by parameters like existing road network, public transport and its related infrastructure, personal vehicles, licensing mechanism and authorities, land ownership, fare structure of public transport, Intelligent Transport System (ITS) mechanism, traffic enforcement agencies and traffic law enforcing mechanisms, goods and freight movement and their operators, road safety and accident management system etc. All these agencies which prepare these policy documents and oversee governing these functions generally work independently and usually there is no synergy between them. It is recommended that an umbrella agency may be created to monitor and integrate these multiple bodies in order to ensure smoother functioning of all aspects related to urban transport.

ANNEXURE 7.1

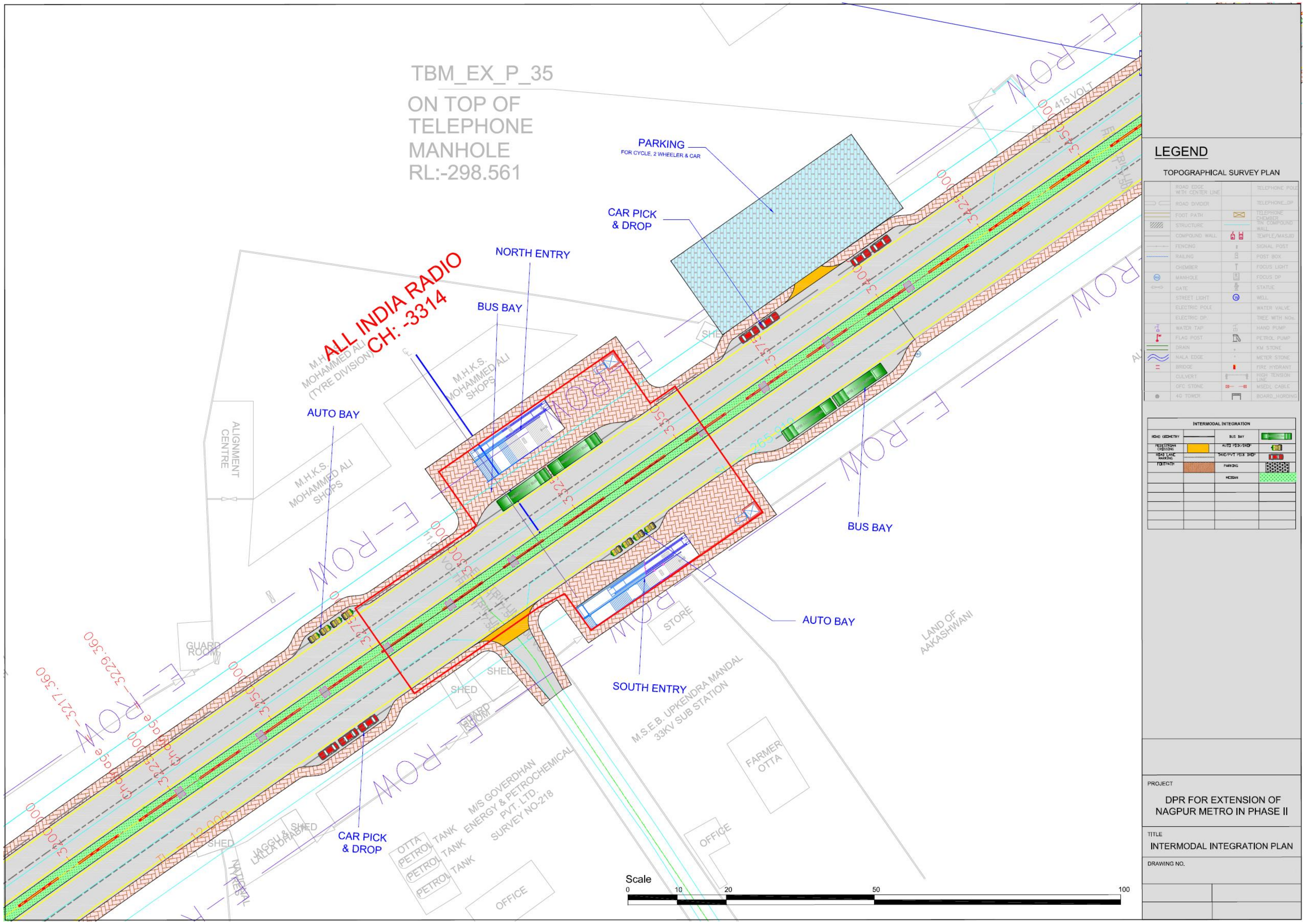
INTERMODAL INTEGRATION PLAN FOR PILI NADI STATION



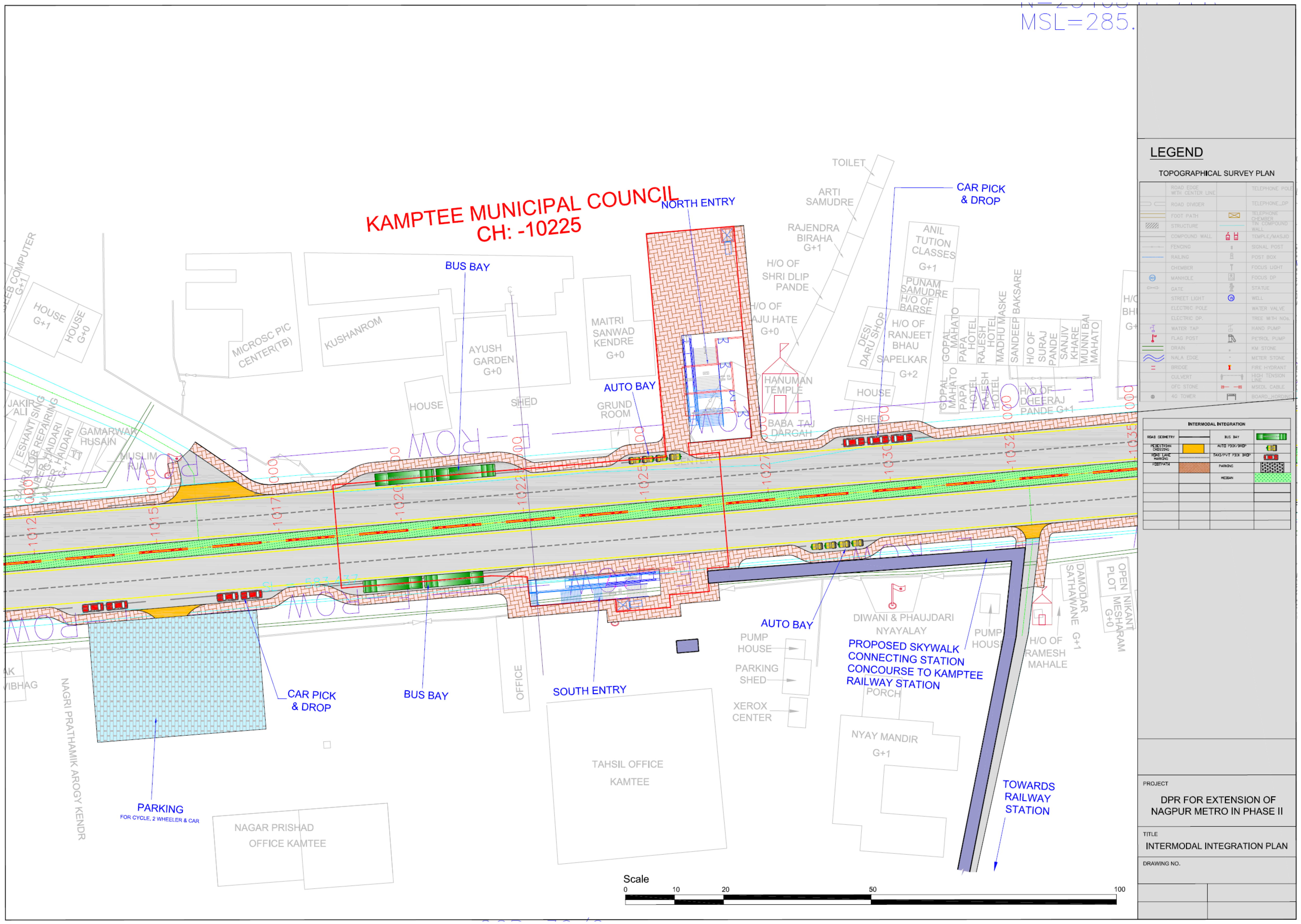
INTERMODAL INTEGRATION PLAN FOR KHASARA FATA STATION



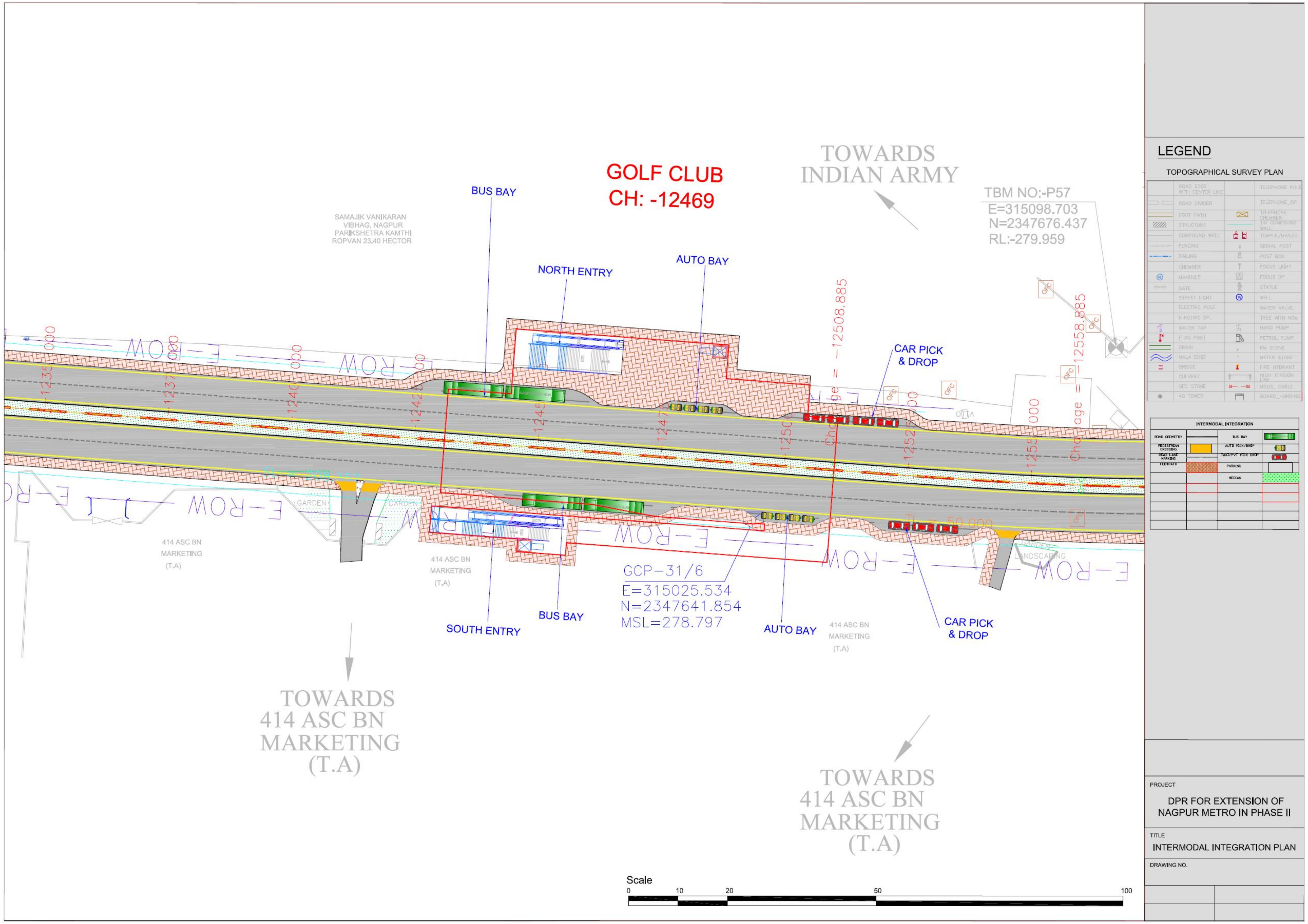
INTERMODAL INTEGRATION PLAN FOR ALL INDIA RADIO STATION



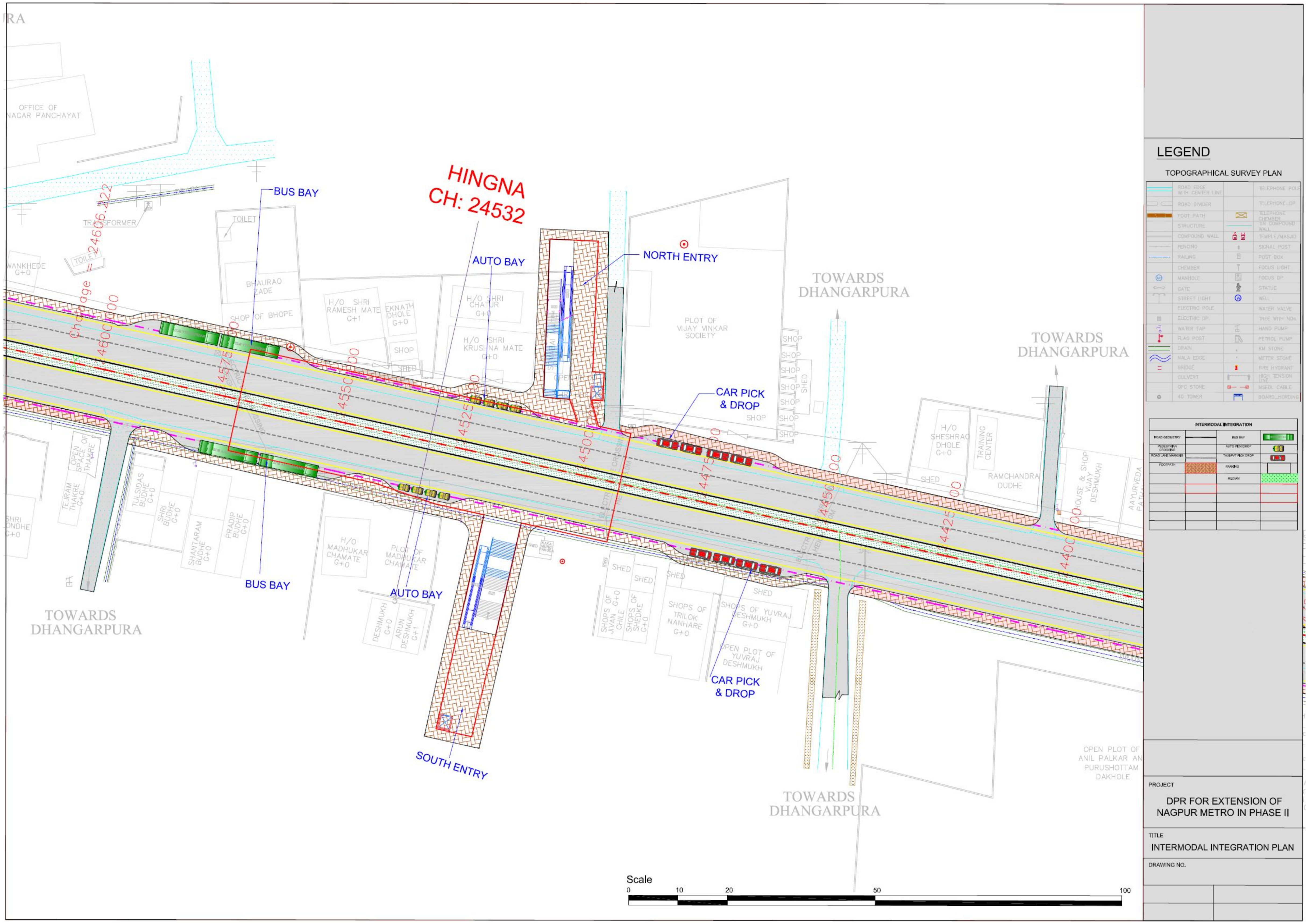
INTERMODAL INTEGRATION PLAN FOR KAMPTEE MUNICIPAL COUNCIL STATION



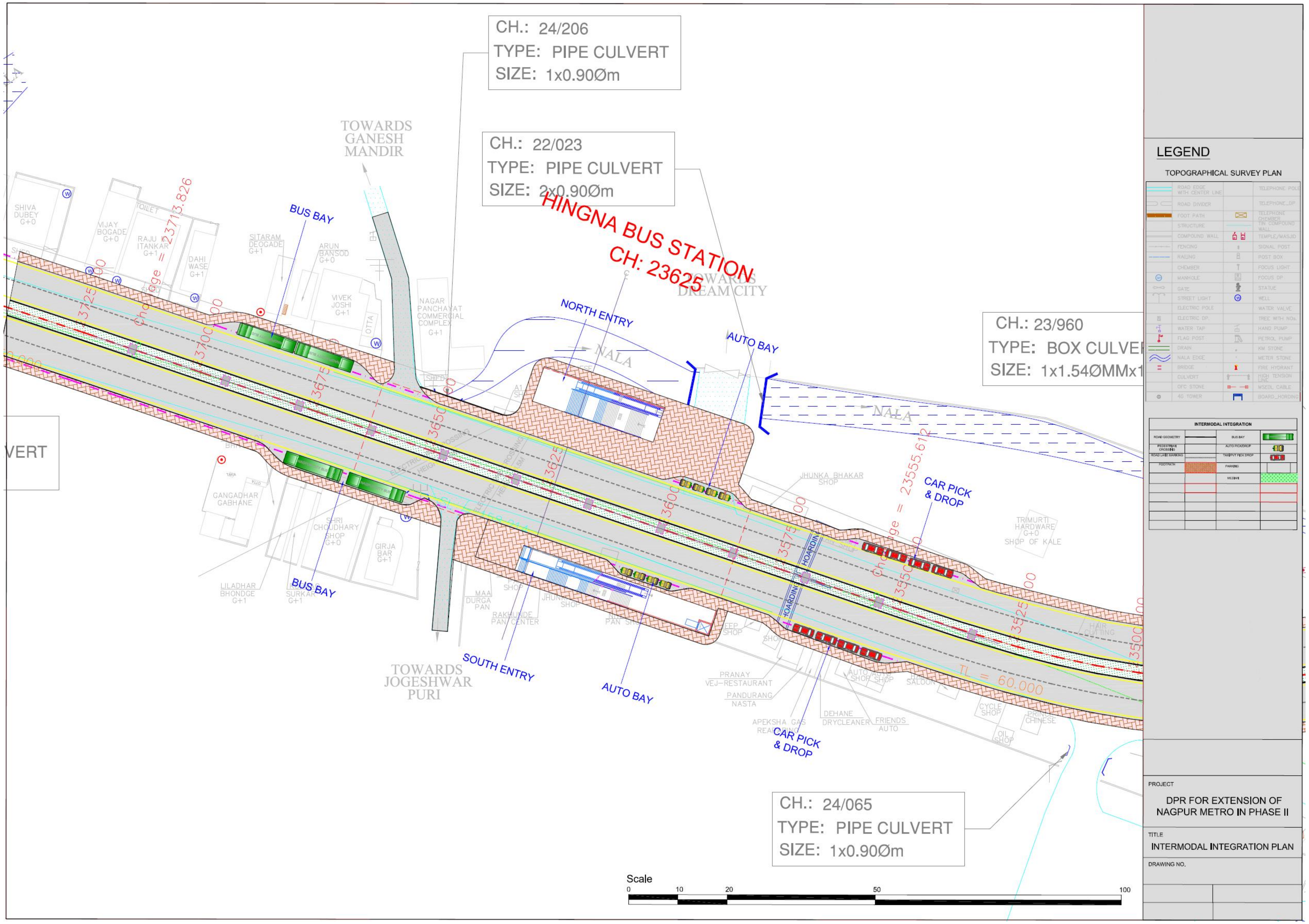
INTERMODAL INTEGRATION PLAN FOR GOLF CLUB STATION



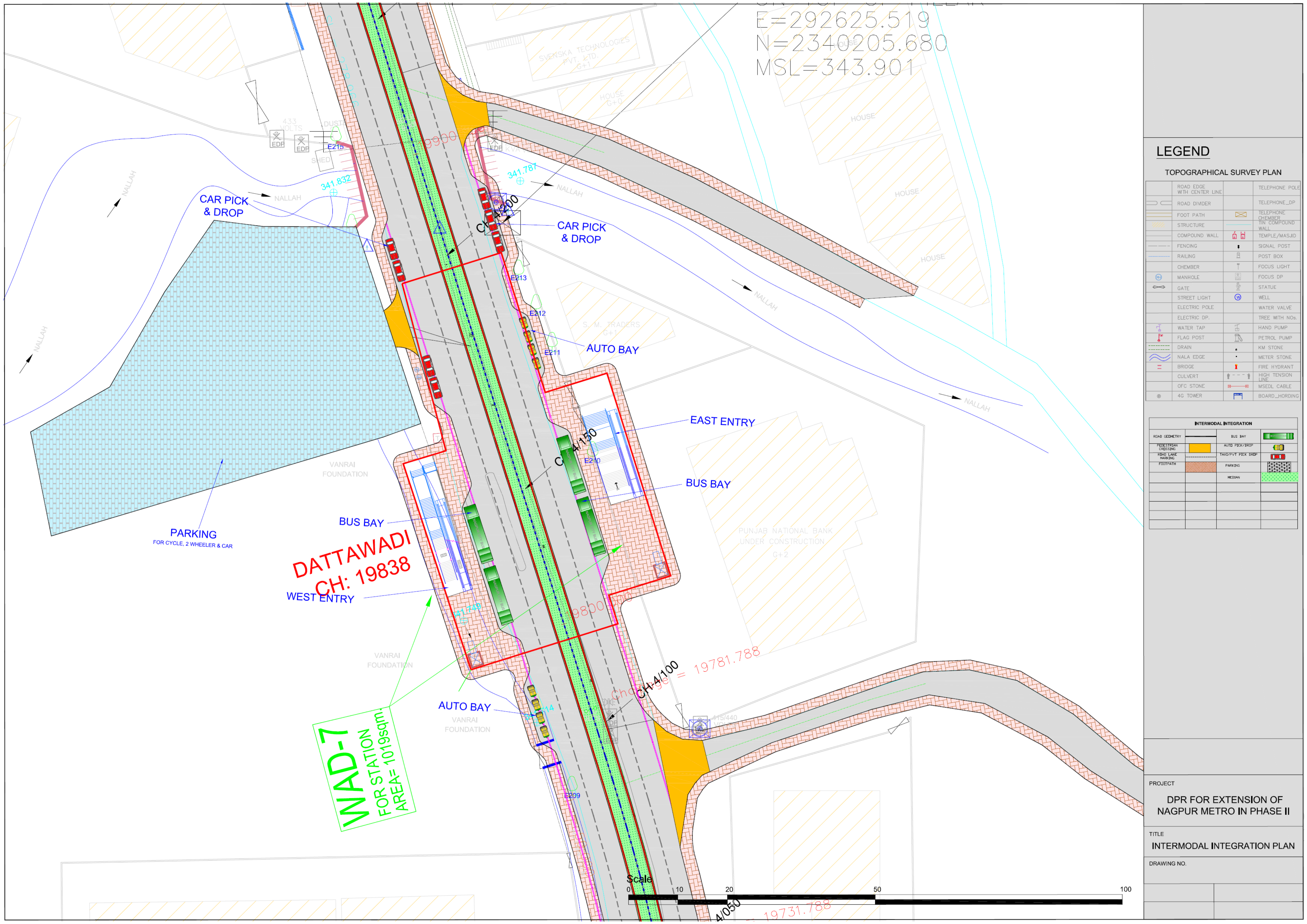
INTERMODAL INTEGRATION PLAN FOR HINGNA STATION



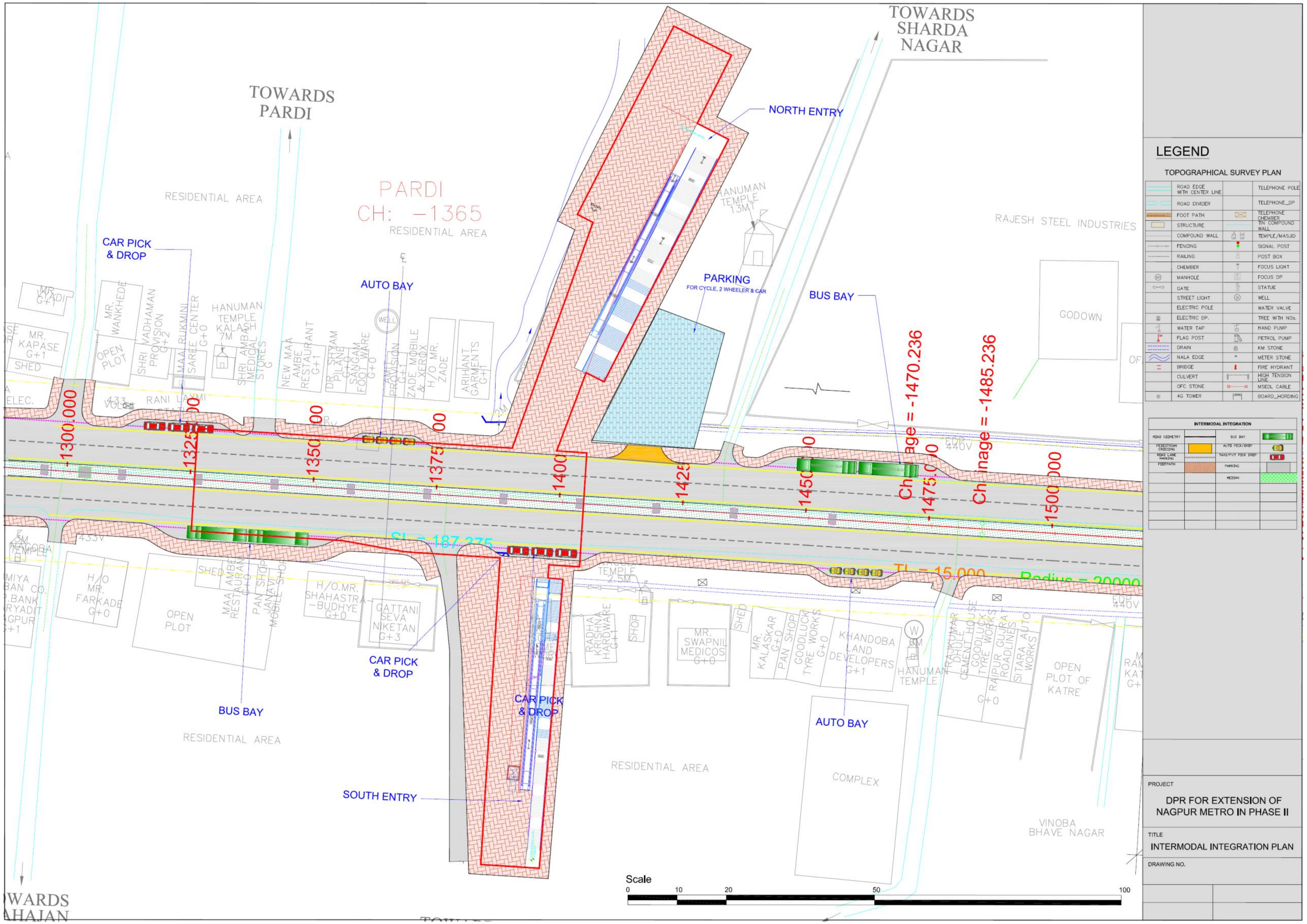
INTERMODAL INTEGRATION PLAN FOR HINGNA BUS STATION



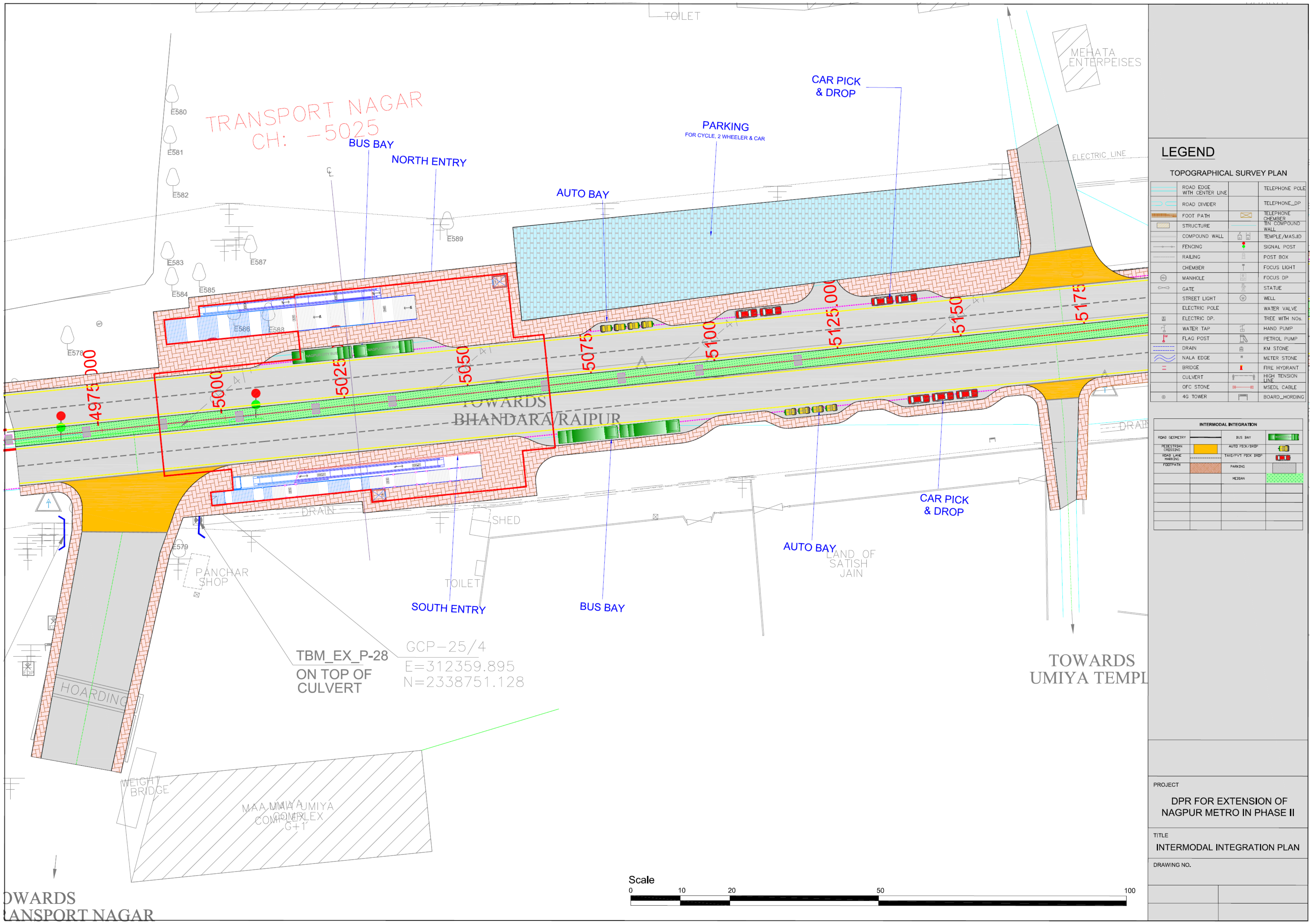
INTERMODAL INTEGRATION PLAN FOR DATTAWADI STATION



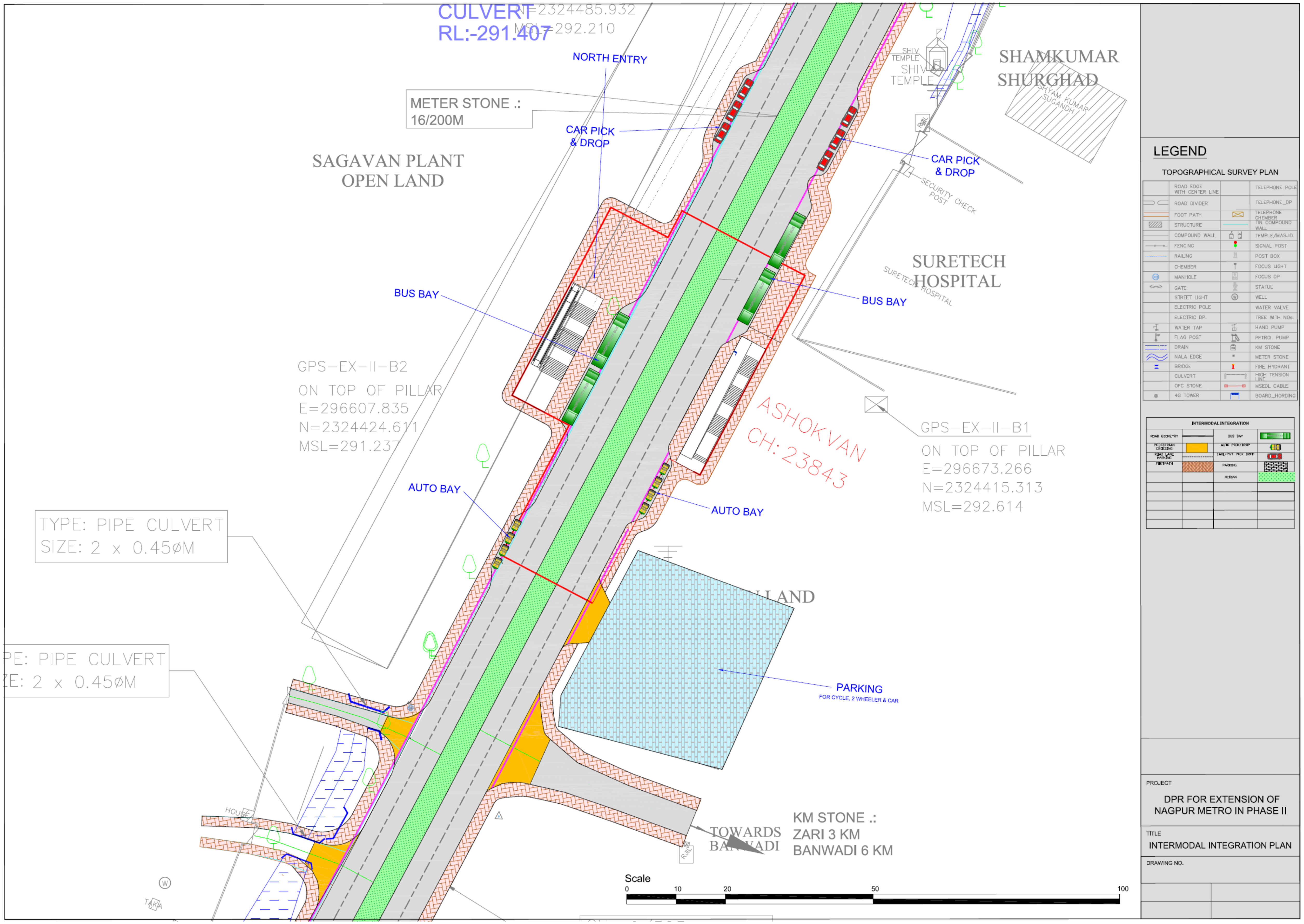
INTERMODAL INTEGRATION PLAN FOR PARDI STATION



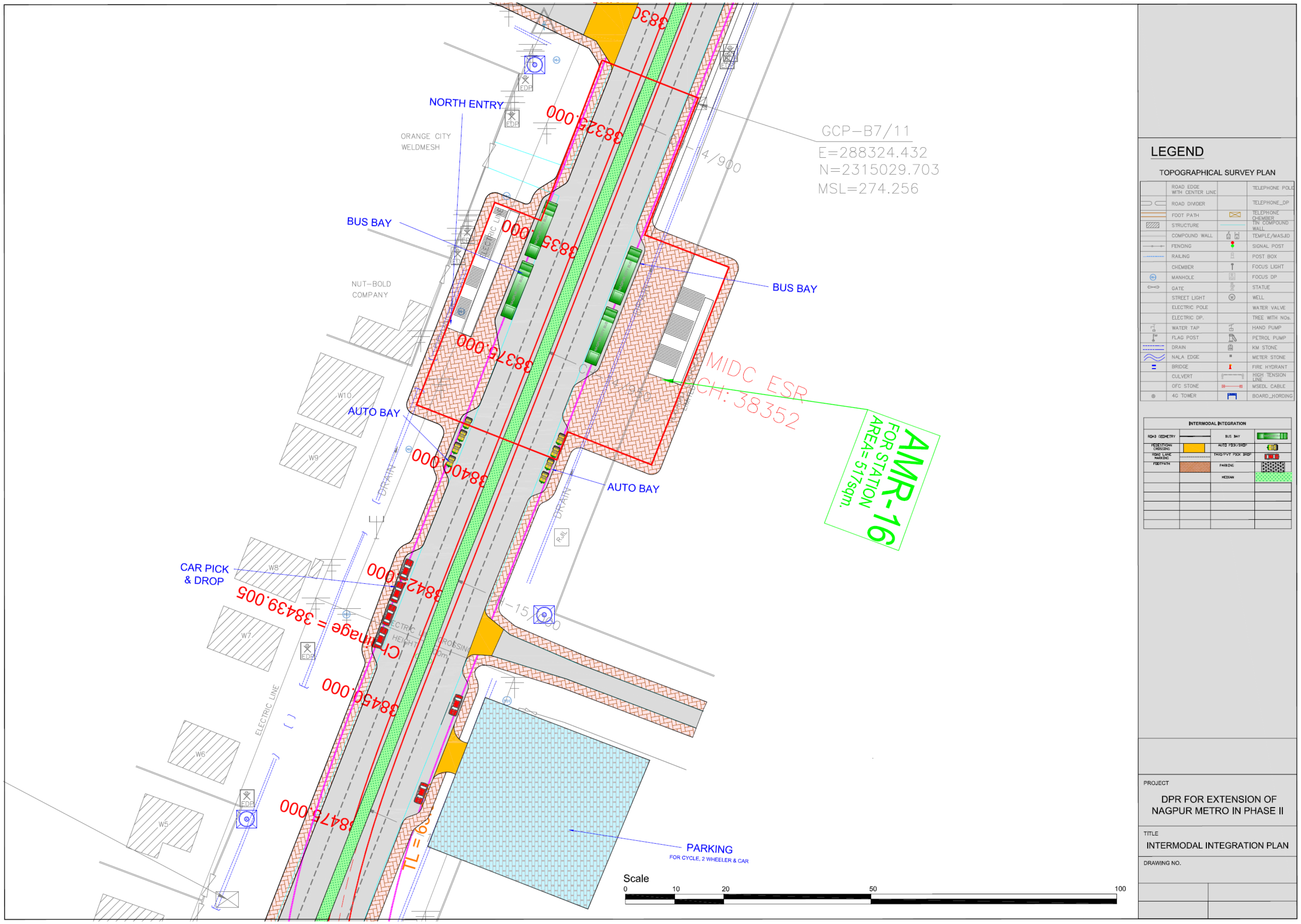
INTERMODAL INTEGRATION PLAN FOR TRANSPORT NAGAR STATION



INTERMODAL INTEGRATION PLAN FOR ASHOK VAN STATION



INTERMODAL INTEGRATION PLAN FOR MIDC ESR STATION



Chapter – 8
TRAIN OPERATION PLAN

8. TRAIN OPERATION PLAN

8.1 TRAIN OPERATION PHILOSOPHY

Train operation plan for proposed Nagpur Metro Phase 2 viz. Kanhan River to MIDC ESR Corridor and Transport Nagar to Hingna Corridor with spur from Vasudev Nagar to Dattawadi has been envisaged based on the ridership assessment. The design year peak hour peak direction trips (PHPDT) is 15743 for Kanhan River to MIDC ESR Corridor and 16889 passengers for Transport Nagar to Hingna Corridor. Since, Phase 2 corridors are the extensions for Phase 1, the train operation plan has been formulated considering the complete section including the Phase 1 corridors. The underlying operation philosophy is to provide mass rapid transit services at economical cost with fixed Infrastructure and rolling stock planning.

- The frequency of train services is optimized to provide sectional capacity commensurate with the peak direction traffic demand during peak hours.
- A minimum train service frequency is provided during lean period so as to keep the option of this service attractive during lean period as well.
- The frequency of services is regulated to meet the growing traffic demand in horizon years.
- Basic unit selected is two motor car and one trailer car.

The train operation plan for proposed corridors is based on following salient features:

- Running of services for 19 hours of a day (5:00 hrs to 00:00 hrs) with a station dwell time of 20-30 second
- Scheduled speed of 34 kmph
- Make up time of 5% with 8% coasting
- Adequate services to ensure comfortable journey for commuters even during off peak periods.

8.1.1 Traffic Demand

Peak hour peak direction traffic demands (PHPDT) for the purpose of planning of services for the proposed corridors for years 2024, 2031 and 2041 are indicated below in **Table 8.1.**

TABLE 8.1: YEAR WISE MAXIMUM PEAK HOUR PEAK DIRECTION TRIPS (PHPDT)

Corridor	Year		
	2024	**2031**	**2041**
Kanhan River to MIDC ESR	12952	13407	15743
Transport Nagar to Hingna	10195	11411	16889
Transport Nagar to Dattawadi	3806	4862	5835

The section wise traffic for Nagpur Metro Phase 1 & 2 corridors for different horizon years is provided in **Chapter 3.**

8.1.2 Train Formation

2.9m wide coaches have been planned for Nagpur Metro Phase 1 corridors and the infrastructure has been planned accordingly. Therefore, in order to maintain smooth operations between Phase 1 and 2 corridors, same 2.9 m wide coaches have been proposed for Phase 2 corridors. The train composition, capacity and headway required for the operation in proposed corridors is given below:

i. Composition

The car composition to be adopted is given below-

DMC : Driving Motor Coach
TC : Non Driving Trailer Coach
3-Car Rake Composition: ***DMC-TC-DMC***
Every coach shall be fully interchangeable with any other coach of same type.

ii. Capacity

For the purpose of calculating rake requirement of rolling stock, passenger carrying capacity is considered as given in **Table 8.2**.

TABLE 8.2: CARRYING CAPACITY OF COACHES

Description	Driving Motor Car (DMC)			Trailer Car (TC)			3 Car Train		
	Normal	Crush	Dense Crush	Normal	Crush	Dense Crush	Normal	Crush	Dense Crush
Seated	43	43	43	50	50	50	136	136	136
Standing	137	205	273	147	220	293	421	630	839
Total	180	248	316	197	270	343	557	766	975

Normal *- 4 Per/sqm,* ***Crush****- 6 Per/Sqm,* ***Dense Crush*** *– 8 Per/Sqm of standee area*

iii. Headway

To meet the projected traffic demand, possibility of running trains with 3 car rake composition at different headways has been examined. The traffic capacity and demand have been matched by suitable regulation of headways.

In order to meet the traffic demand and to maintain the suitable frequency of train operation in all the sections, train operation has been proposed between following sections:

1) North South Corridor including Phase-2 Extensions

- Kanhan River to MIDC ESR
- Kamptee Police Station to Ashokvan

2) East West Corridor including Phase-2 Extensions

- Transport Nagar to Hingna
- Transport Nagar to Dattawadi
- Transport Nagar to Hingna Mount View

The train operation plan envisaged for the N-S and E-W corridors including Phase-2 extensions is given in **Tables 8.3** and **8.4**:

TABLE 8.3: TRAIN OPERATION PLAN FOR N-S CORRIDOR

Train Operation/ Corridors	Items		Year		
			2024	2031	2041
Kanhan River to MIDC ESR	Cars/ Train		3	3	3
	Headway (Sec.)		900	900	600
	Trains/hr		4	4	6
	Capacity Provided	@6p/m^2	3064	3064	4596
		@8p/m^2	3900	3900	5850
	PHPDT Demand		3246	3921	5126
Kamptee Police Station to Ashokvan	Cars/ Train		3	3	3
	Headway (Sec.)		360	360	327
	Trains/hr		10	10	11
	Capacity Provided	@6p/m^2	7660	7660	8426
		@8p/m^2	9750	9750	10725
	PHPDT Demand		12952	13407	15743

TABLE 8.4: TRAIN OPERATION PLAN FOR E-W CORRIDOR

Train Operation/ Corridors	Items		Year		
			2024	2031	2041
Transport Nagar to Hingna	Cars/ Train		3	3	3
	Headway (Sec.)		900	900	900
	Trains/hr		4	4	4
	Capacity Provided	@6p/m^2	3064	3064	3064
		@8p/m^2	3900	3900	3900
	PHPDT Demand		1063	3032	3571
Transport Nagar to Dattawadi	Cars/ Train		3	3	3
	Headway (Sec.)		900	720	600
	Trains/hr		4	5	6
	Capacity Provided	@6p/m^2	3064	3830	4596
		@8p/m^2	3900	4875	5850
	PHPDT Demand		3806	4862	5835
Transport Nagar to Hingna Mount View	Cars/ Train		3	3	3
	Headway (Sec.)		1200	900	450
	Trains/hr		3	4	8
	Capacity Provided	@6p/m^2	2298	3064	6128
		@8p/m^2	2925	3900	7800
	PHPDT Demand		10195	11411	16889

Based on the above train operation, the section wise headway and capacity provided for N-S and E-W corridors for various horizon years are as given in **Tables 8.5** and **8.6.**

TABLE 8.5: HEADWAY AND CAPACITY PROVIDED FOR N-S CORRIDOR

Sections	Items		Year		
			2024	2031	2041
Kanhan River to Kamptee Police Station	Cars/ Train		3	3	3
	Headway (Sec.)		900	900	600
	Trains/hr		4	4	6
	Capacity Provided	@6p/m^2	3064	3064	4596
		@8p/m^2	3900	3900	5850
	PHPDT Demand		1136	1165	1366
Kamptee Police Station to Ashokvan	Cars/ Train		3	3	3
	Headway (Sec.)		257	257	212
	Trains/hr		14	14	17
	Capacity	@6p/m^2	10724	10724	13022

Sections	Items		Year 2024	Year 2031	Year 2041
	Provided	@8p/m²	13650	13650	16575
	PHPDT Demand		12952	13407	15743
Ashokvan to MIDC ESR	Cars/ Train		3	3	3
	Headway (Sec.)		900	900	600
	Trains/hr		4	4	6
	Capacity Provided	@6p/m²	3064	3064	4596
		@8p/m²	3900	3900	5850
	PHPDT Demand		3246	3921	5126

TABLE 8.6: HEADWAY AND CAPACITY PROVIDED FOR E-W CORRIDOR

Sections	Items		Year 2024	Year 2031	Year 2041
Transport Nagar to Vasudev Nagar	Cars/ Train		3	3	3
	Headway (Sec.)		327	277	200
	Trains/hr		11	13	18
	Capacity Provided	@6p/m²	8426	9958	13788
		@8p/m²	10725	12675	17550
	PHPDT Demand		10195	11411	16889
Vasudev Nagar to Hingna Mount View	Cars/ Train		3	3	3
	Headway (Sec.)		514	450	300
	Trains/hr		7	8	12
	Capacity Provided	@6p/m²	5362	6128	9192
		@8p/m²	6825	7800	11700
	PHPDT Demand		3825	5627	8125
Vasudev Nagar to Dattawadi	Cars/ Train		3	3	3
	Headway (Sec.)		900	720	600
	Trains/hr		4	5	6
	Capacity Provided	@6p/m²	3064	3830	4596
		@8p/m²	3900	4875	5850
	PHPDT Demand		3806	4862	5835
Hingna Mount View to Hingna	Cars/ Train		3	3	3
	Headway (Sec.)		900	900	900
	Trains/hr		4	4	4
	Capacity Provided	@6p/m²	3064	3064	3064
		@8p/m²	3900	3900	3900
	PHPDT Demand		1063	3032	3571

The train operation is planned in such a way that the maximum headway in any section is not more than 15 minutes (900 seconds) during the peak hour. This is done to make metro travel an attractive option for the commuters.

The train operation and headway for different horizon years is proposed to meet the Peak hour peak direction traffic demand (PHPDT) with standees @ 6 passengers/m^2 in most of the sections, except in small section (few stations) meeting with standees @ 8 passengers/ m^2. This arrangement will optimise the rolling stock requirement.

8.1.3 Train Operation Plan

1) North- South Corridor Including Phase-2 Extensions (Kanhan River to MIDC ESR)

The train operation is planned between the following sections:

- Kanhan River to MIDC ESR
- Kamptee Police Station to Ashokvan

Train operation for the different horizon years for North-South corridor has been formulated such that there is optimum utilization of the rolling stock and empty running of trains is minimised. The stations length is planned for 3-car length of rolling stock in Nagpur Metro Phase 1. Therefore, the train operation plan is kept with 3 car composition till the ultimate/ design year.

Train operation for N-S corridor (including Phase-2 extensions) has been planned with 3 car rake composition for the year 2024, 2031 and 2041. The mid terminals have been planned at Kamptee Police Station and Ashokvan as the PHPDT in the sections from Kanhan River to Kamptee Police station and Ashokvan to MIDC ESR is less in comparison to Kamptee Police Station to Ashokvan section.

The planned capacity is less than the PHPDT demand in few sections. However, capacity in these sections can be met by carrying standees @ 8 passengers/m^2 which have been deliberatively planned for peak hour train operation for optimum utilization of rolling stock. The graphical representation of train operation plan for different sections of N-S corridor for different horizon years is given in **Figures 8.1, 8.2** and **8.3**.

FIGURE 8.1: DEMAND AND CAPACITY (YEAR 2024) – KANHAN RIVER TO MIDC ESR (NORTH-SOUTH CORRIDOR)

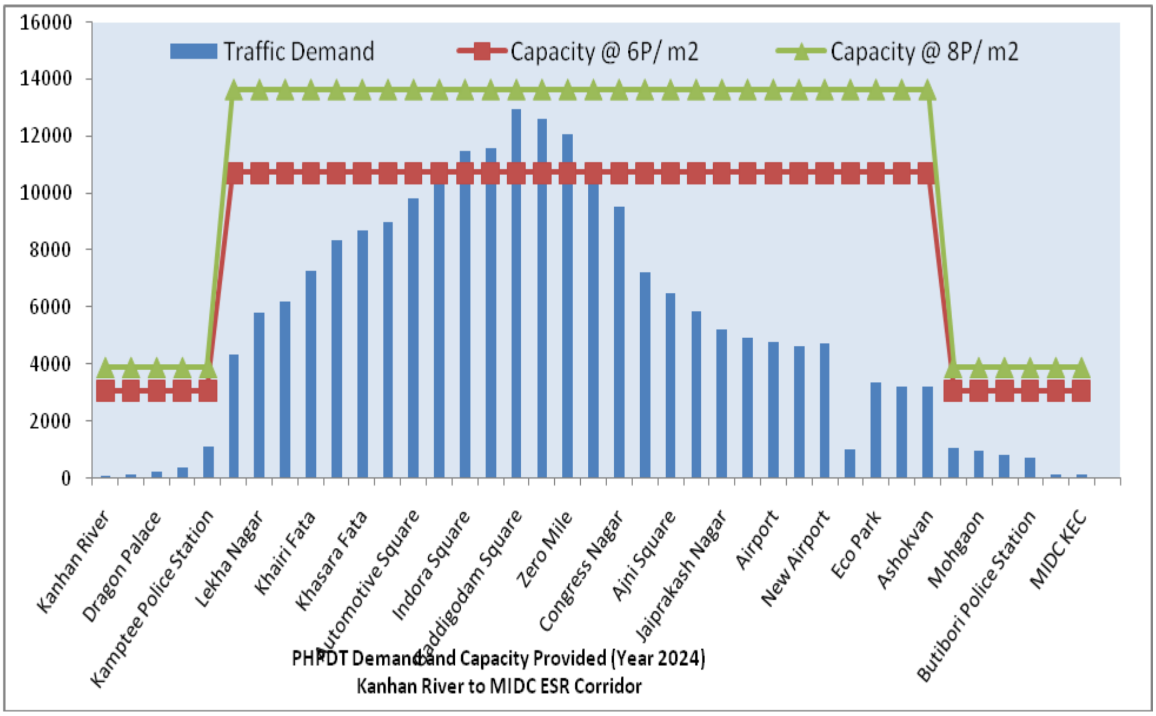


FIGURE 8.2: DEMAND AND CAPACITY (YEAR 2031) – KANHAN RIVER TO MIDC ESR (NORTH-SOUTH CORRIDOR)

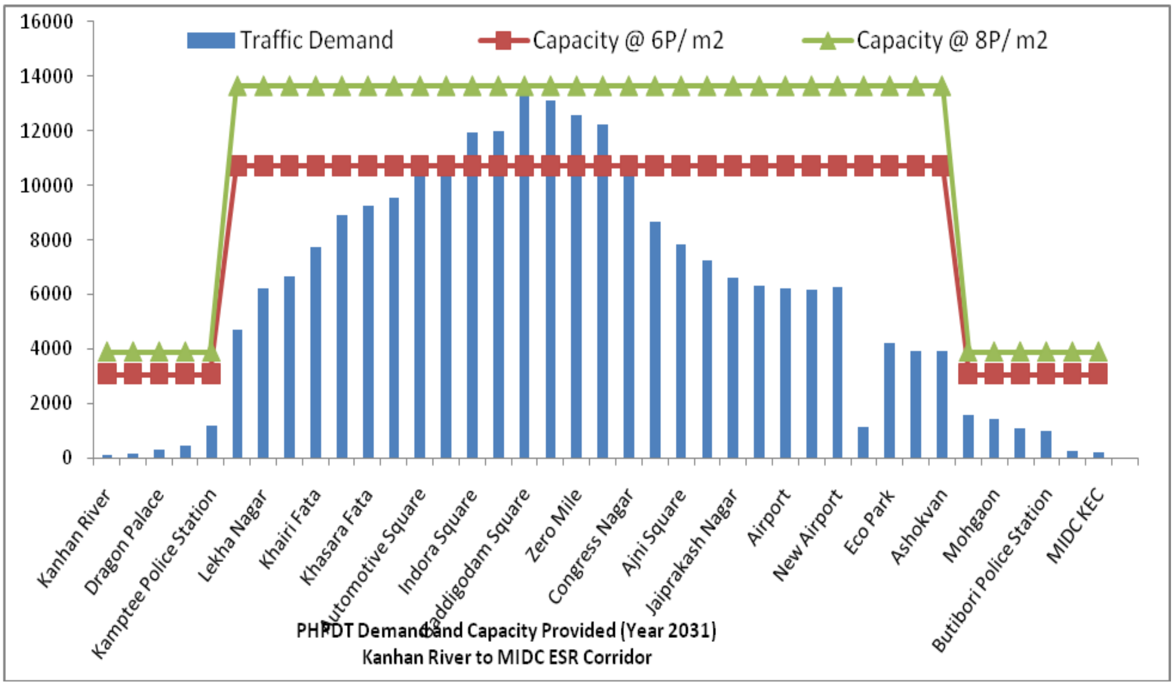
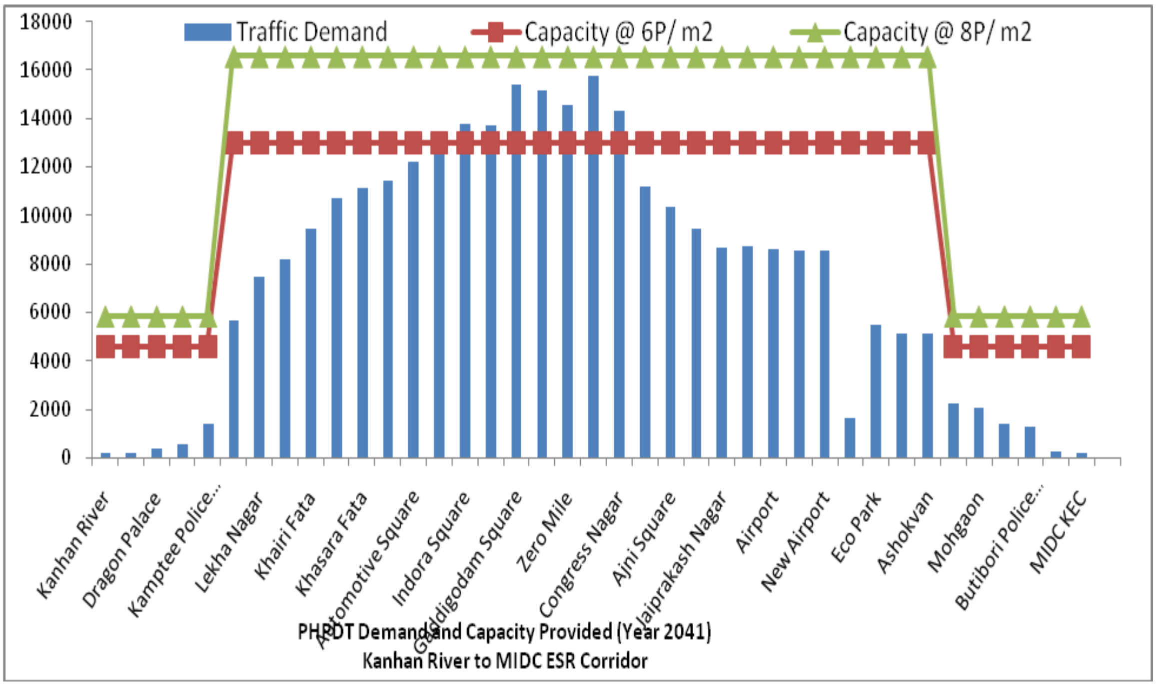


FIGURE 8.3: DEMAND AND CAPACITY (YEAR 2041) – KANHAN RIVER TO MIDC ESR (NORTH-SOUTH CORRIDOR)



2) East – West Corridor Including Phase-2 Extensions (Transport Nagar to Hingna with spur from Vasudev Nagar to Dattawadi)

The train operation is planned between the following sections:

- Transport Nagar to Hingna
- Transport Nagar to Dattawadi
- Transport Nagar to Hingna Mount View

The train operation of East-West corridor including Phase-2 extensions has been planned such that out of total number of trains starting at Transport Nagar station, few trains will continue operation till Hingna and some of trains will divert towards Dattawadi station from Vasudev Nagar station, others will terminate at Hingna Mount View station.

Train operation has been planned with 3 car rake composition for the years 2024, 2031 and 2041. The graphical representation of train operation plan for different sections of E-W corridor for different horizon years is given in **Figures 8.4** to **8.9**.

FIGURE 8.4: DEMAND AND CAPACITY (YEAR 2024) – TRANSPORT NAGAR TO HINGNA (EAST-WEST CORRIDOR)

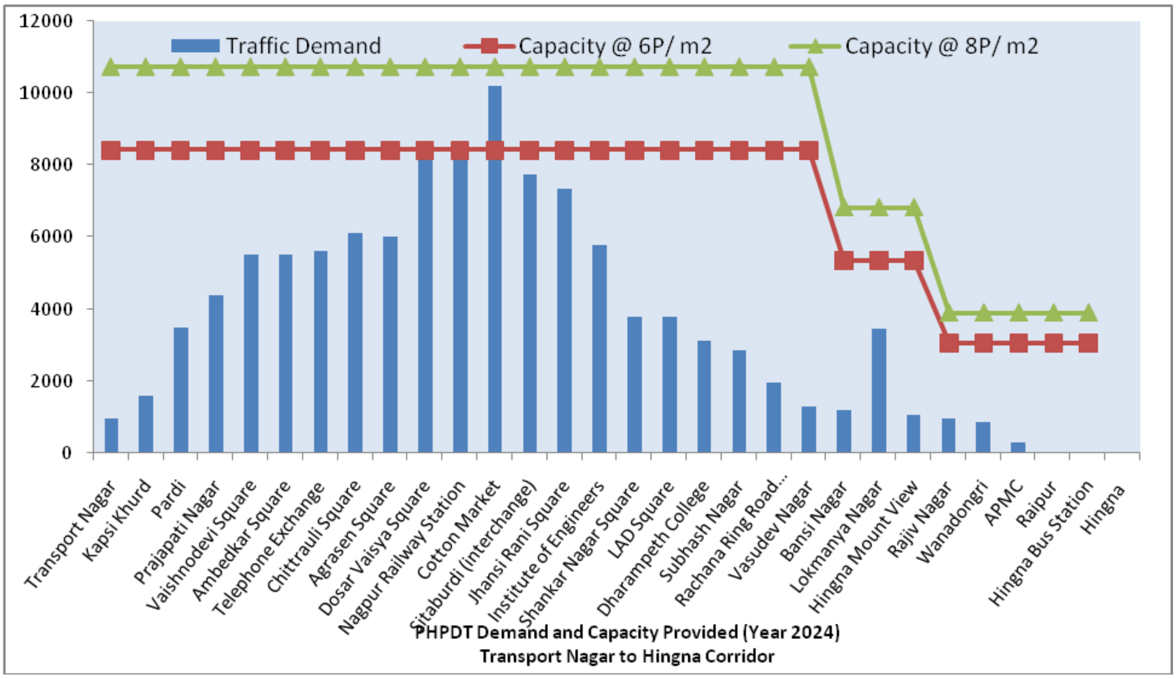


FIGURE 8.5: DEMAND AND CAPACITY (YEAR 2031) – TRANSPORT NAGAR TO HINGNA (EAST-WEST CORRIDOR)

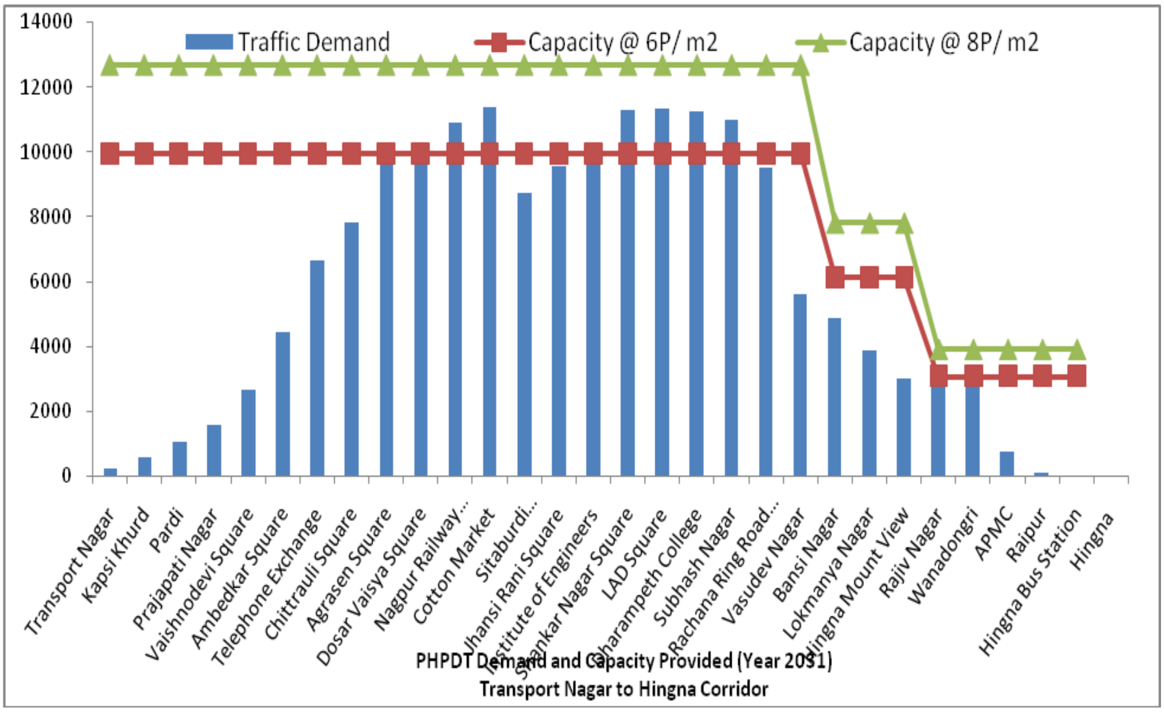


FIGURE 8.6: DEMAND AND CAPACITY (YEAR 2041) – TRANSPORT NAGAR TO HINGNA (EAST-WEST CORRIDOR)

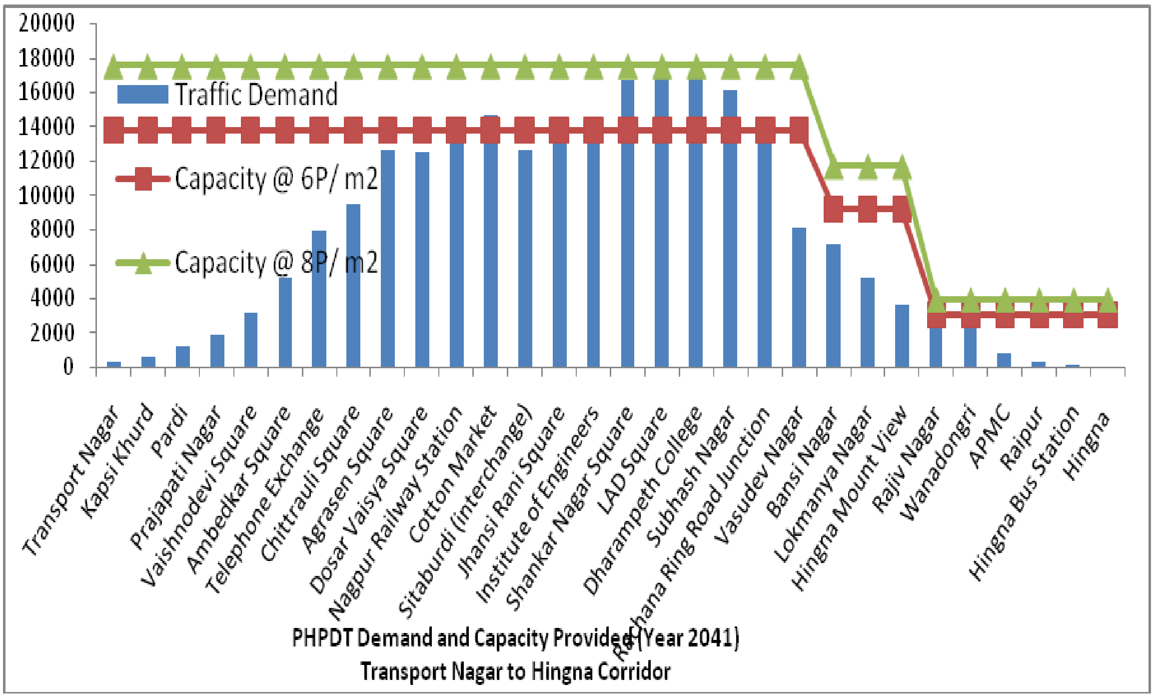


FIGURE 8.7: DEMAND AND CAPACITY (YEAR 2024) – VASUDEV NAGAR TO DATTAWADI (SPUR TO EAST-WEST CORRIDOR)

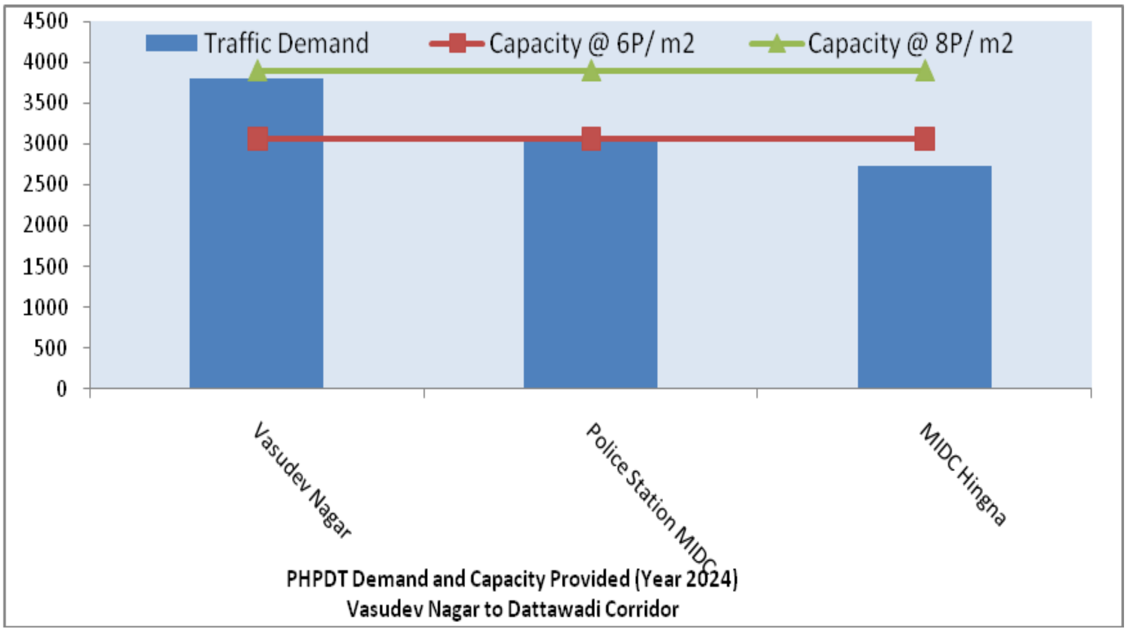


FIGURE 8.8: DEMAND AND CAPACITY (YEAR 2031) – VASUDEV NAGAR TO DATTAWADI (SPUR TO EAST-WEST CORRIDOR)

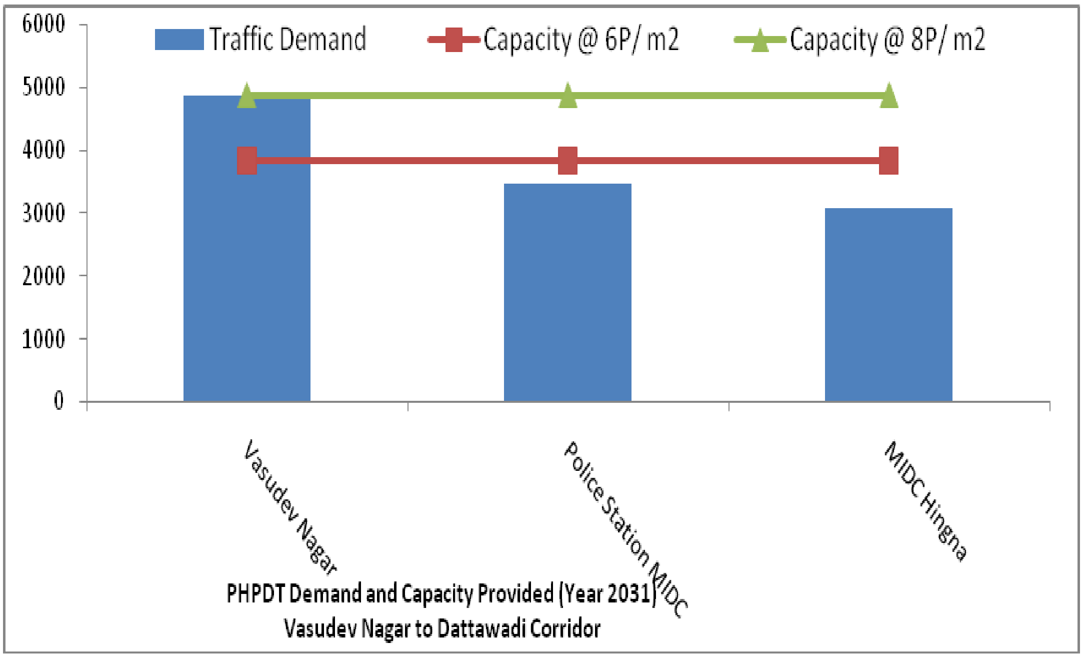
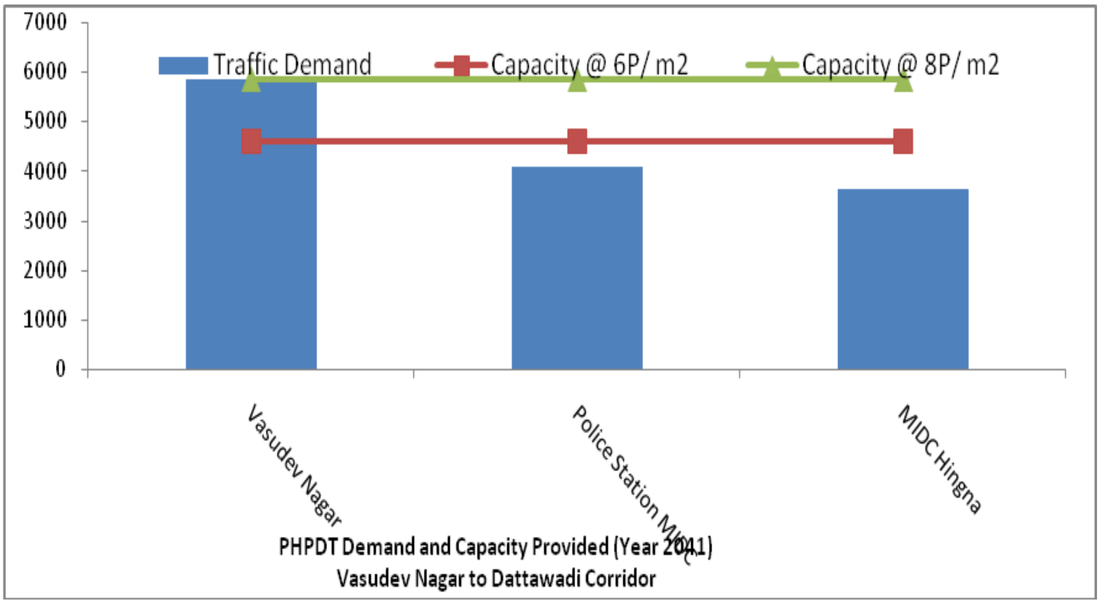


FIGURE 8.9: DEMAND AND CAPACITY (YEAR 2041) – VASUDEV NAGAR TO DATTAWADI (SPUR TO EAST-WEST CORRIDOR)



8.2 SYSTEM FREQUENCY

The services for Nagpur Metro shall be operational for 19 hours of a day (05:00 hrs to 00:00 hrs). No services are proposed between 00:00 hrs. to 05:00 hrs. which are reserved for maintenance of infrastructure and rolling stock.

The traffic demand during off peak hours will be less. Thus, less number of trains/hr are planned for operation during lean hours. The train frequency during the peak and lean hours is presented below in **Tables 8.7** and **8.8**.

TABLE 8.7 : TRAIN FREQUENCY (N-S CORRIDOR INCLUDING PHASE-2 EXTENSIONS)

Sections	2024		2031		2041	
	Peak Hour h/w	Lean Hour h/w	Peak Hour h/w	Lean Hour h/w	Peak Hour h/w	Lean Hour h/w
Kanhan River to MIDC ESR	15 min	20 to 30 min	15 min	20 to 30 min	10 min	12 to 30 min
Kamptee Police Station to Ashokvan	6 min	8 to 30 min	6 min	7.5 to 30 min	5.5 min	6.7 to 30 min

TABLE 8.8 : TRAIN FREQUENCY (E-W CORRIDOR INCLUDING PHASE-2 EXTENSIONS)

Sections	2024		2031		2041	
	Peak Hour h/w	Lean Hour h/w	Peak Hour h/w	Lean Hour h/w	Peak Hour h/w	Lean Hour h/w
Transport Nagar to Hingna	15 min	20 to 30 min	15 min	20 to 30 min	15 min	20 to 30 min
Transport Nagar to Dattawadi	15 min	20 to 30 min	12 min	15 to 30 min	10 min	12 to 30 min
Transport Nagar to Hingna Mount View	20 min	20 to 30 min	15 min	20 to 30 min	7.5 min	10 to 30 min

The hourly distribution of daily train operation of North-South corridor and East-West corridor for various horizon years is enclosed in **Annexure 8.1(a) & 8.1(b)** and **8.2(a), 8.2(b) & 8.2(c)**.

8.3 ROLLING STOCK REQUIREMENT

Requirement of coaches for the corridors are calculated based on following assumptions:

i. Headways during peak hours
ii. Schedule speed is taken as 34 Kmph for the round trip
iii. Turn round time is taken as 4 min at terminal stations

iv. The calculated number of rakes in fraction is rounded off to next higher number

v. Traffic reserve is taken as 5% to cater to failure of train on line and to make up for operational time lost

vi. Repair and maintenance has been estimated as 10% of total requirement (Bare + Traffic Reserve)

Based on above assumptions and train operation plan, the rake requirement for the horizon years 2024 to 2041 including Nagpur Metro Phase-2 extensions are indicated below in **Tables 8.9** and **8.10**

TABLE 8.9 : ROLLING STOCK REQUIREMENT IN N-S CORRIDOR (INCLUDING PHASE-2 EXTENSIONS)

Train Operation/ Corridor	Time horizon Year	No. of trains per hour	Section length km	Rakes Reqd.	Bare rake Reqmt	Traffic spare @5%	Maint. Spare @10%	Total rake req.	Total coach req.
Kanhan River to MIDC ESR	2024	4	49.8	12.2	12.0	0	0	12	36
	2031	4	49.8	12.2	12.0	0	0	12	36
	2041	6	49.8	18.4	18.0	0	0	18	54
Kamptee Police Station to Ashokvan	2024	10	34.2	21.5	21.0	1	1	23	69
	2031	10	34.2	21.5	21.0	1	2	24	72
	2041	11	34.2	23.6	24.0	1	2	27	81

TABLE 8.10 : ROLLING STOCK REQUIREMENT IN E-W CORRIDOR (INCLUDING PHASE-2 EXTENSIONS)

Train Operation/ Corridor	Time horizon Year	No. of trains per hour	Section length km	Rakes Reqd.	Bare rake Reqmt	Traffic spare @5%	Maint. Spare @10%	Total rake req.	Total coach req.
Transport Nagar to Hingna	2024	4	30.4	7.7	8.0	0	1	9	27
	2031	4	30.4	7.7	8.0	0	1	9	27
	2041	4	30.4	7.7	8.0	0	1	9	27
Transport Nagar to Dattawadi	2024	4	24.8	6.4	6.0	0	1	7	21
	2031	5	24.8	8.0	8.0	0	1	9	27
	2041	6	24.8	9.6	10.0	1	1	12	36
Transport Nagar to Hingna Mount View	2024	3	23.2	4.5	4.0	0	0	4	12
	2031	4	23.2	6.0	6.0	0	1	7	21
	2041	8	23.2	12.0	12.0	1	1	14	42

Based on traffic demand, the rake requirement for the horizon years 2024 to 2041 for Nagpur Metro Phase-1 are indicated below in **Table 8.11**

TABLE 8.11 : ROLLING STOCK REQUIREMENT IN PHASE-1

Train Operation/ Corridor	Time horizon Year	No. of trains per hour	Section length km	Rakes Reqd.	Bare rake Reqmt	Traffic spare @5%	Maint. Spare @10%	Total rake req.	Total coach req.
N-S Corridor	2024	13	20.5	17.4	18.0	1	2	21	63
	2031	14	20.5	18.7	19.0	1	2	22	66
	2041	16	20.5	21.4	22.0	1	2	25	75
E-W Corridor	2024	11	19.4	14.0	14.0	1	1	16	48
	2031	12	19.4	15.3	15.0	1	2	18	54
	2041	17	19.4	21.7	22.0	1	2	25	75

8.3.1 Additional Rake Requirement

The train operation plan and rake requirement calculated above in **Tables 8.7** and **8.8** considers the full network of Nagpur Metro Phase 1 & 2. Thus, the additional rake requirement for Phase 2 corridors is given in **Tables 8.12** and **8.13**.

TABLE: 8.12: ADDITIONAL RAKE REQUIREMENT FOR N-S CORRIDOR

Year	2024	2031	2041
Rake Requirement in Phase 1	21	22	25
Rake requirement of Phase 1 & Phase 2	35	36	45
Additional Rake Requirement in Phase 2	14	14	20

TABLE: 8.13: ADDITIONAL RAKE REQUIREMENT FOR E-W CORRIDOR

Year	2024	2031	2041
Rake Requirement in Phase 1	16	18	25
Rake requirement of Phase 1 & Phase 2	20	25	35
Additional Rake Requirement in Phase 2	4	7	10

8.3.2 Stabling of Rakes

Adequate stabling facilities for Nagpur Metro corridors have been planned considering the rake requirement of year 2041. The details have been discussed in **Chapter 14**.

8.3.3 Vehicle Kilometer

Based on the above planning and assuming 340 days service in a year (after considering maintenance period) vehicle kilometers have been estimated. Vehicle Kilometers for the proposed train operation for years 2024, 2031 and 2041 is given in **Tables 8.14** to **8.18.**

TABLE 8.14: VEHICLE KILOMETER: KANHAN RIVER TO MIDC ESR

Year	2024	2031	2041
Section Length	49.8	49.8	49.8
No. of Cars per Train	3	3	3
No. of working Days/year	340	340	340
No. of Trains/Day/Direction	51	51	77
Daily Train –KM	5077.56	5077.56	7666.12
Annual Train - KM (10^5)	17.26	17.26	26.06
Annual Vehicle - KM (10^5)	51.79	51.79	78.19

TABLE 8.15: VEHICLE KILOMETER: KAMPTEE POLICE STATION TO ASHOKVAN

Year	2024	2031	2041
Section Length	34.2	34.2	34.2
No. of cars per Train	3	3	3
No. of working Days/year	340	340	340
No. of Trains/Day/Direction	120	120	135
Daily Train –KM	8208	8208	9234
Annual Train - KM (10^5)	27.91	27.91	31.40
Annual Vehicle - KM (10^5)	83.72	83.72	94.19

TABLE 8.16: VEHICLE KILOMETER: TRANSPORT NAGAR TO HINGNA

Year	2024	2031	2041
Section Length	30.41	30.41	30.41
No. of cars per Train	3	3	3
No. of working Days/year	340	340	340
No. of Trains/Day/Direction	52	52	52
Daily Train –KM	3162.64	3162.64	3162.64
Annual Train - KM (10^5)	10.75	10.75	10.75
Annual Vehicle - KM (10^5)	32.26	32.26	32.26

TABLE 8.17: VEHICLE KILOMETER: TRANSPORT NAGAR TO DATTAWADI

Year	2024	2031	2041
Section Length	24.81	24.81	24.81
No. of cars per Train	3	3	3
No. of working Days/year	340	340	340
No. of Trains/Day/Direction	51	65	75
Daily Train –KM	2530.62	3225.3	3721.5
Annual Train - KM (10^5)	8.60	10.97	12.65
Annual Vehicle - KM (10^5)	25.81	32.90	37.96

TABLE 8.18: VEHICLE KILOMETER: TRANSPORT NAGAR TO HINGNA MOUNT VIEW

Year	2024	2031	2041
Section Length	23.21	23.21	23.21
No. of cars per Train	3	3	3
No. of working Days/year	340	340	340
No. of Trains/Day/Direction	44	50	95
Daily Train –KM	2042.48	2321	4409.9
Annual Train - KM (10^5)	6.94	7.89	14.99
Annual Vehicle - KM (10^5)	20.83	23.67	44.98

Annexure-8.1(a)

HOURLY TRAIN OPERATION PLAN: KANHAN RIVER to MIDC ESR

Time of Day	Year 2024 (3 Car)		Year 2031 (3 Car)		Year 2041 (3 Car)	
	Headway (min)	Trains/ hour	Headway (min)	Trains/ hour	Headway (min)	Trains/ hour
5 to 6	30.0	2	30.0	2	30.0	2
6 to 7	30.0	2	30.0	2	30.0	2
7 to 8	20.0	3	20.0	3	15.0	4
8 to 9	**15.0**	**4**	**15.0**	**4**	**10.0**	**6**
9 to 10	**15.0**	**4**	**15.0**	**4**	**10.0**	**6**
10 to 11	20.0	3	20.0	3	12.0	5
11 to12	30.0	2	30.0	2	15.0	4
12 to 13	30.0	2	30.0	2	20.0	3
13 to 14	30.0	2	30.0	2	30.0	2
14 to 15	30.0	2	30.0	2	20.0	3
15 to 16	30.0	2	30.0	2	15.0	4
16 to 17	20.0	3	20.0	3	12.0	5
17 to 18	**15.0**	**4**	**15.0**	**4**	**10.0**	**6**
18 to 19	**15.0**	**4**	**15.0**	**4**	**10.0**	**6**
19 to 20	20.0	3	20.0	3	12.0	5
20 to 21	20.0	3	20.0	3	12.0	5
21 to 22	30.0	2	30.0	2	20.0	3
22 to 23	30.0	2	30.0	2	20.0	3
23 to 24	30.0	2	30.0	2	20.0	3
Total No. of trains per direction per day		**51**		**51**		**77**

Annexure-8.1(b)

HOURLY TRAIN OPERATION PLAN: KAMPTEE POLICE STATION TO ASHOKVAN

Time of Day	Year 2024 (3 Car)		Year 2031 (3 Car)		Year 2041 (3 Car)	
	Headway (min)	Trains/ hour	Headway (min)	Trains/ hour	Headway (min)	Trains/ hour
5 to 6	30	2	30.0	2	30.0	2
6 to 7	12	5	12.0	5	10.0	6
7 to 8	9	7	8.6	7	7.5	8
8 to 9	6	**10**	6.0	**10**	5.5	**11**
9 to 10	6	**10**	6.0	**10**	5.5	**11**
10 to 11	8	8	7.5	8	6.7	9
11 to12	10	6	10.0	6	8.6	7
12 to 13	12	5	12.0	5	10.0	6
13 to 14	20	3	20.0	3	20.0	3
14 to 15	12	5	12.0	5	10.0	6
15 to 16	10	6	10.0	6	8.6	7
16 to 17	8	8	7.5	8	6.7	9
17 to 18	6	**10**	6.0	**10**	5.5	**11**
18 to 19	6	**10**	6.0	**10**	5.5	**11**
19 to 20	8	8	7.5	8	6.7	9
20 to 21	10	6	10.0	6	8.6	7
21 to 22	12	5	12.0	5	10.0	6
22 to 23	20	3	20.0	3	20.0	3
23 to 24	20	3	20.0	3	20.0	3
Total No. of trains per direction per day		**120**		**120**		**135**

Annexure-8.2(a)

HOURLY TRAIN OPERATION PLAN: TRANSPORT NAGAR TO HINGNA

Time of Day	Year 2024 (3 Car)		Year 2031 (3 Car)		Year 2041 (3 Car)	
	Headway (min)	Trains/ hour	Headway (min)	Trains/ hour	Headway (min)	Trains/ hour
5 to 6	30.0	2	30.0	2	30.0	2
6 to 7	30.0	2	30.0	2	30.0	2
7 to 8	20.0	3	20.0	3	20.0	3
8 to 9	**15.0**	**4**	**15.0**	**4**	**15.0**	**4**
9 to 10	**15.0**	**4**	**15.0**	**4**	**15.0**	**4**
10 to 11	20.0	3	20.0	3	20.0	3
11 to12	30.0	2	30.0	2	30.0	2
12 to 13	30.0	2	30.0	2	30.0	2
13 to 14	30.0	2	30.0	2	30.0	2
14 to 15	30.0	2	30.0	2	30.0	2
15 to 16	30.0	2	30.0	2	30.0	2
16 to 17	20.0	3	20.0	3	20.0	3
17 to 18	**15.0**	**4**	**15.0**	**4**	**15.0**	**4**
18 to 19	**15.0**	**4**	**15.0**	**4**	**15.0**	**4**
19 to 20	20.0	3	20.0	3	20.0	3
20 to 21	20.0	3	20.0	3	20.0	3
21 to 22	20.0	3	20.0	3	20.0	3
22 to 23	30.0	2	30.0	2	30.0	2
23 to 24	30.0	2	30.0	2	30.0	2
Total No. of trains per direction per day		**52**		**52**		**52**

Annexure-8.2(b)

HOURLY TRAIN OPERATION PLAN: TRANSPORT NAGAR TO DATTAWADI

Time of Day	Year 2024 (3 Car)		Year 2031 (3 Car)		Year 2041 (3 Car)	
	Headway in Minutes	Trains per hour	Headway in Minutes	Trains per hour	Headway in Minutes	Trains per hour
5 to 6	30	2	30.0	2	30.0	2
6 to 7	30	2	20.0	3	20.0	3
7 to 8	20	3	15.0	4	15.0	4
8 to 9	15	**4**	12.0	**5**	10.0	**6**
9 to 10	15	**4**	12.0	**5**	10.0	**6**
10 to 11	20	3	15.0	4	12.0	5
11 to12	30	2	20.0	3	15.0	4
12 to 13	30	2	20.0	3	20.0	3
13 to 14	30	2	30.0	2	30.0	2
14 to 15	30	2	20.0	3	20.0	3
15 to 16	30	2	20.0	3	15.0	4
16 to 17	20	3	15.0	4	12.0	5
17 to 18	15	**4**	12.0	**5**	10.0	**6**
18 to 19	15	**4**	12.0	**5**	10.0	**6**
19 to 20	20	3	15.0	4	12.0	5
20 to 21	20	3	20.0	3	15.0	4
21 to 22	30	2	20.0	3	20.0	3
22 to 23	30	2	30.0	2	30.0	2
23 to 24	30	2	30.0	2	30.0	2
Total No. of trains per direction per day		**51**		**65**		**75**

Annexure-8.2(c)

HOURLY TRAIN OPERATION PLAN: TRANSPORT NAGAR TO HINGNA MOUNT VIEW

Time of Day	Year 2024 (3 Car)		Year 2031 (3 Car)		Year 2041 (3 Car)	
	Headway in Minutes	Trains per hour	Headway in Minutes	Trains per hour	Headway in Minutes	Trains per hour
5 to 6	30	2	30.0	2	30.0	2
6 to 7	30	2	30.0	2	15.0	4
7 to 8	30	2	20.0	3	10.0	6
8 to 9	20	**3**	15.0	**4**	7.5	**8**
9 to 10	20	**3**	15.0	**4**	7.5	**8**
10 to 11	30	2	20.0	3	10.0	6
11 to12	30	2	30.0	2	12.0	5
12 to 13	30	2	30.0	2	15.0	4
13 to 14	30	2	30.0	2	30.0	2
14 to 15	30	2	30.0	2	15.0	4
15 to 16	30	2	30.0	2	12.0	5
16 to 17	30	2	20.0	3	10.0	6
17 to 18	20	**3**	15.0	**4**	7.5	**8**
18 to 19	20	**3**	15.0	**4**	7.5	**8**
19 to 20	20	3	20.0	3	10.0	6
20 to 21	20	3	30.0	2	12.0	5
21 to 22	30	2	30.0	2	15.0	4
22 to 23	30	2	30.0	2	30.0	2
23 to 24	30	2	30.0	2	30.0	2
Total No. of trains per direction per day		**44**		**50**		**95**

Chapter – 9
SIGNALING AND TELECOMMUNICATION

9. SIGNALING AND TELECOMMUNICATION

9.1 SIGNALING SYSTEM

9.1.1 Design Parameters

The signaling system shall provide the means of an efficient train control ensuring safety in train movements. It assists in optimization of metro infrastructure investment and running of efficient train services on the network. The system will have following design parameters:

- Ridership: 15743 PHPDT(N-S Corridor)/16889 PHPDT(E-W Corridor)
- Standard Gauge: 1435 mm
- Average Speed: 34Kmph (corridor-E-W)/34Kmph (N-S Corridor)
- Total extension Corridor Length: 26.43 Km (Corridor-N-S Extension)/ 12.50 Km (Corridor E-S extensions excluding London street metro line)
- Total Stations: 20 Stations (Corridor N-S extension)/ 13 Stations (Corridor–E-W Extension)
- Train Configuration: 3 Car Rake
- Required Headway: 3.5 Minutes (Corridor N-S)/ 3.3 Minutes (Corridor E-W)

9.1.2 Options for Signaling Systems

Depending on type of the railway network, Main Line or Metro Rail, Signaling & Train Control can be achieved by adopting any of the following signaling system / technologies available:

i. Automatic Signaling
ii. ETCS Level – 1
iii. ETCS Level – 2
iv. Distance to Go (DTG)
v. Communication Based Train Control (CBTC)

While systems at S.No. (i) – (iii) have been developed / used for main line Railway networks, systems at S.No. (iv) – (v) are for Metro Railway Networks. As Communication Based Train Control (CBTC) system is already implemented in Phase-I and to have a seamless operation, CBTC system is recommended and discussed as below:

a) Communication based Train Control (CBTC) Signaling System

Communication Based Train Control (CBTC) signaling system is mainly used for mass transit networks. It is the latest Signaling and Train Control Technology available and is being adopted by modern metros around the world. It is also being adopted by all new MRTS Networks in India viz, DMRC Phase-III, Kochi Phase-I, BMRCL Phase-II etc.

Communication based Train Control (CBTC) Signaling System also has ATP, ATS, ATO/UTO functionality and works on the Moving or Virtual Block principle to reduce headways and increase transport capacity. CBTC relies on continuous two-way digital communication between each controlled train and a wayside control centre. On a moving block equipped railway, the line is usually divided into areas or regions, each area under the control of a computer and each with its own radio transmission system. Each train transmits its identity, location, direction and speed to the area computer which makes the necessary calculations for safe train separation (moving authority) and transmits this to the following train.

The radio link between each train and the area computer is continuous so the computer knows location of all the trains in its area all the time. It transmits to each train the location of the train in front and gives it a braking curve to enable it to stop before it reaches that train. In effect, it can be termed as a dynamic Distance-to-Go system.

As the CBTC based system has very few way side equipment and supports UTO, total life cycle cost of the system shall be substantially lower than other Signaling Systems due to low Maintenance & Operation (man power) costs.

- **Pros and Cons of CBTC Signaling System:**

The Communication based Train Control (CBTC) Signaling system provides adequate safety level of CENELEC SIL-4 (Safety Integrity Level) and permits an operational headway of 90 seconds with continuous automatic train control. The CBTC Technology is proven now in many Metros around the World and is also suitable for UTO (Unattended Train Operation) / DTO (Driverless Train Operation).

Therefore, Communication based Train Control (CBTC) system, which is the latest technology available, already implemented in Phase-I and to have a seamless operation, CBTC system is recommended for Nagpur Metro Phase 2 corridors.

9.1.3 Interlocking System : Computer Based Interlocking (CBI)

Station with Points and Crossings called “Main” or “CBI” stations, will have Interlocking equipment for achieving Computer Based Interlocking (CBI) for operation of points and crossings and setting of routes. Fixed Signals will be provided at Entry & Exit to Interlocking stations.

- **Train Depot : Signaling**

All depot lines except the ones used for shunting in workshop shall be interlocked. A workstation each shall be provided in the Depot Control Centre for electrical operation of the points, signals and routes of the depot yard.

- **Signaling at Stations with Points and Crossings**

LED type signals for increased reliability and less maintenance efforts shall be provided for Line side signals to protect the points (switches).

9.1.4 Operation Control Centre (OCC)

The OCC shall monitor and control all train operations. During abnormal working, train operation shall fall-back to the fall-back control facilities at interlocked Stations which shall provide the minimum facilities for smooth operations.

OCC operations shall facilitate the safe, secure and reliable operation of planned passenger services and management of unplanned events.

The key functions of the OCC shall be, but not limited to, as under:

(i) Automatic Train Control (ATC);

(ii) Equipment Control and Monitoring System

(iii) Communication systems management

(iv) Operation management functions

(v) Maintenance management functions

9.1.5 Maintenance Philosophy

For efficient operation and functioning of a metro signaling and telecom system, a robust maintenance organization and practices are necessary. Failure in signaling and telecom equipments has to be addressed in preventive and corrective manner. Otherwise, disruptions in operations and passenger dissatisfaction may arise. The operations and maintenance practices have to be adequately planned with proper defect liability support, spares planning, trained manpower, annual maintenance contract of specific subsystems specifically wherever necessary etc. The spares and maintenance personnel also have to be suitably located all along the metro system to address the failures and remedy the same within a reasonable time.

9.1.6 Standards

Table 9.1 below shows the standards that will be adopted with regard to the Signaling system.

TABLE 9.1: STANDARDS TO BE ADOPTED FOR SIGNALING SYSTEM

Description	Standards
CBTC System	IEEE 1474.1
Interlocking	Computer Based Interlocking (CBI) adopted for station having switches and crossing shall be Hot Standby system with object controller conforming to SIL4 level of CENELEC standards EN 50126, EN 50128 and EN 50129.
Operation of Points	With Direct current 110V D.C. point machines or 380 volts 3 phase, 50 Hz. AC point machines.
Signals at Stations with point & crossings	Line Side signals to protect the points (switches). LED type signals for increased reliability and less maintenance efforts.
Train Protection Systems(ATP)	Automatic train protection system conforming to SIL4 level of CENELEC standards EN 50126, EN 50128 and EN 50129.
ATS	Automatic Train Supervision System, movement of all trains to be logged on to a central computer and displayed on workstations in operation control centre (OCC) and at SCR. Remote control of stations from the OCC as well as local control from the interlocked stations. ATS/ATO will conform to SIL2 level of CENELEC standards EN 50126, EN 50128 and EN 50129.
Immunity to External Interference.	All data transmission on Optical Fiber Cables/Radio. All signaling cables will be separated from power cables. CENELEC standards EN50121-2&4 and EN50082-2 and EN 50081-2 as applicable for EMI/EMC.
Fail Safe Principles	SIL4 safety levels as per CENELEC standard for signal application.
Fall back system	Digital Axle Counter

Description	Standards
Other Items	Suitable International Standards like CENELEC etc. shall be followed as per good industry practices.
Maintenance philosophy	Philosophy of continuous monitoring of system status and preventive &corrective maintenance of signaling equipment shall be followed. Card / module / sub-system level replacement shall be done in the field and repairs under taken in the central laboratory/manufacturer's premises.

9.2 TELECOMMUNICATION SYSTEM

9.2.1 Coverage

The telecommunication system acts as communication backbone for signaling and other systems and provides telecommunication services to meet operational and administrative requirements of metro network. The telecommunications system used in different metros are as given **Table 9.2**.

TABLE 9.2: TELECOMMUNICATION SYSTEM USED IN DIFFERENT METROS

Metro Operator		System Used	
DMRC	Line 1	A	Digital Transmission System (DTS) Optical Fiber Cable Main Telecommunications Bearer: SDH - STM 4 155Mbps network
		B	Telephone System : EPABX
		C	Mobile Radio Communications: Digital Trunk Radio System (TETRA)
		D	Public Address (PA) System
		E	Centralized Clock System: Digital & Analog Clocks and Time Synchronization System
		F	Passenger Information Display System: LED based
		G	Network Management & Station Management System
		H	CCTV Cameras were provided later on for Security purposes
DMRC	Line 2 Line 3 Phase II		Same as above with Closed Circuit Television: fixed and PTZ Camera and PIDS LED and LCD based.
BMRCL	Phase I	A	Digital Transmission System (DTS) - Optical Fiber Cable - Main Telecommunications Bearer: SDH - STM 4

Metro Operator		System Used	
			155Mbps network
		B	Telephone System : EPABX
		C	Mobile Radio Communications: Digital Trunk Radio (TETRA)
		D	Public Address System
		E	Centralized Clock System: Digital and Analog Clock System
		F	Passenger Information Display System: LED & LCD based.
		G	Network Management & Station
		H	Closed Circuit Television System : Fixed and PTZ Camera with monitors
Hyderabad Metro	Phase I	A	Digital Transmission System (DTS) - Optical Fiber Cable - IP based system with Layer 2 , Layer 3 and Access switches with OF interfaces
		B	Telephone System: EPABX
		C	Mobile Radio Communications: Digital Trunk Radio (TETRA)
		D	Public Address System
		E	Centralized Clock System: Digital and Analog Clock System
		F	Passenger Information Display System: LED & LCD based.
		G	Central Fault Reporting system (CFRS)
		H	Closed Circuit Television: fixed and PTZ Camera
JMRC	Phase I	A	Digital Transmission System (DTS) - Optical Fiber Cable - Main Telecommunications Bearer: SDH - STM 4 155Mbps network
		B	Telephone System : EPABX
		C	Mobile Radio Communications: Digital Trunk Radio (TETRA)
		D	Public Address System
		E	Centralized Clock System: Digital and Analog Clock System
		F	Passenger Information Display System: LED & LCD based.
		G	Network Management System
		H	Closed Circuit Television: fixed and PTZ Camera
CMRL	Ph- 1	A	Digital Transmission System (DTS) Optical Fiber Cable Main Telecommunications Bearer: SDH - STM 16
		B	Telephone System: Hybrid PBX
		C	Mobile Radio Communications: Digital Trunk Radio System (TETRA)

Metro Operator		System Used	
		D	Public Address/Voice Alarm (PA/VA) System
		E	Centralized Clock System: Digital & Analog Clocks and Time Synchronization System
		F	Passenger Information Display System: LCD based
		G	Network Management & Station Management System
		H	CCTV
		I	SCADA

9.2.2 Proposed Telecommunication System and Transmission Media

The state of art latest technology being used in different metros worldwide, is proposed to be used for the Nagpur Metro Phase 2 Corridors.

9.2.3 Digital Transmission System (DTS)

i. Optical Fibre Cable – Main telecommunication Bearer

IP, GE (Giga Ethernet) based system is proposed for the entire telecom network. OFC backbone network shall be formed by laying two outdoor single mode optical fiber cables (to be laid on either side of tracks). The normal and protected routes shall be arranged in two different cables for path diversity. Considering the channel requirement and keeping in view the future expansion requirements a minimum 144 Fiber, optical fiber cable is proposed to be laid in ring configuration with path diversity. Additional OFC can be considered to be provided if there is a demand for leasing Fiber from Telcos / Industries, providing a source of revenue generation.

The IP network shall consist of highly reliable and fault tolerant Layer-2, Layer-3 and Access switches configured with due redundancy both at Back bone and Access levels for the MAN/LAN. The switches shall have IP interface cards of 20 GBPS for backbone, 20 GBPS for interface with all telecommunication and non-telecommunication sub-systems and 20 MBPS and higher levels for access level. All interfaces with other sub systems shall be IP based with minimum 20 MBPS capacity.

ii. Telephone Exchange

A cost effective solution of an IP PBX having at least 50 IP extensions will be provided at each station and 500 IP extensions PBX will be provided at the central, intermediate location on corridor and depot. The Exchanges will serve the subscribers at all the stations, OCC and depot. Capacity of Exchanges can be suitably augmented, if required, depending on available subscribers. The exchanges will be interconnected at multiple IP interfaces (20 MBPS) through redundant optical fiber cable paths.

iii. Mobile Radio Communication

Mobile Radio communication system having minimum 8 logical channels is proposed for on-line emergency communication between Motorman (Front end and Rear end) of moving train and the Central Control. The system shall be based on Digital Trunk Radio Technology to TETRA International standard. All the stations and the OCC will be provided with fixed radio sets. Mobile communication facility for maintenance parties and Security Personnel will be provided with handheld sets. These persons will be able to communicate with each other as well as with central control as shown in **Figure 9.1.**

FIGURE 9.1: TRAIN CAB RADIO AND COMM. FACILITY FOR MAINTENANCE

The frequency band for operation of the system i.e. 410-430 or 380-400 MHz may be taken as per availability. The system shall provide mobile radio communication between the motorman of the moving cars from any place and the Central Control. The motorman can also contact any station in the network through the central control, besides intimating the approaching trains about any emergency like accident, fire, line blocked etc., thus improving safety performance. To provide adequate coverage, based on the RF site survey to be carried out during detailed Design stage, base stations for the system will be located at sites conveniently selected after detailed survey.

In addition to the TETRA Radio Coverage for the internal use of the Metro, the city is also having Mobile Coverage from Private Operators.

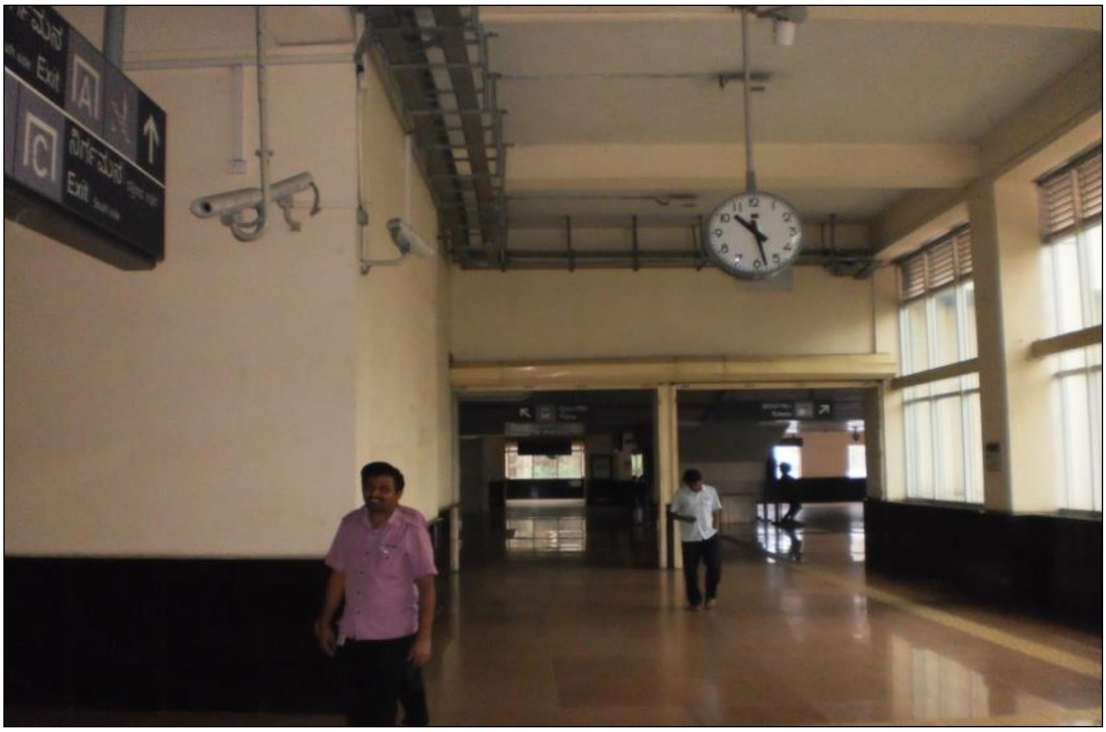
iv. Public Address System

The public Address System shall be capable of digitized voice announcements and long range PA functionality suitable for evacuation situations in emergency. The public address is to for stations will generally operate in automatic mode providing information for the time and destination of the next schedule train, special upcoming event, safety and security announcement at pre-determined intervals and general information to enhance the travel experience for all users but more specially the visually impaired.

v. Centralized Clock System

The Clock System shall provide synchronized time for the whole Rail system. The time source shall be obtained from Global Positioning System (GPS). The synchronized time information shall be displayed on slave clock units and provided to all other sub systems including signaling & AFC via the Digital Transmission System as shown in **Figure 9.2.**

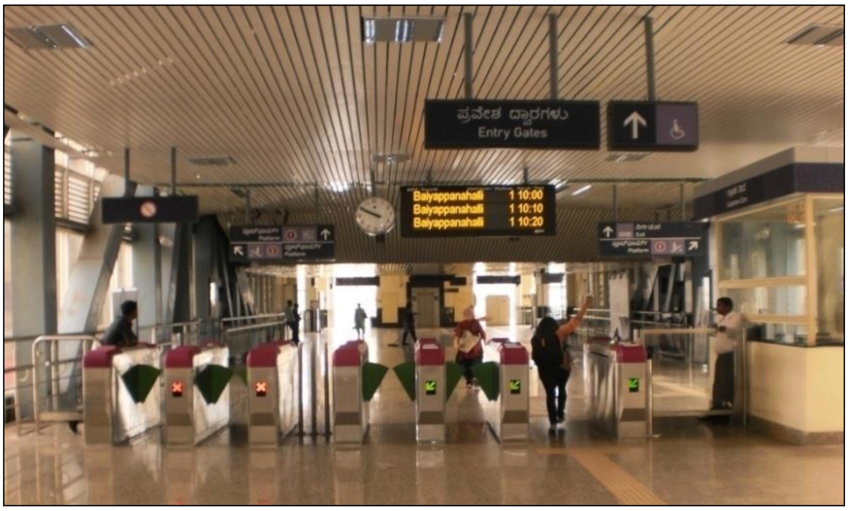
FIGURE 9.2: MASTER CLOCK



vi. Passenger Information Display System (PIDS)

At all stations, suitable Electronic Passenger Information Display Boards preferably LCD/LED (Flat Panel) will be provided as shown in **Figure 9.3**. The PIDS shall be train actuated (controlled by signaling system) along with facility for manual inputs from the local station as well as the central location (OCC).

FIGURE 9.3: PASSENGER INFORMATION DISPLAY SYSTEM



Passenger Information display boards will be provided at convenient locations at all stations to provide trilingual i.e. Hindi, English & Marathi visual indication of the status of the running trains and will typically indicate information such as destination, platform numbers, arrival/departure time, and also special messages in emergencies. The boards will be provided at all platforms and concourses of terminal & junction stations as shown in **Figure 9.4.**

FIGURE 9.4: PIDS AT PLATFORM AND CONCOURSE

It is envisaged that Public Address and Passenger Information Display System is provided in the car so that passengers are continuously advised of the next stoppage station, final destination station, interchange station, emergency situations if any, and other messages. The rolling stock is provided with Talk Back Units inside the cars, which permit conversation between passengers and the drivers in case of any emergency.

vii. Close Circuit Television

CCTV system should ensure real time full coverage, high quality surveillance of all public and selected areas such as tunnel cross passages, ancillary buildings, on board conditions for secure passenger management, crowed control and other emergency situations. Event reloading shall be possible for post video analysis. CCTV cameras shall also be provided in Operational rooms like OCC, SCR etc. A proper IP based recording and storing facility to record and store events for minimum of one month shall be ensured.

viii. Central Voice Recording System (CVRS)

A centralized digital voice recording system will be provided at OCC to record all Two-way Telephone conversation, PA calls from station and OCC, Two Way Radio Conversation of all controllers, TOs, SCRs and other users in OCC and Depot. In addition all conversation of the Radio System including private calls of all subscribers including Controllers, TOs shall also be recorded. Arrangement of free space audio recording in OCC, SCRs and Driver Cab shall also be made available.

ix. Central Fault Reporting System (CFRS)

For efficient and cost effective maintenance of the entire communication network, it is proposed to provide a CFRS / SCADA system which will help in reporting and diagnosing the faults immediately from a central location and attending the same with least possible delay, thus increasing the operational efficiency and reduction in manpower requirement for maintenance.

x. Wi-Fi Services

The Wi-Fi services are proposed to be provided at stations as well as on-board to the passengers. The passengers have to search the available Wi-Fi network of metro and after registering their mobile number, they will get login ID and password through

SMS. After receiving the login ID and password, passengers can access the Metro Wi-Fi network irrespective of their mobile network operator.

xi. LED Display walls

Two (02 nos.) of LED Display walls having size approximately 2.88m (W) x 1.92 m (H), (5.52 Sqm) each are proposed to be provided at suitable locations at all platforms. The outdoor LED displays may be used to run the commercials as well as other useful passenger information as per requirements.

xii. Uninterrupted Power Supply

The uninterrupted power supply (UPS) of 60 KVA, 415 V ± 1%, 3 phase with Battery bank of 800AH capacity at each interlock station and 30 KVA with Battery bank of 400AH capacity at each non-interlock station will be provided for 2 hour back up.

The standards that will be adopted with regard to the Telecommunication systems is shown in **Table 9.3.** These will conform to appropriate IRS/International standards.

TABLE 9.3: STANDARDS TO BE ADOPTED FOR TELECOMMUNICATION SYSTEMS

Description	Standards
Transmission System	**IP, GE (Giga Ethernet) based** system for the entire telecom network. OFC backbone network shall be formed by laying two outdoor single mode optical fiber cables (to be laid on either side of tracks). The normal and protected routes shall be arranged in two different cables for path diversity.
Optical Fiber cable	OFC for underground environment shall be steel armoured and manufactured from Fire Retardant/resistance, Low Smoke and zero halogen materials. For elevated portion of corridor, it shall be steel armored and conforming to IRS specifications.
Public Address System	Passenger Announcement System shall be interfaced with signaling system for online update of train information. IEC 60268 as applicable or any equivalent international/National standard. Fire resistant Low Smoke Zero Halogen cables shall be used to maintain the circuit integrity in case of fire.
Telephone Exchange	IP based Electronic Exchange (IP PBX)

Description	Standards
Passenger Display Information System	It shall be interfaced with signaling system for online update of train information. IEC as applicable or any equivalent international/National standard.
Synchronized Clock system	GPS based, master – slave system IEC 61588 or equivalent standard
CCTV/ Camera	CCTV network shall be as per IEEE standards.
Redundancy (Major System)	Redundancy on Radio base station equipment including server level for all communication sub-systems.
Environmental Conditions	All equipment rooms to be air-conditioned.
Maintenance Philosophy	System to have, as far as possible, automatic switching facility to alternate routes/circuits in the event of failure. Philosophy of preventive checks of maintenance to be followed. System networked with NMS for diagnosing faults and coordination. Card/module level replacement will be done in the field and repairs undertaken in the central laboratory/manufacture's premises.

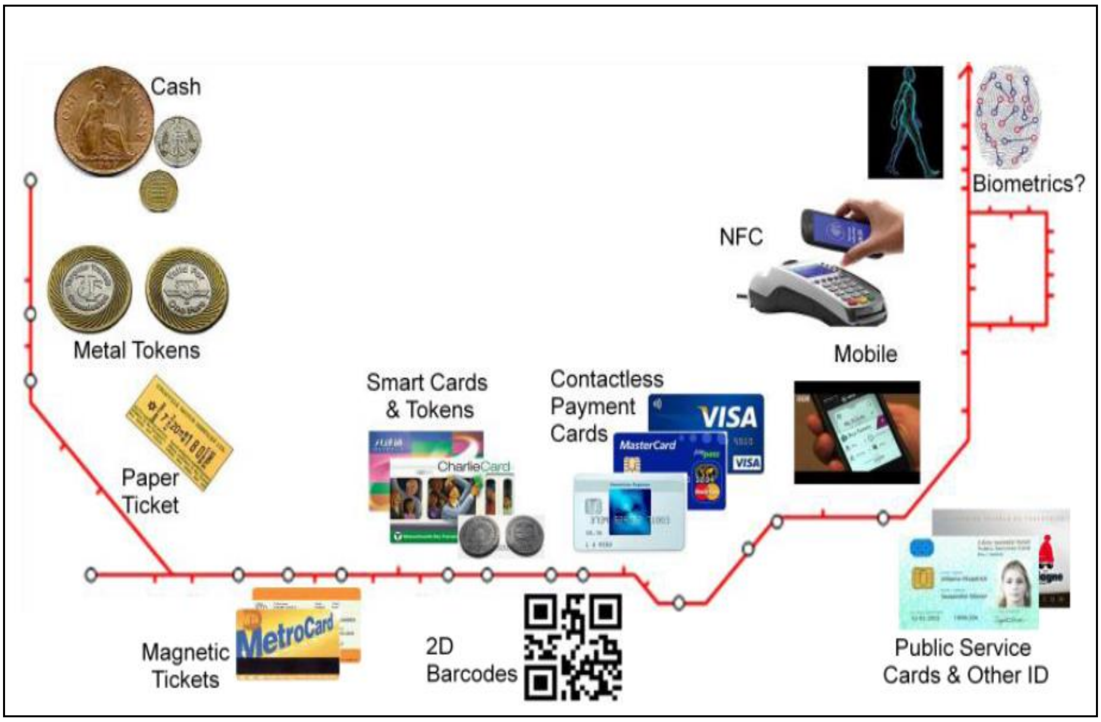
Chapter – 10
FARE COLLECTION SYSTEM

10. FARE COLLECTION SYSTEM

10.1 TICKETING & ACCESS CONTROL

Mass Rapid Transit Systems handle large number of passengers. Ticket issue and fare collection play a vital role in the efficient and proper operation of the system. To achieve this objective, ticketing system shall be simple, easy to use/operate, easy on accounting facilities, capable of issuing single/multiple journey tickets, amenable for quick fare changes and require overall lesser manpower. Automatic fare collection system meets these requirements. Fare collection technology development is as shown in **Figure10.1** below.

FIGURE 10.1: FARE COLLECTION TECHNOLOGY DEVELOPMENT



Keeping in view metro railways automatic fare collection system and the fact that Contactless card/ token technology proves to be cheaper than other technologies in life cycle cost due to reduced maintenance as it has less wear and tear and is less prone to dusty environment, it is proposed to provide computer based automatic fare collection system with Contactless smart token/card type ticketing for the Nagpur Metro.

The equipment for the same may be provided at each station viz. Automatic Fare Gates, Ticket Office Machines, Ticket Readers, Portable Ticket Decoders, Central and Station Computers, Passenger Operated Machines/Ticket Vending Machines (POMs/TVMs) and UPS. The typical AFC System Operation Process and Architecture is shown in **Figures 10.2** & **10.3** respectively.

FIGURE 10.2: AFC OPERATION PROCESS

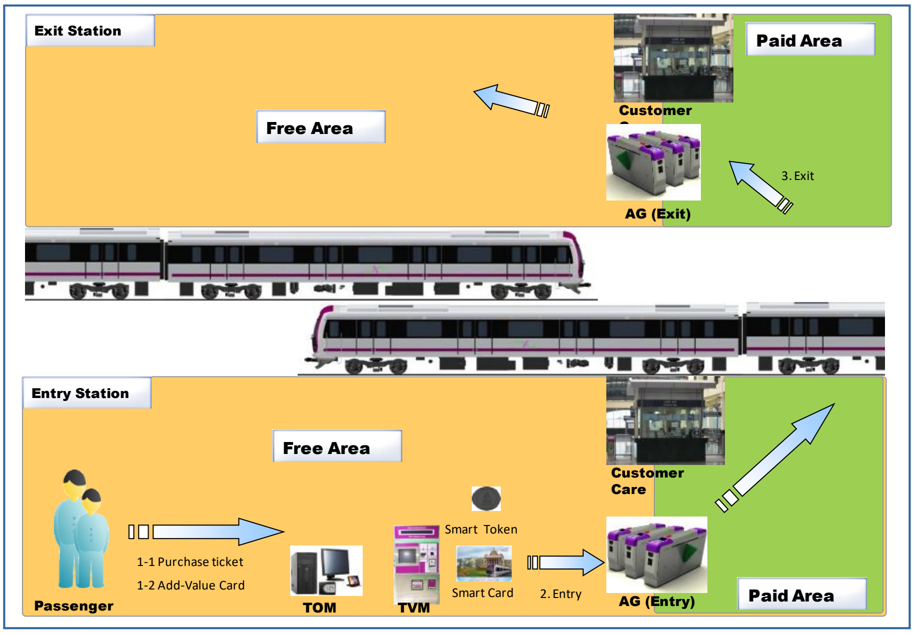
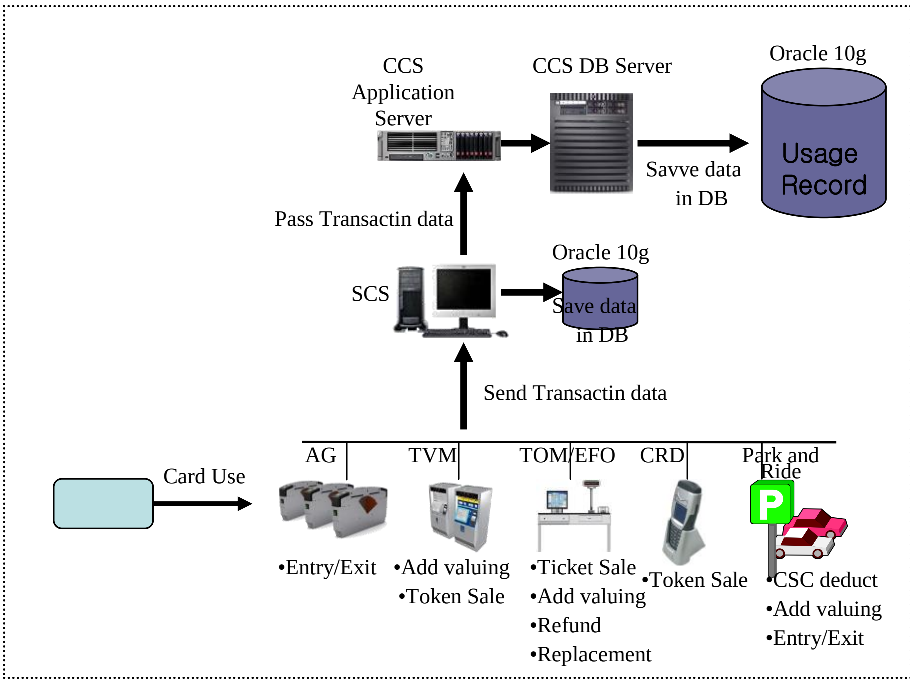


FIGURE 10.3: AFC SYSTEM ARCHITECTURE



The AFC System Central Computer (CC) has a capacity to cater for upto 256 stations. The AFC system shall also have functionality of interface to CCHS (Central Clearing House System) which is capable pf handling upto 32 operators and 10 million transactions with provision of integration with other transit (metro, bus etc.) and non-transit (parking, toll etc.) which may be planned in future in line with the state / national policy.

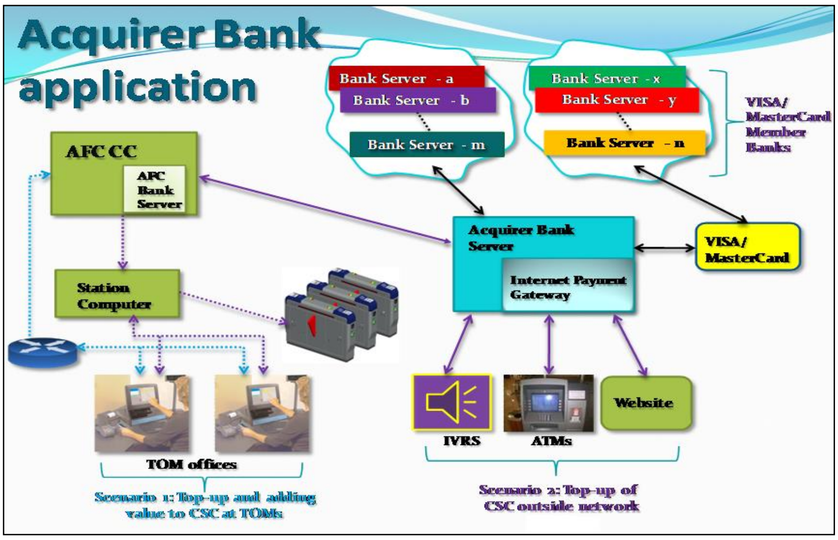
In addition, the proposed AFC system shall also be NFC (Near Field Communication) enabled so that customers can use their NFC enabled Mobile phones for metro travel. Facility of recharging of Travel Cards using Cash, Debit/Credit Cards and Net banking/web portal shall also be available. AFC system shall also support offsite sales terminals also, wherein cards and tokens can be dispensed at locations outside metro premises.

10.2 AUTOMATIC FARE COLLECTION SYSTEM OPTIONS

i. Bank operator: AFC Ticketing system

Recent developments in the mass transit and financial payments industries have created opportunities for convergence and collaboration. The Banks are thus too keen to enter into the transit market. In the present dispensation the banks are only acting as a partner to distribute the combo cards. The ownership of card lies with bank, but the transit product on the card is owned by transit operator. Probably we can think of giving preferential treatment to passengers having links with acquirer Bank e.g. separate queue so that we reduce the rush at the counters. Banks will see this as value addition and probably will pay higher royalty. The banking interface is shown in **Figure 10.4** below.

FIGURE 10.4: BANKING INTERFACE



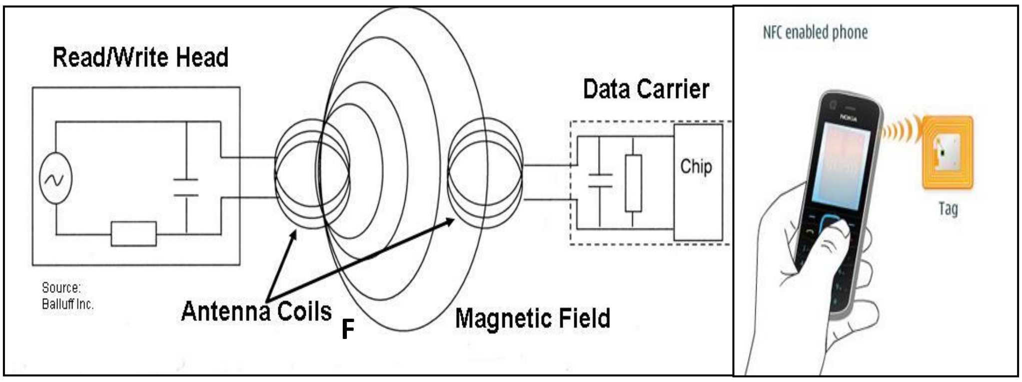
The scope of banks is to provide the following services:

- Providing POS terminals at ticket counters and Automatic Ticket Vending machines
- Topping-up of smart cards at ATMs
- Topping-up of smart cards through Net banking and Mobile banking
- Topping-up of smart cards through Payment gateway at website
- Topping-up of smart cards through Auto-top up using Standing Instructions from Bank customers / commuter.

ii. Near Field Communication (NFC)

It is a Wireless communication technology based on inductive-coupling, enables data transfer between machines and Uses the concept of Radio Frequency Identification (RFID) as shown in **Figure 10.5**. RFID is a technology that does communication through radio waves, that exchanges data between an electronic tag put on an object and a reader. NFC works using magnetic induction between two loop antennas located within each other's 'near field' and its operating frequency is 13.56 MHz. data rate 106 kbit/s to 424 kbit/s. NFC use an initiator and a target; the initiator actively generates an RF field that can power a passive target.

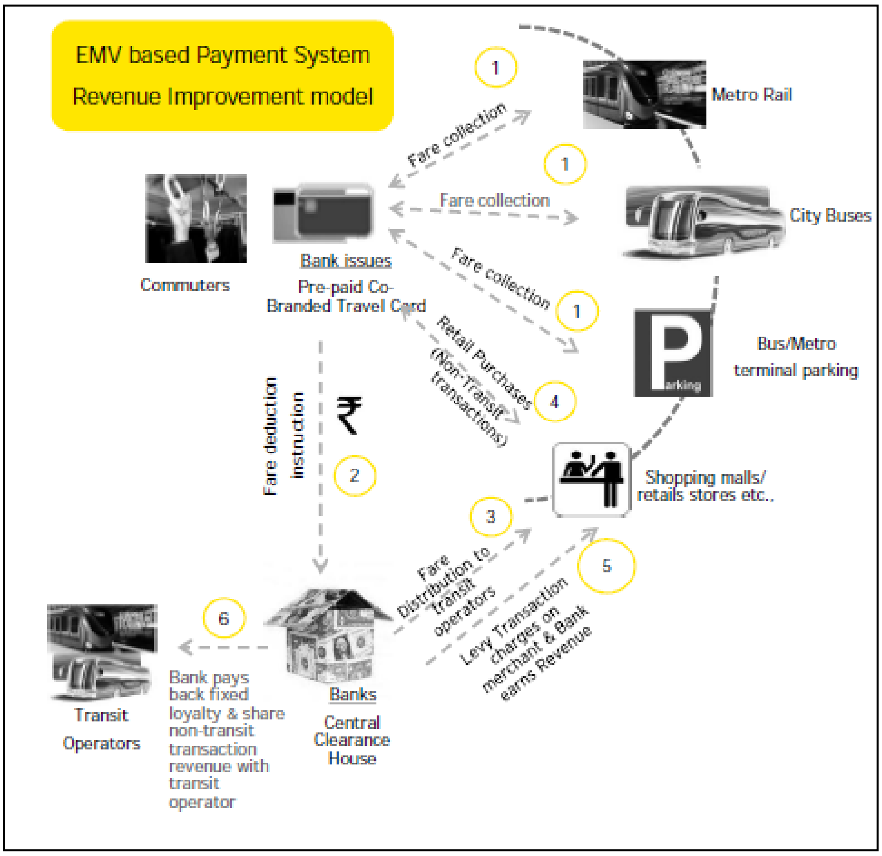
FIGURE 10.5: NEAR FIELD COMMUNICATION



iii EMV Open Loop System

An EMV (Europay, Maser and Visa) a global standard is a credit or debit card with an embedded microchip designed to enable secure payment at compatible point of sale (POS) terminals. EMV cards can also support contactless payment through near-field communication (NFC) wireless connectivity. Transit Operator hires one or multiple financial institutions to issue a prepaid EMV enabled travel card to its commuters. The EMV based smart cards can be accepted within network of transit operator's terminals. The transit operators fare acceptance terminals would need EMV enabled card readers. The same card can be used on network of other payment methods at any merchant outlet. Model is convenient for a commuter as Transit Card and acts as an e-Wallet that can be used for all payment needs as single media. The EMV model also aids commuters to gain loyalty points for usage of cards on transit or non-transit network. The EMV based system is shown in **Figure 10.6.**

FIGURE 10.6:EMV BASED PAYMENT SYSTEM

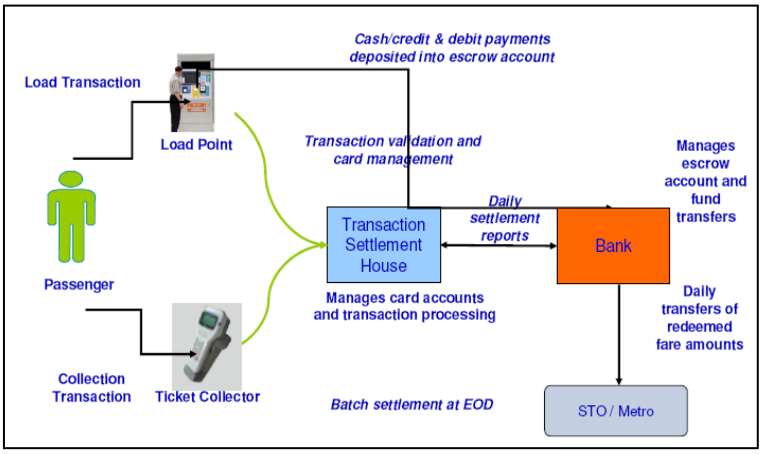


10.3 FARE SYSTEM INTEGRATION WITH OTHER TRANSPORT SYSTEM

i. Common Mobility Card

Common Mobility Card (CMC) Smart Card will provide Common Fare Collection System across different operators (both Government and Private) and different modes of public transport. Tipped as a nationwide interoperable transport card, the card aims to be a single point of transaction, applicable in state buses, Metro and even parking as is being implemented in Phase-I. The whole system overview is presented **Figure 10.7.**

FIGURE 10.7: COMMON MOBILITY CARD OVERVIEW



10.4 AFC SYSTEM EQUIPMENT STANDARDS

The standard equipment proposed for AFC systems are given in **Table 10.1.**

TABLE 10.1: STANDARDS PROPOSED FOR AFC SYSTEMS

Equipment	Description
Fare media	**Contactless smart token** – For single journey. It will have stored value amount for a particular journey. Tokens will be captured at the exit gate. **Contactless smart card** – For multiple journeys.
Gates	Computer controlled automatic gates at entry and exit. There will be following types of gates: Entry/ Exit Reversible – can be set to entry or exit **Disabled** – Wide reversible gate for disabled people.
Station computer, Central computer and AFC Net work	All the **fare collection equipments** will be connected in a **local area network** with a station server controlling the activities of all the machines. These station servers will be linked to the central computer situated in the operational control centre through the optic fiber communication channels. The centralized control of the system shall provide real time data of earnings, passenger flow analysis, blacklisting of specified cards etc.
Ticket office machine (TOM/EFO)	Manned **Ticket office machine** may be installed in the stations for selling cards/ tokens to the passengers.

Equipment	Description
Ticket reader and portable ticket decoder.	**Ticket reader will** be installed near EFO for passengers to check information stored in the token / cards.
Ticket Vending Machine (TVM)	**Ticket Vending Machines (TVMs)** having facility of issue of single journey tokens & recharge of travel cards using cash, debit/credit cards shall be installed in non-paid areas.
UPS (uninterrupted power at stations as well as for OCC).	Common UPS of S&T system will be utilized.
Maintenance philosophy	Being fully Contactless system, manpower requirement for maintenance is much less compared to other systems. However, adequate facilities to be provided similar to that of S&T systems.

10.5 PLATFORM SCREEN DOORS

Platform Screen Doors (PSD) are mainly provided at the metro stations to ensure safety and comfort of passengers. The principle advantages of platform screen doors are:

i) It prevents accidental falls off the platform onto the lower track area, suicide attempts and homicides by pushing.

ii) It prevents or reduces wind felt by the passengers caused by the piston effect which could in some circumstances make people fall over.

iii) It reduces the risk of accidents, especially from service trains passing through the station at high speeds.

iv) It improves climate control within the station especially underground stations (heating, ventilation, and air conditioning are more effective when the station is physically isolated from the tunnel).

v) It improves security - access to the tracks and tunnels is restricted.

vi) It lowers operating costs- eliminate the need for motormen or conductors when used in conjunction with Unattended Train Operation (UTO).

vii) It prevents litter build up on the track, which can be a fire risk.

viii) It improves the sound quality of platform announcements, as background noise from the tunnels and trains that are entering or exiting is reduced.

There are some disadvantages of Platform Screen Doors, which are indicated below:

i) Primary disadvantage is their cost; installing a system typically costs approx Rs. 2 Crores per platform.
ii) When used to retrofit older systems, they limit the kind of rolling stock that may be used on a line, as train doors must have exactly the same spacing as the platform doors;
iii) Maintenance facilities in the depot are required to be augmented for maintenance of platform screen doors also.

Since the advantages far outweigh the disadvantages, platform screen doors (PSD) are proposed to be provided at all the stations of Extensions of Nagpur Phase 1 Corridors to ensure safety & comfort of commuters. The broad outline/details of Platform Screen Doors (PSD) is described hereunder:

10.5.1 System Configuration

The PSD's comprise Platform Screen Doors (PSD), Manual Secondary Doors (MSD), Emergency Escape Doors (EED) and Fixed Screens (FS) to form a glazed barrier along the edge of the platform for the passenger area. The configuration and location of the EED's and FS will be such that the PSD's will correspond to the location of the train doors when the train has berthed in the Correct Stopping Position (CSP) at the platform.

(i) Platform Screen Door (PSD)

These powered glass doors are located along the platform at the platform edge throughout the passenger area and door locations are corresponding to the train car passenger door locations. Opening/closing of the PSD will be after receipt of the doors open/doors close command signals from the Signaling Link. Signaling link enables automatic operation of PSD only when the train stops within ±300 mm limits. The platform screen door is shown in **Figure 10.8**

(ii) Manual Secondary Door (MSD)

These are manual glass doors located at one end of platform providing access from the platform onto the trackside. In case of emergency evacuation from tunnel/trackside the MSD can be opened from the trackside by using a push bar. The door will be designed to swing open and be held at an open position of 90o. The door will be self closing to the closed and locked position safely upon the opening position less than 90o, without need for staff intervention. Operation of the MSD is the same as for the EED. The manual screen door is shown in **Figure 10.9**

FIGURE 10.8: PLATFORM SCREEN DOOR

FIGURE 10.9: MANUAL SCREEN DOOR

(iii) Emergency Escape Door (EED)

EEDs are located around PSDs of leading and trailing passenger cars. If the train does not stop at the correct position and opened train doors are not in front of PSD doors, the train passengers can go to the platform after opening the EED by pressing the emergency push bar located on the track side of the EED. Operation of the EED is the same as for the MSD. The arrangement is shown in **Figure 10.10.**

(iv) Fixed Screens/Panels (FP)

Platform length sections not provided with any of PSD/EED/MSD i.e. fixed panels are provided with fixed glass screens called "Fixed Panel" (FP). Apart from acting as a safety feature for the passengers from falling off on the tracks, PSDs also help in reducing the power consumption for the station HVAC and reduce the track-side noise on the platform.

FIGURE 10.10: EMERGENCY ESCAPE DOORS & FIXED SCREENS/PANELS

10.5.2 Options & Recommendations

There are mainly two options for providing Platform Screen Doors viz Full height PSD or Half height PSD. The advantages & limitations of PSD have been brought out in para 3.10. The half-height and full height PSD are shown in **Figure 10.11** and **Figure 10.12** respectively.

Considering the fact that:

- Half-height platform screen doors are cheaper to install than full height platform screen doors, which require more metallic framework for support.
- Half-height platform screen doors allow natural ventilation to the platform area.

Considering the fact that all the stations of Phase 2 are elevated therefore, it is recommended to provide Half height Platform Screen Doors at all the stations of Nagpur Metro Phase 2 Corridors.

FIGURE 10.11: HALF HEIGHT PSD

FIGURE 10.12: FULL HEIGHT PSD

Chapter – 11
ROLLING STOCK

11. ROLLING STOCK

11.1 ROLLING STOCK

The ridership assessment is the governing factor for the choice of physical parameters of the rolling stock viz. capacity, dimensions etc. Keeping in view, the traffic demand of the city, 2.9m wide coaches have been selected for Phase 1 corridors. Since, Phase 2 corridors are the extensions to the Phase 1 sections and continuous operation is planned between Phase 1 and Phase 2 sections, Rolling Stock similar to Phase 1 has been proposed for adoption in Phase 2 corridors.

Following important criteria is proposed for selection of rolling stock:

- Passenger comfort & safety
- Proven equipment with high reliability
- Energy efficiency
- Light weight equipment and coach body
- High rate of acceleration and deceleration
- Optimized scheduled speed
- Flexibility to meet increase in traffic demand
- Aesthetically pleasing Interior and Exterior
- Low Life cycle cost

The low life cycle cost is achieved by the way of reduced scheduled and unscheduled maintenance and high reliability of the sub-systems.

11.1.1 The selection of following technologies is proposed to ensure low life cycle cost.

i. Car body

In the past carbon high tensile steel was invariably used for car bodies. In-fact almost all the coaches built by Indian Railways are of this type. These steel bodied coaches need frequent painting and corrosion repairs which may have to be carried out up to 4-5 times during the service life of these coaches. It is now standard practice to adopt stainless steel or aluminum car bodies.

ii. Bogies

Bolster less light weight bogies with rubber springs are now universally adopted in metro cars. These bogies require less maintenance and overhaul interval is also of the order of 4,20,000 km. The use of air spring at secondary stage may be considered with a view to keep the floor level of the cars constant irrespective of passenger loading unlike those with coil spring. A smooth curving performance with better ride index will be ensured by provision of above type of bogies.

iii. Braking System

The brake system shall consist of –

- An electro-pneumatic (EP) service friction brake
- A fail safe, pneumatic friction emergency brake
- A spring applied air-release parking brake
- An electric regenerative service brake
- Provision of smooth and continuous blending of EP and regenerative braking

The regenerative braking will be the main brake power of the train and will regain the maximum possible energy and pump it back to the system and thus fully utilize the advantage of 3 phase technology. The regenerative braking should have air supplement control to bear the load of trailer car.

iv. Propulsion System Technology

In the field of Electric Rolling Stock, DC series traction motors have been widely used due to its ideal characteristics and good controllability for traction applications. But these traction motors required intensive maintenance because of commutators and electro-mechanical contactors, resistors etc.

The brush less 3 phase induction motors has now replaced the D.C. series motors in traction applications. The induction motor, for the same power output, is smaller and lighter in weight and ideally suited for rail based Mass Rapid Transit applications. The motor tractive effort and speed is regulated by 'Variable Voltage and Variable frequency' control and can be programmed to suit the track profile and operating requirements. Another advantage of 3 phase A.C. drive and VVVF control is that regenerative braking can be introduced by lowering the frequency and the voltage to reverse the power flow and to allow braking to very low speed.

For Nagpur Metro, three phase AC traction drive with VVVF control is proposed for adoption.

v. Interior and Gang Ways

The passenger capacity of a car is maximized in a Metro System by providing longitudinal seats for seating and utilizing the remaining space for standing passenger. Therefore, all the equipments are mounted on the under frame for maximum space utilization. The gangways are designed to give a wider comfortable standing space during peak hours along with easy and faster passenger movement especially in case of emergency.

vi. Passenger Doors

For swift evacuation of the passenger in short dwell period, four doors of adequate width, on each side of the coach may be considered. These doors shall be of such dimensions and location that all the passengers inside the train are able to evacuate within least possible time without conflicting movement. Automatic door closing mechanism is envisaged from consideration of passenger safety. An emergency door for easy evacuation of the passenger on the track has been provided at the center of the front side of the each cabin which has a easy operation with one handle type master controller.

vii. Air conditioning

With passenger loading of 6 persons/ m^2 for standee area and doors being closed from consideration of safety and with windows being sealed type to avoid transmission of noise, the air conditioning of coaches is considered essential. Each coach shall be provided with two air conditioning units capable of automatically controlling interior temperature throughout the passenger area at all times under varying ambient condition up to full load. For emergency situations such as power failure or both AC failures etc. ventilation provision supplied from battery may be made.

viii. Cab Layout

The modern stylish driver panel shall be FRP moulded which give maximum comfort and easy accessibility of different monitoring equipment to the driver along with clear visibility. The driver seat may be provided at the left side of the cabin.

11.1.2 Broad Features of Rolling Stock

a) Rolling Stock proposed for the Nagpur Phase 2 corridors will be similar to Phase 1. The specifications of the rolling stock and its procurement may be decided on the basis of the project implementation mechanism. The broad features of Rolling Stock which may be followed are indicated in **Table 11.1.**

TABLE 11.1: BROAD FEATURES OF ROLLING STOCK

S. No.	Parameter	Corridor
1	Basic Unit	3 Car basic unit 2 DMC and 1 TC Every coach should be fully interchangeable with any other coach of same type.
2	Train Composition	3 Car: DMC+TC+DMC
3	Coach construction	Light weight stainless steel/ Aluminum body
4	Axle load	≤16 T
5	Braking System	Regenerative Braking
6	Propulsion system	3 phase drive system with VVVF control
7	Type of traction supply	25 kV AC OHE System

b) Coach Dimensions : The following coach dimensions are proposed to be chosen for Nagpur Metro Phase 2 corridors as mentioned in **Table 11.2.**

TABLE 11.2: COACH DIMENSIONS

Type of Coach	Length	Width	Height
Driving Motor Car (DMC)	21.64 m	2.9 m	3.9 m
Trailer car (TC)	21.34 m	2.9 m	3.9 m

**Maximum length of coach over couplers/buffers = 22.6 m*

c) Passenger Carrying Capacity

In order to maximize the passenger carrying capacity, longitudinal seating arrangement shall be adopted. The whole train shall be vestibule to distribute the passenger evenly in all the coaches. Criteria for the calculation of standing passengers are 4 persons per square meter of standing floor area in normal state, 6 persons in crush state of peak hour and 8 persons in dense crush state of peak hour.

The Phase-1 corridors are planned with 3 car train configuration (DMC-TC-DMC) for operation till the design year. Since, continuity in operation is proposed between the two Phases, similar train configuration is proposed for Phase 2 corridors. The stations have been designed considering 3 car length. The carrying capacity of Metro Rail Vehicle is indicated in **Table 11.3.**

TABLE 11.3: CARRYING CAPACITY OF METRO RAIL

Description	Driving Motor Car (DMC)			Trailer Car (TC)			3 Car Train		
	Normal	Crush	Dense Crush	Normal	Crush	Dense Crush	Normal	Crush	Dense Crush
Seated	43	43	43	50	50	50	136	136	136
Standing	137	205	273	147	220	293	421	630	839
Total	180	248	316	197	270	343	557	766	975

Normal - 4 Per/ Sqm of standee area, **Crush**- 6 Per/ Sqm of standee area, **Dense Crush** – 8 Per/ Sqm of standee area.

d) Weight

The weights of motor cars and trailers are estimated in **Table 11.4**, considering the average passenger weight as 65 kg.

TABLE 11.4: WEIGHT OF MASS RAIL VEHICLES (TONS)

Description	DMC	TC	3 Car
Tare Weight (Max.)	43.3	41.4	128
Passenger			
(Normal @ 4p/ m^2)	9.49	10.40	29.38
(Crush @ 6p/ m^2)	16.12	17.55	49.79
(Dense Crush @ 8p/ m^2)	20.54	22.30	63.38
Gross			
(Normal @ 4p/ m^2)	52.79	51.80	157.38
(Crush @ 6p/ m^2)	59.42	58.95	177.79
(Dense Crush @ 8p/ m^2)	63.84	63.70	191.38
Axle Load @ 6p/ m^2	14.86	14.74	
Axle Load @ 8p/ m^2	15.96	15.92	

The axle load @ 6 persons/ m^2 of standees works out in the range of 14.74T to 14.86T per coach. Heavy rush of passengers with loading @ 8 standees per sq. meter can be experienced occasionally during peak hours. It is recommended to design the coaches with sufficient strength so that even with this overload, the design will not result in over stresses in the coach. Coach and bogie should therefore be designed for 16 T axle load.

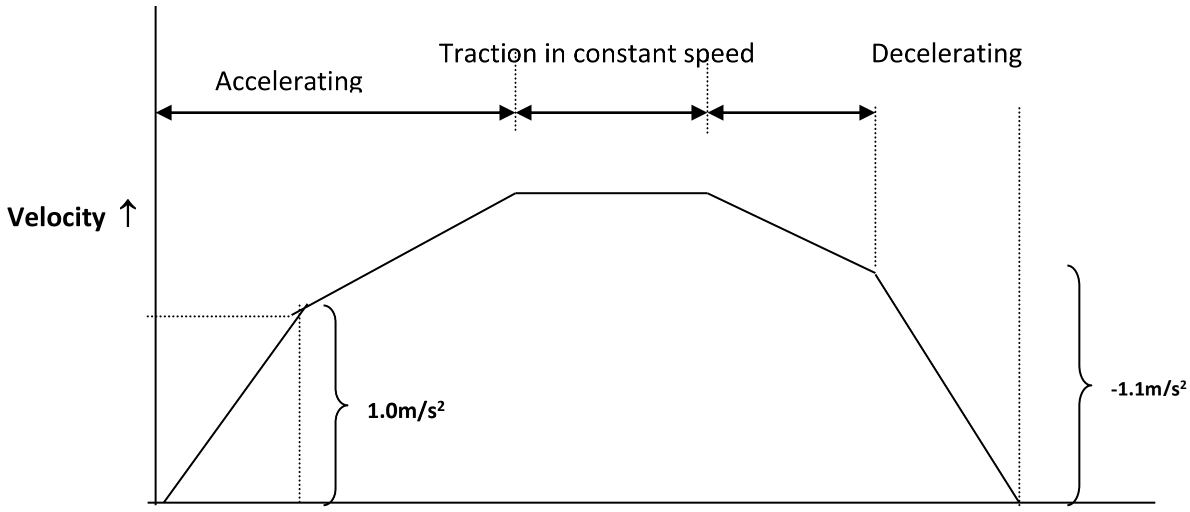
e) Performance Parameters

To achieve the desired schedule speed and running time between stations, the following values of acceleration and deceleration are recommended in consideration of riding comfort, adhesion and requirement of makeup time.

- Max. Design speed : 90 kmph
- Max. operating speed : 80 kmph
- Max. Acceleration : 1.0 m/s^2
- Max. Deceleration : 1.1 m/s^2 (Normal brake)
  More than 1.3 m/s^2 (Emergency brake)

The velocity time operation curve is shown in **Figure 11.1.**

FIGURE 11.1: SIMPLIFIED VELOCITY – TIME OPERATION CURVE



11.2 ROLLING STOCK REQUIREMENT

Rolling Stock requirement for different horizon years has been calculated based on the train operation plan. The calculation for the rake requirement of the two corridors for different horizon years has been given in **Chapter 8** – Train Operation Plan. The coach requirement for the corridors of Phase 2 of Nagpur Metro is given in **Table 11.5**:

TABLE 11.5: COACH REQUIREMENT FOR NAGPUR PHASE 2 CORRIDORS

Corridor	2024	2031	2041
N-S Extension for Phase 2	42	42	60
E-W Extension for Phase 2	12	21	30

Chapter – 12

POWER SUPPLY & TRACTION

12. POWER SUPPLY & TRACTION

12.1 CHOICE OF ELECTRIC TRACTION

Traditionally electric traction has been used to meet the requirement of high acceleration, pollution free services and to achieve the optimum performance in urban, sub-urban and main line rail transport system. Selection of an appropriate technology for traction system may be based on following factors:

- Cost of the technology
- Previous experience & proven-ness
- Maintenance requirements
- Energy Efficiency
- Aesthetics, Economic viability & Sustainability

The cost of traction power system depends upon the following factors:

- Maximum power demand of load
- Level of redundancy & reliability
- Land Cost particularly for Traction Sub-station and Sectioning Posts
- Availability of technology and equipment at Competitive price

This chapter broadly covers the power supply system – selection of most appropriate traction system, power requirement for various horizon years, design load, source of supply and an outline of the distribution network & major equipments etc. for the Nagpur metro extensions in Phase 2.

There are three standard and proven systems of electric traction for use in suburban and metro lines:

- 25 KV AC system
- 1500 V DC Third Rail/ Overhead Catenary System
- 750 V DC Third Rail System

Nagpur Metro Phase 1 corridors are planned with 25kV OHE traction system. To ensure continuity and compatibility of systems, 25kV OHE traction system is proposed for Phase 2 corridors of Nagpur Metro. Since complete elevated corridor is planned for Phase 2, flexible Overhead Equipment (OHE) will be provided.

The 25kV AC system offers following advantages over DC traction system:

The system has the potential to carry large traffic (60,000-100,000) PHPDT. In comparison to DC systems, the regeneration capacity for 25 kV AC system is more and the line losses are less. Energy saving on account of regenerative braking is about 25-35% of traction energy in case of 25kV AC traction as compared to about 20% in case of 750V DC traction.

Unlike DC traction this system does not require substations at frequent intervals due to high voltage, reduced current levels and lower voltage drops, as a result, there is substantial reduction in costs. Overall cost of land and equipments for 25kV AC traction system is significantly lower compared to that for 1500V DC or 750V DC traction system.

In addition, it is widely used traction system (currently being used in Delhi, Jaipur, Chennai and Hyderabad metro rail corporations as well as Indian Railways) with availability of proven indigenous technology for all the components of 25 kV AC systems.

12.2 PROJECTED POWER DEMAND

Electricity is required for operation of metro system for running of trains and station services (e.g. lighting, lifts, escalators, signaling & telecom, fire fighting etc). The power requirements of a metro system are determined by peak-hour demands of power for traction and auxiliary applications.

The power supply system is proposed to be designed for 15743 PHPDT for N-S Corridor i.e. Kanhan River to MIDC ESR and 16889 PHPDT for E-W Corridor i.e. Transport Nagar to Hingna with Spur from Vasudev Nagar to Datttawadi.

The power supply system design has been conceptualized considering 3 car rake composition and train operation at peak headway. The designed system shall ensure high reliability and adequacy of the system to meet unforeseen growth in traffic demand.

The ultimate (design) power requirement for these corridors has been conceptualized considering following norms, directives/guidelines:

- Train operation with 3 car rakes with carrying capacity of 766 passengers (standing @ 6 passengers/m^2).

- Peak period headway for N-S and E-W corridors.
- Specific energy consumption of rolling stock – 75 KWh/ 1000 GTKM
- Regeneration @ 30%
- At grade/ Elevated station load – initially 150 kW, ultimate design 250 kW
- Depot auxiliary load – initially 2000 kW, ultimate design 2500 KW
- Power factor of load – 0.9
- Transmission losses @ 5%

Keeping in view of above norms, power demand estimation for the corridors of Nagpur Metro Phase 1 and Phase 2 is given in **Table 12.1.**

TABLE 12.1: POWER DEMAND ESTIMATION OF PHASE 1 & PHASE 2 CORRIDORS

Corridor	N-S Corridor (in MVA)			E-W Corridor (in MVA)		
Year	**2024**	**2031**	**2041**	**2024**	**2031**	**2041**
Traction	14.10	14.34	17.59	8.44	9.75	12.65
Auxiliary	9.33	12.02	14.58	8.11	10.38	12.54
Total	**23.43**	**26.36**	**32.17**	**16.55**	**20.13**	**25.19**

Power demand estimation for the corridors of Nagpur Metro Phase 1 is given in **Table 12.2.**

TABLE 12.2: POWER DEMAND ESTIMATION OF PHASE 1 CORRIDORS

Corridor	N-S Corridor (in MVA)			E-W Corridor (in MVA)		
Year	**2024**	**2031**	**2041**	**2024**	**2031**	**2041**
Traction	7.89	8.59	9.75	6.69	7.37	9.79
Auxiliary	5.48	6.88	8.17	5.83	7.35	8.75
Total	**13.37**	**15.47**	**17.92**	**12.52**	**14.72**	**18.54**

Additional power demand estimation for the proposed corridors of Nagpur Metro Phase 2 is given in **Table 12.3.**

TABLE 12.3: POWER DEMAND ESTIMATION OF PHASE 2 CORRIDORS

Corridor	N-S Corridor (in MVA)			E-W Corridor (in MVA)		
Year	**2024**	**2031**	**2041**	**2024**	**2031**	**2041**
Traction	6.21	5.75	7.84	1.74	2.39	2.85
Auxiliary	3.85	5.13	6.42	2.28	3.03	3.79
Total	**10.06**	**10.88**	**14.26**	**4.02**	**5.42**	**6.64**

The calculations for the traction and auxiliary power demand estimation are shown in **Annexure 12.1 (a)**, **Annexure 12.1 (b), Annexure 12.1 (c) and Annexure 12.1 (d).** However, this requirement has been worked out based on the conceptual design and therefore, needs to be reaffirmed and fine-tuned by conducting necessary simulation study during detailed design stage of project implementation.

12.3 SOURCES OF POWER SUPPLY

12.3.1 Need for High Reliability of Power Supply

The proposed corridors of Nagpur metro system viz. Kanhan River to MIDC ESR and Transport Nagar to Hingna with spur from Vasudev Nagar to Dattawadi are being designed to cater to about 15743 and 16889 passengers respectively. Incidences of any power interruption, apart from affecting train running, will cause congestion at stations. Interruption of power at night is likely to cause alarm and increased risk to traveling public. Lack of illumination at stations, non-visibility of appropriate signages, disruption of operation of lifts and escalators is likely to cause confusion, anxiety and ire in commuters, whose tolerance level are already low on account of stress. Effect on signal and communication may affect train operation and passenger safety as well. Therefore, uninterrupted power supply is mandatory for efficient metro operations.

It is essential that all the sources of supply and connected transmission & distribution networks are reliable and have adequate built in redundancies.

12.3.2 Sources of Power Supply

Nagpur City has 220kV, 132kV, 33kV power transmission and distribution network to cater to various types of demand in the vicinity of the proposed corridors. Two Receiving Sub Stations (RSS) (one RSS for each corridor) have already been planned to cater to the requirement of both the N-S and E-W corridors in Phase 1. Considering the increased power demand of corridors due inclusion of Phase 2 extension corridors, one additional RSS is required to meet the requirement. The additional RSS is proposed near Kanhan River station.

Discussions are being held with M/s MSETCL to confirm the availability of Input Power Supply Source for the proposed RSS near Kanhan River station. Kanhan

Grid Substation (GSS) has been identified near the corridor alignment for receiving the power at Kanhan River RSS for metro operation.

The Receiving Substations planned for the power requirements of the corridors of Nagpur Metro Phase 1 and Phase 2 have been given in the **Table 12.4:**

TABLE 12.4: SOURCES OF POWER SUPPLY

RSS for Metro System		Feeding Zone
Phase 1	Morris College Ground RSS near Sitabuldi Station (132/33/25 kV)	N-S Corridor (MIDC ESR to Sitabuldi Station)
New proposed	Kanhan River RSS (132/33/25 kV)	N-S Corridor (Sitabuldi to Kanhan River Station)
Phase 1	Jhansi Rani RSS beside Jhansi Rani Station (132/33/25 kV)	E-W Corridor (including Phase 2 extension)

The HT power supply from grid substations at 132kV will be stepped down to 25kV single phase supply for traction purpose and 33kV supply for auxiliary power supply at the Receiving cum Traction Substations (RSS/ TSSs) of MRTS authority. The traction power will be fed to 25kV OHE system through cable feeders and the auxiliary power will be distributed along the alignment through 33kV Ring main cable network for feeding auxiliary loads. These cables will be laid in dedicated ducts/ cable brackets along the viaduct.

The entire power supply system & auxiliary power supply system will be monitored and controlled from a centralized Operation Control Center (OCC) using a SCADA system. The summary of expected power demand at various sources is given below in **Table 12.5.**

TABLE 12.5: POWER DEMAND PROJECTION FOR VARIOUS SOURCES

Name of RSS	Peak Demand – Normal (MVA)			Peak Demand – Emergency (MVA)		
	2024	**2031**	**2041**	**2024**	**2031**	**2041**
RSS Kanhan River (Newly Proposed)						
Traction	5.88	5.97	7.33	14.10	14.34	17.59
Auxiliary	3.50	4.67	5.83	9.33	12.02	14.58
Total (A)	**9.38**	**10.64**	**13.16**	**23.43**	**26.36**	**32.17**
RSS Morris College Ground near Sitabuldi Station						
Traction	8.23	8.36	10.26	14.10	14.34	17.59

Name of RSS	Peak Demand – Normal (MVA)			Peak Demand – Emergency (MVA)		
	2024	2031	2041	2024	2031	2041
Auxiliary	5.83	7.35	8.75	9.33	12.02	14.58
Total (B)	**14.06**	**15.71**	**19.01**	**23.43**	**26.36**	**32.17**
RSS Jhansi Rani beside Jhansi Rani Station (E-W Corridor - Transport Nagar to Hingna with a spur to Dattawadi)						
Traction	8.44	9.75	12.65	16.66	18.12	22.91
Auxiliary	8.11	10.38	12.54	13.94	17.73	21.29
Total (C)	**16.55**	**20.13**	**25.19**	**30.60**	**35.85**	**44.20**

As per Phase-1 power supply arrangement, for N-S corridor, one Receiving Substation (RSS) has been planned at Morris College Ground near Sitabuldi Station. For E-W corridor, one Receiving Substation (RSS) has been planned at Jhansi Rani beside Jhansi Rani Station. The capacity for each RSS for each corridor has been planned as 2 nos. 21.6/ 30.24 MVA Traction transformer and 2 nos. 20/ 25 MVA Auxiliary main transformer.

For Kanhan River to MIDC ESR N-S Corridor, in normal conditions, Morris College Ground RSS near Sitabuldi Station will feed the section from MIDC ESR to Sitabuldi and Kanhan River RSS will feed from Sitabuldi to Kanhan River. Neutral section is proposed near Sitabuldi station. In case Morris College Ground RSS fails, the feed can be extended from Kanhan River RSS. In case of failure of Kanhan River RSS, then Morris College Ground RSS will feed from Kanhan River to MIDC ESR i.e. complete length of the Corridor.

For E-W Corridor i.e. Transport Nagar to Hingna with a spur to Dattawadi, in normal conditions, Jhansi Rani RSS beside Jhansi Rani Station will feed the complete corridor. In case Jhansi Rani RSS fails, the feed can be extended from Morris College Ground RSS planned in N-S Corridor. The interconnection of the power supply arrangement is proposed at Sitabuldi.

When RSS of one corridor fails, the traction supply will be maintained by extending feed from RSS of the other corridor. This ensures the reliability of power supply arrangement. However, in case of total grid failure, all trains may come to a halt, but emergency lighting, fire, hydraulics and other essential services can be catered to by stand-by UPS/ DG sets. Typical receiving sub-station is presented in **Figure 12.1.**

FIGURE 12.1: TYPICAL HIGH VOLTAGE RECEIVING SUB– STATION

Based on estimated emergency power demand at Kanhan River RSS as shown in **Table 12.5**, 2 nos. 21.6/ 30.24 MVA Traction transformer and 2 nos. 20/ 25 MVA Auxiliary main transformer have been proposed. The transformer ratings have been kept similar to the RSS capacity planned in phase 1 corridors.

12.4 TRACTION POWER SUPPLY

12.4.1 25 kV Flexible Overhead Equipment System

25 kV ac Flexible Overhead equipment system shall comprise 150 sq mm HD-copper contact wire and 65sqmm Cd-copper catenary wire. Return conductor (RC) shall be All Aluminum Conductor (AAC) of 233 sq mm cross section. Spring type Auto-Tensioning Device (ATDs) are proposed for tensioning of OHE conductors. Proven catenary fittings are proposed similar to Nagpur Metro Phase 1 system.

12.5 RATING OF MAJOR EQUIPMENTS

Two traction transformers of 132/25 kV, 21.6/ 30.24 MVA capacity and two Auxiliary transformers (132/33 kV) of 20/ 25 MVA capacity each have been planned for the receiving sub stations of Phase 1 corridors. Transformers with similar capacities have been proposed for additional RSS for Phase 2 i.e. Kanhan River RSS.

33kV XLPE insulated FRLSOH cable ring network is proposed for auxiliary ring main network, which shall be adequately rated to transfer requisite auxiliary power during normal as well as emergency situations.

12.5.1 Special Arrangements in Depot

A separate traction sub-station (TSS) has been planned for the depot so as to facilitate isolation of depot traction supply system from main lines in order to operate the depot separately in the case of fault/ maintenance in mainline. The TSS in Mihan and Hingna depots have been planned with 2 nos. 3/ 5 MVA Traction transformers.

12.6 AUXILIARY POWER ARRANGEMENTS

12.6.1 The auxiliary power will be required for:

- Lights & fans for station
- Service buildings
- Foot over bridges/ Subways
- Maintenance depots
- Air-conditioning
- Lifts
- Escalators
- Water Supply Pumping stations – for washing, toilets as well as fire protection measures.
- Equipment – Signaling, Telecom and Automatic Fare Collection etc.

Auxiliary sub-stations (ASS) (**Figure 12.2**) are envisaged to be provided at each station for stepping down 33kV supply to 415V for auxiliary applications. The ASS will be located at mezzanine or platform level inside a room. The demand of power at each elevated station is expected to be about 150 kW in the initial years and is likely to reach 250 kW in the horizon year. The average load considered for elevated station will have to be fine tuned to suit station requirement during detailed design stage.

Each elevated station shall be provided with an Auxiliary Substation with two 33kV/415V, 3-phase, 315 kVA dry type cast resin transformers (one transformer as standby) and the associated HT & LT switchgear. In addition, provision shall be made for one DG set at each station for emergency loads.

FIGURE 12.2: TYPICAL INDOOR AUXILIARY SUB-STATION

12.6.2 E&M Systems

a) LT Power Distribution

33 kV ring main cables running all along the route shall feed each ASS by loop in loop out arrangement. The 33 kV power supply is stepped down to 415 V, 3 phase for distribution to the consumption points (service utilities) viz. Elevators, Escalators, Light & power sockets, Fire system, HVAC system and Signal & Telecom system etc.

The power distribution system shall be designed by using low voltage power cable run on the cable tray, raceway and conduit as suitable to supply power to various loads within station and buildings. The low voltage power distribution cables shall comply with IEC 60502 or other applicable international standard. Fire resistant cables shall be used for safety purpose and comply with the performance requirements of IEC60331 and BS 6387.

b) Illumination System

For Illumination generally, all lighting fixtures shall be applied with 240V, single phase 50Hz power supply. The type and quality of fittings and their luminous intensity shall relate to the space being illuminated and will take into account the effect of architectural space concept and colour scheme as per IS 3646.

The LED lights offer advantages over conventional fluorescent lighting on account of Energy savings, lower life cycle cost, longer life span, rugged nature etc. Considering the benefits of LED light fixtures over the conventional/ fluorescent fixtures, the use of LED light fixtures is recommended at the stations of the corridor.

c) Lifts and Escalators

Lifts and escalators shall be provided at each station for the convenience of the passengers. The power supply for the operation of lifts and escalators is fed from the Auxiliary substation at each station.

d) Fire Detection and Alarm System

The Fire Detection & Alarm System shall be in conformance to the applicable NFPA standard or Other International Standards & also comply with the codes of practice, standards, regulations and requirements of the Statutory Authorities. The coordination of Fire Detection & Alarm System with the following services should be verified, tested, and validated as a complete system before implementation-

i. Fire Detection & Alarm System,
ii. Public Address & Voice Alarm System,
iii. Emergency Lighting System,
iv. Conveying Systems (Lifts & Escalators),
v. HVAC systems (AHUs/ fire dampers/ staircase pressurization fans/ chillers, motorized dampers/ exhaust fans etc.),
vi. Fire Fighting Systems (Fire Pumps/ Sprinkler Valves),
vii. Automatic Doors,
viii. Traction SCADA,
ix. E&M SCADA,
x. Rolling Shutters,
xi. Networking of main fire alarm system, at station to the station control room, and backnet Interface on TCP/IP for third party systems.
xii. Systems not listed above but that requires interfacing with the Main Fire Alarm System.

e) Fire Suppression

- **Portable Fire Extinguishers**

The portable fire extinguishers shall be installed at all the stations in compliance with relevant BS EN Codes and codes of practice, standards, regulations & requirements of the Statutory Authorities. All the covered areas should be provided with suitable type of fire extinguishers. In the Concourse and Platform areas Fire Extinguishers shall be provided in a central location inside a suitably sized cabinet of approved construction. The location and design of the extinguisher cabinets provided shall comply fully to the local fire authority requirements.

Extinguishers shall be conspicuously located in positions where they will be readily accessible and immediately available in the event of fire. They shall be located near to room exits, corridors, stairways, lobbies and landings. Extinguishers shall be installed at a height of 1 m above the floor level and shall be placed in a manner such that the extinguisher operating instructions face outward.

- **Wet Mains System**

The Fire Fighting wet mains system shall be based on BS- 9990: 2006, BS-9999: 2008 & National Building Code. The system shall comprise pipe work, breeching inlets, landing valves, automatic air release valves, fire hose cabinets and fire hose reels etc.

The wet mains system is charged by the Fire pumps set. The fire pump set shall have dual power supply and the system shall be designed to achieve a pressure of 3.5 Bar at the remote fire hydrant point. The system will draw water from the fire water storage tank provided near station building based on the NBC requirements.

- **Fire Hose Cabinets**

The Fire Hose Cabinets shall be provided as per NBC and fire authority regulations in internal and external public areas of the station.

- **Fire Hose Reels**

  The hose reels shall meet the requirements of BS 5306.1: 2006 & BS EN 671 – 3:2004. Hose-reel shall be provided in such a way that it covers the entire Concourse/ Platform areas with suitable number of fire hose cabinets. The hose reels system will be based on direct feed from the Fire Water Wet mains. Hose-reels shall be of the swing-recessed type. Each hose-reel shall be an integral unit consisting of a stop valve, reel, hose, and shut-off assembly. It shall be designed so as to facilitate the swift withdrawal of the hose in any direction with the reel axis horizontal.

- **Gas Flooding System**

  Gas Flooding System is proposed to be provided for protection of the equipments in electrical Auxiliary sub-stations and S&T Equipments in Depot Control Centre/ Operational Control Centre. The design of the system shall be in conformance to NFPA standards.

12.6.3 Standby Diesel Generator (DG) Sets

In the unlikely event of simultaneous tripping of all the RSSs or grid failure, the power supply to stations as well as to trains will be interrupted. It is, therefore, proposed to provide standby DG set of 180 kVA at all elevated stations to cater to the following essential services:

- Lift operation
- Essential lighting
- Signaling & Telecommunications
- Firefighting system
- Fare Collection system

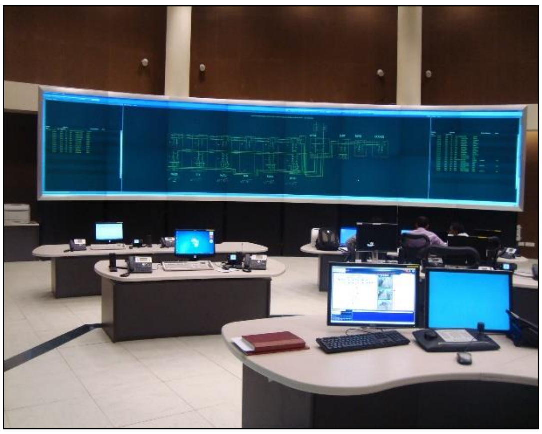
Silent type of DG sets, which have low noise levels and do not require separate room for installation, are proposed. In addition, UPS with adequate power backup may be installed for the very essential lighting load.

12.7 SUPERVISORY CONTROL AND DATA ACQUISITION (SCADA) SYSTEM

The entire system of power supply (receiving, traction & auxiliary supply) shall be monitored and controlled from a centralized Operation Control Centre (OCC) through SCADA system. Modern SCADA system with intelligent remote terminal units (RTUs) shall be provided. Optical fibre cables provided for telecommunications will be used as communication carrier for SCADA system.

Digital Protection Control System (DPCS) is proposed for providing data acquisition, data processing, overall protection control, interlocking, inter-tripping and monitoring of the entire power supply system consisting of 33kV ac switchgear, transformers, 25 kV AC switchgear and associated electrical equipment. DPCS will utilize microprocessor-based fast-acting numerical relays & Programmable Logic Controllers (PLCs) with suitable interface with SCADA system. The SCADA system is presented in **Figure 12.3.**

FIGURE 12.3: SCADA SYSTEM



12.8 ELECTROMAGNETIC INTERFERENCE (EMI) & ELECTROMAGNETIC COMPATIBILITY (EMC)

25kV ac traction currents produce alternating magnetic fields that cause induced voltages in any conductor running along the track. Booster Transformer and Return Conductor (BT/RC) system is proposed for EMI mitigation.

Earthing & Bonding of the power supply & traction system shall be designed in accordance with the latest standards EN50122-1, IEEE80, IS3043 etc. Two earth conductors – Overhead Protection Cable (OPC) and Buried Earth Conductor (BEC) are proposed to be laid along with track. All the concrete and metallic structures, structural reinforcement, running rails etc. will be connected to these conductors to form an equi-potential surface & a least resistance path to the fault currents. The overhead protection cable will also provide protection against lightning to the 25kV OHE on the section.

Detailed specification of equipment e.g. power cables, transformer, switchgear, E&M equipment etc. shall be framed to reduce conducted or radiated emissions as per appropriate international standards. The Metro system as a whole (trains, signaling & telecommunication, traction power supply, E&M system etc.) shall comply with the EMC requirements of international standards viz. EN50121, EN50123, IEC61000 series etc. A detailed EMC plan will have to be developed during project implementation stage.

12.9 SOLAR ENERGY HARNESSING SYSTEM

12.9.1 Introduction

The solar mission, which is part of the National Action Plan on Climate Change has been set up by Govt. of India to promote the development and use of solar energy for power generation and other uses with the ultimate objective of making solar energy competitive with fossil-based energy options.

Considering the futuristic technology and potential for solar power generation, Delhi Metro has recently implemented roof top grid connected solar power systems at selected locations of elevated stations and maintenance depot. Metro Railways under implementation in different cities of the country viz. Jaipur, Lucknow, Nagpur Phase 1 etc. are also exploring the possibilities of harnessing solar photovoltaic energy.

With the downward trend in the cost of harnessing solar energy and appreciation for the need for development of solar power, provision of a grid connected solar photovoltaic power plant utilizing all possible areas viz. roof top of stations is proposed for Nagpur Phase 2 corridors.

12.9.2 Solar PV Power Generation Potential

The roof top on the elevated stations of Nagpur Metro Phase 2 corridors is proposed to be used for SPV installation at suitable orientation and inclination to optimize the solar energy potential. The solar power would be used locally to the extent of load in the building and the generation over and above the requirement of the building would be fed into the grid.

The average raw sunshine available which can be harnessed for the power generation depends on the geometrical coordinates of the place. The intensity of solar radiation varies with time of the day. The combined effect of these factors and the additional complication of the wobble of the seasons is that the average raw power of sunshine per square meter of south-facing roof in India is roughly 100 to 120W/m^2.

The mean global solar radiant exposure at Nagpur varies from 2.23 kWh/m^2/ day in the month of August to 6.96 kWh/m^2/day in the month of February.

Based on the solar radiation intensity in the city of Nagpur, the peak solar power generation of Nagpur Metro corridor is expected to be about 50 kWp for the elevated stations.

The power generation depends upon various factors such as the intensity of the solar radiation, the net useable area available on the roof top, the obstructions due to shadow or the shading factor, the orientation of the solar panels, efficiency of the solar cells etc. The solar power generation potential in Nagpur metro Phase 2 corridors is required to be reviewed and finalized during detail design stage.

12.10 ENERGY SAVING MEASURES

Energy charges of any metro system constitute a substantial portion of its operation & maintenance (O&M) costs. Therefore, it is imperative to incorporate energy saving measures in the system design itself. The auxiliary power consumption of metros is generally more than the traction energy consumed by train movement during initial years of operation. Subsequently, traction power consumption increases with increase in train frequency/composition in order to cater more traffic. The proposed system includes the following energy saving features:

i. Modern rolling stock with 3-phase VVVF drive and lightweight stainless steel coaches has been proposed, which has the benefits of low specific energy consumption and almost unity power factor.
ii. Rolling stock has regeneration features and it is expected that 30% of total traction energy will be regenerated and fed back to 25 kV OCS to be consumed by nearby trains.
iii. Effective utilization of natural light is proposed. In addition, the lighting system of the stations will be provided with different circuits (33%, 66% &

100%) and the relevant circuits can be switched on based on the requirements (operation or maintenance hours etc).

iv. Machine-room less type lifts with gearless drive has been proposed with 3-phase VVVF drive. These lifts are highly energy efficient.

v. The proposed heavy-duty public services escalators will be provided with 3-phase VVVF drive, which is energy efficient & improves the power factor. Further, the escalators will be provided with infrared sensors to automatically reduce the speed (to idling speed) when not being used by passengers.

vi. The latest state of art and energy efficient electrical equipment (e.g. transformers, motors, light fittings etc).

vii. Efficient energy management is possible with proposed modern SCADA system by way of maximum demand (MD) and power factor control.

Annexure 12.1 (a)

Traction and Auxiliary Power Requirement for N-S Corridor i.e. Kanhan River to MIDC ESR (Including Phase 2 Extensions)

S.No.	Description	2024	2031	2041
(A)	**TRACTION LOAD (Kanhan River to MIDC ESR)**			
1	Average speed (S) (Kmph)	34	34	34
2	Headways (H) (Min.)	900	900	600
3	Mean distance between two trains (Km)	8.5	8.5	5.7
4	No. of trains per hour (Frequency) (N)	4	4	6
5	Specific energy consumption (SEC) (KWh/Thou GTKM)	75	75	75
6	Gross tonnage (T) of 3 car rake	184.58	184.58	184.58
7	Corridor length (D) (Km)	49.8	49.8	49.8
8	Power factor of load (PF)	0.9	0.9	0.9
9	Max. demand on TSS (KW)	5513	5513	8270
10	Energy Saving on the account of Regeneration @30%	1654	1654	2481
11	Net Demand	3859	3859	5789
12	Depot Traction Load	1600	1800	2000
	Total Traction Load	5459	5659	7789
	Max. demand on TSS in KVA	6066	6288	8654
	Max. demand on TSS in MVA assuming 5 % loss (MVA)	**6.37**	**6.60**	**9.09**
(B)	**TRACTION LOAD (Kamptee Police Station to Ashokvan)**			
1	Average speed (S) (Kmph)	34	34	34
2	Headways (H) (Min.)	360	360	327
3	Mean distance between two trains (Km)	3.4	3.4	3.1
4	No. of trains per hour (Frequency) (N)	10	10	11
5	Specific energy consumption (SEC) (KWh/Thou GTKM)	75	75	75
6	Gross tonnage (T) of 3 car rake	184.58	184.58	184.58
7	Corridor length (D) (Km)	34.2	34.2	34.2
8	Power factor of load (PF)	0.9	0.9	0.9
9	Max. demand on TSS (KW)	9469	9469	10416
10	Energy Saving on the account of Regeneration @30%	2841	2841	3125
11	Net Demand	6628	6628	7291
12	Depot Traction Load	0	0	0
	Total Traction Load	6628	6628	7291
	Max. demand on TSS in KVA	7365	7365	8101

S.No.	Description	2024	2031	2041
	Max. demand on TSS in MVA assuming 5 % loss (MVA)	**7.73**	**7.73**	**8.51**
	Total Traction Load	**14.10**	**14.34**	**17.59**
(C)	**AUXILIARY LOAD**			
1	Load of each elevated stations (KW)	150	200	250
2	Nos of at grade/elevated station	40	40	40
3	Load of each U/G stations (KW)	1500	1600	1700
4	Nos of U/G stations	0	0	0
5	Load of shed (KW)	2000	2300	2500
6	Total load of the stations & 1 Depot (KW)	8000	10300	12500
7	Power factor of the load	0.9	0.9	0.9
	Total max. power demand of Stations and Depot (KVA)	8889	11444	13889
	Total max. power demandconsidering 5 % loss (MVA)	**9.33**	**12.02**	**14.58**
	Total Max. Power Demand Traction + Aux. (MVA)	22.32	25.10	30.64
	Net demand (MVA) considering 5% distribution loss	**23.43**	**26.36**	**32.17**

Annexure 12.1 (b)

Traction and Auxiliary Power Requirement for
E-W Corridor i.e. Transport Nagar to Hingna with a spur to Dattawadi (Including Phase 2 Extensions)

S.No.	Description	2024	2031	2041
(A)	**TRACTION LOAD (Transport Nagar to Hingna)**			
1	Average speed (S) (Kmph)	34	34	34
2	Headways (H) (Min.)	900	900	900
3	Mean distance between two trains (Km)	8.5	8.5	8.5
4	No. of trains per hour (Frequency) (N)	4	4	4
5	Specific energy consumption (SEC) (KWh/Thou GTKM)	75	75	75
6	Gross tonnage (T) of 3 car rake	184.58	184.58	184.58
7	Corridor length (D) (Km)	30.4	30.4	30.4
8	Power factor of load (PF)	0.9	0.9	0.9
9	Max. demand on TSS (KW)	3368	3368	3368
10	Energy Saving on the account of Regeneration @30%	1010	1010	1010
11	Net Demand	2357	2357	2357
12	Depot Traction Load	1600	1800	2000
	Total Traction Load	3957	4157	4357
	Max. demand on TSS in KVA	4397	4619	4842
	Max. demand on TSS in MVA assuming 5 % loss (MVA)	**4.62**	**4.85**	**5.08**
(B)	**TRACTION LOAD (Transport Nagar to Dattawadi)**			
1	Average speed (S) (Kmph)	34	34	34
2	Headways (H) (Min.)	900	720	600
3	Mean distance between two trains (Km)	8.5	6.8	5.7
4	No. of trains per hour (Frequency) (N)	4	5	6
5	Specific energy consumption (SEC) (KWh/Thou GTKM)	75	75	75
6	Gross tonnage (T) of 3 car rake	184.58	184.58	184.58
7	Corridor length (D) (Km)	24.8	24.8	24.8
8	Power factor of load (PF)	0.9	0.9	0.9
9	Max. demand on TSS (KW)	2748	3435	4121
10	Energy Saving on the account of Regeneration @30%	824	1030	1236
11	Net Demand	1923	2404	2885
12	Depot Traction Load	0	0	0
	Total Traction Load	1923	2404	2885

S.No.	Description	2024	2031	2041
	Max. demand on TSS in KVA	2137	2671	3206
	Max. demand on TSS in MVA assuming 5 % loss (MVA)	**2.24**	**2.80**	**3.37**
(C)	**TRACTION LOAD (Transport Nagar to Hingna Mount View)**			
1	Average speed (S) (Kmph)	34	34	34
2	Headways (H) (Min.)	1200	900	450
3	Mean distance between two trains (Km)	11.3	8.5	4.3
4	No. of trains per hour (Frequency) (N)	3	4	8
5	Specific energy consumption (SEC) (KWh/Thou GTKM)	75	75	75
6	Gross tonnage (T) of 3 car rake	184.58	184.58	184.58
7	Corridor length (D) (Km)	23.2	23.2	23.2
8	Power factor of load (PF)	0.9	0.9	0.9
9	Max. demand on TSS (KW)	1928	2570	5141
10	Energy Saving on the account of Regeneration @30%	578	771	1542
11	Net Demand	1349	1799	3599
12	Depot Traction Load	0	0	0
	Total Traction Load	1349	1799	3599
	Max. demand on TSS in KVA	1499	1999	3998
	Max. demand on TSS in MVA assuming 5 % loss (MVA)	**1.57**	**2.10**	**4.20**
	Total Traction Load	**8.44**	**9.75**	**12.65**
(D)	**AUXILIARY LOAD**			
1	Load of each elevated stations (KW)	150	200	250
2	Nos of at grade/elevated station	33	33	33
3	Load of each U/G stations (KW)	1500	1600	1700
4	Nos of U/G stations	0	0	0
5	Load of shed (KW)	2000	2300	2500
6	Total load of the stations & 1 Depot (KW)	6950	8900	10750
7	Power factor of the load	0.9	0.9	0.9
	Total max. power demand of Stations and Depot (KVA)	7722	9889	11944
	Total max. power demand considering 5 % loss (MVA)	**8.11**	**10.38**	**12.54**
	Total Max. Power Demand Traction + Aux. (MVA)	15.76	19.18	23.99
	Net demand (MVA) considering 5% distribution loss	**16.55**	**20.13**	**25.19**

Annexure 12.1 (c)

Traction and Auxiliary Power Requirement for
N-S Corridor i.e. Automative Square to Khapri (Phase 1)

S.No.	Description	2024	2031	2041
(A)	**TRACTION LOAD**			
1	Average speed (S) (Kmph)	34	34	34
2	Headways (H) (Min.)	277	257	225
3	Mean distance between two trains (Km)	2.6	2.4	2.1
4	No. of trains per hour (Frequency) (N)	13	14	16
5	Specific energy consumption (SEC) (KWh/Thou GTKM)	75	75	75
6	Gross tonnage (T) of 3 car rake	184.58	184.58	184.58
7	Corridor length (D) (Km)	20.5	20.5	20.5
8	Power factor of load (PF)	0.9	0.9	0.9
9	Max. demand on TSS (KW)	7379	7946	9081
10	Energy Saving on the account of Regeneration @30%	2214	2384	2724
11	Net Demand	5165	5562	6357
12	Depot Traction Load	1600	1800	2000
	Total Traction Load	6765	7362	8357
	Max. demand on TSS in KVA	7517	8180	9285
	Max. demand on TSS in MVA assuming 5 % loss (MVA)	**7.89**	**8.59**	**9.75**
(C)	**AUXILIARY LOAD**			
1	Load of each elevated stations (KW)	150	200	250
2	Nos of at grade/elevated station	18	18	18
3	Load of each U/G stations (KW)	1500	1600	1700
4	Nos of U/G stations	0	0	0
5	Load of shed (KW)	2000	2300	2500
6	Total load of the stations & 1 Depot (KW)	4700	5900	7000
7	Power factor of the load	0.9	0.9	0.9
	Total max. power demand of Stations and Depot (KVA)	5222	6556	7778
	Total max. power demand considering 5 % loss (MVA)	**5.48**	**6.88**	**8.17**
	Total Max. Power Demand Traction + Aux. (MVA)	12.74	14.74	17.06
	Net demand (MVA) considering 5% distribution loss	**13.37**	**15.47**	**17.92**

Annexure 12.1 (d)

Traction and Auxiliary Power Requirement for E-W Corridor i.e. Prajapati Nagar to Lokmanya Nagar (Phase 1)

S.No.	Description	2024	2031	2041
(A)	**TRACTION LOAD**			
1	Average speed (S) (Kmph)	34	34	34
2	Headways (H) (Min.)	327	300	212
3	Mean distance between two trains (Km)	3.1	2.8	2.0
4	No. of trains per hour (Frequency) (N)	11	12	17
5	Specific energy consumption (SEC) (KWh/Thou GTKM)	75	75	75
6	Gross tonnage (T) of 3 car rake	184.58	184.58	184.58
7	Corridor length (D) (Km)	19.4	19.4	19.4
8	Power factor of load (PF)	0.9	0.9	0.9
9	Max. demand on TSS (KW)	5911	6449	9136
10	Energy Saving on the account of Regeneration @30%	1773	1935	2741
11	Net Demand	4138	4514	6395
12	Depot Traction Load	1600	1800	2000
	Total Traction Load	5738	6314	8395
	Max. demand on TSS in KVA	6376	7016	9328
	Max. demand on TSS in MVA assuming 5 % loss (MVA)	**6.69**	**7.37**	**9.79**
(C)	**AUXILIARY LOAD**			
1	Load of each elevated stations (KW)	150	200	250
2	Nos of at grade/elevated station	20	20	20
3	Load of each U/G stations (KW)	1500	1600	1700
4	Nos of U/G stations	0	0	0
5	Load of shed (KW)	2000	2300	2500
6	Total load of the stations & 1 Depot (KW)	5000	6300	7500
7	Power factor of the load	0.9	0.9	0.9
	Total max. power demand of Stations and Depot (KVA)	5556	7000	8333
	Total max. power demand considering 5 % loss (MVA)	**5.83**	**7.35**	**8.75**
	Total Max. Power Demand Traction + Aux. (MVA)	11.93	14.02	17.66
	Net demand (MVA) considering 5% distribution loss	**12.52**	**14.72**	**18.54**

Chapter – 13
VENTILATION AND AIR CONDITIONING SYSTEM

13. VENTILATION AND AIR CONDITIONING SYSTEM

13.1 ALIGNMENT ANALYSIS AND NEED FOR VENTILATION

Nagpur Metro Phase 1 & 2 corridors have been planned between Kanhan River to MIDC ESR (North-South Corridor) and Transport Nagar to Hingna (East-West Corridor) with spur from Vasudev Nagar to Dattawadi. The complete length of these corridors is planned as elevated. The air conditioning and ventilation requirement in elevated stations of the corridors is mainly for ancillary spaces such as staff room, equipment rooms etc. It is essential to maintain an acceptable environment for the operating and maintenance personnel, to prolong the life of equipment by proper control of temperature, pressure, humidity, and to mitigate possible gas accumulation.

13.2 DESIGN PARAMETERS

Nagpur city has warm climate. The month of May is the warmest month of the year and January has the lowest temperature. The air conditioning systems has been designed considering the following:

Ambient Temperature

Summer: 44.4°C (DB), 24.4°C (WB)

Winter: 15.6°C (DB), 11.1°C (WB)

Inside Conditions: Summer and Monsoon: 23.0 ± 1°C

Fresh Air: As per ASHRAE

13.3 STATION VENTILATION AND AIR CONDITIONING OF ANCILLARY SPACES

13.3.1 Station Air Conditioning

Variable Refrigerant Volume (VRV) system has been provided for the air conditioning of the rooms inside the station area. The VRV air conditioning system consists of modular condensing units connected to multiple indoor units, each having the capability of individual set point control. Generally, following rooms of the elevated station are provided with the air conditioning units:

- Station control room
- Ticket office
- EFO
- Signal Maintenance room
- Signal Equipment room
- Telecom equipment room
- UPS (S&T) room

Ancillary spaces such as staff room, equipment plant room, will be mechanically ventilated or air conditioned in accordance with the desired air change rates and temperatures/ humidity. Provision of air conditioning systems is essential for the equipment rooms viz. signaling equipment rooms, telecom equipment rooms. The equipments kept inside these rooms are low voltage devices which are temperature sensitive. These are designed to operate normally at some specified temperatures. Therefore, temperature control inside the rooms is required for the reliable and proper functioning of the equipments. Other areas which are required to be air conditioned can be decided as per the consumer specific requirements.

13.3.2 Ventilation Requirements at Elevated Stations

Ventilation has generally been envisaged for the following rooms:

- TSS/ASS Room
- Toilets
- Pump Room
- DG set room
- Battery rooms

Suitable exhaust systems will be installed in the rooms. Fresh air louvers may be provided in ASS/ TSS room for the fresh air intake. Ventilation has been provided in all the rooms as per the relevant standards. The ventilation requirements i.e. the required number of air changes per hour for different rooms inside the station area will be in accordance with the ASHRAE standards.

Chapter – 14
DEPOTS

14. DEPOTS

14.1 DEPOT LOCATION AND APPROACH TO MAINTENANCE

For the North-South corridor, maintenance depot has been planned at MIHAN Depot and the Maintenance depot for the East –West corridor of Nagpur Metro Phase 1 has been planned at Hingna Depot.

The depots will have infrastructure to maintain the rakes with necessary facilities viz stabling lines, scheduled inspection lines, workshop for overhaul, unscheduled maintenance including major repairs, wheel profiling, heavy interior/under frame/roof cleaning etc. for the rolling stock operational on the corridor as well as maintenance facilities for Civil – track, buildings, water supply; Electrical – Traction, E&M; Signalling & Telecomm.; Automatic Fare Collection etc.

In broad terms, based on the planned rolling stock requirements, this chapter covers the conceptual design of the following aspects of the Depots.

- Conceptual design and layout of Servicing Shed and Workshop to provide maintenance facilities and stabling facilities for Rolling Stock.
- Operational and functional safety requirements.
- Ancillary buildings for other maintenance facilities.
- Electrical & Mechanical Services, power supply and distribution system.
- Water Supplies, Drainage & Sewerage.

The details of the two depots are provided on conceptual design basis and will work as a guideline for detailed design later.

14.1.1 Maintenance Philosophy

The outline of the maintenance philosophy followed would be as below:

- Typical Maintenance schedules being followed by Nagpur Metro have been considered for determining the requirement of lines in depot.
- Unit replacement and to get essential repairs to major equipments done by the OEMs.
- Automation with state-of-the-art machinery to ensure quality and reliability. Labour intensive procedures will be kept to the minimum.
- Maintenance staff shall be given special training to develop high-level skills in their trade to ensure quality and productivity in their performance.

- Adequate facilities for the stabling have been provided at the depot.
- To maintain high degree of cleanliness, Automatic washing plant has been proposed for cleaning of rakes.

14.1.2 Planning of Maintenance Facilities Setup

Based on assumptions in train operation plan, the rake requirement for various horizon years for the two corridors of Nagpur Metro Phase 2 is indicated in **Table 14.1** and **Table 14.2.**

TABLE 14.1: RAKE REQUIREMENT IN N-S CORRIDOR (INCLUDING EXTENSIONS)

Train Operation / Corridor	Time horizon Year	Number of Train per hour	Section length km	Rake required	Bare Rake requirement	Traffic spare@5 %	Maint. Spare @10%	Total Rake requirement	Total Coach Requirement
Kanhan River to MIDC ESR	2024	4	49.8	12.2	12.0	0	0	12	36
	2031	4	49.8	12.2	12.0	0	0	12	36
	2041	6	49.8	18.4	18.0	0	0	**18**	**54**
Kamptee Police Station to Ashokvan	2024	10	34.2	21.5	21.0	1	1	23	69
	2031	10	34.2	21.5	21.0	1	2	24	72
	2041	11	34.2	23.6	24.0	1	2	**27**	**81**

TABLE : 14.2 RAKE REQUIREMENT IN E-W CORRIDOR (INCLUDING EXTENSIONS)

Train Operation/ Corridor	Time horizon Year	Number of Train per hour	Section length km	Rake required	Bare Rake requirement	Traffic spare@5%	Maint. Spare @10%	Total Rake requirement	Total Coach Requirement
Transport Nagar to Hingna	2024	4	30.4	7.7	8.0	0	1	9	27
	2031	4	30.4	7.7	8.0	0	1	9	27
	2041	4	30.4	7.7	8.0	0	1	**9**	**27**
Transport Nagar to Dattawadi	2024	4	24.8	6.4	6.0	0	1	7	21
	2031	5	24.8	8.0	8.0	0	1	9	27
	2041	6	24.8	9.6	10.0	1	1	**12**	**36**
Transport Nagar to Hingna Mount View	2024	3	23.2	4.5	4.0	0	0	4	12
	2031	4	23.2	6.0	6.0	0	1	7	21
	2041	8	23.2	12.0	12.0	1	1	**14**	**42**

The MIHAN Depot for N-S corridor and Hingna Depot for E-W corridor will be capable to meet the infrastructure to maintain the rakes with necessary facilities viz stabling lines, scheduled inspection lines, workshop for overhaul, unscheduled maintenance including major repairs, wheel profiling, heavy interior/under frame/roof cleaning etc. for the rolling stock operational on the corridor up to year 2041.

For the North-South corridor, maintenance depot has been planned at MIHAN. All the stabling line could not be accommodated at MIHAN depot hence, twenty four no. stabling of 3 car has been planned after the Metro city station to meet the rake requirement up to year 2041.The major infrastructure facilities planned at MIHAN Depot is summarized in **Table 14.3**.

TABLE 14.3 INFRASTRUCTURE FACILITIES PLANNED AT MIHAN DEPOT

Facility	Phase 1	Future (Phase 2)
Stabling Lines	3 lines of 6 car length	3 lines of 6 car length
Inspection Lines	3 lines of 3 car length	3 lines of 3 car length
Workshop Lines	2 lines of 3 car length	2 lines of 3 car length

The Maintenance depot for the East-West corridor of Nagpur Metro Phase 1 has been planned at Hingna. Five stabling lines in Hingna depot has been extended to accommodate 10 more stabling lines of 3 car, hence area of 160x53m will be required at the end in Hingna depot. The major infrastructure facilities planned at Hingna Depot is summarized in **Table 14.4**.

TABLE 14.4 :INFRATRUCTURE FACILITIES PLANNED AT HINGNA DEPOT

Facility	Phase 1	Future (Phase 2)
Stabling Lines	3 lines of 6 car length	8 lines of 6 car length
Inspection Lines	3 lines of 3 car length	3 lines of 3 car length
Workshop Lines	2 lines of 3 car length	2 lines of 3 car length

14.1.3 Rolling Stock Maintenance Needs

➢ **Maintenance Schedule**

Servicing requirements shall be determined from the Rolling Stock manufacturer. Depending upon manufacturer's requirements, servicing facilities may be provided to include the ability to carry out the inspection, maintenance, overhaul and repair of the rolling stock fleet, including the following components:

- Body;
- Bogies;
- Wheels (Re-discing/ re-axling is planned at workshop only);
- Traction motors;
- Electrical components;
- Electronics; PA/ PIS
- Mechanical components;
- Batteries;

- Rolling stock air conditioning;
- Brake modules;
- Vehicle doors, windows and internal fittings.

The modern, fully equipped facilities are to be provided that meet these requirements efficiently and in full. In meeting these requirements, it shall be assumed that the average daily distance travelled by each rolling stock unit is approximately 300 km. The following maintenance schedule in **Table 14.5** in DPR for Nagpur Metro Phase 1 has been followed for the conceptual design:

TABLE 14.5: PROPOSED MAINTENANCE SCHEDULE

Type of Schedule	Interval	Work content	Locations
Daily	Daily	Check on the train condition and function at every daily service completion. Internal cleaning / mopping of floor and walls with vacuum cleaner.	Stabling Lines
A Service Check	5,000 Km (approx. 15 days)	Detailed inspection and testing of sub-systems, under frame, replacement/ topping up of oils & lubricants.	Inspection Bays
B Service Check	15,000 Km (approx. 45 days)	Detailed inspection of 'A' type tasks plus items at multiples of 15,000 Km ('B' type tasks)	Inspection Bays
Intermediate Overhaul (IOH)	420,000 Km (approx. 3.5 years)	Check and testing of all sub-assemblies (Electrical + Mechanical). Overhaul of pneumatic valves, Compressor. Condition based maintenance of sub-systems to bring them to original condition. Replacement of parts and rectification, trial run.	Workshop
Periodical Overhaul (POH)	840,000 Km (approx. 7 years)	Dismantling of all sub-assemblies, bogies suspension system, traction motor, gear, control equipment, air-conditioning units etc. Overhauling to bring them to original condition.	Workshop

Type of Schedule	Interval	Work content	Locations
		Checking repair and replacement as necessary. Inspection and trial.	
Heavy Repairs	-	Changing of heavy item such as bogies, traction motor, axles, gear cases & axle boxes etc.	Workshop

The above Schedule may need slight revision based on the actual earned kilometers per train and the specific maintenance requirements of Rolling Stock finally procured.

- **Washing Needs of Rolling Stock**

The Metro trains are maintained to a high degree of cleanliness and therefore needs the maintenance schedule as mentioned in **Table 14.6.**

TABLE 14.6: SCHEDULE OF CLEANING

S.N.	Kind of Inspection	Maintenance Cycle	Time	Maintenance Place
1.	Outside Cleaning (wet washing on automatic washing plant)	3 Days	10 mins	Automatic washing plant of Depot Single Pass
2.	Outside heavy Cleaning (wet washing on automatic washing plant and Front Face, Vestibule/ Buffer area, Floor, walls inside/ outside and roof Manually)	30 days	3 Hrs	Automatic washing Plant & washing line

14.2.0 DESIGN OF DEPOT FACILITIES AND DEPOT LAYOUT PLANS

14.2.1 Depot Layout Plans

The layouts of MIHAN depot for N-S corridor, Hingna depot for E-W corridor and stabling shed have been placed at **Annexure 14.1, 14.2** & **14.3** respectively.

14.2.2 Infrastructure Facilities Planned at Depot

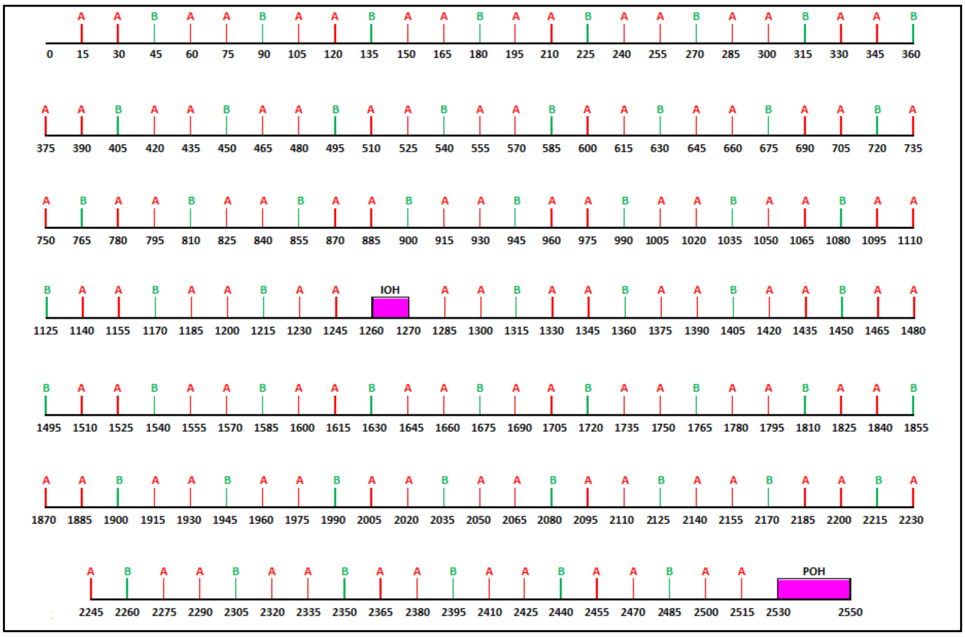
A) Inspection lines and workshop lines in depot

As per the frequency of inspections indicated in **Table 14.5**, the visits of rakes to Depots are as shown below in **Figure 14.1.**

To assess the number of lines required to maintain the rakes, following assumptions are made:

i. For Washing of rakes, an automatic washing plant is proposed. Hence, no separate washing line is needed exclusively for washing. However, one line is provided for heavy cleaning (Manual cleaning of Floor, walls inside/outside and roof).

FIGURE 14.1: RAKE VISITS TO DEPOTS AND WORKSHOPS



ii. In a day, two rakes are taken for ‘A check’ on a pit line.

iii. In a day, one rake is taken for ‘B checks’ on a pit line.

iv. Based on the number of holidays as given below, total numbers of working days are taken as 300 for calculating the requirement of lines.

- No. of days of Public holidays in a year : 13
- No. of Sundays in a year : 52
- No. of available working days in a year : 365 - 65 = 300 days.

As against above requirement, the infrastructure provided for Schedule inspection of the rakes for Nagpur Metro corridors is indicated in **Table 14.7** and **Table 14.8**.

N-S corridor will have maintenance facility at MIHAN Depot which will have the infrastructure to maintain 45 rakes of 3 car. Based on the calculations indicated in **Table 14.7**, the depot is proposed to be planned with 3 inspection lines and 3 workshop lines.

TABLE 14.7: INSPECTION AND WORKSHOP LINES FOR MIHAN DEPOT

Schedule	Total visits per rake in 7 years	Avg. visits /year	Total Arising (for 45 rakes)	Line Occupancy	Lines Required (3 car length)	Lines Provided (3 car length)
Inspection Shed						
A Service Check	112	16	720	2 rakes/ day	1.20	1
B Service Check	54	7.71	347	1 rakes/ day	1.16	1
Adjustment line for minor repair/testing after POH						1
Inspection Lines Provided						**3**
Workshop Shed						
IOH	1	0.14	6.4	1 rake 10 days	0.43	1
POH	1	0.14	6.4	1 rake 20 days	0.86	1
Unscheduled Repair / Lifting /Wheel/Bogie sections etc.						1
Workshop Lines Provided						**3**

TABLE:14.8 INSPECTION AND WORKSHOP LINES FOR HINGNA DEPOT

Schedule	Total visits per rake in 7 years	Avg. visits /year	Total Arising (for 35 rakes)	Line Occupancy	Lines Required (3 car length)	Lines Provided (3 car length)
Inspection Shed						
A Service Check	112	16	560	2 rakes/ day	0.93	1
B Service Check	54	7.71	270	1 rakes/ day	0.90	1
Adjustment line for minor repair/testing after POH						1
Inspection Lines Provided						3
Workshop Shed						
IOH	1	0.14	5.0	1 rake 10 days	0.33	1
POH	1	0.14	5.0	1 rake 20 days	0.67	1
Unscheduled Repair / Lifting /Wheel/Bogie sections etc.						1
Workshop Lines Provided						**3**

Hingna Depot will have the infrastructure for the inspection and overhaul of 35 rakes of 3 car. Accordingly, 3 lines are proposed to be provided for the schedule inspections & 3 lines for periodical overhaul/ major unscheduled repairs etc.

The facilities have been proposed to ensure the maintenance services to complete fleet of rolling stock to meet the requirement of Phase 2. It will also ensure adequacy of system to meet unforeseen growth of traffic beyond the horizon year.

B) Stabling Facilities for Rakes

- **MIHAN Depot**

The total rake requirement for the N-S corridor works out to be 45 rakes of 3 car length for the ultimate/design year.

The MIHAN Depot is provided with the facility to stable 12 rakes of 3 car length in phase-1. Two rakes will remain under inspection at a given time. Thus, considering the above arrangement, the existing stabling facility provided at MIHAN depot may not be sufficient to cater the stabling needs of the corridor, hence, twenty four no stabling of 3 car has been planned just after the Metro city station to meet the rake requirement up to year 2041.

- **Stabling Arrangement for N-S Corridor.**

As per the calculation the rake requirement up to the year 2041 is 45 rakes of 3 car, 14 rakes are maintained at MIHAN Depot, remaining 22+(2 stabling for future) rakes are accommodated in stabling shed located just after Metro city Station and rest are stabled on corridor as **Table 14.9**

TABLE 14.9: RAKES ARRANGEMENT AT N-S- CORRIDOR FOR 10 RAKES

No of Rakes	Location	Arrangement
2	At MIDC ESR	2 rakes at station
2	At Ashokvan	2 rakes at station
2	At Kamptee Police Station	2 rakes at station
4	At Kanhan River	2 at end station 2 at end terminal

- **Hingna Depot**

The total rake requirement for the E-W corridor works out to be 35 rakes of 3 car length for the ultimate/design year.

Hingna Depot has six stabling lines which shall accommodate 12 rakes of three car each. Two rakes will remain in inspection at a given period of time. Thus, considering the above arrangement, the existing stabling facility provided at Hingna depot may not be sufficient to cater to the stabling needs of the corridor. Hence five stabling lines in Hingna depot has been extended to accommodate ten more stabling lines of 3 car, hence area of 160x53m will be required at the end in Hingna depot.

- **STABLING ARRANGEMENT FOR E-W CORRIDOR.**

As per the calculation the rake requirement up to the year 2041 is 35 rakes of car, 24 rakes are maintained at Hingna Depot, remaining 11 rakes are stabled on corridor as in **Table 14.10.**

TABLE 14.10: RAKES ARRANGEMENT AT E-W- CORRIDOR FOR 11 RAKES.

No of Rakes	Location	Arrangement
5	At Transport Nagar	2 rakes at station 3 rakes at end terminal
2	At Hingna Mount View	2 rakes at station
2	At Hingna	2 rakes at station
2	At Dattawadi	2 rakes at station

The depot layouts of MIHAN, Hingna and stabling shed of N-S and E-W corridor have been placed at **Annexure 14.1, Annexure 14.2**and **Annexure 14.3** respectively.

14.2.3 Depot cum Workshop Planning

The workshop bay in MIHAN Depot and Hingna Depot is 86 X 40 m^2 The track spacing between the adjacent Lines shall is 100 m.

i) Stabling Lines in Depot

Looking to the car width of 2900 on Standard Gauge, 5m Track Centre is kept for all the stabling lines. Thus, space between stabling shall be sufficient to include a pathway to be constructed between tracks to provide access for internal train cleaning and undercarriage inspection.

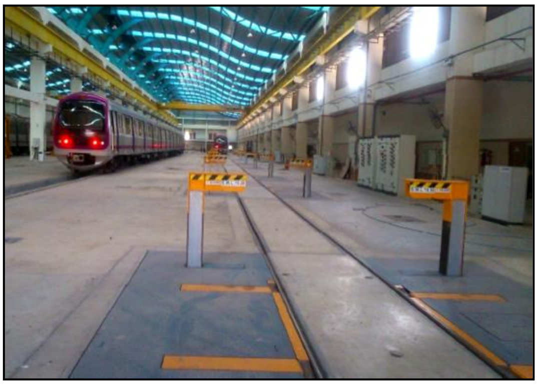
ii) Inspection Lines in Depot

The inspection bay in MIHAN Depot is 86 X 22.4 m² and Hingna Depot is 86 X 23.2 m² size with three inspection lines having sunken floor. The track spacing between the adjacent inspection Bay Lines is 6.70 m.
There would be lighting below the rail level to facilitate the under frame inspection. Ramps of 1:8 slopes, 3 meter wide should be provided with sunken floor system for movement of material for the cars. Further, 3.5 m cross pathways are left at each end for movement of material by fork lifter/ Leister/ Hand trolley. Stinger system shall be provided for 750V DC traction power supply to the rolling stock. 415V 3 phase 50 Hz, 230V 1 phase 50 Hz AC supply and Pneumatic supply shall also be made available on each inspection shed columns. Air-circulators shall be provided on each column.

Roof and walls shall be of such design that optimum natural air ventilation occurs all the time and sufficient natural light is also available. Each Inspection bay will also have arrangement close by for cleaning of HVAC filter under high pressure water jet.

iii) Workshop in depot

The size of the workshop shed in in MIHAN Depot and Hingna Depot is 86 X 40 m² each and an additional covered space is provided in the depots to cater for offices cum maintenance sections, costly item store, locker room, toilet etc. Following equipment repair/overhaul facilities are planned in the workshop.



- Body furnishing
- Bogie
- Wheels
- Traction Motor
- Axle box and axle bearing
- Battery
- Air compressor
- Air conditioning equipments
- Brake equipment
- Door actuators

- Control and measuring equipments
- Pneumatic equipments
- Dampers and Springs
- Couplers/ Gangways

Cross track equipped with bogie turntables have been provided for movement between bays.

iv) Pit Wheel Lathe

A separate building is planned for housing pit wheel lathe (PWL) in both the Depot which is approachable from workshop, inspection bay and stabling lines through rail and road for placement of cars for re- profiling of wheels within the depot along with space for depot of scrap.

v) Engineering Train Unit Workshop

Since the workshop cum depot is designed optimally, it would not be wise to waste its capacity in maintaining the other than passenger Rolling Stock vehicles. Carrying these vehicles to the inspection shed affects the Rolling Stock maintenance as shunting is also involved. Therefore, other vehicles like rail cum road vehicle, tower wagons, etc. may be housed and given required inspection attention in a separate shed called ETU workshop, for which 1 line have been provided in the depots. However for the heavy lifting needs, these vehicles may be taken to main workshop for required attention.

vi) Car Delivery Area

The newly procured coaches, which are transported by road, shall reach the Depot-cum Workshop by the road on trailers. To unload the coaches and bring them to the track, provision of space, along the side of shunting neck, has to be made for unloading of cars and other heavy materials. There should be enough space available for movement of heavy cranes for lifting of coaches. The unloading area should be easily accessible for heavy duty hydraulic trailers.

vii) Automatic Coach Washing Plant (AWP)

Provision to be made for Rolling Stock exterior surfaces to be washed using a fully automated Train Washing System with a throughput capacity of approximately six trains per hour. The AWP shall be situated at such a convenient point on the incoming route so that incoming trains can be washed before entry to the depot and undesirable movement/shunting over ingress and egress routes within the depot is avoided.

viii) Test Track

A test track of 905 mts. length in MIHAN Depot is provided beside workshop. It shall be equipped with signaling equipments (ATP/ATO). It shall be used for the commissioning of the new trains, their trials and testing of the trains after the IOH and POH. In compliance to safety norms, the boundary of the track shall be completely fenced to prevent unauthorized trespassing across or along the track.

ix) Internal Cleaning Shed

Monthly heavy cleaning of interior walls, floors, seats, windows glasses etc, outside heavy cleaning, Front/rear Face, Vestibule/ Buffer area, outside walls and roof shall be done manually in the interior cleaning plant designed for cleaning of one at a time. A line adjacent to inspection shed should be so provided that placement of rakes is possible from workshop or inspection lines & vice – versa conveniently and with ease.

x) Train Operators Booking Office

Suitable office facility adjacent to the stabling lines at each depot should be provided so that train operators reporting 'On' duty or going 'Off' duty can obtain updates regarding 'Special Notices', 'Safety Circulars' and other technical updates/ information in vogue. These offices should have an attached cycle/scooter/car stand facility for convenience of the train operating staff.

xi) Administrative Building

An administrative building close to the main entrance is planned. It can be suitably sized and architecturally designed at the detailed design stage. A time and security office is also provided close to main entrance. It shall be equipped with suitable Access control system for all the staff working in the complex.

xii) Operation Control Centre and Depot Control Centre

Control of train operation will be done centrally from Operations Control Center (OCC), which will house Traffic Control Centre, SCADA System for Traction Power Control & Monitoring, SCADA System for Auxiliary Power, VAC Control & Monitoring, Telecommunication, CCTV Control & Monitoring etc. Movement of trains inside depot shall be controlled from Depot Control Centre (DCC) located inside the depot.

xiii) Parking Facilities

a) Ample parking space shall be provided for the two wheelers and four wheelers at the following points.

i) Close to the depot entry.
ii) Close to the stabling lines.
iii) Close to the Workshop/ IBL.

b) Space for parking of road and re-railing equipments
Enough space for parking of road vehicle/ trailers/ trucks etc. Enough space will also have to be earmarked adjacent to workshops. Similarly, provision of space for parking of re-railing equipments will have to be made close to the main exit gate of the Depot.

xiv) Watch Towers

There shall be provision of adequate number of watch towers for the vigilance of depot boundary.

xv) Power Supply

An auxiliary substation of 2500 KVA capacity has been planned for catering to the power supply requirement of the depot. Details of connected load, feeder may be worked out during detailed designing stage.

xvi) Standby Power Supply

The standby power supply is proposed through silent DG set of 2X320 KVA adequate capacity to supply all essential loads without over loading.

xvii) Compressed Air Supply

Silent type compressor units shall be suitably installed inside the depots at convenient location for the supply of compressed air to workshop and Inspection sheds. Thus, the pneumatic pipeline shall run within the workshop and inspection bays as to have compressed air supply line at all convenient points.

xviii) Water Supply, Sewerage and Drainage Works

In house facilities shall be developed for the water supply of each depot. Sewerage, storm water drainage shall be given due care while designing the depots for efficient system functioning. Past records of Municipal Corporation shall be used to design the drainage system. Rainwater harvesting would be given due emphases to charge the underground reserves.

xix) Plant And Machinery

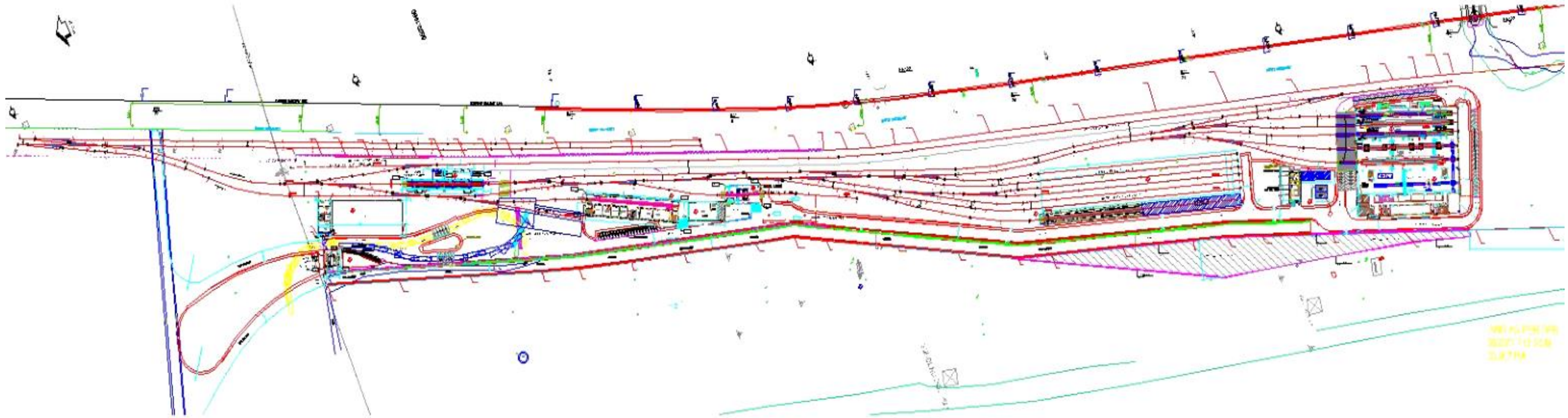
Some of the major equipments used in the Maintenance Depot are given in figure below:

Synchronized Mobile Jacks

Synchronized Pit Jacks

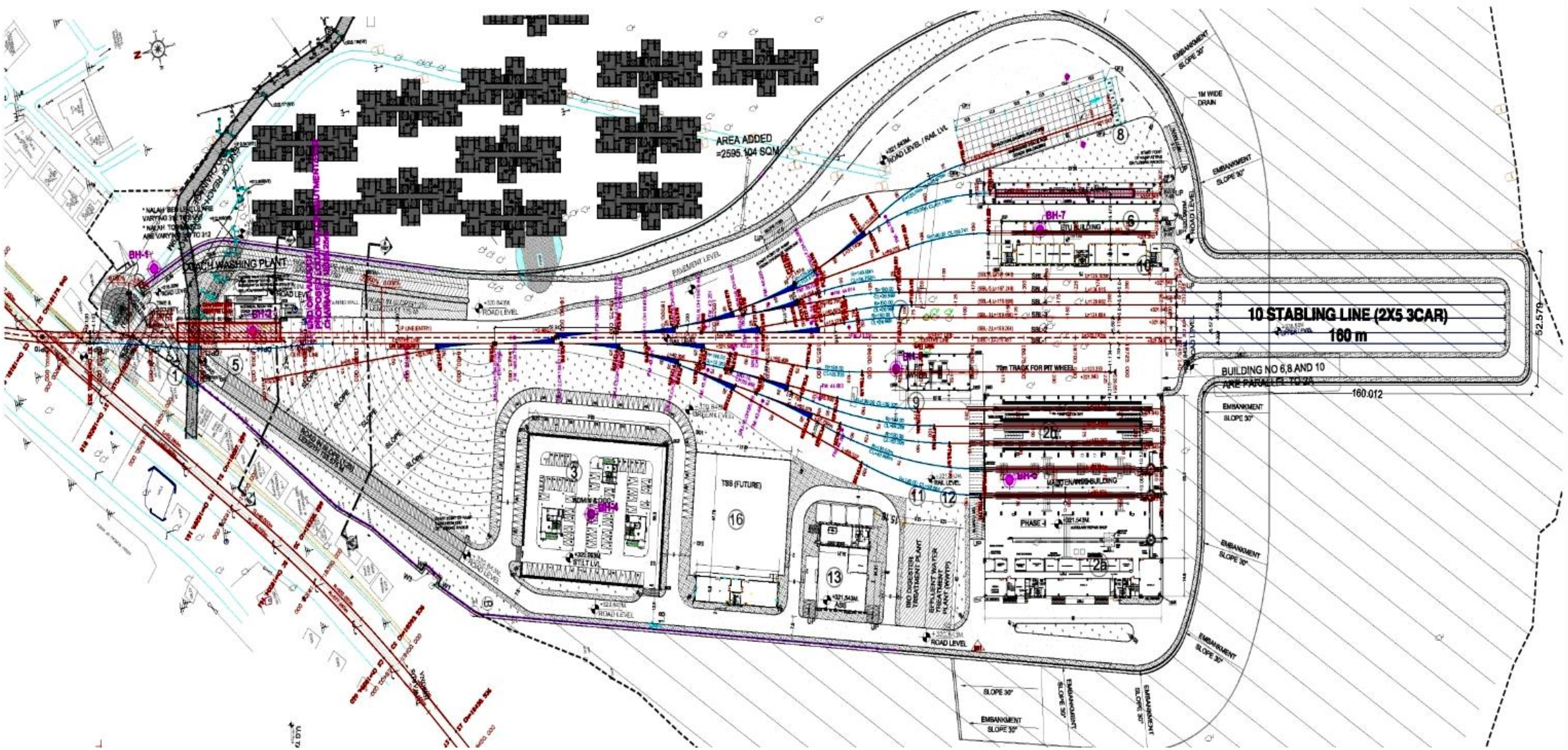
Annexure 14.1

LAYOUT PLAN FOR MIHAN DEPOT



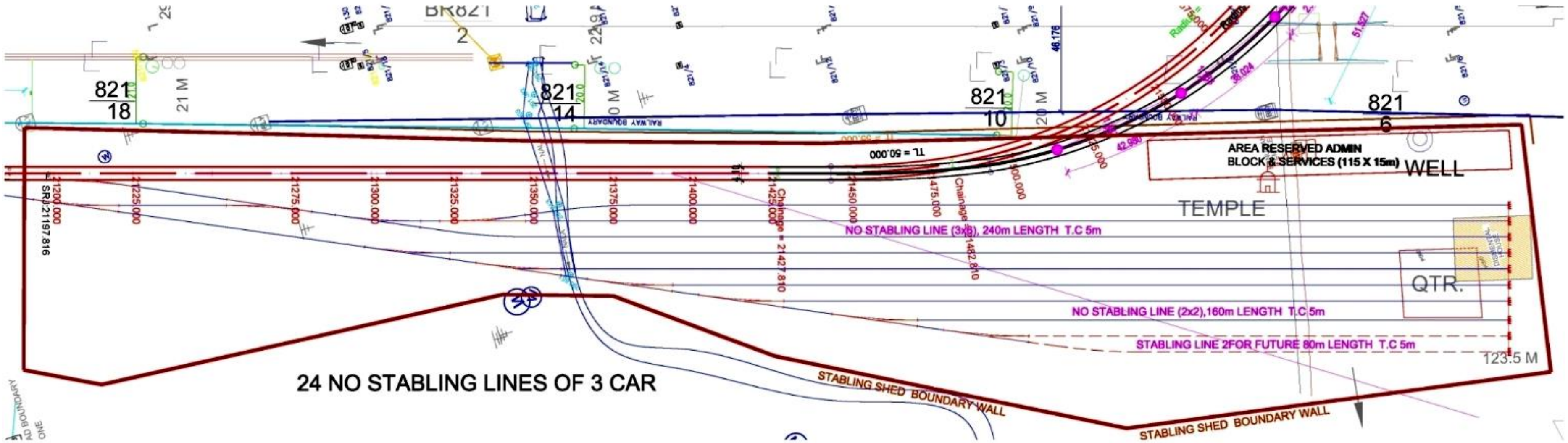
Annexure 14.2

LAYOUT PLAN FOR HINGNA DEPOT



Annexure 14.3

STABLING LINES AFTER METRO CITY STATION



Chapter – 15
ENVIRONMENTAL AND SOCIAL IMPACT ASSESSMENT

15. ENVIRONMENTAL AND SOCIAL IMPACT ASSESSMENT

15.1 EXISTING SCENARIO

A scoping matrix was formulated to identify the attributes likely to be affected due to the development of proposed project and is presented in **Table 15.1**. Environmental attributes and frequency of baseline survey for water quality, soil quality, ambient air and noise environment in the project area is presented in **Table 15.2**.

TABLE 15.1: SCOPING MATRIX FOR THE PROJECT

Aspect of Environment	Likely Impacts
A. Land Environment	
Construction Phase	Increased soil erosion
	Pollution by construction spoils
	Solid waste from worker colonies, construction sites
B. Water Resources & Water Quality	
Construction Phase	Water quality impacts due to disposal of wastewater from worker camps and construction sites, spoils.
	Depletion of groundwater resources
Operation Phase	Drainage, Water requirement, and Disposal of waste water
C. Air Pollution	
Construction Phase	Impacts due to emissions generated by construction machinery
	Fugitive emissions from various sources
D. Noise Pollution	
Construction Phase	Noise due to operation of various construction equipment
	Noise due to increased vehicular movement
	Noise due to DG sets
Operation Phase	Noise from Metro operation
	Noise due to DG sets
E. Ecology	
Construction Phase	Removal of vegetation cover/loss of biomass
F. Socio-Economics	
Construction Phase	Improved employment potential during project construction phase
	Development of allied sectors leading to greater employment
	Pressure on existing infrastructure facilities
Operation Phase	Increase in Employment Opportunities in direct and indirect sectors

The collection and compilation of environmental baseline data is essential to assess the impacts on environment due to the project activities. The general environmental attributes pertaining to the proposed metro project along with parameters to be collected and its frequency are presented in **Table 15.2**.

TABLE 15.2: ENVIRONMENTAL ATTRIBUTES AND FREQUENCY OF MONITORING

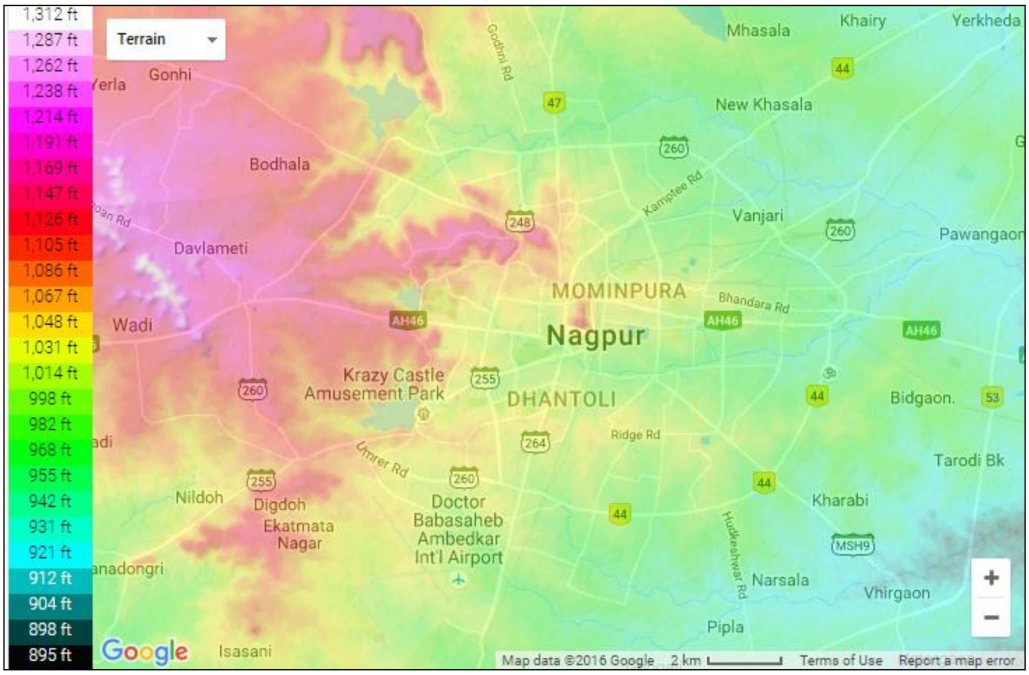
S. No	Attribute	Parameter	Frequency	Source
LAND ENVIRONMENT				
1	Soil	Soil Characteristics	Once	Field studies/literature review
2	Geology	Geological History	---	Literature review
3	Seismology	Seismic Hazard	---	Literature review
WATER ENVIRONMENT				
4	Water Quality	Physical, Chemical and Biological parameters	One Season	Field studies/literature review
AMBIENT ENVIRONMENT				
5	Ambient Air Quality	$PM_{2.5}$, PM_{10}, SO_2,, NO_2, CO	24 hr in one Season	Field Studies
6	Meteorology	Temperature, Relative humidity, Rainfall, wind direction and speed	Last five years/available	India Meteorological Department/literature review
7	Noise	Noise levels in dB (A)	24 hr in one Season	Field studies
SCIO-ECONOMIC				
9	Socio-Economic Aspects	Socio-economic characteristics	Once	Field Studies, Literature review
ECOLOGY				
10	Ecology	Flora & Fauna	Once	Literature and Field observations

15.1.1 Land Environment

The land environment primarily consists of physiography, soil, geology & minerals, and land use pattern.

Physiography: Nagpur is located at the exact centre of the Indian peninsula. The city has a Zero Mile stone locating the geographical centre of India, which was used by the British to measure all distances within the Indian subcontinent. It is located at latitude 21.15° N and longitude 79.09° E with an elevation of 310 m above mean sea level. The greater part of the district is an undulating plain, but it is traversed by low hill ranges. In the north a strip of the Satpura hills is included within its twelve miles or more towards the east. Immediately south of them lies the western extremity of the Ambagarh hills, on which stand the well-known temples of Ramtek. The hills attain to no great altitude, the highest not exceeding 2000 feet, but vary greatly in appearance, being in places extremely picturesque and clothed with forest, while elsewhere they are covered by loose stones and brushwood, or wholly bare and arid. The topographical map of Nagpur is shown in **Figure 15.1.**

FIGURE 15.1: TOPOGRAPHICAL MAP OF NAGPUR



Geomorphology and Soils: The district forms part of Deccan Plateau having flat topped and terraced features. Eastward and north eastwards the landscape changes due to the change in the underlying rocks. The rocks of Gondwana series present a low rolling topography with a poor soil cover and vegetation. On the north the upland ranges are the extension of Satpuras which gradually narrows down towards west. The north eastern and east central part of the district is drained by the Wainganga and its tributaries. The central and western portion is drained by the Wena which is a tributary of Wardha river. There are six types of soils found in Nagpur district. The details are as follows:

1) **Kali soils:** These are black cotton soils which are fine grained clayey in texture and varies in depth from 1 m to 6 m or more and retain moisture. They are found around Kalmeshwar, Saoner and Nagpur.
2) **Morand soils:** These are predominant in the district. They are black cotton soils with higher percentage of lime than the Kali soils.

3) **Khardi soils:** They are shallow soils mixed with sand and found mainly in hills. These are grey in colour, clay loam in texture. 5
4) **Bardi soils:** They are red gravel covered with boulders found on summits and slopes of trap hills and are less fertile in nature.
5) **Kachchar soils:** They are mainly found in the banks of Kanhan river and are alluvial soils, loamy in nature and vary in depth from 1 to 3 m.
6) **Wardi soils:** They are red soils with a large amount of sand. They are shallower and clayey loam in nature. They are mainly found in the paddy tracts in the eastern part of the district.

One sample each at 10 locations were tested along the proposed extension of metro corridors. The location names are given in **Table 15.3** and geographical locations are shown in **Figure 15.2.**The laboratory analysis results so obtained are reported in **Table 15.4**. The soils are slightly alkaline in nature. The soils are mainly silty clay in texture. Organic matter content in soils varies from 1.96 to 2.32 g/100g.

TABLE 15.3: SAMPLING LOCATIONS FOR SOIL

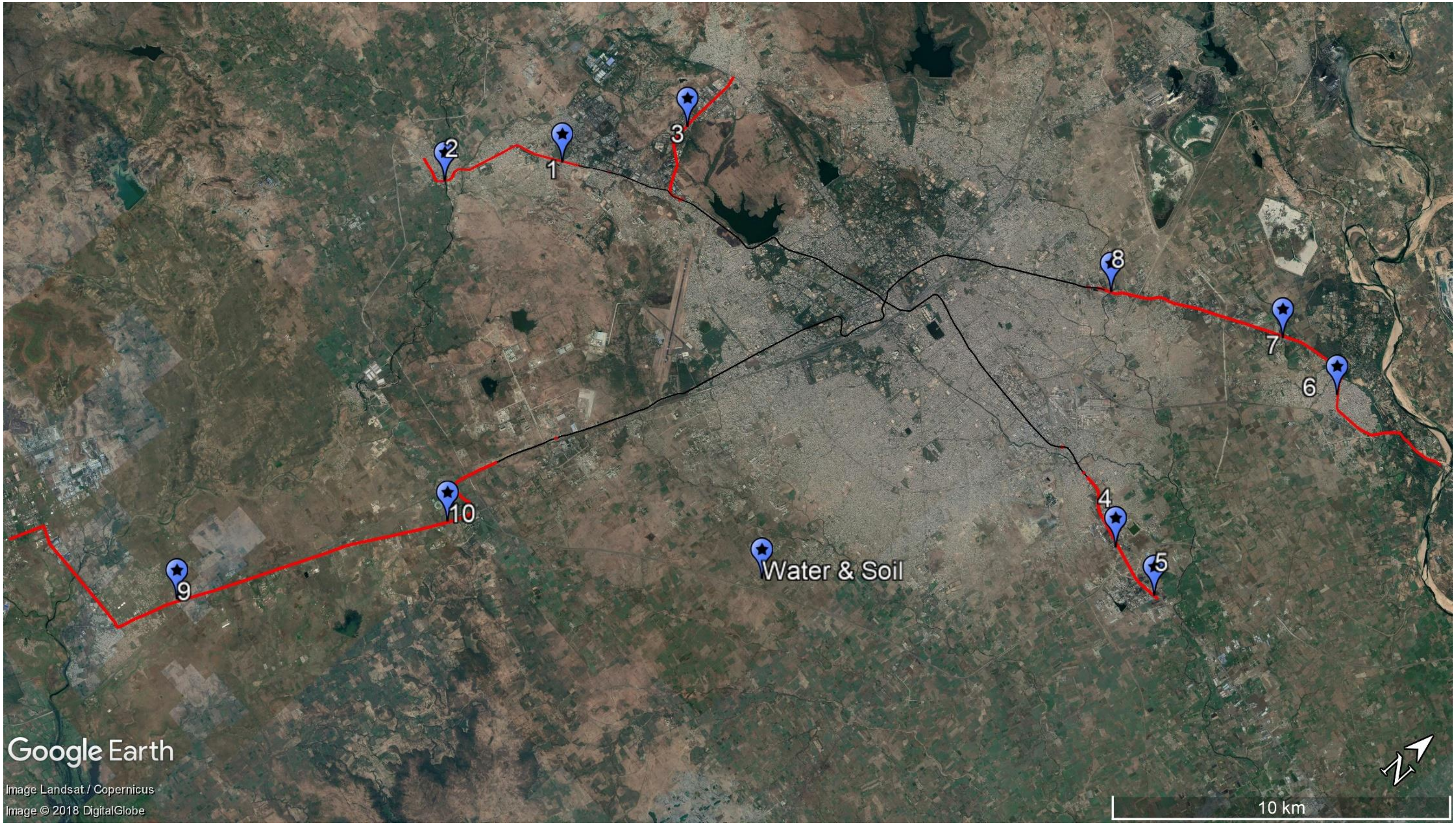
S. No.	Soil Sample Location	Corridors
1.	Gajanan Nagar,Hingna	Hingna
2.	Near Raipur, Hingna	
3.	Near BEML Office MIDC Road, Wadi Ring Road	Wadi
4.	Near Pardi Petrol Pump	Kapsi
5.	Transport Nagar, NH 6	
6.	Near Primary Health Centre,Kamptee	Kanhan
7.	Near Budhha Bhumi, Kamptee Road	
8.	Near Pili Nadi, Kamptee Road	
9.	Near Satgaon Bus Stop, Wardha Road	Butibori
10.	Jamtha T point, Wardha Road	

TABLE 15.4: RESULTS OF LABORATORY ANALYSIS OF SOIL SAMPLES

S. No.	Parameter	Unit	Hingna		Wadi	Kapsi		Kanhan			Butibori	
			1	2	3	4	5	6	7	8	9	10
1	pH (1:2% Aq. Extract)	-	7.90	6.6	7.50	7.51	6.5	7.48	7.60	6.8	7.57	7.77
2	Soil Texture	-	Silty clay	-	Slity clay	Slity clay	Silty clay loam	Slity clay	Slity clay	Silt clay	Silty Clay	Silty Clay
3	Sand	g/100g	62	-	24	12	-	14	11	-	12	10
4	Silt	g/100g	22	-	42	46	-	47	49	-	48	48
5	Clay	g/100g	16	-	34	42	-	39	40	-	40	42
6	Calcium (as Ca)	mg/kg	159.36	364.94	317.33	318.72	212.29	236.03	239.71	212.94	159.08	239.42
7	Magnesium (as Mg)	mg/kg	194.22	107.52	193.37	194.22	129.23	191.78	96.88	129.59	96.44	96.77
8	Potassium (as K)	Kg/ha	135	300.3	650	693	37.10	687	231	635.9	290	600
9	Chloride (as Cl)	mg/kg	292.83	152.26	291.55	292.82	244.08	192.76	293.65	146.85	292.30	293.29
10	Bicarbonate (as HCO3)	mg/kg	2126.49	485.33	628.72	948.21	466.67	623.52	633.24	702.15	630.24	632.48
11	Sulphate (as SO4)	mg/kg	272.31	463.92	306.62	272.31		189.72	143.25	204.98	169.22	313.05
12	Available Nitrogen (as N)	Kg/ha	131.71	231.72	191.29	185.02	234.79	178.75	197.56	325.28	172.18	150.46
13	Available Phosphorous (as P)	Kg/ha	8.40	16.39	38.40	22.29	18.21	18.58	69.10	21.24	28.11	64.42
14	Total Organic Matter	g/100g	2.18	0.77%	2.32	2.08	1.12%	2.10	1.96	0.63%	2.32	2.12
15	Organic Carbon	g/100g	1.26	0.45%	1.34	1.20	0.65%	1.21	1.13	0.37%	1.34	1.23
16	Electrical Conductivity (1:2% Aq. Extract)	µs/cm	203.6	152.26	177.1	136.1	250.6	101.8	71.85	212.7	121.4	100.7
17	Carbonate (as CO3)	mg/kg	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
18	Orthophosphate	mg/kg	3.75	7.31	17.14	9.95	8.12	8.29	3.08	9.48	12.55	28.75
19	Phosphate (as PO4)	g/100g	0.09	0.067	0.11	0.09	904.77	0.086	0.07	0.17	0.09	0.081
20	Sulphur (as SO4)	g/100g	0.63	0.51	0.47	0.51	4261.96	0.48	0.63	0.17	0.60	0.54
21	Arsenic (as As)	g/100g	ND	Absent	ND	ND	Absent	ND	ND	ND	ND	ND

S. No.	Parameter	Unit	Hingna		Wadi	Kapsi		Kanhan			Butibori	
			1	2	3	4	5	6	7	8	9	10
22	Boron (as B)	g/100g	0.012	0.028	0.025	0.008	45.12	0.01	0.01	0.031	0.005	0.014
23	Cadmium (as Cd)	g/100g	ND	0.0035	ND	ND	2.49	ND	ND	0.003	ND	ND
24	Copper (as Cu)	g/100g	0.005	0.0057	0.011	0.002	126.33	0.002	0.002	0.007	0.005	0.009
25	Iron (as Fe)	g/100g	3.22	4.01	6.79	2.20	4216.39	2.84	2.86	4.27	0.19	3.49
26	Lead (as Pb)	g/100g	ND	0.001	ND	ND	10.62	ND	ND	0.001	ND	ND
27	Manganese (as Mn)	g/100g	0.10	0.10	0.005	0.071		0.08	0.11	0.076	0.007	0.09
28	Mercury (as Hg)	g/100g	ND	ND	ND	ND	2.49	ND	ND	Absent	ND	ND
29	Molybdenum (as Mo)	mg/kg	ND	ND	ND	ND	Absent	ND	ND	Absent	ND	ND
30	Nickel (as Ni)	g/100g	ND	0.005	ND	ND	58.97	ND	ND	0.004	ND	ND
31	Zinc (as Zn)	g/100g	0.004	0.002	0.088	0.004	1.8	0.009	0.004	0.002	0.006	0.014

FIGURE 15.2: WATER AND SOIL SAMPLING LOCATION MAP



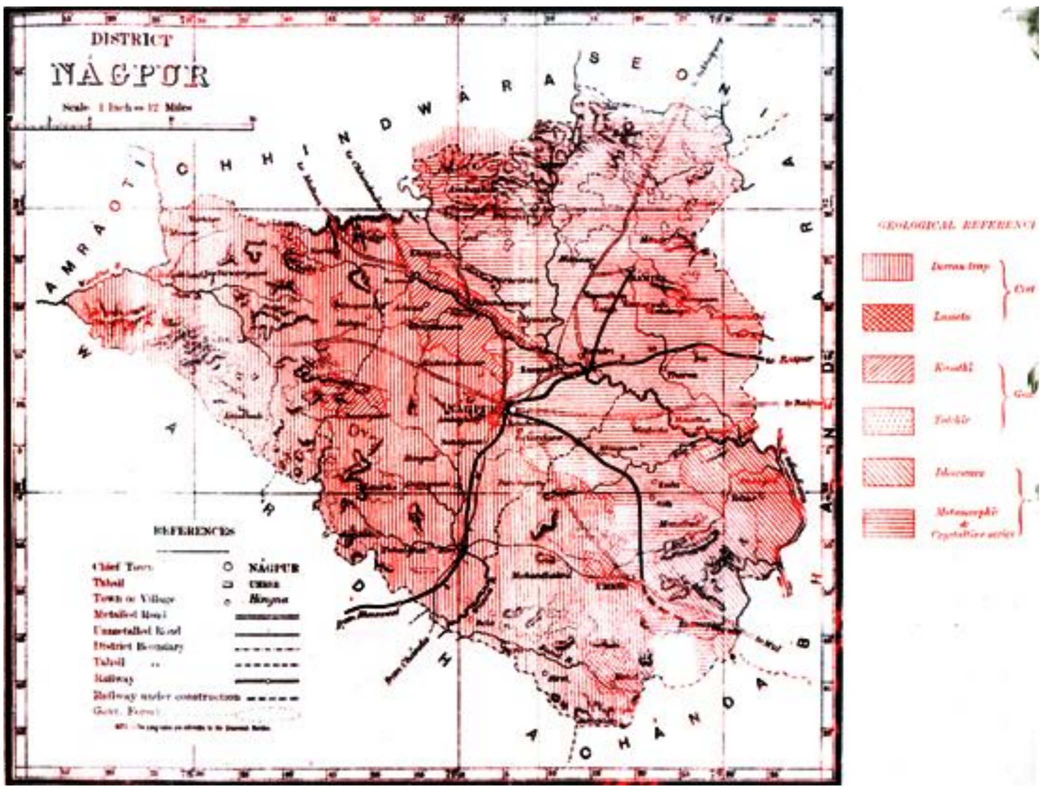
1 to 10 Locations- Soil & Water: Refer Table 15.3

Phase II Extension Corridors

Geology and Minerals: The town of Nagpur stands upon the eastern edge of the undulating trap country, the cantonment and civil station of Sitabuldi being, for the most part, built upon the trap itself. The country to the west does not rise into hills of any great height, though it is interspersed with low ranges, and both these and the valleys between are covered with black soil, much mixed with stones, Southward the country is similar to that to the west. The district can be divided into two main areas, namely the country to the west of Nagpur occupied by the Deccan Trap formation and the country to the east of Nagpur occupied by the metamorphic and crystalline series; the two other formations, the Lametas and the Gondwanas, are found only along the junction of the trap and crystallines. To the south-east, east, and north-east the surface is, for the most part, a plain covered with the alluvial deposits of the Kanland its tributaries.

To the east this plain extends as far as the eastern boundary of Nagpur, but in the north-eastern corner of the district the becomes very hilly and rather wild, this being the area where the crystalline rise to form hills and are seen to the best advantage. The general level of the Nagpur plain is about 900 to 1000 feet. The geological map of Nagpur District is shown in **Figure 15.3**.

FIGURE 15.3: GEOLOGICAL MAP OF NAGPUR DISTRICT



Source: Nagpur Gazetteer

Landuse: Majority of land within the Nagpur Metropolitan Area (NMA) is a combination of farmland, forest areas, and urban activities along the major transport corridors such as the national and state highways, and railway routes. The periphery of the Nagpur city also houses a variety of urban uses. The land use classes are given in **Table 15.5**. Land uses related to areas that have already been developed (converted from its natural setting) have been classified into developed land with categories including uses like residential, commercial, industrial, public/semi-public, and transportation including roads, railway and transport interchanges. Total developed area in the NMA accounts to about 9.2 percent of the entire NMA area.

TABLE 15.5: AREA COVERED UNDER EXISTING LAND USES IN THE NMA

S. No.	Land use Class	Area (sq km)	Percent of Total area
1	Residential	97.30	2.73%
2	Commercial	6.91	0.19%
3	Industrial	66.48	1.86%
4	Public-Semi-public	13.30	0.37%
5	Public Utility	1.51	0.04%
6	Recreation/Open space	0.92	0.03%
7	Defence	21.73	0.61%
8	Transportation	122.25	3.43%
9	Hills	113.63	3.19%
10	Mines/Quarries	28.44	0.80%
11	Agriculture	2,357.91	66.10%
12	Forest	508.47	14.25%
13	Water bodies	228.53	6.41%
	Total Area	3,567.37	100.00%

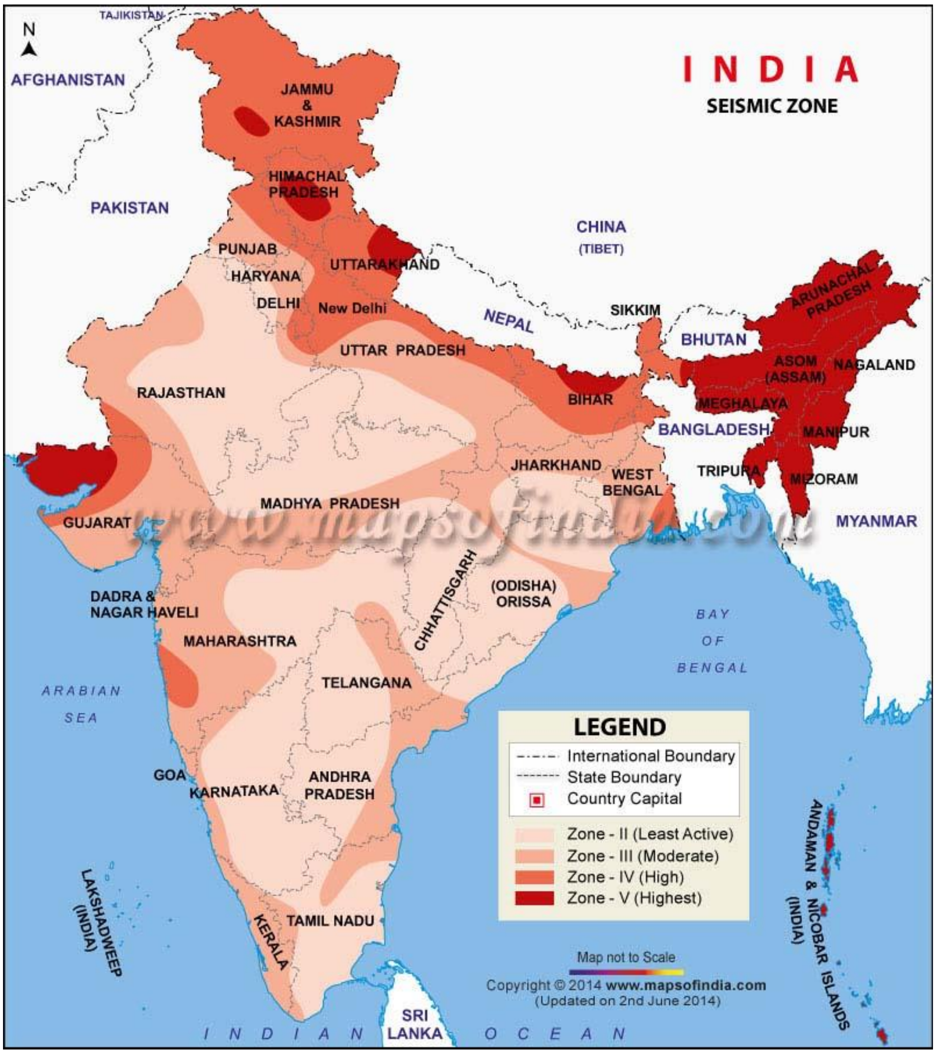
Source: Development Plan for NMA 2032

Seismicity: In the seismic zoning map of India prepared by Bureau of Indian Standards (BIS) the area of Nagpur and its neighbourhood lies in Zone II as shown in **Figure 15.4**. It means that Nagpur has close to zero chances of getting a major earthquake which may cause huge devastation. Recent history also supports the fact that Nagpur region is relatively very safe as far as earthquakes are concerned.

15.1.2 Water Environment

Water environment consists of water resources and its quality. Its study is important from the point of view to assess the sufficiency of water resources for the needs of in its various stages of the project cycle and also to assess the impact of the project activities on water environment.

FIGURE 15.4: SEISMIC ZONING MAP OF INDIA



Hydro-geological Characteristics: The hydro-geological characteristics are discussed below;

Consolidated Formations - Archeans and the Deccan trap basalts are the two consolidated formations, which form the Hard rock aquifers occurring in the district. **Archaean,** The crystalline rocks comprising of gneiss, schist, pegmatite and quartzite are the main formations occurring in north-eastern and south eastern parts of the district. In these rocks, weathered zone which is down to a depth of 25 m below ground level, forms the important shallow aquifer for dug wells. **Deccan Traps,** Basalt is the main formation of the district. Ground water occurs under phreatic conditions in the exposed lava flows and in semi-confined to confined state in the subsurface flows. Ground water is present in pore spaces in the vesicular unit of each flow and in the jointed and fractured portions of massive unit.

Semi-Consolidated Formations - two types of semi consolidated formations i.e. Lameta and Gondwanas occur in the district. They along with the unconsolidated Alluvial formation form the soft rock aquifers occurring in the district. **Lameta beds,** it is not a good water bearing formation. **Gondwana Sediments,** Gondwana formation, occurs in the northern part of the Nagpur city extending from Kamptee to Saoner, and an isolated patch also occurs near north of Sathnaori. These constitute the important water bearing formations in the district.

Unconsolidated Alluvial Formations - Alluvium consisting of sand, silt, clay and kankar forms the potential water bearing formations and occurs in southern part of the district from Butibori to Bela. These formations are highly productive aquifers and sustain long duration pumping with very less drawdown and fast recuperation. Ground water occurs in water table and semi-confined conditions in the alluvial formation.

Water Resources: Nagpur city gets water from the three sources namely Gorewada tank, Kanhan River and Pench Canal. As the area is mostly covered by Deccan traps, unclassified gneisses, granites, sandstones and shales, the underground aquifers are mostly due to secondary porosity and fractures in the rocks. The yields range between 1 to 5 litres/sec in the NMA. Ground water is available from both confined and unconfined aquifers. Dug wells generally tap upper shallow aquifer and whereas bore wells tap both upper shallow and deep aquifers. According to CGWB report for Nagpur district pre-monsoon (May 2011) depth to water level is 0.08 to 15.59 m bgl and post-monsoon (Nov 2011) depth to water level is 0.60 to 10.60 m bgl. In general the groundwater flow direction in the entire area is towards east. As per the estimation during 2004, the total annual ground water recharge in the Nagpur District was1102.27 million cubic meter (MCM) with the natural discharge of 60.38 MCM, thus the net annual groundwater availability came out to be 1041.89 MCM. The allocation for domestic and industrial water requirements for the next 25 years is worked at 102.28 MCM. The net ground water availability for future irrigation is estimated at 567.62 MCM. Stage of ground water development varies from 13.57 percent (Mauda) to 98.53 percent (Katol).

Drainage: The Nagpur Metropolitan Area is drained by the Kanhan and Pench rivers in the centre, the Wardha in the west, and the Wainganga in the east. Both Wardha and Wainganga rivers later merge as Pranahitha, tributary of Godavari River. The area has a natural slope in two directions. The upper portion slopes from north to southeast and lower portion has slopes from south west to southeast. Due to the slope in dual direction and because of presence of many nallahs and rivers the total project area has excellent natural drainage pattern. Approximately 70 percent of the NMA drains into

River Wainganga through Kanhan River and its tributaries. Tributaries of Kanhan that drain from project area are Pench, Chandra Bagha, Nag, Pilli and Kanhari.

Water Quality: Water quality includes the physical, chemical and biological characteristics of water. An understanding of the various factors influencing water quality is thus very important as human health is largely dependent on the quality of water available for use.

One sample each at 10 representative locations along the extension of corridors were tested for quality. The locations from which water samples were collected are shown in **Figure 15.2** and details of water sample locations are given in **Table 15.6**. The samples were analyzed for physical and chemical constituents for the purpose of domestic and irrigation use. The results of water analysis are compared with CPHEEO manual for Drinking Water Specifications and IS 10500:2012. The results of analysis are presented in **Table 15.7**.

TABLE 15.6: WATER QUALITY MONITORING LOCATIONS

S. No.	Water Sample Location	Corridors	Remark
1.	Gajanan Nagar Hingna	Hingna	Bore Water
2.	Near Raipur		Canal Water
3.	Near BEML Office MIDC Road, Wadi Ring Road	Wadi	Tap Water
4.	Near Pardi Petrol Pump	Kapsi	Well Water
5.	Transport Nagar, NH 6		Bore water
6.	Near Primary Health Centre, Kamptee	Kanhan	Hand Pump
7.	Near Budhha Bhumi, Kamptee Road		Canal Water
8.	Pili Nadi, Kamptee Road		Surface water
9.	Near Satgaon Bus Stop, Wardha Road	Butibori	Hand Pump
10.	Jamtha T- point,		Hand Pump

The analysis of results of water samples indicates that most of the parameters are within the permissible limit but Coliform found in all samples except at no 1.Water from these sources should be treated before using it for drinking purposes. Bacteriological contamination may be due to existing sewer/drains flowing adjacent to the source.

TABLE 15.7: PHYSICO-CHEMICAL ANALYSIS OF WATER SAMPLES

S. No.	Parameter	Unit	Hingna		Wadi	Kapsi		Kanhan			Butibori		Acceptable Limit	Permissible Limit
			1	2	3	4	5	6	7	8	9	10		
1	Turbidity	NTU	0.8	-	1.4	0.2	8	3.6	28	-	0.4	14	1	5
2	Total suspended solids	mg/l	< 10	<10	< 10	< 10		< 10	< 10	<10	<10	<10	-	-
3	pH at 25°C	-	7.00	6.80	6.85	7.25	7.46	6.78	7.90	7.4	6.88	6.75	6.5 to 8.5	No relaxation
4	Total dissolved solids	mg/l	1146	410	398	1168	318	1042	722	296	918	684	500	2000
5	Total hardness (as $CaCO_3$)	mg/l	564	224.22	152	412	193.28	406	102	204.24	464	376	200	600
6	Chloride (as Cl)	mg/l	149.69	101.07	70.45	203.51	118.54	90.99	15.65	45.94	81.21	30.33	250	1000
7	Sulphate (as SO_4)	mg/l	79.55	10.36	15.57	102.41	42.92	93.67	10.31	8.03	28.01	31.04	200	400
8	Fluoride (as F)	mg/l	0.55	0.28	0.53	0.69	0.26	0.7	0.47	0.31	1.62	1.41	1.0	1.5
9	Nitrate (as NO_3)	mg/l	43.56	1.83	4.50	25.24	7.19	38.18	< 2	1.68	14.99	28.64	45	No relaxation
10	Calcium (as Ca)	mg/l	155.2	51.50	36	122.4	58.19	105.6	29.6	-	105.6	108	75	200
11	Magnesium (as Mg)	mg/l	42.85	23.24	15.09	25.81	11.64	34.58	6.82	24.86	48.7	25.81	30	100
12	Alkalinity (as $CaCO_3$)	mg/l	325	190	127.4	286	237.82	102.5	97.5	144	504.4	384.8	200	600
13	Free residual chlorine	mg/l	< 0.1	-	< 0.1	< 0.1	<0.1	< 0.1	< 0.1	-	<0.1	<0.1	Min. 0.2	1
14	Phenolic compounds (as C_6H_5OH)	mg/l	< 0.001	< 0.001	< 0.001	< 0.001	<0.001	< 0.001	< 0.001	< 0.001	<0.001	<0.001	0.001	0.002
15	Cyanide (as CN)	mg/l	< 0.005	-	< 0.005	< 0.005	<0.005	< 0.005	< 0.005	-	<0.005	<0.005	0.05	No relaxation
16	Oil & grease	mg/l	< 4	-	< 4	< 4	-	< 4	< 4	-	<4	<4	-	-
17	Dissolved oxygen	mg/l	4.5	6.0	4.7	4.9	6.1	4.7	5.4	5.7	5.2	4.7	-	-
18	Biochemical oxygen	mg/l	< 2	7.54	< 2	< 2	-	< 2	< 2	12.4	<2	<2	-	-

S. No.	Parameter	Unit	Hingna		Wadi	Kapsi		Kanhan			Butibori		Acceptable Limit	Permissible Limit
			1	2	3	4	5	6	7	8	9	10		
	demand (at 27^0 C for 3 days)													
19	Chemical oxygen demand	mg/l	< 4	24.0	< 4	< 4	-	< 4	< 4	37.1	< 4	< 4	-	-
20	Dissolved Phosphate (as P)	mg/l	< 0.03	-	< 0.03	< 0.03	--	< 0.03	< 0.03	-	< 0.03	< 0.03	-	-
21	Free Ammonia (as NH_3)	mg/l	< 0.01	-	< 0.01	< 0.01	-	< 0.01	< 0.01	-	< 0.01	< 0.01	-	-
22	Ammonical nitrogen (as N)	mg/l	0.48	-	< 0.1	0.43	-	0.44	< 0.05	-	0.26	0.29	0.5	No relaxation
23	Nitrate nitrogen (as N)	mg/l	5.56	-	1.01	5.24	7.19	8.18	< 2	-	3.38	6.27	-	-
24	Total nitrogen (as N)	mg/l	45.18	-	5.20	15.63	-	42.18	2.80	-	18.64	30.20	-	-
25	Sulphide (as H_2S)	mg/l	< 0.03	-	< 0.03	< 0.03	-	< 0.03	< 0.03	-	<0.03	<0.03	0.05	No relaxation
26	Potassium (as K)	mg/l	1.08	6.46	5.53	13.2	-	0.8	2.1	6.46	1.12	0.87	-	-
27	Sodium (as Na)	mg/l	94.6	75.0	59.0	205	-	194	34.1	59.44	89.2	49.6	-	-
28	Organic phosphorus (as P)	mg/l	< 0.03	-	< 0.3	< 0.03	-	< 0.3	< 0.03	-	<0.03	<0.03	-	-
29	Iron (as Fe)	mg/l	0.10	0.07	0.13	0.21	-	0.34	0.18	0.19	0.16	0.42	1.0	No relaxation
30	Manganese (as Mn)	mg/l	< 0.05	0.26	0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	0.1	0.3
31	Copper (as Cu)	mg/l	< 0.03	-	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	0.05	1.5
32	Aluminium (as Al)	mg/l	< 0.005	< 0.005	0.19	< 0.005	< 0.1	0.01	< 0.005	< 0.005	0.02	0.05	0.03	0.2
33	Zinc (as Zn)	mg/l	< 0.1	0.42	< 0.1	< 0.1	0.17	3.11	< 0.1	< 0.1	4.79	0.16	5	15
34	Arsenic (as As)	mg/l	< 0.01	< 0.01	< 0.01	< 0.01	< 0.1	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.01	No relaxation

S. No.	Parameter	Unit	Hingna		Wadi	Kapsi		Kanhan			Butibori		Acceptable Limit	Permissible Limit
			1	2	3	4	5	6	7	8	9	10		
35	Cadmium (as Cd)	mg/l	< 0.001	0.02	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	<0.01	< 0.001	< 0.001	0.003	No relaxation
36	Hexavalent chromium (as Cr^{+6})	mg/l	< 0.03	-	< 0.03	< 0.03	-	< 0.03	< 0.03	-	< 0.03	< 0.03	-	-
37	Lead (as Pb)	mg/l	< 0.001	0.08	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.07	< 0.001	< 0.001	0.01	No relaxation
38	Selenium (as Se)	mg/l	< 0.001	-	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	-	< 0.001	< 0.001	0.01	No relaxation
39	Mercury (as Hg)	mg/l	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	0.001	No relaxation
40	Total Phosphate (as PO_4)	mg/l	< 0.03	0.05	< 0.02	< 0.02		< 0.02	< 0.02	0.59	< 0.02	< 0.02	-	-
41	Total Chromium (as Cr)	mg/l	0.16	0.05	< 0.03	< 0.03	< 0.03	0.05	< 0.03	0.42	< 0.03	< 0.03	0.05	No relaxation
42	Boron (as B)	mg/l	< 0.03	-	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	-	< 0.1	< 0.1	0.5	1.0
43	Barium (as Ba)	mg/l	< 0.001	-	0.02	< 0.001	-	0.03	< 0.001	-	< 0.001	< 0.001	0.7	No relaxation
44	Silver (as Ag)	mg/l	< 0.01	-	< 0.001	< 0.001	-	< 0.001	< 0.001	-	< 0.001	< 0.001	0.1	No relaxation
45	Vanadium (as V)	mg/l	< 0.01	-	< 0.01	< 0.01	-	< 0.01	< 0.01	-	< 0.01	< 0.01	-	-
46	Nickel (as Ni)	mg/l	< 0.01	< 0.01	< 0.01	< 0.01	-	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.02	No relaxation
47	Total coliform	MPN/100 ml	Absent	63	< 2	50	< 2	< 2	542	1600	<2	<2	Absent	Absent
48	Faecal coliform	per 100 ml	< 0.03	-	Absent	Absent	Absent	Absent	Absent	-	Absent	Absent	-	-

15.1.3 Meteorology and Air Environment

Meteorology is an important parameter in environmental impact assessment study. It is responsible for the movement of air pollutants.

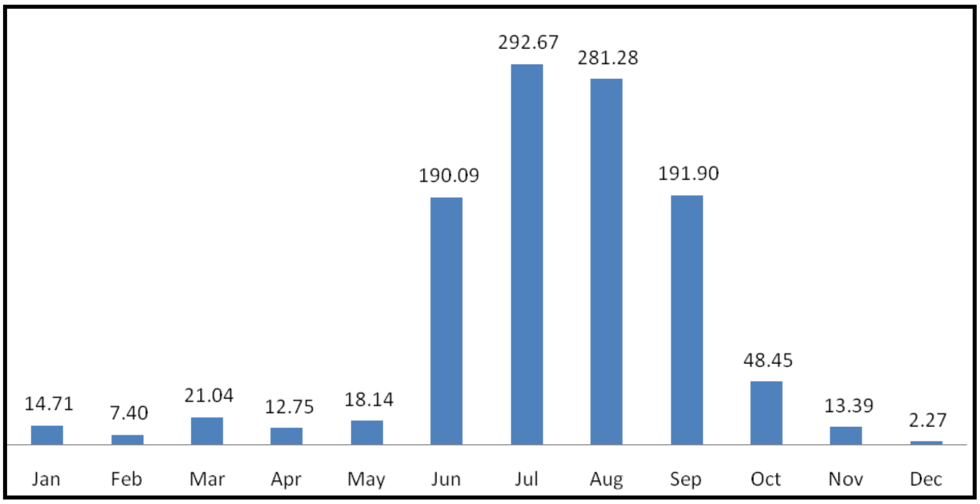
Climate and Rainfall: The climate of the district is characterized by a hot summer and general dryness throughout the year except during the south-west monsoon season, i.e., June to September. The mean minimum temperature is 12°C and means maximum temperature is more than 45°C. The normal annual rainfall (1901-1992) over the district ranges from about 1000 mm to 1200 mm. It is the minimum in the western parts around Katol (985.4mm) and increases in the eastern direction and reaches a maximum around Umrer (1213.6 mm). On an average the Nagpur district receives an annual rainfall of about 1,200 mm which classifies it in the moderate rainfall zone. Nagpur receives precipitation on account of both monsoons, namely southwest and northeast. The southwest monsoon occurs during June to September and northeast monsoon during October to December. Rainfall data from 14 rain gauge stations for the periods 2002-2011 are given in **Table 15.8**. Average monthly rainfall at Nagpur is shown in **Figure 15.5.**

TABLE 15.8: AVERAGE RAINFALL OF THE CITY (2002-2011) IN mm

Place	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	Avg.
Nagpur City	1176.1	1431.5	702.3	973.4	975.7	741	952.9	954.4	1395.3	879.4	1018.2
Nagpur Gramin	966.7	1229	689	1274.7	1205.5	966.3	953.2	947.4	1494.7	913.8	1064.0

Source: www.agri.mah.nic.in

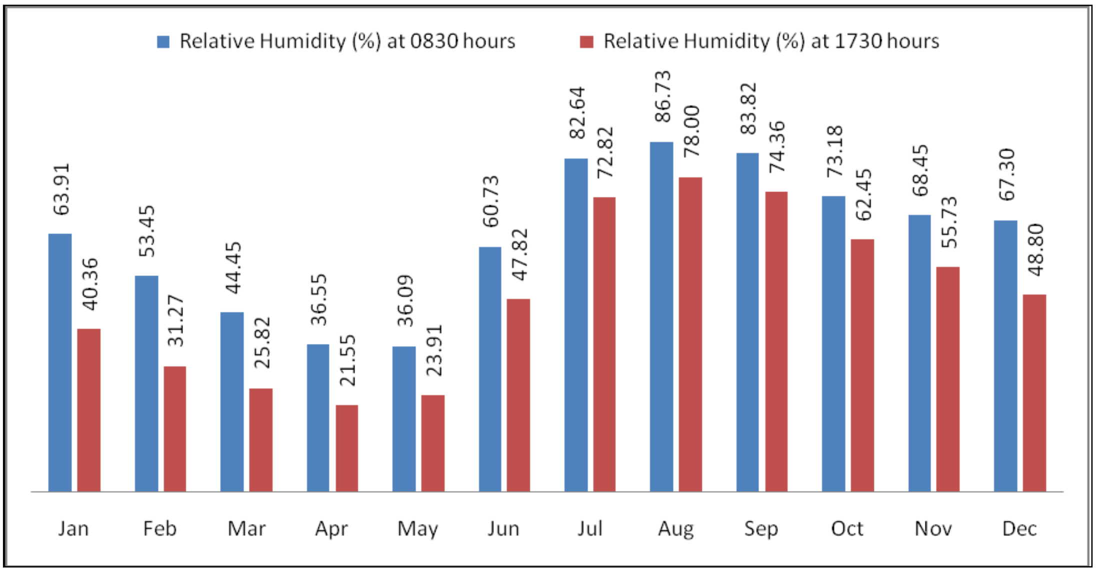
FIGURE 15.5: AVERAGE MONTHLY RAINFALL (mm)



Source: IMD data, 2001-2011

Humidity: Monthly variation of humidity at Nagpur has been given in the **Figure 15.6**. An increase in temperature results in corresponding decrease in relative humidity and vice versa. Therefore, as observed from the figure, summer months form the driest part of the year when relative humidity is low, particularly in April and May. The climate is highly humid in monsoon, particularly in August. The average relative humidity in monsoon months goes as high as 85 percent.

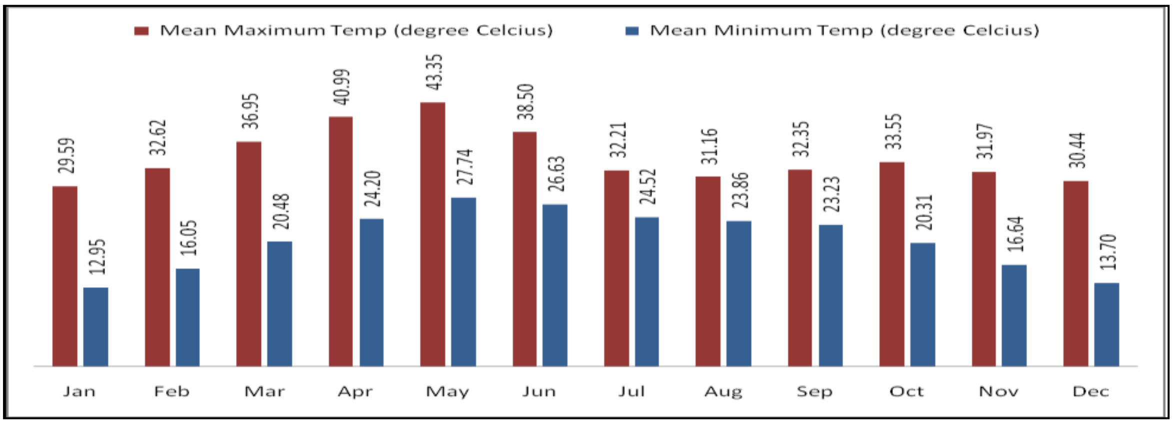
FIGURE 15.6: MONTHLY AVERAGE VARIATION IN RELATIVE (PERCENT) HUMIDITY



Source: IMD data, 2001-2011

Temperature: Monthly variation in temperature at Nagpur from 2001-2011 has been shown in **Figure 15.7.** It is clear from figure that May is the hottest month of the year with mean daily maximum temperature of about 430C. With the onset of monsoon, temperature decreases appreciably in June but remains steady thereafter till September. The climate becomes cool in December and continues up to February. December and January are the coldest months of the year.

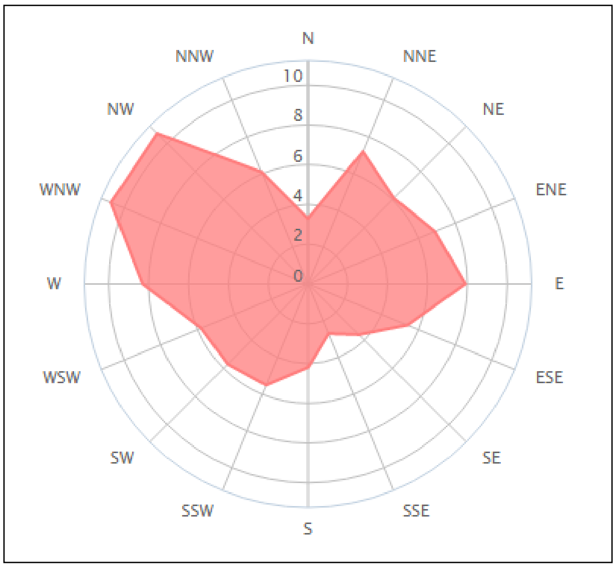
FIGURE 15.7: MONTHLY AVERAGE VARIATION IN TEMPERATURE



Source: IMD data, 2001-2011

The wind rose diagram for the Nagpur city at Sonegaon observatory is shown in **Figure15.8**. Statistics based on observations taken between 03/2013 - 10/2016 daily from 7am to 7pm local time. The prominent wind directions are West and West North West.

FIGURE 15.8: WIND ROSE DIAGRAM

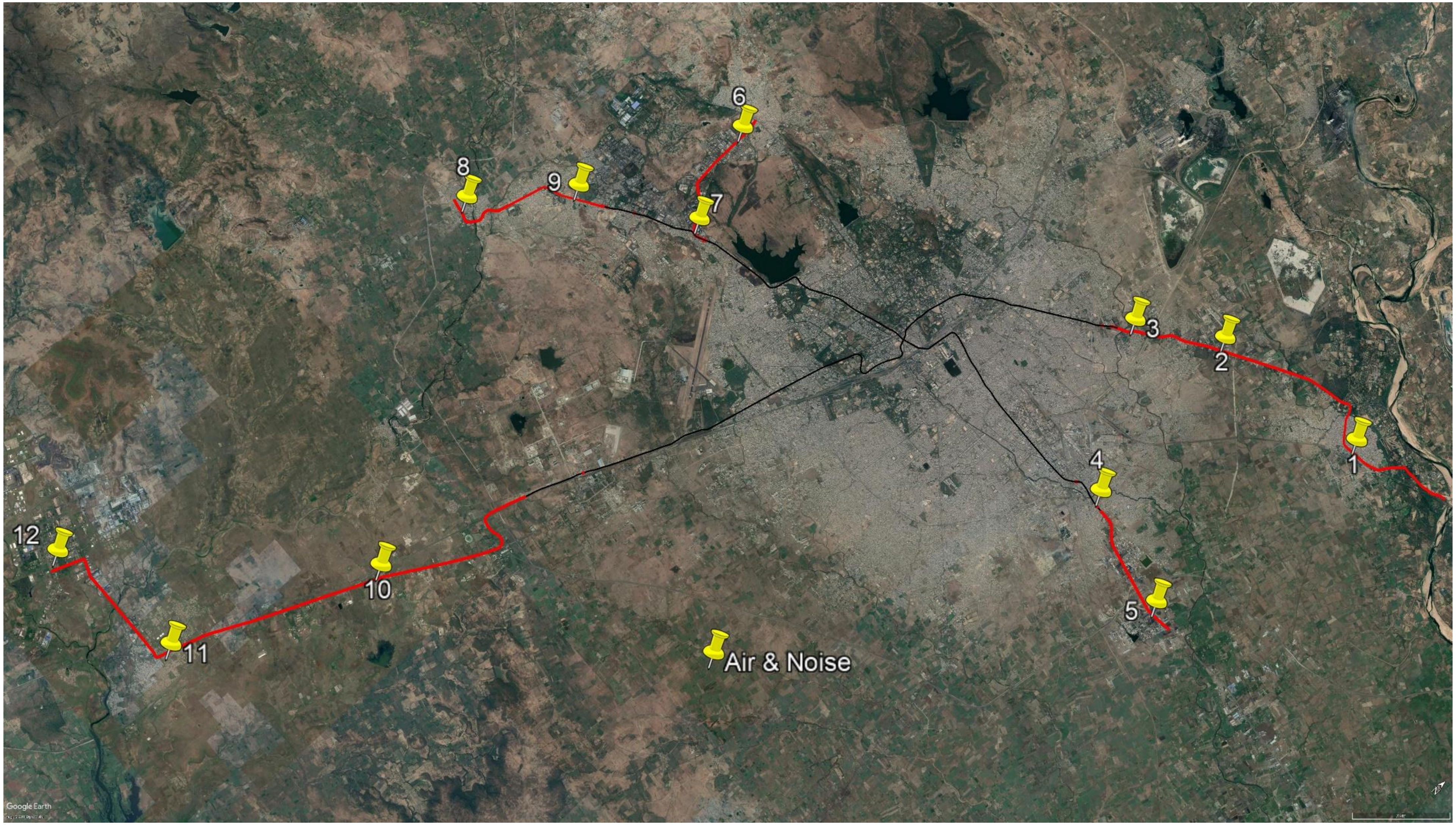


Air Quality: 12 air and noise monitoring stations were selected at strategic locations along the corridors as given in **Table 15.9** and **Figure 15.9**.The monitoring results for ambient air quality are presented in **Table 15.10.** The monitoring stations were selected to generate the representative samples for air quality covering residential, institutional and industrial area along the corridors. The ambient air and noise monitoring was carried out from 11.11.2016 to 16.11.2016 and 21.03.2018 to 23.03.2018.

TABLE 15.9: AIR AND NOISE MONITORING LOCATIONS

Loc. No.	Location Name	Corridors
1	Near Auto Riksha Stand Kamptee	Kanhan
2	J P College Kamptee Road	
3	Near Pili Nadi Bus Stop, Kamptee Road	
4	Pardi Bazar Chawk (NH 6)	Kapsi
5	Transport Nagar, NH 6	
6	Near Amravati Road	Wadi
7	Near Sanjay Nagar	
8	Riapur, Hingna	Hingna
9	Rajiv Nagar near Wanadongri	
10	Dongargaon	Butibori
11	Butibori T-Point	
12	Near Indorama Colony MIDC	

FIGURE 15.9: AIR AND NOISE MONITORING LOCATION MAP



1 to 12 Locations- Air & Noise :Refer Table 15.9 Phase II Extension Corridors

The National Ambient Air Quality Standard (NAAQS) laid down by Ministry of Environment, Forest & Climate Change (MoEFCC) on 16th November 2009 has been given in **Table 15.11**. The result of air quality monitoring compared with National Ambient Air Quality Standard and found that all the parameters are within permissible limit.

TABLE 15.10: AIR QUALITY MONITOIRNG RESULTS

Corridor Name	Location No.	Concentration of Pollution				
		Particulate matter (PM10)	Particulate Matter (PM2.5)	Sulphur Dioxide (SO2)	Nitrogen Dioxide (NO2)	Carbon Monoxide (CO)*
Kanhan	1	76.82	24.56	23.16	32.58	0.317
	2	71.47	23.52	9.64	27.38	0.219
	3	67.26	23.63	12.38	26.14	0.241
Kapsi	4	93.14	37.29	24.71	43.86	0.382
	5	87.26	32.48	26.18	48.39	0.592
Wadi	6	87.16	42.38	13.51	37.92	0.359
	7	81.64	38.51	14.28	32.17	0.473
Hingna	8	68.17	23.38	13.52	36.91	0.516
	9	62.19	18.72	11.64	26.58	0.268
Butibori	10	76.14	28.39	12.68	34.92	0.307
	11	82.37	32.64	17.92	41.68	0.351
	12	73.82	31.64	21.48	43.17	0.451

*Total monitoring period 8 Hrs. Location no 1 to 12 Refer Table 15.9

TABLE 15.11: NATIONAL AMBIENT AIR QUALITY STANDARDS

Pollutant	Time	Concentration	
		Industrial, Residential, Rural & other Area	Ecological Sensitive area
Sulphur Dioxide (SO2) in µg/m^3	Annual	50	80
	24 Hours	80	80
Oxides of Nitrogen (NOx) in µg/m^3	Annual	40	30
	24 Hours	80	80
Particulate Matter size less than 10µm (PM10) in µg/m^3	Annual	60	60
	24 Hours	100	100
Particular Matter size less than 2.5µm (PM2.5) in µg/m^3	Annual	40	40
	24 Hours	60	60
Carbon Monoxide (CO) in mg/m^3	8 Hours	02	02
	1 Hour	04	04
Ozone (O3) in µg/m^3	8 Hours	100	100
	1 Hour	180	180

Pollutant	Time	Concentration	
		Industrial, Residential, Rural & other Area	Ecological Sensitive area
Lead (Pb) µg/m^3	Annual	0.50	0.50
	24 Hours	1.0	1.0
Ammonia (NH_3)µg/m^3	Annual	100	100
	24 Hours	400	400

Source: Central Pollution Control Board (CPCB)

15.1.4 Noise Environment

The hourly noise monitoring was carried out from 11.11.2016 to 16.11.2016 and 21.03.2018 to 23.03.2018 at 12 locations along the metro corridors as given in Table 15.9 and **Figure 15.9**. The result was analysed to evaluate Leq, L_{10}, L_{50}, L_{90}, L_{day}, L_{night}, L_{DN}, L_{MAX} and L_{MIN} which is depicted in **Table 15.12.**

TABLE 15.12: AMBIENT NOISE LEVEL MONITORING RESULT in dB(A)

Corridor Name	Monitoring Location	Leq	Lday	Lnight	LDN	Lmax (24 Hrs)	Lmin (24 Hrs)	L90	L50	L10
Kanhan	1	70.7	76.5	63.4	75.6	74.9	66.5	68.5	70.7	73.1
	2	61.0	66.2	58.9	67.5	64.7	57.9	59.2	61	63
	3	66.1	72.9	58.9	71.8	69.3	62.1	63.8	66.1	68
Kapsi	4	62.8	67.8	63.4	70.8	67	60.8	60.9	62.8	64.1
	5	77.7	74.3	53.8	72.5	84.2	47.3	69.9	77.6	82.8
Wadi	6	74.9	76.7	76.2	82.7	80.8	69.3	71.7	74.9	79.4
	7	64.9	62.4	48.6	61.3	72.9	42.4	59.6	64.8	70.7
Hingna	8	59.6	58.4	50.5	59.3	61.8	47.2	56.9	59.6	61.7
	9	67.6	74.9	66.3	75.5	73	63.9	65.4	67.6	71
Butibori	10	62.1	69.2	64.0	71.6	70.7	59.6	61.6	62.1	63.7
	11	60.6	64.7	60.8	68.0	65.1	56.8	57.8	60.6	62.9
	12	64.9	62.4	48.6	61.3	72.9	42.4	59.6	64.8	70.7

Location no 1 to 12 refer Table 15.9

The Ambient Noise Quality criteria laid down by CPCB has been given in **Table 15.13**.The noise level monitoring results are exceeding the permissible limit specified for residential area. In case of industrial area like Wadi, Hingna, Kanhan noise levels are exceeding the permissible limit and within the limit for Butibori. For commercial area noise level on all five corridor in day time exceed the permissible limit.

TABLE 15.13: AMBIENT NOISE STANDARDS

Area Code	Category of Area	Limits in dB (A) Leq	
		Day time*	Night time
A	Industrial area	75	70
B	Commercial area	65	55
C	Residential area	55	45
D	Silence Zone**	50	40

Source: *CPCB guideline (*as per The Noise Pollution (Regulation And Control) Rules, 2000)

***** Day time*** *is from 6.00 AM to 9.00 PM, *****Silence Zone*** *is defined as an area up to 100m around premises of Hospitals, Educational Institutions and Courts.*

15.1.5 Ecology

The predominant tree species along the corridors are Gulmohur, Neem, Babul, Badam, and Pipal etc. The predominant shrub species observed in the study area is *Nerium oleander, Lantana camara*. About 1108 trees will be felled in site construction activities. The inventory of trees in the corridors (viaduct), at station location and proposed parking spaces are likely to be felled has been prepared and summarized in **Table 15.14**. Estimated cost of compensatory afforestation is included in the Environmental Management Plan (EMP).Common birds observed in the project area are pigeons, parrot and crows. The predominant mammals observed in the project area are bat, languor and mice etc. It is not ecologically sensitive area.

TABLE 15.14: SUMMARY OF TREE INVENTORY

SR NU	NAME OF ALIGNMENT	ALIGNMENT	STATIONS	PARKING
1.	**Kanhan** (Automotive Square To Kanhan River)	15	462	38
2.	**Kapsi** (Prajapati Nagar To Transport Nagar)	0	11	0
3.	**Wadi** (Vasudev Nagar To Dattavadi)	58	60	01
4.	**Hingna** (Lokamanya Nagar To Hingna)	14	31	0
5.	**Butibori** (Mihan to MIDC ESR-I)	383	34	01
Total		**470**	**598**	**40**

15.1.6 Archaeological Monuments/Sites

No archaeological monuments/sites are located along the corridors.

15.2 ENVIRONMENTAL NORMS AND REGULATIONS

The environmental legislation aimed at ensuring the development process meets the overall objective of promoting sustainability and safeguards in the long run. The legislation relevant to this project are:

- Environment (Protection) Act, 1986 amended 1991 and Environment (Protection) Rules 1986 amended 2018
- EIA Notification 2006 and its amendments:

  Prior Environmental Clearance: Metro Railway is not listed among activities requiring prior Environmental Clearance in EIA Notification 2006.

  March 2016 in case of Nagpur Metro, MoEFCC clarified that construction of building for commercial purposes having built area equal to or more than 20,000 sqm shall require prior EC from SEIAA.

  Feb. 2015 Principal Bench of NGT- construction of a 'bridge' or similar activity covering a build-up area ≥ 1,50,000 sq. m and/or covering an area of ≥ 50 hectares, would be covered under Entry 8(b) of Schedule to the Regulations of 2006.
- Consent to Establish and Operate
- The Maharashtra Felling of Trees (Regulation) Act, 1964 The Maharashtra (urban areas) protection and preservation of tree Act, 1975
- Aircraft Act 1934 with Aircraft (Amendment) Act, 2007 (44 of 2007)& Ministry of Civil Aviation (Height Restrictions for Safeguarding of Aircraft Operations) Rules, 2015 that are further amended in 2018.
- Maharashtra Ground Water (Development and Management) Act, 1993
- The Water (Prevention and Control of Pollution) Act 1974 (Amendment 1988).
- The Water (Prevention and Control of Pollution) Cess Act 1977 (Amendment 2003).
- The Water (Prevention and Control of Pollution) Cess Rules 1978, 1991.
- Drinking water – Specifications IS 10500: 2012 and CPHEEO Manual 2012
- The Air (Prevention and Control of Pollution) Act 1981 amended 1987.
- The Air (Prevention and Control of Pollution) (Union Territories) Rules 1982, 1983
- National Ambient Air Quality Standards 2009
- Guidelines for Ambient Air Quality Monitoring , CPCB, 2003
- Noise Pollution (Regulation and Control) Rules 2000 amendment 2002, 2006.
- Construction and Demolition Waste Management Rules 2016

- Metro Rail Transit System, Guidelines for Noise and Vibrations, RDSO, Ministry of Railways, September 2015
- Hazardous and Other Wastes (Management and Transboundary Movement) Rules 2016
- Solid Waste Management Rules, 2016
- Maharashtra Regional and Town Planning Act, 1966
- The Maharashtra Jeevan Authority Act, 1976 amended in 2013
- Maharashtra Ground Water (Development and Management) Act, 1993
- Forest (Conservation) Rules 2003 and Forest (Conservation) Amendment Rules, 2014 (procedure for FC)
- The Wild Life (Protection) Act 1972 Amendment 2002
- The Metro Railways (Operation and Maintenance) Act 2002 as amended vide The Metro Railways (Amendment) Act 2009
- The Ancient Monuments and Archaeological sites and Remains Act,1958 amended in 2010 with Ancient Monuments and Archaeological Sites and Remains (Amendment) Act, 2017
- Indian Treasure Trove Act, 1878, modified up to the 01/09/1949
- The Building and Other Construction Workers (Regulation of Employment and Conditions of Service) Act, 1996
- Maharashtra Regional and Town Planning Act, 1966
- Metro Rail Transit System, Guidelines for Noise and Vibrations, RDSO, Ministry of Railways, September 2015
- The Maharashtra Jeevan Authority Act, 1976 amended in 2013

15.3 POSITIVE ENVIRONMENTAL IMPACT

Based on project particulars and existing environmental conditions, positive potential impacts have been identified that are likely to result from the proposed metro project and where feasible within the scope of this report these are quantified. The positive environmental impacts are listed below:

- Employment Opportunities,
- Benefits to Economy,
- Traffic Congestion Reduction, Quick Service and Safety,
- Traffic Noise Reduction,
- Reduction of Traffic on Road,
- Less Fuel consumption,

- Reduced air pollution.

15.3.1 Employment Opportunities

It is assumed that the civil works of the project is likely to be completed in a period of 5 years. During this period manpower will be needed for various project activities. In post-construction phase, about 1686 people will be employed for operation and maintenance of the system. In addition to these, more people would be indirectly employed for allied activities.

15.3.2 Benefits to Economy

The project will streamline and facilitate movement of public between different parts of Nagpur. These corridors will yield tangible and non-tangible saving due to equivalent reduction in road traffic and certain socio-economic benefits. Introduction of this metro will result in the reduction in number of buses, usage of private vehicles. This in turn will result in significant social benefits due to reduction in fuel consumption, vehicle operating cost and travel time of passengers and road accidents. With the extension of five corridors of Nagpur Metro, it is likely that more people will be involved in trade, commerce and allied services.

15.3.3 Traffic Noise Reduction

Reduction in traffic volume of 10% & 50% reduces noise at the tune of 0.5 dB & 3.0 dB respectively. An introduction of Metro Rail substantially reduces the vehicular traffic which ultimately reduces noise level.

15.3.4 Reduction of Traffic on Road

On implementation of the project, the consumption of petrol, diesel and LPG will get reduced. The estimated numbers of vehicles kilometres that will be reduced due to construction corridors of Nagpur Metro Ph-II are given in **Table 15.15**.

TABLE 15.15: REDUCTION IN DAILY VEHICLE KILOMETERS

S No	Mode	Daily Vehicle Km Reduced due to Phase II Metro in Horizon years		
		2024	2031	2041
1	Car	77593	92109	125358
2	2-Wheelers	692782	806546	987512
3	Auto Rickshaw	46293	51599	72221
4	Shared Auto	61016	86652	114411
5	Bus/Public Tran.	27076	29168	31105

15.3.5 Less Fuel Consumption

Based on reduction of vehicle kilometres, reduction in fuel (diesel, petrol & LPG) consumption is reported in **Table 15.16**. It is estimated that about 8.30 million litre of total fuel will be saved in year 2024 and 11.93 million litre in 2041.

TABLE 15.16: REDUCTION IN FUEL CONSUMPTION PER YEAR

Year	Diesel (million liter)	Petrol (million liter)	LPG (million Kg)
2024	2.28	5.80	0.22
2031	2.51	6.88	0.27
2041	2.83	8.73	0.37

The saving of Diesel, Petrol and LPG will directly benefit the country in monetary terms. Net saving on fuel expenditure at current price level (May 2018) is given in **Table 15.17**. The estimated total savings on fuel will be of Rs 670 million in year 2024, Rs 780 million in year 2031 and Rs 966 million in year 2041.

TABLE 15.17: NET SAVING ON FUEL EXPENDITURE PER YEAR (RS MILLIONS)

Fuel	2024	2031	2041
Diesel	165	181	204
Petrol	493	585	741
LPG	12	15	21
Total	669.93	780.60	966.10

15.3.6 Reduced Air Pollution

Ambient emissions from operation of metro rail are limited to those from backup DG equipment. System-level generation of CO_2 from generation of grid electricity which powers Metro are not included in the ambient emissions. The major vehicular pollutants that define the ambient air quality are: Particulate matter, Nitrogen oxides, Carbon monoxide, Hydro Carbons, Carbon dioxide, Sulphur dioxide. In addition to the above pollution, un-burnt products like aldehydes, formaldehydes, acrolein, acetaldehyde and smoke are by products of vehicular emissions. The reduction of air pollutants with the present corridors are presented in **Table 15.18**. This reduction and treatment cost has been estimated using pollution factors and cost prescribed in Metro Appraisal Guidelines, MoHUA, GoI, Sept 2017.

TABLE 15.18: POLLUTION REDUCTION (TON/YEAR)

Pollutant	Horizon Year		
	2024	**2031**	**2041**
Carbon Monoxide (CO)	490.07	579.50	724.11
Hydro-Carbons (HC)	197.68	233.50	289.01
Nitrogen Oxide (NOx)	138.32	156.42	181.16
Particulate Matter (PM)	17.43	20.48	25.03
Carbon Dioxide (CO_2)	20506.09	23679.82	27238.50
Treatment cost Rs (Lakh)	946.03	1108.30	1355.49

15.4 NEGATIVE ENVIRONMENTAL IMPACTS

Based on project particulars and existing environmental conditions potential negative impacts likely to result from the proposed development are quantified. Negative impacts are listed under the following headings:

- Impacts due to project location;
- Impacts due to project design;
- Impacts due to construction; and
- Impacts due to project operation.

15.4.1 Impacts due to Project Location

During this phase, those impacts, which are likely to take place due to the layout of the project, have been assessed. These impacts are:

- Project Affected People (PAPs)
- Change of Land use;
- Loss of trees;
- Utility/Drainage Problems
- Impact on archaeological and heritage assets and
- Impact on Local Transport Facilities

15.4.1.1 Project Affected People (PAPs)

People will be displaced or lose livelihood due to the acquisition of land for proposed metro corridors. This impact has been dealt in the SIA part of this Chapter.

15.4.1.2 Change of Land use

Land will be required permanently for stations and running sections. Both government and private land will be acquired for the project. The details are given in SIA part.

15.4.1.3 Loss of trees

The proposed corridors do not pass through any forests. There are approximately 885 trees along all the extension of corridors. These trees are likely to be affected during construction. Trees are major assets in purifications of urban air, which by utilizing CO2 from atmosphere, release oxygen into the air. However, with removal of these trees, the process for CO2 conversion will get effected and the losses are reported below:

i)	Total number of Trees	:	1108
ii)	Decrease in CO_2 absorption due to loss of trees	:	3,324 kg/year
iii)	Decrease in Oxygen production due to tree loss	:	12,188 kg/year

15.4.1.4 Utility/Drainage Problems

The proposed metro corridors are planned to run through the urban area above the ground i.e. elevated. The alignment will cross drains, large number of sub-surface, surface and utility services, viz. sewer, water mains, storm water drains, telephone cables, overhead electrical transmission lines, electric pipes, traffic signals etc. These utilities/ services are essential and have to be maintained in working order during different stages of construction by temporary/permanent diversions or by supporting in position. Plans and cost of such diversions are covered in the section on Civil Engineering.

15.4.1.5 Impact on Archaeological and heritage monuments/sites

No Archaeological or heritage monuments/sites are located along the proposed extension of metro corridors.

15.4.1.6 Impact on Local Transport Facilities

The metro system has been proposed to cater the additional demand of present and future traffic requirement. The drivers of local transport facilities like buses, taxis, autos and rickshaws may be utilized to cater the requirement of transport to and from metro stations. Additional employment opportunities are also anticipated due to the proposed metro.

15.4.2 Impacts due to Project Design

Impacts due to project design are seen in following ways:

- **Right of way:** Visually less-intrusive viaduct and stations can be constructed subject to construction cost on account of specialized formwork and high strength materials. In case of elevated metro energy consumption is lower while noise is higher in comparison to underground metro.
- **Alignment and architectural design:** An alignment with less number of curves and radius - which is desirable rather than minimum, optimal station spacing, track with elastic fittings result in decrease in energy consumption, wear & tear and noise & vibration. Elevated metro with sleek structural elements provides aesthetically appealing structures. The spatial design of station has significant impact on safely of passengers, time spent in ingress & egress from station and energy consumption in stations.
- **Inter-modal integration:** Physical and operational integration of metro with other modes especially walk, public transport and intermediate public transport (hired modes) is found to increase ridership and decrease congestion inside and outside the stations.
- **Uses of Energy and water at stations:** Consumption of energy for climate control, lighting and other facilities at stations is significantly reduced by proper design of passenger flow inside stations, space & facilities inside stations.
- **Risk Due to Natural Hazards:** Engineering construction shall be done so as to meet codal provisions. No other natural hazards such as due to climate change are foreseen.

15.4.3 Impact Due to Project Construction

Although environmental hazards related to construction works are mostly of temporary nature, it does not mean that these should not be considered. Appropriate measures should be included in the work plan and budgeted for. The most likely negative impacts related to the construction works are:

- Soil erosion and Land subsidence,
- Traffic diversion,
- Air Pollution,
- Increased water demand,
- Impact due to labour camp,
- Welfare of Labour on construction site

- Safety of Labour
- Impact due to supply of construction material,
- Impact due to construction/demolition waste Disposal
- Impact due to Hazardous Waste
- Impact due to Pre-casting yards and Material stockpiling
- Loss of Archaeological Monuments/sites,
- Impact on ground water and surface water quality,
- Noise pollution,
- Vibration and risk to existing buildings.

15.4.3.1 Soil Erosion and Land Subsidence

Run off from unprotected excavated areas can result in excessive soil erosion, especially when the erodibility of soil is high. Land subsidence is anticipated at stations which will be constructed by cut and cover method.

15.4.3.2 Traffic Diversions

During construction period, complete/partial traffic diversions on road will be required, as most of the construction activities are on the road.

15.4.3.3 Dust Generation and Air Pollution

Air pollution occurs due to excavation, loading and unloading of construction materials, and emissions from vehicles, construction equipment and DG sets etc. It also occurs in sites of muck disposal, debris disposal and pre-casting yards. Air pollution from road based vehicles especially particulates are found to cause diseases of brain, heart, lungs and kidneys.

During the period of construction emission due to truck movement on account of transportation of civil construction material and disposal/backfill of earth is estimated to be as follows: CO, HC, NOx, PM, CO_2 and VOC will be about 31 ton, 1 ton, 64 ton,1.4 ton, 3988 ton and 10 ton respectively. Such transportation is estimated to result in fugitive dust emission of about 7.6 ton during the period of construction.

15.4.3.4 Increased Water Demand

Water consumption during construction is of the order of 722 KLD.

15.4.3.5 Impact due to Labour Camp

Sewage and municipal solid waste generated from labour camp need to be treated before disposal. The labour camp of Phase-I will be used for the extensions of corridors.

15.4.3.6 Welfare of Labour on construction site

Facilities such as shelter at workplace, canteen, first aid and day crèche are statutory requirement and essential to productivity.

15.4.3.7 Safety of Labour

Safety of labour during construction is a statutory requirement and also has impact on progress of work.

15.4.3.8 Impact due to Supply of Construction Material

Construction material such as aggregate and earth are sourced from approved quarries such that environmental impacts as well as wastage of natural resources are minimized and mitigated.

15.4.3.9 Impact due to construction/demolition waste Disposal

Debris disposal can result in air and water pollution, noise, diversion of green parks and temporary displacement.

15.4.3.10 Impact due to Hazardous Waste

Hazardous waste would mainly arise from the maintenance of equipment which may include used engine oils, hydraulic fluids, waste fuel, spent mineral oil/cleaning fluids from mechanical machinery, scrap batteries or spent acid/alkali, spent solvents etc. Unsafe disposal can result in water and soil pollution, diversion of green parks and temporary displacement.

15.4.3.11 Impact due to Pre-casting yards and Material stockpiling

Sites for casting of structural concrete elements and material stockpiling can result in air and water pollution, noise, diversion of open areas like green parks and temporary displacement.

15.4.3.12 Loss of Archaeological and heritage monuments/sites

No Archaeological nor heritage monuments/sites will be lost.

15.4.3.13 Impact on Ground and Surface Water Quality

Ground water contamination can take place if sewage from labour camp or chemical substances from construction site or dumped muck or construction/demolition waste or used water from the RMC plant get leached by precipitation of water and percolate to the ground water table.

Proposed project will not alter the existing water quality of Pili nadi and Vena River. Bridge is planned on the alignment on Pili Nadi and Vena River. It is proposed to construct the bridge with well foundation, substructure with mass concrete and superstructure with PSC girder. On construction of these, no major impact on flow of water, surface water and ground water quality is anticipated due to this project. Contamination of surface water bodies may result due to spillage of construction material, however, the quantity of such spills will be negligible.

15.4.3.14 Noise Pollution

Noise is a contributing factor to degradation of human health. The major sources of noise pollution during construction are movement of vehicles for transportation of material and equipment. Permitted number of impacts (example piling) at various noise levels is prescribed under Model Rules of the Factories Act, 1948. Actual noise from construction equipment (Lmax) measured at 50 feet distance typically ranges from 76 dB(A) to 84 dB(A); vibratory pile driver at 101 dB(A). CPCB standards specified for limited construction equipment reflect that noise emission specifications for such equipment should not exceed 75 dB (A). With respect to occupational exposure, the permissible threshold is 90 dB (A) (continuous exposure over 8 hours).

Considering typical noise from a range of construction equipment, sensitive receptors (i.e. labour colonies) should be located beyond 125 meters from the noise generating source location during construction activities.

15.4.3.15 Vibration and Risk to Existing Buildings

If significant impacts due to vibration are expected, mitigation measures have to be implemented and building condition survey have to be conducted before, during and after construction.

Damage to structures is a possibility in case of pile driving or trains passing within 7.5 m from normal buildings or unreinforced structures or between 15m to 30m from historical buildings or buildings in poor condition; heavy truck traffic within 30m, major construction within 60m, freight trains within 90m or pile diving within 180m can cause disruption of operation of sensitive instrumentation. Threshold criteria are listed in

Table 15.19. These criteria for monuments are more stringent than those prescribed in UK, Germany, Switzerland and Japan.

TABLE 15.19: Guideline Vibration Damage Threshold Criteria

Structure and Condition	Maximum PPV (in/sec)	
	Transient Sources	Continuous/Frequent Intermittent Sources
Extremely fragile historic buildings, ruins, ancient monuments	0.12	0.08
Fragile buildings	0.2	0.1
Historic and some old buildings	0.5	0.25
Older residential structures	0.5	0.3
New residential structures	1.0	0.5
Modern industrial/commercial buildings	2.0	0.5

Note: Transient sources create a single isolated vibration event, such as blasting or drop balls. Continuous / frequent intermittent sources include impact pile drivers, pogo-stick compactors, crack-and-seat equipment, vibratory pile drivers, and vibratory compaction equipment.

Source: Transportation and Construction Vibration Guidance Manual, Caltrans, September 2013

Vibration source levels for typical construction equipment are listed in Table 15.20. In case of construction of underground stations or tunneling by NATM in hard rock which require controlled blasting, vibration in structures will be observed. As per Transportation and Construction Vibration Guidance Manual (Sept 2003) by Caltrans, using cast-in-place or auger cast piles eliminates impact driving and limits vibration generation to the small amount generated by drilling, which is negligible.

TABLE 15.20: Vibration Source levels for Construction Equipment

Equipment		PPV at 25 ft (in/sec)	Approximate L_v# at 25 ft
Pile Driver (impact)	Upper Range	1.518	112
	Typical	0.644	104
Pile Driver (sonic)	Upper Range	0.734	105
	Typical	0.170	93
Calm shove drop (slurry wall)		0.202	94
Hydromill (slurry wall)	in soil	0.008	66
	in rock	0.017	75
Large bulldozer		0.089	87
Caisson drilling		0.089	87
Loaded trucks		0.076	85
Jackhammer		0.0345	79
Small bulldozer		0.003	58
# RMS velocity in decibels (VdB) re 1 µinch/sec			

Source: Transit Noise & Vibration Impact Assessment, FTA 2006

As per RDSO Guidelines 2015 for vibration studies of metro projects, screening distances for vibration are prescribed **(Table 15.21)**. Accordingly vibration studies have to be conducted before and during construction and during operation along the corridors to determine the extent of impacts. If significant impacts are expected mitigation measures have to be implemented and building condition survey have to be conducted before and during construction.

TABLE 15.21: SCREENING DISTANCES (m) FOR VIBRATION ASSESSMENT

Type of Project	Critical Distance for Land Use Categories Distance from Right-of-Way or Property Line		
	Category 1	Category 2	Category 3
Conventional Commuter Railroad	183	61	37
Rail Rapid Transit	**183**	**61**	**37**
Light Rail Transit	138	50	30
Intermediate Capacity Transit	61	30	15
Category 1: Buildings where vibration would interfere with interior operations including concert halls and TV studios **Category 2:** Residences and buildings where people normally sleep including theaters and auditoriums **Category 3:** Institutional and uses with primarily day time use			

Source: Guidelines for Noise and Vibrations, MRTS, RDSO, Ministry of Railways, September 2015

15.4.4 Impacts Due to Project Operation

The project may cause the following negative impacts during operation of the project due to the increase in the number of passengers and trains at the stations:

- Noise pollution,
- Water supply and sanitation at Stations,
- Pedestrians and traffic congestion issues,
- Vibration.

15.4.4.1 Noise Pollution

Typical noise level due to rapid rail transit on viaduct at speed 50 mph and distance 50 feet from tracks is 85 dB (A); respective value for at grade is 80 dB (A); and rail transit at stations is 65dB (A). During the operation phase the main source of noise will be from running of metro trains. Noise radiated from train operations and track structures generally constitute the major noise sources. Noise levels at particular distance from the source are predicted and presented in **Table 15.22**. It is assumed that train average speed is 32 km/hr, and no barrier is present. Due to reduction of vehicular traffic, the road traffic noise is expected to come down.

TABLE 15.22: NOISE LEVELS (LDN) IN dB(A) AT DIFFERENT DISTANCES

Distance (m)	Noise Level (dB)
10	84
20	78
30	74
40	71
50	70
60	68
70	67
80	65
90	64
100	64

15.4.4.2 Water Supply and Sanitation

The water demand at stations arises from cleaning and air conditioning of stations and drinking and toilet demands for staff. Water Demand is calculated and presented in **Table 15.23.**

TABLE 15.23: WATER REQUIREMENT

S.No.	Particular	Water Demand at Each Station (KLD)	Total Water Demand (KLD)
1	At Stations for Drinking Purpose	6.000	198.000
2	In Elevated stations for AC, cleaning, chiller and other purposes	16.600	547.800
		Total	**745.800**

15.4.4.3 Congestion around stations

Commencement of metro services results in passenger rush at stations which in turn results in congestion around stations.

15.4.4.4 Vibration

Passing of trains on elevated section causes vibrations.

15.5 ENVIRONMENTAL MANAGEMENT PLAN (EMP)

This section has been divided into three sections:

- Mitigation measures,
- Disaster management, and
- Emergency measures.

15.5.1 Mitigation measures

The main aim of mitigation measures is to protect and enhance the existing environment of the project. This section includes measures for:

- Compensatory afforestation,
- Provisions for Green Buildings and solar power
- Use of Energy and Water
- Supply of Construction Material
- Pre-casting yards and Material Stockpiling
- Construction Material Management and Housekeeping
- Safety Management Measures,
- Labour Camp,
- Energy Management
- Hazardous Waste Management
- Construction and Demolition Waste Management,
- Utility Plan,
- Air Pollution Control Measures,
- Noise Control Measures,
- Vibration Control Measures,
- Traffic Diversion/Management,
- Soil Erosion Control,
- Water Supply, Sanitation and Solid Waste management,
- Rain water harvesting,
- Training and Extension, and
- Establishment of Environmental Division

15.5.1.1 Compensatory Afforestation

The Municipal Corporation of Nagpur is responsible for the conservation and management of trees in the project area. According to the results of the present study, it is found that about 1108 trees are likely to be lost along the five extensions of corridors. It is proposed to plant five saplings for each tree to be cut. Hence, total 5,540 trees need to be planted. The estimated compensatory afforestation cost will be about **Rs 20.60 lakh** for Kanhan, **Rs 16.72 lakh** for Butibori, **Rs 4.76 lakh** for Wadi, **Rs 1.80 lakh** for Hingna and **Rs 0.44 Lakh** for Kapsi. The total compensatory afforestation cost for all five extensions of corridors will be about **Rs 44.32 lakh**. The native plant species and miscellaneous indigenous tree species recommended for afforestation. 5,540 trees, on maturing will absorb about 16,620 kg of CO_2 per year and will release 60,940 kg of Oxygen per year.

15.5.1.2 Provisions for Green Buildings and solar power

Green building refers to both a structure and the using of processes that are environmentally responsible and resource-efficient throughout a building's life-cycle: from siting to design, construction, operation, maintenance, renovation, and demolition. Green buildings help in better preservation of environment as in such structures there are provisions for better saving of energy, water and CO2. Such buildings also have better waste management arrangements. All stations and Depot buildings can be designed as green buildings.

15.5.1.3 Use of Energy and Water

Requirement of electrical energy for climate control, lighting and other facilities at stations shall be optimized by proper use of natural day/night light and design of passenger flow inside stations and on streets outside stations. Installations for solar power will be implemented at stations and Depot where feasible.

Water supply in stations for air conditioning, cleaning and use of staff and passengers will be procured from municipal supply. Water for depots will be sourced from municipal supply.

15.5.1.4 Supply of Construction Material

The procurement source of the construction materials will be decided by the Contractor, but it will be from the licensed supplier.

15.5.1.5 Pre-casting yards and Material Stockpiling

Sites for casting of structural concrete elements and material stockpiling will be decided before start of construction. Land for these sites will be temporarily acquired such that displacement of persons is not involved to the extent possible.

15.5.1.6 Construction Material Management and Housekeeping

Procedures for storage, handling and transport of construction material shall be prescribed in SH&E method statement approved for construction.

Housekeeping is to keep the working environment cleared of all unnecessary waste, thereby providing a first-line of defence against accidents and injuries. It is the responsibility of Contractor and all site personnel. Some of the measures are listed below:

- Full height fence, barriers, barricades etc. shall be erected around the site in order to prevent the surrounding area from excavated soil, rubbish etc, which may cause inconvenience to and endanger the public.
- All stairways, passageways and gangways shall be maintained without any blockages or obstructions. All emergency exits passageways, exits fire doors, break-glass alarm points, fire-fighting equipment, first aid stations, and other emergency stations shall be kept clean, unobstructed and in good working order.
- All surplus earth and debris shall be removed/disposed off from the working areas to officially designated dumpsites. Trucks carrying sand, earth and any pulverized materials etc. shall be covered while moving.
- Unused/surplus cables, steel items and steel scrap within the working areas shall be removed to identified locations.
- All wooden scrap, empty wooden cable drums and other combustible packing materials, shall be removed from work place to identified locations.
- Empty cement bags and other packaging material shall be properly stacked and removed.
- Proper and safe stacking of material is of paramount importance at yards, stores and such locations for future use. The storage area shall be well laid out with easy access and material stored / stacked in an orderly and safe manner.
- Flammable chemicals/compressed gas cylinders shall be safely stored.

15.5.1.7 Safety Management Measures

Prior to the construction, identification of safety hazard would be made by Project Authority to establish the safety programmes following rules, regulations and guidelines. The comprehensive safety programmes will include deployment of a full time safety engineer who will prepare safety plan/schedule for their implementation during construction and operation. The personnel working would wear protective headgear, footwear and other special garments that applicable code requires. The weatherproof first aid boxes will be made available at appropriate locations.

15.5.1.8 Labour Camp

The contractor during the progress of work will provide, erect and maintain necessary (temporary) living accommodation and ancillary facilities for labour to standards and scales approved by the Maha Metro. All temporary accommodation must be constructed and maintained in such a fashion that uncontaminated water is available for drinking, cooking and washing. Adequate health care is to be provided for the work force. In addition the following facilities will be provided in the labour camps sanitation facilities like toilets and drains, shelter at workplace, canteen facilities, first aid facilities, day crèche facilities, health awareness campaigns to prevent Infectious Diseases, facilities for water supply and waste water treatment and solid waste management. The labour camp of the Phase-I shall be used for these extensions as well.

15.5.1.9 Energy Management

The contractor shall use and maintain equipment so as to conserve energy and shall be able to produce demonstrable evidence of the same upon the request of officer of the Project Implementation Unit.

Measures to conserve energy include but not limited to the following:

- Optimizing the use of tools, plants and equipment to perform tasks with correct power, cable size and joint can control voltage drops,
- Use of energy efficient motors (90% efficiency or more) and pumps (at least 80% efficiency),
- Replacing inefficient lamps with the most efficient lamp for the purpose, taking into account size, shape, colour and output of the lamp,
- Adequate and uniform illumination level at construction sites suitable for the task,
- Use of energy efficient air conditioner,
- Engine of DG set shall complies with CPCB norms,
- Planning in advance and selecting location to receive and store material such that these are at the least distance from the place of use.
- Maintenance schedule
- The rooms shall be well insulated to enhance the efficiency of air conditioners and the use of solar films on windows may be used where feasible.

Capital and operating cost are included in engineering cost and therefore is not included in EMP.

15.5.1.10 Hazardous Waste Management

The contractor shall identify the nature and quantity of hazardous waste generated as a result of his activities and shall file an application for obtaining authorization with Maharashtra Pollution Control Board (MPCB). Hazardous waste would mainly arise from the maintenance of equipment which may include used engine oils, hydraulic fluids, waste fuel, spend mineral oil/cleaning fluids from mechanical machinery, scrap batteries or spent acid/alkali, spend solvents etc. Hazardous Waste needs to be stored in a secure place and adequately labelled and packaged. The contractor shall maintain a record of sale, transfer, storage of such waste and make these records available for inspection.

15.5.1.11 Construction and Demolition Waste Management

Construction and Demolition (C&D) waste is part of solid waste that results from land clearing, excavation, construction, demolition, remodelling and repair of structures, roads and utilities. C&D waste has the potential to save natural resources (stone, river sand, soil etc.) and energy, reduce transportation over long distances for dumping, and reduce space occupied at landfill sites. C&D waste generated from metro construction has potential use after processing, grading solid waste and recycling. Part of this waste will be hazardous in nature.

- Segregation and temporary storage of reusable and recyclable materials at identified locations. Transport recyclable materials to construction sites.
- sale of metal scrap and other saleable waste to authorized dealers
- Identification of intended transport means and route.
- Obtaining permission, where required, for treatment of the hazardous component and its disposal.
- The treatment and disposal sites will be identified in consultation with local agencies such that pollution of water bodies and green areas are not impacted and displacement of persons is not involved. Before dumping, recyclable material will be removed. The disposal sites will be cleaned and then treated so that leached water does not contaminate the ground water.

15.5.1.12 Utility Plan

The proposed metro alignment runs along major arterial roads of the city, serving Institutional, Commercial and Residential areas. Large number of sub-surface, surface and overhead utility services, viz. sewers, water mains, storm water drains, telephone cables, electrical transmission lines, electric poles, traffic signals etc. already exist along the proposed alignments. These utility services are essential and have to be maintained in working order during different stages of construction by temporary/permanent diversions or by supporting in position. As such, these may affect construction and project implementation time schedule/costs, for which necessary planning/action needs to be initiated in advance.

Prior to the actual execution of work at site, detailed investigation of all utilities and location will be undertaken well in advance by making trench pit to avoid damage to any utility. While planning for diversion of underground utility services e.g. sewer lines, water pipe lines, cables etc., during construction of Metro, the following guidelines could be adopted:

- Utility services shall be kept operational during the entire construction period and after completion of project.
- Sewer lines and water supply lines are mainly affected in underground cut and cover construction. These services are proposed to be maintained by temporarily replacing them with CI/Steel pipelines and supporting them during construction, these will be encased in reinforced cement concrete after completion of construction and retained as permanent lines.
- Where permanent diversion of the affected utility is not found feasible, temporary diversion with CI/Steel pipes without manholes is proposed during construction. After completion of construction, these will be replaced with conventional pipes and manholes.
- The elevated viaduct does not pose any serious difficulty in negotiating the underground utility services, especially those running across the alignment. In such situation, the spanning arrangement of the viaduct may be suitably adjusted to ensure that no foundation need be constructed at the location, where, the utility is crossing the proposed metro alignment.

15.5.1.13 Air Pollution Control Measures

During the construction period, the impact on air quality will be mainly due to increase in Particulate Matter (PM) along haul roads and emission from vehicles and construction machinery. Mitigation measures which shall be adopted to reduce the air pollution are presented below:

- The contractor shall take all necessary precautions to minimize fugitive dust emissions from operations involving excavation, grading, and clearing of land

and disposal of waste. He shall not allow emissions of fugitive dust from any transport, handling, construction or storage activity to remain visible in atmosphere beyond the property line of emission source for any prolonged period of time without notification to the Employer.

- Contractor's transport vehicles and other equipment shall conform to emission standards fixed by Statutory Agencies of Government of India or the State Government from time to time. The Contractor shall carry out periodical checks and undertake remedial measures including replacement, if required, so as to operate within permissible norms.
- The contractor shall cover loads of dust generating materials like debris and soil being transported from construction sites. All trucks carrying loose material should be covered and loaded with sufficient free - board to avoid spills through the tailboard or sideboards.
- The temporary dumping areas shall be maintained by the Contractor at all times until the excavate is re-utilized for backfilling or as directed by Employer.
- The contractor shall place material in a manner that will minimize dust production. Material shall be minimized each day and wetted, to minimize dust production. During dry weather, dust control methods must be used daily especially on windy, dry days to prevent any dust from blowing across the site perimeter.
- The contractor shall water down construction sites as required to suppress dust, during handling of excavation soil or debris or during demolition. The Contractor will make water sprinklers, water supply and water delivering equipment available at any time that it is required for dust control use. Dust screens will be used, as feasible when additional dust control measures are needed especially where the work is near sensitive receptors.
- The contractor shall design and implement blasting techniques so as to minimize dust, noise, and vibration generation and prevention fly rock.

Capital and operating cost are included in engineering cost and therefore is not included in EMP.

15.5.1.14 Noise Control Measures

During construction exposure of workers to high noise levels can be minimized by job rotation, automation, protective devices, noise barriers, and soundproof compartments, control rooms etc. Measures to mitigate noise impact in construction zones shall be implemented by the contractors the cost of which is included in the project engineering cost. During operation use of ballast-less track with elastic and absorbent fittings is a standard provision for noise control. At depots use of green belt with vegetation of thick foliage helps reduce noise; where site layout permits barrier blocks of less-vulnerable buildings can be used; alternatively freestanding barrier walls can be built. Screening of noise shall be ensured by providing parabolic noise barriers on each side of the track on viaduct and at sensitive receptors during operation.

Noise barriers are recommended along the curved portion and sensitive area of the viaduct which is provided near YCCE College etc (140+91+44=275m) along Hingna Corridor, Kamptee Cantonment Area (@115m) along Kanhan Corridor, 89m (40+17+7+16+9) along MIDC ESR (Butibori) corridor, 52 m along Transport Nagar corridor, 32 m along Dattawadi corridor. The estimated cost is **Rs 27.5 lakh, Rs. 11.5 lakh, Rs 8.9 lakh, Rs 5.2 lakh** and **Rs 3.2 Lakh** for five corridors respectively.

15.5.1.15 Vibration Control Measures

During construction, the vibrations are resulted from use of piling in elevated sections. In cases of piling in elevated sections, vibratory piling can be evaluated for suitability in comparison to impact piling. Cast-in-situ auger piles will also result in reduced vibration. At locations where the alignment is close to protected monuments, heritage assets or other sensitive structures, the contractor shall conduct building condition surveys and monitor vibration before and during construction.

Vibration during operation can be reduced by minimizing surface irregularities of wheel and rail, improving track geometry, providing elastic fastenings, and separation of rail seat assembly from the concrete plinth with insertion of resilient and shock absorbing pad. Deep and narrow trenches in the ground shall be tested at vibration-sensitive structures.

15.5.1.16 Traffic Diversion/Management

In order to retain satisfactory levels of traffic flow during the construction period; traffic management and engineering measures need to be taken. They can be road widening exercises, traffic segregation, one-way movements, traffic diversions on influence area roads, acquisition of service lanes, etc.

- All construction workers should be provided with high visibility jackets with reflective tapes at most of viaduct/tunneling and station works or either above or under right-of-way. The conspicuity of workmen at all times shall be increased so as to protect from speeding vehicular traffic.

- Warn the road user clearly and sufficiently in advance.
- Provide safe and clearly marked lanes for guiding road users.
- Provide safe and clearly marked buffer and work zones
- The primary traffic control devices used in work zones shall include signs, delineators, barricades, cones, pylons, pavement markings and flashing lights.

During operation decongestion scheme should involve taxi and auto rickshaw stands, a halting space for public buses, drop off-pick up for owned modes. Parking space at stations if any is to be planned well. Capital and operating cost are included in engineering cost and therefore is not included in EMP.

15.5.1.17 Soil Erosion Control

Prior to the start of the relevant construction, the contractor shall submit to the Maha Metro for approval, his schedules for carrying out temporary and permanent erosion/sedimentation control works as are applicable for the items of clearing and grubbing, roadway and drainage excavation, embankment/sub-grade construction and other structures across water courses, pavement courses and shoulders and his plan for disposal of waste materials. The surface area of erodible earth material exposed by clearing and grubbing, excavation shall be limited to the extent practicable. Works such as construction of temporary berms, slope drains and use of temporary mulches, fabrics, mats, seeding, or other control devices or methods as necessary to control erosion and sedimentation may be involved. Mitigation measures include careful planning, timing of cut and fill operations and re-vegetation. Capital and operating cost are included in engineering cost and therefore is not included in EMP.

15.5.1.18 Water Supply, Sanitation and Solid Waste Management

Water requirement for construction will be met through municipal supply or through sewage treated and re-used.

During operation water supply, sanitation and toilets are needed at the stations. Drinking water and raw water requirement for elevated stations can be provided from municipal source in consultation with local agencies. During operation rainwater harvesting will be carried out at stations and elevated corridors. Non-hazardous municipal solid waste generated in stations will be collected and transported to local municipal bins and thence to disposal site by municipality.

15.5.1.19 Rain water harvesting

To conserve and augment the storage of groundwater, it has been proposed to construct roof top rainwater harvesting structure of suitable capacity at the elevated stations and in the elevated alignment. Each pillar can have inbuilt downpipes to collect the rainwater from the viaduct and into the underground tanks. A recharge tank shall be constructed at suitable distance. The water collected will percolate down to the subsoil through numerous layers of sand, gravel and boulders. Total elevated length of the corridors including station length is about 48.16 km. Average annual rainfall of Nagpur is 1200 mm. Considering a runoff coefficient of 0.85 the annual rainwater harvesting potential of elevated stations and elevated section is estimated as 6,20,136 cubic meter per year. Estimated cost for the rainwater harvesting for Dattawadi corridor is **Rs 103.28 lakh**, Hingna corridor is **Rs 129.78 lakh**, Transport Corridor is **Rs 109.13 lakh**, Kanhan Corridor is **Rs 253.33 lakh** and MIDC ESR (Butibori) corridor **is Rs 342.97 lakh**. The cost of RWH has been included in EMP cost.

15.5.1.20 Training

The training for engineers and managers will be imparted by Maha Metro on regular basis to implement the environmental protection clauses of the tender document and to implement the best environmental practices during the construction phase. Apart from training, programmes should include guidelines for safety, methods of disaster prevention, action required in case of emergency, fire protection, environmental risk analysis etc. The cost involved for such programmes is estimated as **Rs 15.75 lakh** for the extensions of all five corridors, details are given in **Table 15.24.**

TABLE 15.24: COST FOR TRAINING PROGRAMME (Rs)

Sl. No.	ITEM	Kanhan River	Transport Nagar, Dattawadi & Hingna	MIDC ESR (Butibori)
1	Curriculum Development and course preparation 1 month Rs.30000/month	30,000	30,000	30,000
2	1 Extension Officer (1 year) Rs.20, 000/month	240,000	240,000	240,000
3	Instructor 6 sessions of 10 days each (@ 30000/session)	180,000	180,000	180,000
4	Demonstration/Presentation Aids	50,000	50,000	50,000
5	Material etc	25,000	25,000	25,000
	Total	**5,25,000**	**5,25,000**	**5,25,000**

15.5.1.21 Establishment of Environmental Division

It is recommended that the environmental division established for the Phase-I shall be utilised for these extension of corridors.

15.5.2 Disaster and Risk Management

The recommended approach is to manage disaster risk rather than managing disasters. Disaster risk is the combination of the severity and frequency of a hazard, the numbers of people and assets exposed to the hazard, and their vulnerability to damage. The main opportunity in reducing risk lies in reducing exposure and vulnerability. Disaster Risk Management includes the following actions:

- Reduction and prevention: Measures to reduce existing and avoid new disaster risks, for instance relocating exposed people and assets away from a hazard area. In case of mass transit like Metro such measures are not actionable.
- Mitigation: The lessening of the adverse impacts of hazards and related disasters. For instance implementing strict land use and building construction codes. This aspect is accounted for in design and construction of the project.
- Transfer: The process of formally or informally shifting the financial consequences of particular risks from one party to another, for instance by insurance. This is not yet available.
- Preparedness: The knowledge and capacities of governments, professional response and recovery organisations, communities and individuals to effectively anticipate, respond to, and recover from the impacts of hazard events or conditions, for instance installing early warning systems, identifying evacuation routes and preparing emergency supplies.

Risk Management process comprises the following stages:

- Description of the system that is at risk
- Identify the potential hazards or sources of risk (the list of initiating events or scenarios of events leading to the undesired outcome – technological and human)
- Risk analysis to estimate the likelihood of the scenarios or events occurring and each scenario’s consequence
- Compare and rank the various risk drivers
- Action plan in response to the identified major risks
- Regular monitoring, review and updation of the process.

For example, the system at risk needs to be defined as to include inter-modal integration. Examples of potential hazards are fire risk or security alarms or failure of train control or motive power or passenger doors / escalators / platform screen doors on trains or in stations; staff training and work environment; inadequate maintenance.

- Action plan shall include the following.
- Procedures and Records
- Evaluation of progress and effectiveness of EMP and EMoP, response to inquiries, complaints and requests for information surveillance, incident reporting, corrective and preventive actions, emergencies, training and emergency exercises, response to emergencies,
- Identification of resources: Sources of repair equipment, personnel, transport and medical aid for use during emergency will be identified.
- Emergency systems: Back-up systems for ventilation, communication and train control, lighting etc. shall be established.
- Evacuation procedures: Evacuation procedures will be prepared in consultation with local administration and notified. To ensure coordinated action, an Emergency Action Committee shall be constituted.
- Communication System: Primary and back-up system shall be put in place

Review and Updation: Drawing inputs from the incident reporting system the Action Plan shall be reviewed at pre-decided intervals and upon occurrence of defined ``trigger events`` and suitably updated.

15.6 ENVIRONMENTAL MONITORING PLAN AND ENVIRONMENT MANAGEMENT SYSTEM

Environment monitoring and environment management system is avital process of any Environmental Management Plan (EMP) of development project for review of indicators and for taking immediate preventive action.

15.6.1 Environment Monitoring Plan

Environmental monitoring should be an integral part of works towards better environmental management of air, noise, vibration, water quality etc both during construction and in operation phases of the project. The following parameters are proposed to be monitored:

- Water Quality,
- Air Quality,
- Noise and Vibration,
- Environmental Sanitation and Waste Disposal,

- Ecological Monitoring and Afforestation,
- Workers Health and Safety

Environmental monitoring during pre-construction phase is important to know the baseline data and to predict the adverse impacts during construction and operations phases. The estimated environmental monitoring cost during construction and operation is about **Rs 252.64 Lakh** for all five extensions of corridors; details are given in **Table 15.25** and **Table 15.26**.

15.6.1.1 Construction Phase

During construction stage environmental monitoring will be carried out for air quality, noise levels, water quality and ecology. At this stage it is not possible to visualize the exact number of locations where environmental monitoring must be carried out. However keeping a broad view of the sensitive receptors and also the past experience an estimate of locations has been made and are summarized in **Table 15.25**.

TABLE 15.25: CONSTRUCTION STAGE MONITORING SCHEDULE

Parameter	Frequency per year	Locations	Years
Air Quality	2x24 hours, twice in a month, 24 times in a year	23	5
Noise	2x24 hours, twice in a month, 24 times in a year	23	5
Water	Once in six month, twice in a year	14	5
Soil	Once in six month, twice in a year	14	5

These numbers could be modified based on need when the construction actually commences.

Water Quality

The water quality parameters are to be monitored during the entire period of project construction. Monitoring should be carried out by NABL Accredited/MoEFCC recognized private or Government agency. Water quality should be analyzed following the procedures given in the standard methods. Parameters for monitoring will be as per BIS: 10500. The monitoring points could be ground and surface water.

Air Quality

Air quality should be monitored at the locations of baseline monitoring. The parameter recommended is Particulate Matter ($PM_{2.5}$ and PM_{10}), SO_2, NO_X, CO and HC. The contractor will be responsible for carrying out air monitoring during the entire construction phase under the supervision of Maha Metro.

Noise Monitoring

The noise levels will be monitored at construction sites for entire phase of construction by the site contractor and under the supervision of Maha Metro.

Ecological Monitoring

The project authority in coordination with the Department of Forest shall monitor the status of ecology/trees along the project corridors at least 4 times in a year during construction phase in order to maintain the ecological environment. The plantation/afforestation of trees by Department of Forest, Government of Maharashtra will be review four times a year during construction phase.

Workers Health and Safety

Monitoring of health risk issues that might arise throughout the project life time will be done. Epidemiological studies at construction sites will be performed to monitor the potential spread of diseases. Regular inspection and medical checkups shall be carried out to workers health and safety monitoring. Any reoccurring incidents such as irritations, rashes, respiratory problems etc shall be recorded and appropriate mitigation measures shall be taken. Contractor will be the responsible person to take care health and safety of workers during the entire period of the construction and project proponent is responsible to review/audit the health and safety measures/plans.

15.6.1.2 Operation Phase

Even though the environmental hazards during the operation phase of the project are minimal, the environmental monitoring will be carried out for air, noise, water and ecology during operation phase of the project. The parameters monitored during operation will be Particulate Matter ($PM_{2.5}$ and PM_{10}), SO_2, NOx, CO and HC for ambient air quality. Water quality parameters that will be monitored will be as per BIS 10500. The monitoring schedule is presented in **Table 15.26**. Monitoring should be carried out by NABL Accredited/MoEF recognized private or Government agency under the supervision of Maha Metro. Project Operator will be responsible for successful environmental monitoring of the proposed project during operation phase.

The environmental monitoring results will be submitted to management quarterly during construction phase and semi annually during operation phase.

TABLE 15.26: OPERATION STAGE MONITORING SCHEDULE

Parameter	Frequency per year	Locations	Years
Air Quality	2x24 hours, in a week for each season, three seasons in a year	12	3
Noise	2x24 hours, in a week for each season, three seasons in a year	12	3
Water	Once in six month, twice in a year	11	3
Soil	Once in six month, twice in a year	11	3

15.6.2 Environment Management System (EMS)

Environment Management System is intended to facilitate implementation, tracking and reporting of mitigation and monitoring measures proposed for the project. Roles and responsibilities are summarized in **Tables 15.27** and **15.28.**

TABLE 15.27: ROLES AND RESPONSIBILITIES - SECURING APPROVALS/CLEARANCES

S. No.	Issue	Provision of Laws & Regulations	Due Date	Approving Authority
Pre-Construction Phase				
1.	Permission for felling of trees and compensatory afforestation	"The Maharashtra Felling of Trees (Regulation) Act, 1964 The Maharashtra (urban areas) protection and preservation of tree Act, 1975	Before Construction	Tree authority Municipal Corporation
2.	Prior Environmental Clearance Prior Environmental Clearance: Metro Railway is not listed among activities requiring prior Environmental Clearance in EIA Notification 2006. March 2016 in case of Nagpur Metro, MoEFCC Clarified that construction of building for commercial purposes having built area equal to or more	EIA Notification 2006 and its amendments		SEIAA

S. No.	Issue	Provision of Laws & Regulations	Due Date	Approving Authority
	than 20,000 sqm shall require prior EC from SEIAA. Feb. 2015 Principal Bench of NGT- construction of a 'bridge' or similar activity covering a build up area ≥ 1,50,000 sq. m. would be covered under Entry 8(b) of Schedule to the Regulations of Notification 2006.			
3.	Building Permissions for Depot, stations, property development	EIA Notification 2006 and its amendments		Municipal Corporation
4.	Utility / traffic diversion	Respective Acts and Rules		Local Offices of respective Agencies.
5.	Consent to Establish construction yards, labour camps, stations and depots (since non-residential)	Water (Prevention and Control of Pollution) Act 1974, Air (Prevention and Control of Pollution) Act ,1981		State Pollution Control Board; Development Authority for landuse clearance
6.	Sites to establish labour camps, pre-casting and material yards	Land use Master Plan and DC&PR		Municipal Corporation
7.	NOC from Airport Authority: Project is located within 20km from airport (VFR) or 56km (IFR) and proposed height of structure is more than or equal to 150m	Aircraft Act 1934 with Aircraft (Amendment) Act, 2007 (44 of 2007) Ministry of Civil Aviation (Height Restrictions for Safeguarding of Aircraft Operations) Rules, 2015 that are further amended in 2018.		Airport authority of India
Construction Phase				
8.	• Consent to Establish and Operate hot mix plant, crushers, batching plant etc and • Consent to Establish labour camps	Air (Prevention and Control of Pollution) Act, 1981	Before Construction	• State Pollution Control Board • Municipal Corporation
9.	Permission for drawal of	Environment (Protection)	Before	Regional Director,

S. No.	Issue	Provision of Laws & Regulations	Due Date	Approving Authority
	groundwater for construction **(not recommended)**	Act, 1986	Construction	Central Ground Water Board and Municipal Corporation
10.	Authorization for Disposal of Hazardous Waste	Hazardous Waste (Management and Handling and trans boundary movement) Rules 2016	Before Construction	State Pollution Control Board
11.	Consent for disposal of waste water from construction sites and sewage from labour camps	Water (Prevention and Control of Pollution) Act 1974	Before Construction	State Pollution Control Board
12.	Labour employment, safety, welfare measures	The Building and Other Construction Workers (Regulation of Employment and Conditions of Service) Act, 1996	Before Construction	District Labour Commissioner
13.	Permission for management of C&D waste and muck	Construction and Demolition Waste Management Rules 2016	Before Construction	Municipal Corporation and State Pollution Control Board
Operation Phase				
14.	Consent to Operate Depot	Environment Protection Act , 1986	After Construction	State Pollution Control Board
15.	Installation and operation of DG sets at stations	Air (Prevention and Control of Pollution) Act, 1981	After construction	State Pollution Control Board

TABLE 15.28: ROLES AND RESPONSIBILITIES –PREPARATION AND IMPLEMENTATION OF ENVIRONMENTAL MANAGEMENT PLAN (EMP) AND ENVIRONMENTAL MONITORING PLAN (EMOP)

S.No.	Environmental Impact	Mitigation Measure	Implementing Entity	Responsible Entity
Location and Design Phase				
1	Displacement and private property acquisition, impact of	Alignment design to avoid or minimize impact.	DPR and design consultant	PIU

S.No.	Environmental Impact	Mitigation Measure	Implementing Entity	Responsible Entity
	environmentally sensitive areas.			
2	Loss of trees and water bodies		DPR and design consultant	PIU
3	Visual intrusion	Capital and operating cost and vibration impact of underground line in trade off with visual intrusion. To design aesthetic structures of viaduct and stations on elevated sections.	DPR and design consultant	PIU
4	Archaeological monuments	Alignment design to avoid or minimize impact.	DPR and design consultant	PIU
Pre-construction Phase				
5	Displacement and private property acquisition.	Implement R&R Plan	PIU	PIU
6	Loss of trees and water bodies	Implement compensatory afforestation	Municipal Corporation	Municipal Corporation
7	Site measures	Prepare Safety, Health and Environment (SH&E) Manual and secure approval.	Contractor	PIU
8	Water supply; sewage and solid waste disposal	Requirement for construction to be planned so as to avoid use of ground water.	Contractor	PIU
9	Environmental Management and Monitoring	Implement institutional requirements for implementation of EMP and EMoP.	Contractor	PIU
Construction Phase				
10	Soil erosion, fugitive dust generation, muck disposal and C&D waste management	Implement suitable construction methods and as per SH&E Manual	Contractor	PIU
11	Air and noise Pollution	Vehicles and machinery are to be maintained to emission standards; machinery noise muffles etc and personal protective gear to workers.	Contractor	PIU
12	Vibration	Implement vibration monitoring and building condition surveys at sensitive structures	Contractor	PIU

S.No.	Environmental Impact	Mitigation Measure	Implementing Entity	Responsible Entity
13	Water pollution	Implement measures such as precipitation tanks on site	Contractor	PIU
14	Soil pollution	Implement measures to prevent ingress of toxic / heavy metals	Contractor	PIU
15	Labour camp: water supply; sewage and solid waste disposal; health	Implement measures as per SH&E Manual	Contractor	PIU
16	Facilities on site and workplace safety		Contractor	PIU
17	Incident Management	Prepare Incident Management Plan with reporting formats.	Contractor	PIU
18	Environmental Monitoring	Prepare Environmental Monitoring Plan.		
19	Availability of institutional capacity	Implement training and establish environment unit.	Contractor	PIU
Operation Phase				
20	Noise Pollution	Implement and maintain noise barriers on viaduct	PIU	PIU
21	Vibration	Implement vibration monitoring and building condition surveys at sensitive structures.	PIU	PIU
22	Water supply, sanitation, sewage and solid waste disposal at stations and depots	Implement prescribed measures including rain water harvesting at stations and depots; green belt and water recycling at depots.	PIU	PIU
23	Sewage and effluent disposal	Implement STP and ETP at depots.	PIU	PIU
24	Incident Management	Implement Incident Management Plan.	PIU	PIU
25	Environmental Monitoring	Implement Environmental Monitoring Plan.	PIU	PIU

The range of documentation required to be generated and maintained as part of EHS before and during construction and during operation is as follows:

- Controlled documents of mandatory environmental Approvals and clearances along with record extensions thereof

- Controlled documents of approved SH&E Manual, EMP and EMoP with revisions thereof and time schedule of such revisions if any.
- Controlled documents of formats of site inspection checklists with revisions thereof and time schedule of such revisions if any
- Reports of site inspections, monitoring data, reports of internal or external audit, observations of PIU and local statutory agency if any like Pollution Control Board, local municipal authority, Forest Department etc. and subsequent remedial action taken by Contractor, if any
- Records of coordination meetings of PIU/GC and Contractor with subsequent remedial action taken by Contractor, if any
- Records of incident reporting and remedial action taken by Contractor if any and followup of such incidents

A typical EMS organization is depicted in **Figure 15.10.** One indicative activity i.e., approval of EMS documents is shown in this organisation chart.

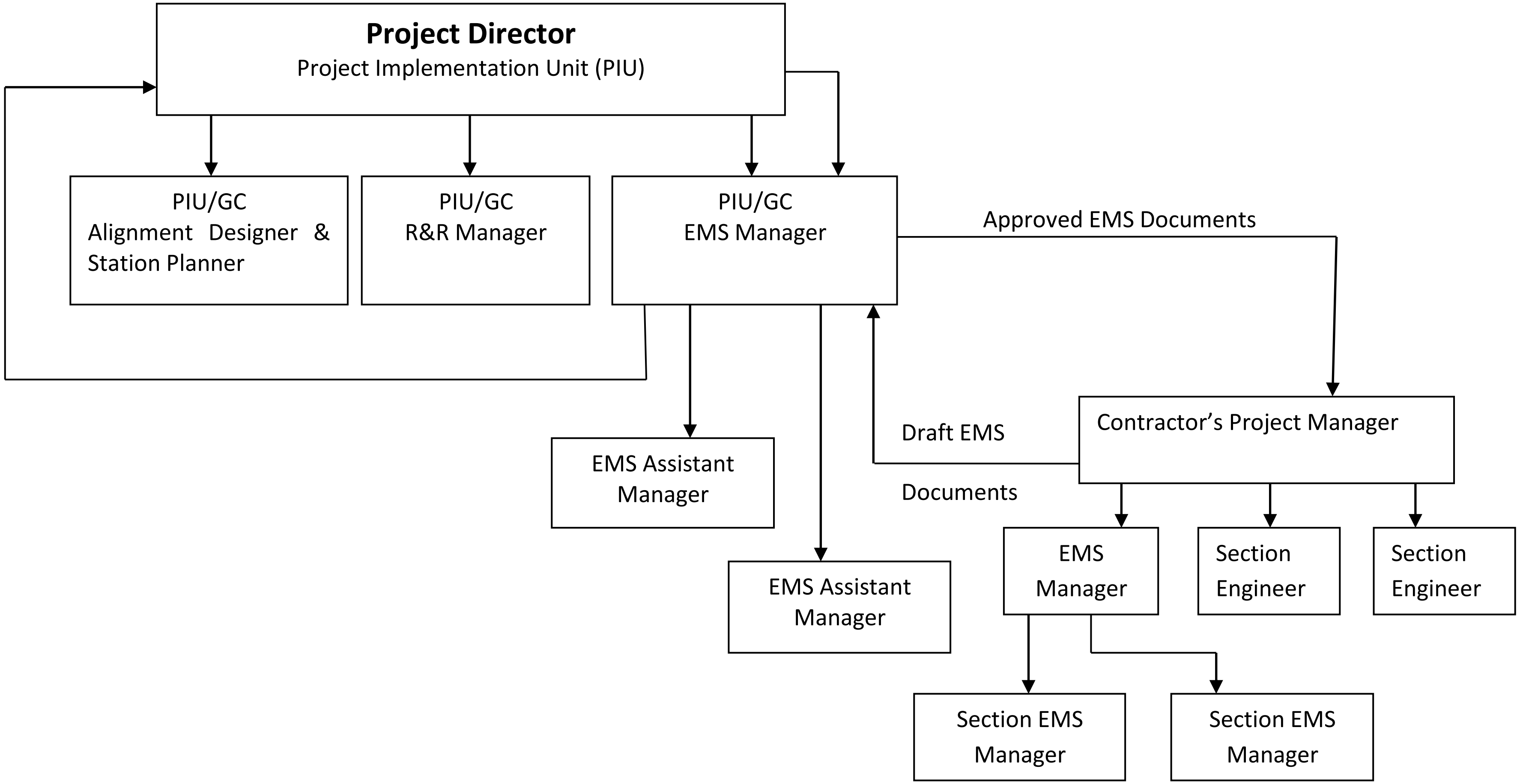
15.7 SUMMARY OF ENVIRONMENTAL COST ESTIMATE

Estimated environmental cost for the proposed extensions of metro corridors is about **Rs 1307.49 lakh**. Summary of cost estimate is given in the following **Table 15.29**.

TABLE 15.29: SUMMARY OF COST ESTIMATE OF EMP IMPLEMENTATION

S No	Item	Estimated Cost (Rs lakh)				
		Datta Wadi	Kapsi (Transport Nagar)	Hingna	Kanhan	Butibori (MIDC ESR)
1	Compensatory Afforestation	4.76	0.44	1.80	20.60	16.72
3	Noise Barriers	3.2	5.2	27.5	11.5	8.9
4	Rain Water Harvesting	103.28	109.13	129.78	253.33	342.97
5	Environmental Monitoring	43.28	43.64	43.64	56.01	66.06
6	Training and Extension	1.75	1.75	1.75	5.25	5.25
	Total	**156.27**	**160.16**	**204.47**	**346.69**	**439.9**

FIGURE 15.10: EMS ORGANIZATION



* GC: General Consultant as Project Management Consultant

15.8 SOCIAL IMPACT ASSESSMENT

Development of proposed five metro rail extensions involves acquisition of land for stations, running sections, TSS, Depot and for other facilities. Acquisition of this private land may cause social disruption and economic loss for the families/people who are likely to be affected. While implementing the project, there is a need to take into account these disturbances and losses due to the project, their impact on socio-economic condition of the people and plan for their mitigation measures to minimise any negative impacts. The details of number of affected structures and expected families likely to be affected and preliminary Resettlement Action Plan (RAP) is presented in this section.

15.8.1 Objective of SIA and RAP

The objective of Social Impact Assessment is to (i)Identify Project Affected Families (PAFs) by type and extent of loss (ii) Identify the possible adverse impacts of the project on the people and the area (ii) Suggest culturally and economically appropriate measures for mitigation of adverse impacts of the project (iii) Recommend institutional mechanism for implementation of RAP (iv) Recommend grievance redress mechanism (v) Identify time frame for implementation of RAP (vi) Estimate budget for RAP and (vii) Recommend mechanism for Monitoring and Evaluation (M&E) of implementation of RAP.

15.8.2 Approach & Methodology

This preliminary SIA which includes RAP has been prepared in accordance with the State and national policy and guidelines. The input tasks are desk research, site visits and information dissemination, enumeration of affected structures and families, sample socio-economic survey and local public consultation.

15.8.3 Land Requirement and Acquisition

The project shall require the acquisition/transfer of 10.2453 ha of land. Out of the total land, 7.2175 ha is private land and 3.0278 is government land. The details of land requirement and acquisition are presented in **Table 15.30**.

TABLE 15.30: LAND REQUIREMENT AND ACQUISITION (in Sqm.)

Corridor	Pvt. Land	Govt. Land	Total
MIHAN to MIDC ESR	4.5989	0	4.5989
Automotive Square to Kanhan river	0.6731	1.3874	2.0605
Lokmanya Nagar to Hingna	1.1207	0.8211	1.9418
Prajapati Nagar to Transport Nagar	0.3248	0.4214	0.7462
Vasudev Nagar to Dattawadi	1.1207	0.8211	1.9418
Total	**7.2175**	**3.0278**	**10.2453**

15.8.4 Inventory of Affected Structures

The number of affected structures as identified on the basis of alignment drawings and site visit. There are 61 structures likely to be affected in proposed five corridors. Majority of structures are affected in Automotive Square to Kanhan River and Lokmanya Nagar to Hingna corridors. Out of the total structures,9 are residential,40 are commercial,7 are residential cum commercial structures. About five are other structure includes temple and community property (**Table 15.31**).

TABLE 15.31: CORRIDOR WISE AFFECTED STRUCTURES

Corridor	C	R	R+C	Other	Total
Mihan to MIDC ESR	4	1	1	1	7
Automotive Square to Kanhan River	7	6	4	3	20
Lokmanya Nagar to Hingna	14	1	2	1	18
Prajapati Nagar to Transport Nagar	4	1	0	0	5
Vasudev Nagar to Dattawadi	11	0	0	0	11
Total	40	9	7	5	61

C=Commercial; R=Residential: R+C=Residential+Commercial

Other structure includes temple and community property

Corridor and station wise number of structures is likely to be affected is presented in **Table 15.32.**

TABLE 15.32: CORRIDOR AND STATION WISE AFFECTED STRUCTURES

Corridor/Station	C	R	R+C	Other	Total
Automotive Square to Kanhan River					
KAMPTEE POLICE ST.	0	0	2	0	2
DRAGON PALACE STAT..	0	5	0	0	5
BETWEEN KAMPTEE PO..	1	0	0	3	4
BETWEENALL INDIA RA..	0	0	1	0	1
Kasara Fata STATION	6	0	1	0	7
LEKHA NAGAR STATION	0	1	0	0	1

Corridor/Station	C	R	R+C	Other	Total
Sub-total	**7**	**6**	**4**	**3**	**20**
Lokmanya Nagar to Hingna					
APMC STATION	4	1	0	0	5
BETWEEN APMC AND HI..	2	0	2	0	4
HINGNA BUS STATION	1	0	0	0	1
HINGNA BUS STATION..	6	0	0	1	7
RAJIV NAGAR STATION	1	0	0	0	1
Sub-total	**14**	**1**	**2**	**1**	**18**
Mihan to MIDC ESR					
BETWEEN METRO CITY ..	2	0	1	1	4
BUTIBORI STATION TU..	2	1	0	0	3
Sub-total	4	1	1	1	7
Prajapati Nagar to Transport Nagar					
KAPSI KHURD STATION	2	0	0	0	2
PARDI STATION	2	1	0	0	3
Sub-total	4	1	0	0	5
Vasudev Nagar to Dattawadi					
BETWEEN VASHUDEV NA..	11	0	0	0	11
Sub-total	11	0	0	0	11
Total	**40**	**9**	**7**	**5**	**61**

Table 15.33 depicts corridor wise fully affected structures. Out of the total structures about 43 structures are fully affected. Among the total fully affected structures, majority (31) are commercial structures and two are residential structures.

TABLE 15.33: CORRIDOR WISE FULLY AFFECTED STRUCTURES

Corridor	C	R	R+C	Other	Total
Mihan to MIDC ESR	3	1	0	1	5
Automotive Square to Kanhan River	1	6	2	2	11
Lokmanya Nagar to Hingna	13	1	0	0	14
Prajapati Nagar to Transport Nagar	2	1	0	0	3
Vasudev Nagar to Dattawadi	10	0	0	0	10
Total	**29**	**9**	**2**	**3**	**43**

Table 15.34 summarises partially affected structures. Out of the total partially affected structures four are residential, 11 are commercial and five are residential cum commercial structures. It is observed that majority of structures which are likely to be affected either partially or fully are commercial.

TABLE 15.34: CORRIDOR WISE PARTIALLY AFFECTED STRUCTURES

CORRIDOR	C	R	R+C	other	Total
Mihan to MIDC ESR	1	0	1	0	2
Automotive Square to Kanhan River	6	0	2	1	9
Lokmanya Nagar to Hingna	1	0	2	1	4
Prajapati Nagar to Transport Nagar	2	0	0	0	2
Vasudev Nagar to Dattawadi	1	0	0	0	1
Total	**11**	**0**	**5**	**2**	**18**

About 82 families consisting 451 persons shall be affected due to the proposed metro project. Majority of families shall be affected in Lokmanya Nagar to Hingna corridor (185 PAFs) followed by Vasudev Nagar to Dattawadi corridor (144 PAFs). Corridor wise number of PAFs and PAPs are presented in **Table 15.35**. *Exact number of affected and displaced families/persons will be found out during detailed Census/Baseline Socio-Economic Survey (BSES) after peg marking of alignment on the ground.*

TABLE 15.35: IMPACT ON PAFs AND PAPs

Name of Corridor	Total affected structures	Total PAFs	Total PAPs*	Average family size
Mihan to MIDC ESR	7	8	37	4.6
Automotive Square to Kanhan River	20	17	63	3.7
Lokmanya Nagar to Hingna	18	27	185	6.9
Prajapati Nagar to Transport Nagar	5	5	22	4.4
Vasudev Nagar to Dattawadi	11	25	144	5.8
Total	**61**	**82**	**451**	**5.5**

The number of PAPs were enquired and analysed from field survey

As shown in **Table 15.36 and Table 15.37** there are 43 title holders and 39 non-title holders affected families. Out of the total titleholders, 30 PAFs are commercial, 6 PAFs are residential cum commercial and 7 PAFs are residential. Similarly, out of the total non-titleholders, 27 PAFs are commercial tenants and 2 PAFs are residential tenants 10 PAFs are commercial encroachers. During social survey 45 encroachers are found in all five corridors. But out of the total encroachers, 10 encroachers are fully affected. Therefore, 10 encroachers are considered for R&R purpose.

TABLE 15.36: TITLE HOLDERS PAFs

Name of Corridor	Title Holders			
	R	C	R+C	Total
Mihan to MIDC ESR	0	2	0	2
Automotive Square to Kanhan River	6	0	4	10

Name of Corridor	Title Holders			
	R	C	R+C	Total
Lokmanya Nagar to Hingna	1	7	2	10
Prajapati Nagar to Transport Nagar	0	1	0	1
Vasudev Nagar to Dattawadi	0	20	0	20
Total	**7**	**30**	**6**	**43**

TABLE 15.37: NON-TITLE HOLDERS PAFs

Name of Corridor	Non-Title Holders			
	R	C	Encroacher	Total
Mihan to MIDC ESR	1	2	3	6
Automotive Square to Kanhan River	0	6	1	7
Lokmanya Nagar to Hingna	0	12	5	17
Prajapati Nagar to Transport Nagar	1	2	1	4
Vasudev Nagar to Dattawadi	0	5	0	5
Total	**2**	**27**	**10**	**39**

It is evident from the **Table 15.38** that five community structures are likely to be affected. Of these one is school, and four are religious structures.

TABLE 15.38: LOSS OF COMMON PROPERTY RESOURCES

Corridor	School	Temple	Total
Mihan to MIDC ESR	0	1	1
Automotive Square to Kanhan River	0	3	3
Lokmanya Nagar to Hingna	1	0	1
Prajapati Nagar to Transport Nagar	0	0	0
Vasudev Nagar to Dattawadi	0	0	0
Total	**1**	**4**	**5**

15.8.5 Socio-economic Profile of Project Influence Area

Nagpur is a city in the central part of India in Maharashtra State. Nagpur Limits encompass 217.56 sq km of land area. Nagpur's population (SRS Bulletin,2016) is about 24.05 lakhs with an average density of 11065 persons per sq.km. As per provisional reports of Census of India, population of Nagpur in 2011 is 24,05,421; of which male and female are 12,26,610 and 11,78,811 respectively. Nagpur urban agglomeration/ metropolitan region's population is 24, 97,777 of which 12,75,750 are males and 12,22,027 are females. The sex ratio of Nagpur city is 963 per 1000 males. Child sex ratio of girls is 926 per 1000 boys. The average literacy rate of Nagpur city is 91.92 percent of which male and female literacy is 94.44 and 89.31 percent.

Nagpur city is important for the banking sector as it hosts the regional office of Reserve Bank of India, which was opened on September 10, 1956. Sitabuldi Market in central Nagpur, known as the heart of the city, is the major commercial market area of city. Nagpur is also emerging as an important industrial town. Butibori Industrial area, which is one of the largest industrial areas, is located in Nagpur. Salient characteristics are presented in **Table 15.39.**

TABLE 15.39: SOCIO-DEMOGRAPHIC CHARACTERISTICS OF NAGPUR CITY

S.No.	Description	Nagpur City	Maharashtra
1	Area (Sq. km.)	217.56	9897
2	Population (Lakh)	24.05	1123.74
2.1	Males (Lakh)	12.25	582.43
2.2	Females (Lakh)	11.80	541.31
2.3	Population density (per sq. Km.)	11,056 persons	365
2.4	Population growth (2001-11)	19%	16%
2.6	Sex ratio	963	929
2.7	Child sex ratio (0-6 yrs)	926	894
2.7.1	Infant Mortality Rate	31.1#	22*
2.7.2	Maternal Mortality Rate	not available	87
2.8	Literacy rate	91.92%	82.34%
2.8.1	Male	94.44%	88.38%
2.8.2	Females	89.31%	75.87%
2.8.3	Gender Gap in literacy rate	5.13%	12.51%
2.9	Religion		
2.9.1	Hindu	69.46%	79.83%
2.9.2	Buddhist	15.56%	5.81%
2.9.3	Muslim	11.95%	11.54%
2.9.4	Others	3.03%	2.82%
2.1	Household Size	4.5	4.6
# Nagpur Municipal Corporation data; *SRS Bulletin 2016,			

15.8.5.1 Socio-economic Profile of PAFs

Table 15.40 shows demographic characteristics (i.e. sex, age and marital status) of sample PAPs. Among the surveyed population it is observed that 43.32% are male and remaining 56.68% are female. The sex ratio is 1309 per 1000 males. The persons of surveyed families have been categorized into four age groups. The distribution of person’s age in various group shows that about 15% of the total persons belong to below 17 years; about 35% belong to the 18-34 years age group that is potentially productive group. About 37.33% belongs to 35-39 years. About 13% of total persons belong to above 60 years, who are dependent population. It is observed that majority of persons belong to 35 to 59 years age group and average age of surveyed population is 35 years. It is observed that out of total surveyed people, majority of them (70%) are married, and about 30 % are unmarried.

TABLE 15.40: DEMOGRAPHIC CHARACTERISTICS OF SAMPLE PAPS

Characteristics	Number	Percent
Sex		
Male	94	43.32
Female	123	56.68
Sex ratio	1309	
Age group		
0-17	32	14.75
18-34	76	35.02
35-59	81	37.33
60 & above	28	12.9
Mean ± SD	35.6	
Marital status		
Married	135	69.95
Unmarried	58	30.05
Sub-total	193	
Total	**217**	**100.0**

Table 15.41 shows social characteristics like religious and social groups, family pattern and its size of PAFs and educational level of PAPs. The study result shows that about 93% of the surveyed families are Hindu followed by Jain (4.65%) and Muslim (2.33%). Majority of families are Hindu in all three corridors. Majority of surveyed families belong to OBCs (70%) followed by General Caste(23.26%).About 4.65% and 2.33% of surveyed families belong to SC and ST caste groups respectively. Majority of surveyed families are joint (62.79%) followed by nuclear (34.88%). About 44.2% are medium in size followed by small (32.5%) and remaining 23.2% families have their members more than seven. The analysis indicates that out of the total surveyed people, about 11.6% are illiterate. So far as educational attainment is concerned 13% are educated up to primary class, 39% are educated up to secondary, about one-fifth studied up to graduation and above graduation.

TABLE 15.41: SOCIAL CHARACTERISTICS OF SAMPLE PAFS

Characteristics	Number	Percent
Religious groups		
Hindu	40	93.02
Muslim	1	2.33
Jains	2	4.65
Caste groups		
SC	2	4.65
ST	1	2.33
OBC	30	69.77
General	10	23.26
Family pattern		
Joint	27	62.79
Nuclear	15	34.88
Individual	1	2.33
Family size		
Small (2-4)	14	32.56
Medium (5-7)	19	44.19
Large (Above 7)	10	23.26
N		
Education (PAPs)		
Illiterate	24	11.59
Primary	27	13.04
Secondary	81	39.13
Higher Secondary	38	18.36
Graduation	30	14.49
Above graduation	7	3.38
	207	
N	43	

Table 15.42 shows that main occupation of majority of the head of the households is business (81.41%). Majority of families' monthly income is more than Rs.15000/-. The average income of a family is Rs.36674/- per month. Monthly per capita income is Rs.6791/-. Average family expenditure is Rs.18242/- per annum. In majority of families the earning member is one whereas in majority of families the dependent member per family is more than three.

TABLE 15.42: OCCUPATIONAL CHARACTERISTICS OF SAMPLE PAFS

Characteristics	Number	Percent
Household main occupation		
Business	35	81.41

Characteristics	Number	Percent
Govt. Job	2	4.66
Others#	6	13.96
Household monthly income		
Rs. <15000	16	37.21
Rs. 15000 -30000	16	37.21
Rs. >30000	11	25.58
Average monthly income (Rs.)	36674	
Average monthly per capita income	6791	
Monthly household expenditure		
Rs. <15000	28	65.12
Rs. 15000 -30000	10	23.26
Rs. >30000	5	11.63
Average monthly expenditure (Rs.)	18242	
Average monthly per capita expenditure	3378	
Earning members in family		
1 Member	25	58.14
2-3 Members	15	34.88
Above 3 Members	3	6.98
Dependent members in family		
< 2 members	1	2.33
2-3 Members	16	37.21
> 3 Members	26	60.47

Note: Monthly per capita expenditure has been adopted from the report on household consumer expenditure based on 68th NSS round, July 2011-June 2012. Government of Maharashtra.
#Others include labourers and farmers

Key Findings of Public Consultation

The consultant briefed the participants about the objectives of the meeting regarding various social issues related to the project i.e. land acquisition, compensation, loss of livelihood, cost of travelling, employment and development of city etc. The participants were invited to give their valuable suggestions on the above issues and were assured for suitable incorporation of such suggestions in the project within

the technical limitations and scope of the project. The major findings from public consultation are as follows.

The issues raised during the public consultation across the corridors can be broadly classified under traffic reduction, increase connectivity, reduction in pollution and problems related to land acquisition and displacement. For instance, near Kasara fata in Automotive Square to Kanhan River, some of the respondents reported that they have enough number of buses and other means of transportation in the city of Nagpur. So, the metro project is not going to be feasible as it has a higher fare in comparison with other means of transportation. Similarly, the issue of compensation was raised at Hingna bus station: participants felt that metro train will surely augment infrastructure and other facilities, but suggested that the affected families/people should get adequate compensation in order to re-instate the life of people. In the similar vein, the issue of livelihood has been raised Pardi station. Further, at many places, participants of public consultation appreciated the upcoming extension metro project as it will increase connectivity, reduce the traffic load and reduce existing level of pollution. Participants from Kasara Fata, Pardi station and Hingna bus station highlighted their concern regarding air and noise pollution and suggested that metro project should not affect the existing level of greenery. Similarly the participants of Hingna Bus station raised their concern regarding high fares of travelling in metro rail. Participants suggested that the fares should be affordable in order to increase accessibility.

15.8.5.2 Applicable Laws, Guidelines for Land Acquisition, Rehabilitation and Resettlement

Following guidelines and circulars of Government of Maharashtra are applicable for land acquisition, rehabilitation and resettlement compensation.

- Government Circular No. Misc.-03/2015/C.N34/A-2 dated 12th May 2015, 30th September, 2015 and LQN-01/2017/CN 12/A-2 dated 25th January, 2017, Revenue Forest Department, Government of Maharashtra, in the context of acquiring land of private sector by method of direct purchase through private negotiation for irrigation and other projects.

- Direct purchase method ensures that the property owners are negotiated directly for purchase of land by giving them an amount amicably accepted by the affected person which is 250% of the market value. In the process the concerned person is getting better price for the involved land and structure. This has been adopted for this DPR.

- The Right to Fair Compensation and Transparency in Land Acquisition, Rehabilitation and Resettlement Act, 2013.
- The Metro Railways (Construction of Works) Act, 1978.

15.8.6 Institutional Arrangement

15.8.6.1 Executing Agency (EA)

Maharashtra Metro Rail Corporation Limited (Maha Metro) was incorporated by Government of India- Ministry of Corporate affairs on 18th February 2015 as a Special Purpose Vehicle (SPV) for smooth implementation and operations of the Nagpur Metro Rail Project. It has now been converted into a Joint Venture of Government of India (GoI) and Government of Maharashtra (GoM) with equal equity holding.

The GoM and GoI will be the executing agency of the proposed five corridors of metro project. The GoM will be responsible for overall execution of the RAP. An independent Monitoring and Evaluation (M&E) Agency/Specialist will be hired by GoM to monitor the implementation of the various provisions and activities planned in the RAP. The independent M&E Agency/Specialist will review the plan implementation in lights of targets, budget and duration that had laid down in the plan.

15.8.6.2 Implementing Agency (IA)

Maha Metro shall be responsible for implementation of the proposed five corridors of metro rail project. The Managing Director (MD) will be the in charge of the overall project activities and will facilitate land acquisition, capacity building and implementation of RAP. Maha Metro will be responsible for coordinating with other concerned government departments, NGO, and R&R Supervision Consultant for land acquisition, planning and implementation of RAP which will include the disbursement of compensation, assistance, shifting and relocation of affected people. Maha Metro will be accountable to the GoM (i.e. the EA) for the implementation of the RAP.

15.8.6.3 Project Implementation Unit (PIU)

The PIU headed by the Project Director (PD) is responsible for the overall execution of the project and planning and implementation of resettlement and rehabilitation component during preparation, implementation and post implementation phase of the project. The PIU will coordinate with all implementing agencies and monitoring the progress of the project.

15.8.6.4 Social Management Unit (SMU)

Maha Metro shall set up a Social Management Unit (SMU) which shall look after land acquisition, resettlement and rehabilitation activities. A Senior Social Development Officer (SSDO) will be appointed on full time by Maha Metro. The SMU shall ensure that all land acquisition issues are handled according to the Land Acquisition and Rehabilitation & Resettlement Act. It will also monitor that all the procedural and legal issues involved in land acquisition are fulfilled. The SMU will assist for getting all the necessary clearances and implementation of the resettlement activities prior to start of any civil work.

A Resettlement and Rehabilitation Officer (RRO) may be appointed in this SMU to supervise and monitor overall activities of RAP and he/she will report day to day progress to SSDO. RRO will also work closely with the District Collector to expedite the payment of compensation for land acquisition and assistance to APs. The RRO will form Local Resettlement Committees (LRC) in each project affected areas consisting of local representatives and other stakeholders. Specific functions of the SMU in regards to resettlement management will include the following:

- Overall responsibility of planning, implementation and monitoring of land acquisition, resettlement and rehabilitation activities in the project;
- Ensure availability of budget for R&R activities;
- Liaison lined agencies support for land acquisition and implementation of land acquisition and resettlement;
- Coordinating with line departments

Moreover, the SMU will also look after the Corporate Social Responsibility (CSR) activities of Maha Metro on long term basis for sustainable development of affected communities.

15.8.6.5 Role of Non-Government Organization (NGO)

An NGO will be appointed by Maha Metro to extend implementation support to Maha Metro in the form of assisting affected families/persons during relocation and preparation of Income Restoration Plan (IRP). The NGO will help educating PAPs on proper utilization of compensation and rehabilitation grant and help them in getting financial assistance. The NGO will be supervised by SSDO, SMU.

15.8.6.6 Implementation Support Consultant(R&R)

During implementation phase of RAP, Maha Metro will appoint a consultant(R&R) through General Engineering Consultancy (GEC) to assist Maha Metro in implementation of resettlement plan. The consultant will carry out due diligence in the implementation of resettlement and rehabilitation programmes through periodic monitoring. The consultant will be responsible for (i) preparation of database of affected structures, families, persons, (ii) verification of database through field survey,(iii)improve monitoring system,(iv)capacity building of implementation staff ,(v)regular follow up implementation activities and other relevant activities.

15.8.6.7 Grievance Redress Committee (GRC)

Efficient grievance redressal mechanism will be developed to assist the PAPs resolve their queries and complaints. Grievances of PAPs will be first brought to the attention of field level staff of Maha Metro. Grievances not redressed by the staffs (field level) will be brought to the Grievance Redressal Committee (GRC). The proposed GRC will have representatives from PAPs, women, NGO and local body; Project Director (PIU), SSDO, SMU of Maha Metro and Land Acquisition Officer (LAO). The main responsibilities of the GRC are to: (i) provide support to PAPs on problems arising from land/property acquisition; (ii) record PAPs grievances, categorize, and prioritize grievances and resolve them; (iii) immediately inform the SMU of serious cases; and (iv)report to PAPs on developments regarding their grievances and decisions of the GRC.

Other than disputes relating to ownership rights under the court of law, GRC will review grievances involving all resettlement benefits, compensation, relocation, replacement cost and other assistance.

15.8.6.8 Training and Capacity Building

Establishing sufficient implementation capacity to launch and carry out those components of project resettlement that must be completed before civil works. Exposure visits and training through specialists in the field will be arranged for SMU staff.

15.8.6.9 Implementation Schedule of Resettlement Action Plan

The implementation of RAP will consist of four major stages:

1. Identification of Cut-off Date (CoD) and notification for land acquisition is either by The Right to Fair Compensation and Transparency in Land Acquisition, Rehabilitation and Resettlement Act, 2013 or The Construction of Metro Act, 1978 or by Direct Purchase Method. For non-titleholders the cut-off date for each corridor shall be from the start of Census Survey.
2. Verification of properties of PAFs/PAPs and estimation of their type and level of losses.
3. Preparation of list of PAFs/PAPs for relocation/rehabilitation.
4. Relocation and rehabilitation of the PAPs.

- **Timing of Resettlement**

The resettlement process must be completed before the start of civil works on the particular corridor. Requisite procedure will be developed by the Maha Metro to carry out resettlement of PAPs located within Corridor of Impact (CoI), before the civil work starts on any section of the project. All activities related to the land acquisition and resettlement shall be planned to ensure that 100% compensation is paid prior to displacement and the affected people will be given at least four months of notice to vacate their property before civil work begins. Stretches which are free of encroachment and other encumbrances will be handed over first to the contractor.

15.8.6.10 Implementation Schedule

The period for implementation of RAP has been taken as two and half years. However, monitoring and evaluation will continue beyond the period of implementation. The R&R activities of proposed project are in three phases: project preparation, RAP implementation and Monitoring and Evaluation (M&E).

- **Project Preparatory Stage (Pre-Implementation Stage)**

Setting up relevant institutions for the resettlement activities will be the major task during the preparatory stage which is pre implementation phase. The major activities to be performed in this period include establishment of SMU and additionally, the GRC needs to be appointed at this stage.

- **RAP Implementation Stage**

  The RAP, at this stage, needs to be approved and will be disclosed to the PAPs. Upon the approval of RAP, all the arrangements for fixing the compensation and the disbursement needs to be done which includes payment of all eligible assistance; relocation of PAPs; initiation of economic rehabilitation measures; site preparation for delivering the site to contractors for construction and finally commencement of the civil work. Internal monitoring will be the responsibility of Maha Metro which will start in early stage of the project when implementation of RAP starts and will continue till the completion of the implementation of RAP. Maha Metro will be responsible for carrying out the monitoring on half yearly basis.

- **RAP Implementation Schedule**

  RAP implementation schedule for R&R activities in the proposed project including various sub tasks and time line matching with civil work schedule will be finalised after finalisation of station locations and subsequent socio-economic survey of project affected areas.

15.8.6.11 R&R Cost Estimate

As mentioned in 15.8.5.2, compensation cost for land shall be calculated @ 250% of the circle rate. This will include cost of land, value of assets attached to the land, solatium, one time resettlement and rehabilitation cost i.e transportation, compensation for livelihood, subsistence allowance etc. A tentative R&R cost has been calculated based on Schedule-II of Right to Fair Compensation and Transparency in Land Acquisition, Rehabilitation and Resettlement Act,2013. The tentative R&R cost of proposed metro rail is **INR 12.46 crore.**

Chapter – 16
DISASTER MANAGEMENT AND SECURITY MEASURES

16. DISASTER MANAGEMENT AND SECURITY MEASURES

16.1 DISASTER MANAGEMENT ANDIMPERATIVES

Disaster is a crisis that results in massive damage to life and property, uproots the physical and psychological fabric of the affected communities and outstrips the capacity of the local community to cope with the situation. Disasters are those situations which cause acute distress to passengers, employees and outsiders and may even be caused by external factors. As per the disaster management act, 2005 "disaster" means a catastrophe, mishap, calamity or grave occurrence in any area, arising from natural or manmade causes, or by accident or negligence which results insubstantial loss of life or human suffering or damage to, and destruction of, property, or damage to, or degradation of, environment, and is of such a nature or magnitude as to be beyond the coping capacity of the community of the affected area.

World Health Organization (WHO), defines disaster as “Any occurrence that causes damage, economic disruption, loss of human life and deterioration of health and services on a scale sufficient to warrant an extra ordinary response from outside the affected community or area.”

16.2 NEED FOR DISASTER MANAGEMENT

Disaster brings about sudden and immense misery to humanity and disruptions to normal human life in established social and economic patterns. It has the potential to cause large scale human suffering.

Metro systems will carry thousands of passengers daily, therefore the effect of any disaster spread over in operational area (station, tunnels, viaducts etc.) is likely to be considerable. It may also cause destruction or damage to infrastructure, buildings and communication channels of Metro.

16.3 TYPE OF DISASTERS IN METRO SYSTEM

Metro specific disasters can be classified into two broad categories as Man-made and Natural.

a. Man Made Disaster

- Terrorist attack
- Bomb threat/ Bomb blast
- Hostage Situations
- Release of Chemical or biological gas in trains, stations or tunnels
- Fire in metro buildings, underground/ elevated infrastructures, power stations, train depots etc.
- Train accident and train collision/derailment of a passenger carrying train
- Sabotage
- Stampede

b. Natural Disaster

- Earthquakes
- Floods

16.4 OBJECTIVES OF DISASTER MANAGEMENT PLAN

The main objectives of Disaster Management Measures are as follows:

- Save life and alleviate the sufferings.
- Provide help to stranded passengers and arrange their prompt evacuation.
- Instill a sense of security amongst all concerned by providing accurate information.
- Protect Metro Rail property.
- Expedite restoration of train operation as early as possible.
- Lay down the actions required to be taken by staff in the event of a disaster in Nagpur Metro Rail Corporation in order to ensure prompt handling of crisis situation in a coordinated manner.
- To ensure that all officials who are responsible to deal with the situation are thoroughly conversant with their duties and responsibilities in advance. It is important that these officials and workers are adequately trained in anticipation to avoid any kind of confusion and chaos at the time of the actual situation and to enable them to discharge their responsibilities with alertness and promptness.

16.5 PREPAREDNESS OF STAFF FOR DISASTERS

Being a technologically complex system with a new set of staff, intensive mock drills for the staff concerned is very essential to train them to become fully conversant with the actions required to be taken up while handling emergencies. They also need to be trained in appropriate communication skills while addressing passengers during incident management to assure them about their wellbeing seeking their cooperation. Since learning can only be perfected by 'doing' the following Mock Drills are considered essential:

i. Fire Drill - This shall include

- Making announcements
- Protecting the area
- Summoning assistance
- Using firefighting equipment locally available
- Passenger evacuation in case of need

ii. Rescue of a disabled train

- Identifying causes, isolating fault.
- Announcement to passengers
- Passenger evacuation
- Coupling / Uncoupling of trains for clearing a failed train by an assisting train.
- Driving from an intermediate cab with Cab to Cab telephone communication from front cab.

iii. Detrainment of passenger between stations

- Blocking adjacent line
- Announcement to passengers.
- Use of emergency doors.
- Guiding passengers to next station.

iv. Passenger evacuation from station

- Announcement to passengers.
- Closing of booking offices.
- Opening of AFC gates/ Emergency exits

- Changing the direction of escalators.
- Crowd control with assistance of security staff and Police/Metro Police.
- Working of TVS system.
- Working of fire suppression and detection system

v. Drill for use of rescue & relief train

- The following items need to be noted
- Time taken by the staff to report for duty from the time of first information.
- Departure time of rescue and relief train.
- Testing of all vital systems like generators, control panel.etc.
- Demonstrating a few key functions

vi. Hot line telephone communication with state disaster management authority.

16.5.1 Authorities Coordination in Case of Disaster, Command & Control at the National, State & District Level

Authority coordination is essential for disasters of such a nature or magnitude as to be beyond the coping capacity of the community of the affected area. Following provisions have been considered for Nagpur Metro Rail:

i. National Disaster Management Authority (NDMA)

Establishment of National Disaster Management Authority:

i. With effect from such date as the Central Government may, by notification in the Official Gazette appoint in this behalf, there shall be established for the purposes of this Act (The Disaster Management Act, 2005), an authority to be known as the National Disaster Management Authority.

ii. The National Authority shall consist of the Chairperson and such number of other members, not exceeding nine, as may be prescribed by the Central Government and, unless the rules otherwise provide, the National Authority shall consist of the following:

  - The Prime Minister of India, who shall be the Chairperson of the National Authority, Ex officio;
  - Other members, not exceeding nine, to be nominated by the Chairperson of the National Authority.

iii. The Chairperson of the National Authority may designate one of the members nominated under clause (b) of sub-section (ii) to be the Vice-Chairperson of the National Authority.

iv. The term of office and conditions of service of members of the National Authority shall be such as may be prescribed.

ii. State Disaster Management Authority

Establishment of State Disaster Management Authority:-

i. Every State Government shall, as soon as may be after the issue of the notification under sub-section (1) of section 3, by notification in the Official Gazette, establish a State Disaster Management Authority for the State with such name as may be specified in the notification of the State Government.

ii. A State Authority shall consist of the Chairperson and such number of other members, not exceeding nine, as may be prescribed by the State Government and, unless the rules otherwise provide, the State Authority shall consist of the following members, namely:

- The Chief Minister of the State, who shall be Chairperson, ex officio;
- Other members, not exceeding eight, to be nominated by Chairperson of State Authority;
- The Chairperson of State Executive Committee, ex officio.

iii. The Chairperson of State Authority may designate one of the members nominated under clause (b) of sub-section (ii) to be the Vice- Chairperson of the State Authority.

iv. The Chairperson of the State Executive Committee shall be Chief Executive Officer of the State Authority, the Chief Minister shall be the Chairperson of the Authority established under this section.

v. The term of office and conditions of service of members of the State Authority shall be such as may be prescribed.

iii. Command & Control at the National, State & District Level

The mechanism to deal with natural as well as manmade crisis already exists and that it has a four tier structure as stated below:

i. National Crisis Management Committee (NCMC) under chairmanship of

Cabinet Secretary

ii. Crisis Management Group (CMG) under chairmanship of Union Home Secretary.

iii. State Level Committee under the chairmanship of Chief Secretary.

iv. District Level Committee under the Chairmanship of District Collector.

All agencies of Government at National, State and district levels will function in accordance with guidelines and directions given by these committees.

iv. Plans by Different Authorities at District Level and their Implementation

Every office of the Government of India and of the State Government at the district level and the local authorities shall, subject to the supervision of the District Authority:

i. Prepare a disaster management plan setting out following, namely:-

- Provisions for prevention and mitigation measures as provided for in the District Plan and as is assigned to the department or agency concerned;
- Provisions for taking measures relating to capacity-building and preparedness as laid down in the District Plan;
- The response plans and procedures, in the event of, any threatening disaster situation or disaster;

ii. Coordinate the preparation and the implementation of its plan with those of the other organizations at the district level including local authority, communities and other stakeholders;

iii. Regularly review and update the plan; and

iv. Submit a copy of its disaster management plan, and of any amendment thereto, to the District Authority.

16.6 PROVISIONS AT METRO STATIONS/OTHER INSTALLATIONS

An effective system needs to be provided which includes Fire Detection and Suppression System, Smoke Management, Environmental Control System (ECS), Tunnel Ventilation System, Track-way Exhaust System (TES), Lighting System, Station Power Supply System, DG Sets & UPS, Seepage system, Water Supply and Drainage System, Sewage System, Station Area Lights and other facilities which may be deemed necessary.

The above said provisions are suggestive and an exhaustive set of facilities have to be provided based on site conditions, location and other internal and external factors.

16.6.1 Measures in Case of Fire

Fire has been recognized as one of the most dreaded accidents on metros primarily because of large concentration of passengers at stations and in trains. Fire prevention and prompt response to any incident of fire or smoke emission is therefore the most important component of disaster management on Metros. For better management and safety from fire disaster on metro system, various signages like prohibition signs, warning signs, emergency escape signs etc. shall be installed as mentioned in NFPA 130, Standard for Fixed Guideway Transit and Passenger Rail Systems and National Building Code of India, 2016 part 4. Universally accepted measures for fire prevention include:

- Rigid observance of nonsmoking regulations
- Total ban on carriage of inflammable/ explosive substance within metro premises and in trains
- Non accumulation of garbage in the metro station premises and inside trains
- All staffs posted at stations must ensure instructions are rigidly enforced by regular checks.
- Installation of fire alarms and detection systems.

A. Fire and Smoke

In the event of fire and / or smoke either in train , station premises, right of way including the tunnel or other metro premises, every Metro Rail official whether on duty or not shall,

- Report the occurrence to the nearest Station Controller (SC) or Chief Controller (OCC). A reporting system shall be developed as per NFPA Guidelines and officials shall be trained accordingly.
- Take all possible steps to extinguish fire like using portable fire extinguishers, blankets, water, sand etc. that is available on site depending on the source of fire. Standards steps/measures to extinguish

may be followed from NBC of India, 2016 and NFPA 130.

- Disconnect electric supply, if required
- Prevent the fire from spreading
- Seek assistance of Fire services.

B. Fire in a Train

The guidelines set out below are based on the content analysis of past accidents on other Metros and are in the nature of best practices. Since every fire incident is unique, the train operator is to exercise quick judgment based on:

- The nature of fire whether localized or widespread in passenger area.
- The extent of occupation of the train-number of passengers-if the number is manageable he will ask passengers of the affected coach to move away to other coaches.
- Proximity of the next station – passenger evacuation and handling of emergency is much easier at station than in between stations. Train Operator (TO) has to exercise his judgment about those extreme cases where the train has to be stopped forthwith to save life by prompt evacuation or taken to the next station expeditiously.

C. Fire in Train at the Station Platform

The Train Operator shall open all train doors on the platform side and ask passengers to vacate the train. He will inform OCC and Station Controller and take assistance from station staff as required.

D. Special Instructions for underground sections

Entire underground Metro network is equipped with Tunnel Ventilation system, capable of Centralized operation from OCC and also local operation from Station Control Rooms.

In the event of a 'fire incident' the system is designed to:

- Provide smoke free evacuation route
- Make available adequate fresh air
- Remove smoke and heat

- Cut off supply to the fire affected area during emergency.

A water pipeline should run along the entire underground Metro corridor. These pipelines have hydrants fixed every 15 m where hose pipes can be connected. The pipes are of great help to quickly extinguish any fire outbreak. Each underground section should equip with one to three cross passages between the up and down tunnels. These passages can be used for speedy evacuation of commuters in case of emergency. There is a Fire Detection and Suppression system equipped to automatically activate alarms for Vents, Fans and Dampers & Suppression equipment. The system is operated from a panel located in the Station Control Room.

E. Fire Suppression System

A wet Fire Main System covers the station area as well as the entire length of the tunnels. In addition there are automatic sprinklers, inert gas based suppression systems and portable fire extinguishers at various locations. Immediately on receipt of information about a train with fire incident held up between stations – Auxiliary System Controller (ASC) will

- Identify the location of fire (front/rear of the train)
- Identify affected ventilation zone/s
- Other trains held up needing increased ventilation
- Help OCC to decide the correct direction of passenger evacuation.
- Identify the appropriate TVS Master mode and operate TVS system.
- Inform TO through TC the direction of evacuation.

Before starting evacuation, ASC/ Traction Power Controller (TPC) shall check for the adequacy of Tunnel Lighting and correct Operation of TVS & ECS and Tunnel lights can be switched on from Station control room by BMS controller/ nominated E&M staff.

F. Fire at Metro Station Premises

The fire can be at the following locations:

- In areas, where the passengers enter for purchasing tickets or leave the station after performing their train journey including lifts, staircases and escalators.

- Concourse
- Auxiliary electrical substations.

In case of fire in areas where passengers enter/leave the station premises, the endeavor of station staff should be to cordon off the area so that it is not approachable for intending Metro users or by Metro passengers leaving the station area.

16.6.2 Measures in Case of Collision of Trains

In the event of a train collision involving Metro trains, any employee witnessing, discovering or being involved in a train collision shall inform the Operations Control Center (OCC) and provide the following information-

- Callers name and identification,
- Reason for the call,
- Train identification,
- Location of the collision (Line identification , track (UP/DN), OHE mast no., nearest station if not at station),
- Need for medical assistance,
- Presence of smoke or fire

If the employee making the first report is a Train Operator (TO), Traffic Controller (TC) shall instruct the Train Operator to secure the train, inform the passengers about the incident, check if any passenger or employee needs medical attention. The TO will inform TC accordingly. If the other TO has not communicated with OCC, TC will ask TO to collect similar information about the second train and report.

A. Train Operator (TO) shall

- Look for presence of smoke or fire. Furnish details of visible damage, if any coaches are derailed or
- If the other track is obstructed.
- The OCC /TC shall instruct Train Operators of trains in approach of the collision site, in both directions, to stop their trains at stations and report their positions.

B. Duties of Train Operator:

- In the event of collision taking place involving his train, the train operator shall inform OCC by giving as many details as possible.

- In case of adjacent track is infringed, he will first protect the adjacent track to avoid multiple accidents as per prescribed procedure.
- He will inform passengers about the incident advising them about rescue and relief arrangements being made.
- He shall quickly assess the situation particularly in respect of passenger's injury and again inform OCC with as much details as available seeking medical and other assistance as required.
- He will render first aid to passengers and check for injury and damage to the train (both his train and other train).
- Shall seek OCC's permission for passenger evacuation.
- Shall await further instructions from OCC.

C. Duties of Station Controller:

- The Station Controller on receipt of information about collision at his station shall inform OCC.
- Arrange for immediate medical assistance as required.
- Inform Metro rail police/Local police.
- Mobilize the staff for evacuation of passengers and rendering of first aid to the injured and their hospitalization as required.
- Inform passenger waiting at the station of the likely delays.
- Station controller will evacuate passengers as per instructions of OCC.

D. Duties of Traffic Controller:

- On receiving information about train collision the Traffic Controller shall block all movement on both the tracks to protect the site of accident.
- Inform Maha-Metro Disaster Management Team members.
- And other designated Maha-Metro departments and Personnel.
- Mobilize medical assistance as required.
- Inform the train depot to be in readiness to move rescue and relief train.
- Instruct Station Superintendent to depute staff for evacuation of passengers and providing medical aid to the injured.
- Regulate train services and inform all stations on the route about the likely dislocation in train services.
- Activate ventilation system based on condition of the scene (for tunnel section only).

- Arrange for Public Address announcements to be made to passengers in trains and at stations.
- Initiate operating procedure to relieve train congestion at collision site by: a) Single track operation (Single Line Working), b) Turning trains on both sides of collision site (Short Loop Operation) etc.
- The OCC Chief Controller shall inform the Disaster Management Team, ED/OP, GM/OP and all controllers in OCC, the Police/Metro Police and Security Controller to secure the accident scene and Station Superintendent/Station Controllers on the affected line. Chief Controller shall also inform emergency services. All controllers in OCC shall inform their respective officers, maintenance/emergency team and others as applicable.

E. Medical Assistance

The TO/SC requesting medical assistance to OCC shall provide an estimate of the likely number of people requiring medical assistance and also indicate the most convenient access point for medical personnel to enter. (The names and addresses of person requiring/receiving medical assistance and the names of medical agencies and personnel shall be recorded in the Accident Log book maintained at site/at OCC).

16.6.3 Measures in Case of Train Derailment

A. Duties of Train Operator:

i. The TO becoming aware that his train has derailed shall stop the train immediately if not, already stopped and secure the train.
ii. Inform passengers of the problem and action being taken.
iii. Inform OCC providing following information:

- Train Operator identification
- Location (line identification, Track (UP/DN), & Mast No.)
- Train description (Train no. & train set no.)
- Adjacent track obstructed or clear.
- Passenger injury or presence of smoke or fire.
- Seek instruction for passenger evacuation.

B. Duties of Traffic Controller:

- TC shall instruct TOs of trains approaching the derailment site on both tracks to stop their trains and report their positions.

- TC shall immediately notify DMT and all concerned Metro departments, Police/Metro Police and Security Controller to secure the accident site and Station Superintendents on the affected line for informing waiting passengers at stations about the likely delay. OCC/TC will also arrange to inform passengers aboard trains held up.
- Mobilize medical assistance as required.
- Inform the depot to be in readiness to move the rescue and relief train.
- Instruct Station Managers to depute staff for evacuation of passengers and providing medical aid to the injured in case of derailment between stations.
- Regulate train services and inform all stations on the route about the likely dislocation in train services.
- Activate ventilation system based on condition of the scene (for tunnel section only).
- Arrange for Public Address announcements to be made to passengers in trains and on stations.
- Request assistance of Police / Metro Police / Security/ Watch & Ward for crowd control at critical stations.
- Initiate operating procedure to relieve train congestion at derailment site by:
- Single track operation (Single Line Working),
- Turning trains on both sides of derailment site (Short Loop Operation) etc.

C. Medical Assistance:

The employee requesting medical assistance to OCC shall provide an estimate of likely number of people requiring medical assistance and will also indicate the most convenient access point for medical personnel to enter. (The names and addresses of passengers requiring medical assistance and the names of medical agencies and personnel shall be recorded in the Accident Log book maintained at site/in OCC).

16.6.4 Measures in Case of Terrorist Actions

Increase in terrorist actions against public transport worldwide, indicates that public transport systems are becoming more vulnerable and potential targets for terrorist. It is clear that preventing terrorist activities is the primary responsibility of security agencies and state police.

However, concern for passenger wellbeing and their security and adverse effects of such mishaps on the public image of transport systems itself, requires best possible level of preparedness for prevention of such threats within Metro premises. Key components of such preparatory and preventive action include:

- Encouraging and guiding passengers to be cautious themselves.
- An awareness program – appealing users to be on the alert and report any suspect package.
- Well thought out crisis communication to prevent misinformation, confusion, panic and shock.
- Clear procedures and systems of communications need to be established for emergencies and regularly tested, in order to ensure a working communication during crisis situation.
- Frequent mock drills to test effectiveness of passenger evacuation systems including the collaboration and response of passengers.
- Training all frontline staff to prevent dangerous situations and handle incidents.
- Once they have happened act with courage, promptitude and alertness, reassuring passengers and providing regular information for their guidance.
- Terrorist attack may take place anywhere in the metro rail's jurisdictions, however when it takes place, on the right of way particularly underground section, at metro station and in running trains it may have serious impact in terms of human distress and restoration of normal operation. On receipt of information of any terrorist act on Metro Trains, stations or on the Right of Way, OCC will take prompt action to get the entire metro network cleared of all passengers.

A. Terrorist attack at Station

Duties of Station Superintendent/Station Controller:

- Shall visit the affected spot, assess the extent of impact on human life and also how it may affect train services.
- Shall inform the OCC about details of incident.
- Sound the hooter and get the station premises vacated of all the passenger
- Depute staff to announce at 5 minute interval, through the station PA system what has happened and what the passengers are expected to do without getting panic.
- Mobilize resources to render first aid and evacuate the injured.
- In case any person is seen moving in a suspicious manner, he may be detained for interrogation with the help of security staff.
- Passengers found near the affected area may also be asked about their firsthand knowledge of the occurrence and their statement with name and addresses recorded.
- Inform Police/Metro Police and depute station security staff to protect and cordon the site to preserve the clues and leave the site undisturbed for police investigation.

Duties of Traffic Controller/Chief Controller:

Immediately on receipt of the information about terrorist attack, Chief Controller shall:

- Inform Police/Metro Police and security personnel and ask them to rush to the spot of occurrence.
- Mobilize Medical Assistance and/ or Fire Services to reach the spot.
- Inform the DMT and other Maha-Metro departments and personnel.
- Hold trains at stations. Train movement shall only be resumed after confirming that the running of train through the affected station is safe, till the position becomes clear regular announcement to be made to passengers in train and at station of the likely delay and evacuation procedures started. The entire Metro network shall remain closed till rescue and search operations have been completed. Revenue operations shall only be started after ensuring that the system is fully safe and secure.

B. Terrorist Attack in Train:

Of all the cases of terrorist attack, those within a train will have most disastrous consequences and very prompt action will be necessary to restrict the damage to men and material. Such a situation may include:

- A Bomb on the track which detonates under a train.
- Detonation of Bomb / igniting of inflammable material inside a train.
- Release of chemical / biological gases in a train.
- Criminal interference with train running equipments which causes fire in the coaches while on run.
- Other terrorist activities incapacitating the train on run.

C. Bomb Blast on Track:

There may be derailment of the train with large scale damage to the train and fixed structures as well as injury to the passengers in the train. In case of derailment, the train will immediately come to a stop. The Train Operator shall immediately inform Traffic Controller about the occurrence and ask for immediate assistance as required. TO shall seek permission for evacuation of passengers. In case the situation does not permit detrainment from one end, it may be arranged from both ends. The injured passengers should be evacuated as soon as the Medical Team arrives on the spot.

D. Bomb Blast inside the Train:

The Train operator shall:

- Inform Traffic Controller
- Inspect the impact of explosion and if the train is in a position to move, he will try to take the train to the next station at reduced speed.
- In case he is not able to take the train to the next station, Shall stop the train and inform the Traffic Controller about the incident.
- Shall seek assistance of fire services and medical services as required, take the permission of the TC to detrain the passengers.
- Shall make an on the spot assessment of the situation including the injury/death of passengers and inform the Traffic Controller for immediate appropriate action.

- The TO shall make announcement to the passengers through the train PA system about the situation and ask them to remain calm indicating that action has already been taken to arrange for detrainment of passengers.
- The TO will arrange evacuation of the passenger when authorized by OCC.
- This will help in reaching prompt assistance to the injured and disabled passengers on arrival of the Security and Medical Team.
- Train Operator will thereafter arrange to detrain the injured passengers with the help of security and medical staff.

E. Release of Chemical Poisonous or biological gases in tunnels, trains or at stations

Whenever other terrorist activities described above produce loud noise, explosion, fire and smoke, release of lethal or harmful gases works silently and can only be generally inferred from-

- Unusual smell
- Passengers or employees complaining of Breathing problems- including choking/fainting, Severe eye/Skin irritation and Vomiting etc.

Receiving any such complaint the Train Operator or Station Controller/ Station Manager will take serious note of it and immediately inform OCC to take prompt action to handle the emergency as case of suspected release of poisonous gases. If gas release is detected in a train, TO will inform OCC and expeditiously bring the train to the next station, open train doors and request all passengers to detrain. He will personally check with station staff, security and Police/Metro Police that the train has been completely vacated.

To prevent further spreading of gas in platform area and to help Police and Medical teams to investigate and identify the gas he will close the train doors. In the event of gas release in station premises, the station should be fully vacated and kept closed unless certified free of contamination by medical authorities.

Whereas, release of gases on the Right of Way in Rail corridors may not have serious impact, with gas spreading into atmosphere. In tunnel sections it will be necessary to

- Locate the presence of gas in specific ventilation zones.
- Activate appropriate TVS modes to dilute the gas.

- Degasify the tunnel portion or the entire tunnel, depending upon the severity of the case informing civil authorities of the likely discharge of gas in certain areas which may require to be protected.
- Pending this, the affected portion or the entire tunnel will have to be vacated of all passengers and staff.

Normal operation should only be resumed after running of a trial train with Police, Medical and metro authorities confirming that the section has been made free of contamination.

16.6.5 Measures in Case of Natural Calamities

On being informed about an earthquake in the city of Nagpur or experiencing the same, OCC Traction Power Controller (TPC) will switch off Traction power Supply in a manner which does not shut down station supplies informing the Traffic Controller who will instruct the TOs to stop their trains and report their position.

In the event of a significant earthquake, TO experiencing the impact or being informed by passengers or OCC will bring his train to a stop and inform OCC the location of the train.

- If at station, he will not move the train, inform OCC and advice passengers to remain inside the train.
- After receiving OCC instructions that the earthquake has subsided, the trains waiting at stations will detrain passengers.
- For the trains held up between stations, TOs to visually check the track. If the track is unaffected and there are no visible obstruction after informing OCC/TC, train can be moved at walking speed up to the next station where passengers shall be detrained.
- Train Operator (TO) will keep passengers informed of the problem and requests them to maintain calm.

In case of any doubt, OCC will arrange for passenger evacuation on the right of way as per procedure. Normal operation of revenue trains shall only be resumed after the track and structures department issuing of a certificate of fitness for normal operations which will be issued after detailed physical inspection. OCC and Station Superintendent/Station Controllers will continuously inform passengers of the situation and likely time for commencement of train services.

16.7 SECURITY MEASURES, ESSENTIALS OF SECURITY MANAGEMENT, SECURITY SYSTEM DESIGN PARAMETER

16.7.1 Security Measures & Essentials of Security Management

Metro Rail System has emerged as the most reliable mode of urban transportation system in India. The inherent characteristics of metro system make it an ideal target for terrorists and miscreants. Metro systems are typically open and dynamic systems which carry thousands of commuters. Moreover, high cost of infrastructure, its economic impacts to the society, being the life line of city with high news value pose greater threat to its security. Security is a relatively new challenge in the context of public transport. It addresses problems caused intentionally and differs from safety which addresses problems caused accidentally. Security problems or threats are caused by people whose actions aim to undermine or disturb the public transport system and/or to harm passengers or staff. These threats range from daily operational security problems such as disorder, vandalism and terror threat.

The public transportation system is increasingly becoming important for urban areas to prosper in the face of challenges such as reduction in congestion and pollution. Therefore, security system for public transportation like metro rail plays an important role in helping the system to become the preferred mode choice for commuters. Therefore, provision of an excellent and reliable security system is a prerequisite for metro system for increasing its market share. Metro railway administration must ensure that security model keep pace with the rapid expansion of the metro and changing security scenario.

16.7.2 Security System Design Parameter

Security means protection of human, intellectual assets and infrastructure either from criminal interference, destruction by terrorists or criminals or incidental to technological failures or natural hazardous events. Three important pillars of security are as follows:

- The Human factor;
- Procedures; and
- Technology

Staff interaction with passengers create a sense of re-assurance which cannot fully be achieved by technology. For human factor to be more effective, staff has to be qualified, trained, well equipped and motivated. The staff members should be skillful, trained, drilled and experienced. The security risk assessment is the first step for understanding the needs and prioritizing resources. The organization of security should be clear and consistent. Security incidents, especially major ones, often happen without warning. Emergency and contingency plans must be developed, communicated and tested in advance. There are number of technologies which can be used to enhance security e.g. surveillance systems. The objectives of the security systems differ i.e., detection of the plan before an attack, deny the access for carrying out an attack and mitigation measures after an attack.

16.7.3 Different Phases of Security

There are three different phases associated with the security system in metro. These phases are as under:

i. Prevention

These are the measures which can prevent a security breach from taking place. These can be identified by conducting risk assessment and gathering intelligence. Prevention begins with the daily operational security problems. Care has to be given in controlling unused, damaged properties which could otherwise prove to be a breeding ground for more serious crimes.

ii. Preparedness

Plans have to be prepared to respond to incidents and to mitigate the impacts. Staff have to be accordingly trained to carry out the exercises. The results of the risk assessment will give basis for such plans.

iii. Recovery

Urban transport system should have laid down procedures/instructions for quick recovery of normal service after an incident. Financial health is important for the recovery operation, but it also sends a clear message to public, it reassures passengers and gives them confidence to continue using the system. Communication is key to the quick restoration after such incidents. Restoration should also include an evaluation process for the lessons learnt.

16.7.4 Responsibilities and Partnerships

The responsibility of the Security lies with the state. Security in public requires clear governance. Responsibility should be clearly defined. In the present scenario, this is the responsibility of the State Government to ensure secured travel in Nagpur Metro.

16.8 SECURITY SYSTEMS RECOMMENDED FOR NAGPUR METRO

For providing an efficient security system in metro station areas the following provisions are suggested:

i. CCTV coverage of all metro stations with provision of monitoring in the Station Security Room as well as at a Centralized Security Control Room with video wall, computer with access to internet TV with data connection, printer and telephone connection (Land Line and EPBX) for proper functioning, cluster viewing for stations.
ii. Minimum one Baggage Scanners on all entry points (1 per AFC array). Additional requirement of baggage scanners at heavily crowed stations i.e at interchange may also be required.
iii. Multi-zone Door Frame Metal Detector (DFMD) minimum three per entry (2 per AFC array). The number can increase in view of the footfall at over crowed stations.
iv. Hand held Metal Detector (HHMD) as per requirement of security agency, minimum two per entry, which varies from station to station with at least 1.5 per DFMD installed at the station.
v. Bomb Detection Equipments with modified vehicle as per requirement of security agency. One BDS team per 25 - 30 station will be required at par with present criteria of DMRC.
vi. Bomb Blanket at least one per station and depot.
vii. Wireless sets (Static and Handheld) as per requirement of security agency.
viii. Dragon light at least one per metro station.
ix. Mobile phones, land lines and EPBX phone connections for senior security officers and control room etc.
x. Dog Squads (Sniffer Dog), at least one dog for 4 metro stations. Dog Kennels along with provision for dog handlers and MI room will also be provided by metro train depot administration including land at suitable places line wise.
xi. Bullet proof Morcha one per security check point (i.e. AFC array) and entry gate of metro train depot administration.
xii. Bullet proof jackets and helmets for Quick Response Team (QRTs) and riot

control equipments including space at nominated stations. One QRT Team looks after 5-6 metro stations as per present arrangement. One QRT consist of 5 personnel and perform duty in three shifts.

xiii. Furniture to security agency for security room and checking point at every entry point at stations. Scale is one office table with three chairs for security room & office and one steel top table with two chairs for checking point.

xiv. Ladies frisking booth - 1 per security check point (AFC) Wooden Ramp - 1 per DFMD for security check points.

xv. Wall mounted/ pedestal fan at security check point, ladies frisking booth and bullet proof morcha, as per requirement.

xvi. Physical barriers for anti-scaling at Ramp area, low height of via duct by providing iron grill of appropriate height & design/concertina wire.

xvii. Adequate number of ropes. Queue managers, cordoning tapes, dragon search lights for contingency.

xviii. Iron grill at station entrance staircases, proper segregation of paid and unpaid areas by providing appropriate design grills etc.

xix. Proper design of emergency staircase and fireman entry to prevent unauthorized entry.

Chapter – 17

DETAILED PROJECT COST ESTIMATES

17. DETAILED PROJECT COST ESTIMATES

17.1. CAPITAL COST ESTIMATE

17.1.1. Coverage

Cost estimate for Nagpur Metro Phase 2 corridors has been prepared covering civil, electrical, signaling and telecommunications works, rolling stock, environmental protection, rehabilitation, etc. at April 2018 price level.

While preparing the capital cost estimates, various items have generally been grouped under three major heads on the basis of (i) Route km length of alignment, (ii) Number of units of that item and (iii) Item being an independent entity. All items related with alignment, construction, permanent way, OHE, Signaling & Telecommunication, etc. have been estimated at rate per Route km/km basis.

Cost of station structures, other electrical services at these stations and Automatic Fare Collection (AFC) installations at all stations have been assessed in terms of each station as a unit. Similarly, for items like Rolling stock costs have been estimated in terms of number of units required for each item. In remaining items, viz. land, utility diversions, rehabilitation, etc. the costs have been assessed based on each item, taken as an independent entity.

In order to arrive at realistic cost of various items, costs have been assessed on the basis of recently awarded rates of Nagpur Metro, Ahmedabad Metro, DPR of DMRC Ph-IV, Lucknow Metro and other various Metros and suitable escalation factor has been applied to bring these costs to April’2018 price level.

Basic cost is exclusive of taxes and duties. i.e. GST and Custom duty. Taxes and duties mainly comprising of latest prevalent GST & Custom duty are worked out for each corridor. Current rates of Taxes have been taken into consideration.

17.1.2. Land Requirement

a. Finalization of alignment, location of stations, entry / exits etc. has been done with the objective of keeping land requirement to the bare minimum. For this purpose, alignment, stations, depots, parking and Property Development (PD) have been planned in the State Government land unless and until it becomes unavoidable to plan these facilities in Central Government land or private land. The summary of land requirement for Corridor – 1 to 5 is as **Table 17.1, Table 17.2, Table 17.3, Table 17.4 & Table 17.5.**

TABLE 17.1: LAND & STRUCTURES REQUIREMENT (IN SQM) FOR CORRIDOR-1A

Ownership	Purpose	Permanent Land (In HA)	Temporary Land (In HA)	Structures (Floor area) (In HA)
Central Govt	Alignment / Stations, ancillary building, Misc., etc	0	0	0
	Total	**0**	**0**	**0**
State Govt	Alignment / Stations, ancillary building, Misc., etc	0	0	0
	Casting Yard (Approx.)	0	10	0
	Total	**0**	**10**	**0**
Private	Alignment / Stations, ancillary building, Misc., etc	4.3522	0	0.0621
	Parking cum PD	0.2467	0	0
	Total	**4.5989**	**0**	**0.0621**
Grand Total		**4.5989**	**10**	**0.0621**

TABLE 17.2: LAND & STRUCTURES REQUIREMENT (IN SQM) FOR CORRIDOR-2A

Ownership	Purpose	Permanent Land (In HA)	Temporary Land (In HA)	Structures (Floor area) (In HA)
Central Govt.	Alignment / Stations, ancillary buildings, Misc., RSS etc	0.6175	0	0
	Parking cum PD	0.6397	0	0
	Total	**1.2572**	**0**	**0**
State Govt	Alignment / Stations, ancillary building, Misc, etc	0.1302	0	0
	Parking cum PD	0	0	0
	Casting Yard (Approx.)	0	10	0
	Total	**0.1302**	**10**	**0**
Private	Alignment / Stations, ancillary building, Misc, etc	0.6731	0	0.0869
	Parking cum PD	0	0	0
	Total	0.6731	0	0.0869
Grand Total		**2.0605**	**10**	**0.0869**

TABLE 17.3: LAND & STRUCTURES REQUIREMENT (IN SQM) FOR CORRIDOR-3A

Ownership	Purpose	Permanent Land (In HA)	Temporary Land (In HA)	Structures (Floor area) (In HA)
Central Govt	Alignment / Stations, ancillary building, Misc., etc	0	0	0
State Govt	Alignment / Stations, ancillary building, Misc., etc	0.4217	0	0.0424
	Parking cum PD	0.3994	0	0

Ownership	Purpose	Permanent Land (In HA)	Temporary Land (In HA)	Structures (Floor area) (In HA)
	Casting Yard (Approx.)	0	10	0
	Total	**0.8211**	**10**	**0.0424**
Private	Alignment / Stations, ancillary building, Misc., etc	1.1207	0	0.2152
	Parking cum PD	0	0	0
	Total	**1.1207**	**0**	**0.2152**
Grand Total		**1.9418**	**10**	**0.2576**

TABLE 17.4: LAND & STRUCTURES REQUIREMENT (IN SQM) FOR CORRIDOR-4A

Ownership	Purpose	Permanent Land (In HA)	Temporary Land (In HA)	Structures (Floor area) (In HA)
Central Govt	Alignment / Stations, ancillary building, Misc., etc	0	0	0
State Govt	Alignment / Stations, ancillary building, Misc., etc	0.1954	0	0.0456
	Parking cum PD	0.226	0	0
	Casting Yard (Approx.)	0	10	0
	Total	**0.4214**	**10**	**0.0456**
Private	Alignment / Stations, ancillary building, Misc., etc	0.3248	0	0.0944
	Parking cum PD	0	0	0
	Total	**0.3248**	**0**	**0.0944**
Grand Total		**0.7462**	**10**	**0.14**

TABLE 17.5: LAND & STRUCTURES REQUIREMENT (IN SQM) FOR CORRIDOR-5

Ownership	Purpose	Permanent Land (In HA)	Temporary Land (In HA)	Structures (Floor area) (In HA)
Central Govt	Alignment / Stations, ancillary building, Misc., etc	0	0	0
State Govt	Alignment / Stations, ancillary building, Misc., etc	0.1079	0	0
	Parking cum PD	0.29	0	0
	Casting Yard (Approx.)	0	10	0
	Total	**0.3979**	**10**	**0**
Private	Alignment / Stations, ancillary building, Misc., etc	0.5	0	0.2217
	Parking cum PD	0	0	0
	Total	**0.5**	**0**	**0.2217**
Grand Total		**0.8979**	**10**	**0.2217**

b. The land area for piers of elevated alignment, elevated stations falling over the existing road and entry/exit falling on road / State Government land has not been accounted for in the land requirement and costing as present land use is not getting affected by these facilities. Land requirement for other metro utilities like ramp, off the road elevated stations, depot, RSS, ancillary buildings etc. have been accounted as far as per details in subsequent paras.

c. Rate of Central Govt. required on permanent basis has been taken from Circle rates. No solatium has been applied to the basic land cost.

d. Rate of State Govt. Land required on permanent basis has been taken from Circle rates. No solatium has been applied to the basic land cost. In case, State Govt. is in a position to provide its land free of cost or at reduced rates, it will further improve the financial statistics of the project.

e. Rate of Central Govt. land and State Govt. land required on temporary basis for 5 years construction period, has been taken @ 1% Per annum on Circle rates. No solatium has been applied to the basic land cost.

f. Rate of Private land have been taken from Circle rates. As per Policy of Govt. of Maharashtra, compensation for land in Urban areas (Municipal corporation and Municipal Council areas) is computed as under:

- Cost of land as per RR rates.
- Solatium = 100% of cost of Land
- Incentive @ of 25% on above, if acquisition is by Direct Purchase Method.

g. Efforts have been made to provide parking for maximum possible stations. Details of land required for parking is mentioned separately in relevant chapter.

h. Rates of Structures have been taken from Circle rates after applying depreciation (depending on age of structures). Additional 4% water charges, 4% sanitary charges & 4% Electrical charges has been taken into account for calculation of structures rates.

i. The total cost of Land works out to be **Rs. 216.36 Crores** for Phase-II based on current Ready Reckoner. However, latest RR rates shall be applicable during the time of acquisition.

17.1.3. Items other than Land

Cost of items other than land is based upon LAR / DPR rates as given in **Table 17.6**. Serial number of item in the table denotes the serial number of item in detailed cost estimate. Escalation of 5% per annum is applied to bring the rates at current price level of April,2018.

TABLE 17.6: BASIS OF RATES

Item No.	Item	Basis of Rates
2.0	**Alignment and Formation**	
2.1	Elevated section excluding viaduct length in station	Based on Last Accepted Rates of Reach-I of Nagpur Metro Phase-1.
2.2	Third line for Mid-terminal	Rates in 2.1 increased by 20% for additional width of viaduct.
3.0	**Station Buildings**	
3.1	**Elevated Station Buildings (80mx21m)**	
a	Civil Works including Viaduct	Based on Last accepted rates dated 21.07.16 for 7 elevated and 3 At grade stations. Total cost divided by 9.4 stations (considering 3 At grade Station cost as 2.4 elevated stations). Tax @ 13.5% deducted.
b	EM Works etc.	Kochi Metro, KE-10 dt. 12.12.2014. Avg. cost 4.21 Cr. per station + Escalation
3.2	Elevated Station-Architectural Finishes	Based on Lucknow Metro Last accepted cost in July'15
3.3	**Lifts & Escalators**	
a	Lifts	Nagpur Metro awarded rates
b	Escalators	Nagpur Metro awarded rates
4.0	**Maintenance Depot**	
a	Civil works	Lumpsum cost for minimum upgradation of Phase-1 Depots
b	EM works + Machinery & Plant + General Works	
5.0	**P-Way**	
5.1	Ballastless track for main line	Avg. Of Esc. Rates of DMRC Ph-4 DPR May'14 & LMRC DPR May'13
6.0	**Traction & power supply incl. OHE, ASS etc. Excl. lifts & Escalators**	
6.1	Elevated section including SCADA	Nagpur LAR dated 21.10.2016 plus escalation
7.0	**Signalling and Telecommunications**	
7.1	Signalling	Ahmedabad Metro LAR March 17
7.2	Telecommunication	90% of LMRC/System/S&T/Tele/LKS02/LOA
7.3	Automatic fare collection	Lucknow Metro LAR
7.5	Platform Screen Doors	70% of (DMRC / 20/111 - 196/2014 (Lot 3), May'15, Rs. 2.26 Cr. For 6 Coahes, 24 doors.)
8.0	**Environmental & Social Impact Assessment**	
a	Environmental Cost	As per DPR chapter
b	R & R	As per DPR chapter
9.0	**Misc. Utilities, road works, Topographic Surveys, Geotechnical Investigation, Barricading, Tree Cutting and replanting, other civil works such as signage's, Environmental protection and traffic management**	

Item No.	Item	Basis of Rates
a	Civil works	Estimated rates are based upon average of escalated rates of DMRC Ph-IV DPR May'14 & LMRC DPR May'13.
b	Electrical Works	
10.0		**Capital Expenditure on Security**
a	Civil works	Estimated rates are based upon average of escalated rates of DMRC Ph-IV DPR May'14 & LMRC DPR May'13.
b	EM works	
11.0		**Staff Quarters and OCC Building**
a	Civil works	Estimated rates are based upon average of escalated rates of DMRC Ph-IV DPR May'14 & LMRC DPR May'13.
b	EM works	
16.0	**Rolling Stock**	Estimated rates are based upon LMRC accepted rates SEP'15.

17.2. INNOVATIONS PROPOSE TO REDUCE THE COST

All efforts have been made to reduce the capital cost. Rates for various components involved in Metro Rail Systems like Civil works, E&M works, Traction & Power supply, Signaling & Telecommunication etc. costs have been assessed comparing the awarded rates of Nagpur Metro, Lucknow Metro, Ahmedabad Metro, DPR for DMRC Ph-IV and other Metro systems across the country.

The size of tunnel proposed is similar to what has been / being constructed in Lucknow Metro for optimal utilization of Tunnel Boring Machines being used. This shall encourage indigenous development and manufacturing of components that are being presently imported. Such steps shall induce progressive increase in local content in procurement, construction etc.

The cost of rolling stocks has been assessed considering establishment of manufacturing / assembling units of major suppliers of rolling stocks in India. The type / size of the rolling stock has been taken similar to Lucknow Metro for optimal utilization.

17.3. COSTING OF ENTIRE PROJECT

17.3.1. Corridor-Wise Capital Cost Estimate

Detailed capital cost estimate for Corridor-1, 2, 3, 4 & 5 is given in **Table 17.7**, **Table 17.8, Table 17.9, Table 17.10** and **Table 17.11** respectively.

TABLE 17.7: CAPITAL COST ESTIMATE CORRIDOR-1A

April'2018, Price Level
CORRIDOR - 5: FROM ECO PARK TO MIDC ESR
Total Length = 18.652Km, From = 20200m to 38852m, UG = 0 Km & ELEV = 18.652 Km
Stations = 10, Elevated = 10 No's, U/G by Cut & cover = 0 No's
Rs. In Crores

S. No.	Item	Unit	Rate	Qty.	Amount Without taxes
1.0	**Land**				
a	Central Govt. Land-Permanent (without Solatium)	**Ha**	0.00	0.0000	0.00
	Central Govt. Land-Permanent (for Parking cum PD)	**Ha**	0.00	0.0000	0.00
b	Central Govt. Land -Temporary	**Ha**	0.00	0.0000	0.00
c	Central Govt. Structures- Permanent	**Ha**	0.00	0.0000	0.00
d	State Govt. Land -Permanent (for Alignment, Ancillary Bldgs., Misc., without Solatium)	**Ha**	0.00	0.0000	0.00
e	State Govt. Land -Permanent (for Parking cum PD)	**Ha**	0.00	0.0000	0.00
f	State Govt. Land -Temporary	**Ha**	0.41	10.0000	4.12
g	State Govt. Structures -Permanent (Depreciated cost)	**Ha**	0.00	0.0000	0.00
h	Private Land-Permanent (for Alignment, Ancillary Bldgs, Misc., with 250% Solatium including R&R cost)	**Ha**	20.580	4.3522	89.57
i	Private Land-Permanent (for Parking cum PD)	**Ha**	20.580	0.2467	5.08
j	Private Structure - Permanent including Solatium as per LARRA	**Ha**	10.842	0.0621	0.67
	Sub Total (1)				**99.43**
2.0	**Alignment and Formation**				
2.1	Elevated section excluding viaduct length in station	R. Km.	40.00	17.36	694.48
2.2	Third line for Mid-terminal	R. Km.	48.00	0.30	14.40
2.3	Special Span	Each	15.14	2.00	30.28
	Sub Total (2)				**739.16**
3.0	**Station Buildings**				
3.4	**Elevated Station Buildings (80mx21m)**				

S. No.	Item	Unit	Rate	Qty.	Amount Without taxes
a	Elevated station - Civil Works including Viaduct	Each	38.20	10.00	381.99
b	Elevated station - EM Works etc.	Each	4.95	10.00	49.50
3.6	**Elevated Station- Architectural Finishes**	Each	5.92	10.00	59.20
3.7	**Lifts & Escalators (Elevated and UG stations)**				
a	Lifts	Each	0.48	40.00	19.20
b	Escalators	Each	0.74	40.00	29.60
	Sub Total (3)				**539.49**
4.0	**Maintenance Depot**				
a	Civil works	LS			30.00
b	EM works + Machinery & Plant + General Works	LS			30.00
	Sub Total (4)				**60.00**
5.0	**P-Way**				
5.1	Ballastless track for main line	Route Km.	9.08	18.45	167.55
5.2	Ballasted track for Depot	Track Km.	4.54	1.92	8.72
5.3	Ballastless track for entry to Depot	Route Km.	9.08	0.00	0.00
	Sub Total (5)				**176.26**
6.0	**Traction & power supply incl. OHE, ASS etc. Excl. lifts & Escalators**				
6.2	Elevated section including SCADA	R. Km.	10.00	18.45	184.52
6.3	For Depot	R. Km.	10.00	1.92	19.20
6.4	For 220kV GIS and 220kV cable in RSS	Each	66.24	0.00	0.00
	Sub Total (6)				**203.72**
7.0	**Signalling and Telecom.**				
7.1	Signalling	R. Km.	8.35	18.45	154.07
7.2	Telecommunication	Per Station	5.23	10.00	52.30
7.3	Automatic fare collection	Per station	3.31	10.00	33.10
7.4	Central Clearing House System (CCHS)	Each	20.00	0.00	0.00
7.5	Platform Screen Doors	Per Station	3.64	10.00	36.40
	Sub Total (7)				**275.87**
8.0	**R & R incl. Hutments etc.**				
a	Environmental Cost	As per DPR chapter			44.10
b	R & R	As per DPR chapter			1.70
	Sub Total (8)				**45.80**
9.0	**Misc. Utilities, road works, Topographic Surveys, Geotechnical Investigation, Barricading, Tree Cutting and replanting, other civil works such as signage's,**				

S. No.	Item	Unit	Rate	Qty.	Amount Without taxes
	Environmental protection and traffic management				
a	Civil works	R. Km.	4.51	18.452	83.14
b	Electrical Works	R. Km.	3.74	18.452	69.00
	Sub Total (9)				**152.14**
10.0	**Capital Expenditure on Security**				
a	Civil works	Per Station	0.30	10.00	3.03
b	EM works	Per Station	0.07	10.00	0.72
	Sub Total (10)				**3.75**
11.0	**Staff Quarters and OCC Building**				
a	Civil works	R. Km.	1.33	18.452	24.58
b	EM works	R. Km.	0.32	18.452	5.97
c	Cost of OCC Building - Civil Works	LS			0.00
d	Cost of OCC Building - E&M Works	LS			0.00
e	Cost for Green Building concept	LS			10.00
	Sub Total (11)				**40.56**
12.0	**Capital Expenditure on Inter modal integration including Footpath for pedestrians, Feeder Buses and Bicycles @2% of Total Cost excluding Land, R&R and Rolling Stock**				**44.70**
13.0	**Total of all items except Land, R&R and Rolling stock**				**2279.76**
14.0	**General Charges including Design charges @ 5% on all items except land, R&R and Rolling Stock**				**113.99**
15.0	**Total of all items including G. Charges**				**2393.75**
16.0	**Rolling Stock**	Each	10.86	12.00	130.32
17.0	**Total of 15 +16**				**2524.07**
18.0	**Contingencies @ 3 % on all items except land & R&R**				**75.72**
19.0	**Gross Total including Contingencies (excluding Land & R&R Cost)**				**2599.79**
20.0	**Gross Total including Contingencies (including Land & R&R Cost)**				**2700.93**
	Central Taxes & Duties				**216.28**
	State Taxes & Duties				**185.85**
	Total Cost including Taxes & Duties				**3103.05**

TABLE 17.8: CAPITAL COST ESTIMATE CORRIDOR-2A

April 2018, Price Level					
CORRIDOR - 1: FROM PILI NADI TO KANHAN RIVER					
Total Length = 12.925 Km, From = (-) 575m to (-)13500m, UG = 0 Km & ELEV = 12.925 Km					
Stations = 12, Elevated = 12 No's, U/G by Cut & cover = 0 No's					
					Rs. In Crores
S. No.	**Item**	**Unit**	**Rate**	**Qty.**	**Amount Without taxes**
1.0	**Land**				
a	Central Govt. Land -Permanent (without Solatium)	**Ha**	8.64	0.6175	5.34
	Central Govt. Land -Permanent (for Parking cum PD)	**Ha**	8.64	0.6397	5.53
b	Central Govt. Land -Temporary	**Ha**	0.00	0.0000	0.00
c	Central Govt. Structures- Permanent	**Ha**	0.00	0.0000	0.00
d	State Govt. Land -Permanent (for Alignment, Ancillary Bldgs, Misc., without Solatium)	**Ha**	8.64	0.1302	1.12
e	State Govt. Land -Permanent (for Parking cum PD)	**Ha**	8.64	0.0000	0.00
f	State Govt. Land -Temporary	**Ha**	0.43	10.0000	4.32
g	State Govt. Structures -Permanent (Depreciated cost)	**Ha**	0.00	0.0000	0.00
h	Private Land-Permanent (for Alignment, Ancillary Bldgs, Misc., with 250% Solatium including R&R cost)	**Ha**	22.3493	0.6731	15.04
i	Private Land-Permanent (for Parking cum PD)	**Ha**	22.3493	0.0000	0.00
j	Private Structure - Permanent including Solatium as per LARRA	**Ha**	25.7488	0.0869	2.24
	Sub Total (1)				**33.59**
2.0	**Alignment and Formation**				
2.1	Elevated section excluding viaduct length in station	R. Km.	40.00	11.75	470.08
2.2	Third line for Mid-terminal	R. Km.	48.00	0.30	14.40
2.3	Special Span	Each	15.14	2.00	30.28
	Sub Total (2)				**514.76**
3.0	**Station Buildings**				
3.4	**Elevated Station Buildings (80mx21m)**				

S. No.	Item	Unit	Rate	Qty.	Amount Without taxes
a	Elevated station - Civil Works including Viaduct	Each	38.20	12.00	458.39
b	Elevated station - EM Works etc.	Each	4.95	12.00	59.40
3.6	**Elevated Station- Architectural Finishes**	Each	5.92	12.00	71.04
3.7	**Lifts & Escalators (Elevated and UG stations)**				
a	Lifts	Each	0.48	48.00	23.04
b	Escalators	Each	0.74	48.00	35.52
	Sub Total (3)				**647.39**
4.0	**Maintenance Depot**				
a	Civil works	LS			20.00
b	EM works + Machinery & Plant + General Works	LS			20.00
	Sub Total (4)				**40.00**
5.0	**P-Way**				
5.1	Ballastless track for main line	Route Km.	9.08	13.00	118.04
5.2	Ballasted track for Depot	Track Km.	4.54	0.00	0.00
5.3	Ballastless track for entry to Depot	Route Km.	9.08	0.00	0.00
	Sub Total (5)				**118.04**
6.0	**Traction & power supply incl. OHE, ASS etc. Excl. lifts & Escalators**				
6.2	Elevated section including SCADA	R. Km.	10.00	13.00	130.00
6.3	For Depot	R. Km.	10.00	0.00	0.00
6.4	For 220kV GIS and 220kV cable in RSS	Each	66.24	1.00	66.24
	Sub Total (6)				**196.24**
7.0	**Signalling and Telecom.**				
7.1	Signalling	R. Km.	8.35	13.00	108.55
7.2	Telecommunication	Per Station	5.23	12.00	62.76
7.3	Automatic fare collection	Per station	3.31	12.00	39.72
7.4	Central Clearing House System (CCHS)	Each	20.00	0.00	0.00
7.5	Platform Screen Doors	Per Station	3.64	12.00	43.68
	Sub Total (7)				**254.71**
8.0	**R & R incl. Hutments etc.**				
a	Environmental Cost	As per DPR chapter			33.87
b	R & R	As per DPR chapter			1.86
	Sub Total (8)				**35.73**
9.0	**Misc. Utilities, road works, Topographic Surveys, Geotechnical Investigation, Barricading, Tree Cutting and replanting, other civil works such as signage's,**				

S. No.	Item	Unit	Rate	Qty.	Amount Without taxes
	Environmental protection and traffic management				
a	Civil works	R. Km.	4.51	13.000	58.57
b	Electrical Works	R. Km.	3.74	13.000	48.61
c	Additional cost for Utiity shifting near Lok Vihar station	LS			5.00
	Sub Total (9)				**112.19**
10.0	**Capital Expenditure on Security**				
a	Civil works	Per Station	0.30	12.00	3.64
b	EM works	Per Station	0.07	12.00	0.86
	Sub Total (10)				**4.50**
11.0	**Staff Quarters and OCC Building**				
a	Civil works	R. Km.	1.33	13.000	17.32
b	EM works	R. Km.	0.32	13.000	4.21
c	Cost of OCC Building - Civil Works	LS			0.00
d	Cost of OCC Building - E&M Works	LS			0.00
e	Cost for Green Building concept	LS			10.00
	Sub Total (11)				**31.53**
12.0	**Capital Expenditure on Inter modal integration including Footpath for pedestrians, Feeder Buses and Bicycles @2% of Total Cost excluding Land, R&R and Rolling Stock**				**39.06**
13.0	**Total of all items except Land, R&R and Rolling stock**				**1992.29**
14.0	**General Charges including Design charges @ 5% on all items except land, R&R and Rolling Stock**				**99.61**
15.0	**Total of all items including G. Charges**				**2091.90**
16.0	**Rolling Stock**	Each	10.86	30.00	325.80
17.0	**Total of 15 +16**				**2417.70**
18.0	**Contingencies @ 3 % on all items except land & R&R**				**72.53**
19.0	**Gross Total including Contingencies (excluding Land & R&R Cost)**				**2490.23**
20.0	**Gross Total including Contingencies (including Land & R&R Cost)**				**2525.68**
	Central Taxes & Duties				**216.64**
	State Taxes & Duties				**180.85**
	Total Cost including Taxes & Duties				**2923.16**

TABLE 17.9: CAPITAL COST ESTIMATE CORRIDOR-3A

April 2018, Price Level
CORRIDOR - 2: FROM MOUNT VIEW TO HINGNA
Total Length = 6.657 Km, From = 18218m to 24875m, UG = 0 Km & ELEV = 6.657 Km
Stations = 7, Elevated = 3 No's, U/G by Cut & cover = 0 No's
Rs. In Crores

S. No.	Item	Unit	Rate	Qty.	Amount Without taxes
1.0	**Land**				
a	Central Govt. Land -Permanent (without Solatium)	**Ha**	0.00	0.0000	0.00
	Central Govt. Land -Permanent (for Parking cum PD)	**Ha**	0.00	0.0000	0.00
b	Central Govt. Land -Temporary	**Ha**	0.00	0.0000	0.00
c	Central Govt. Structures- Permanent	**Ha**	0.00	0.0000	0.00
d	State Govt. Land-Permanent (for Alignment, Ancillary Bldgs, Misc., without Solatium)	**Ha**	3.547	0.4217	1.50
e	State Govt. Land -Permanent (for Parking cum PD)	**Ha**	3.547	0.3994	1.42
f	State Govt. Land -Temporary	**Ha**	0.18	10.0000	1.77
g	State Govt. Structures -Permanent (Depreciated cost)	**Ha**	25.7488	0.0424	1.09
h	Private Land-Permanent (for Alignment, Ancillary Bldgs, Misc., with 250% Solatium including R&R cost)	**Ha**	20.002	1.1207	22.42
i	Private Land-Permanent (for Parking cum PD)	**Ha**	0.00	0.0000	0.00
j	Private Structure - Permanent including Solatium	**Ha**	25.7488	0.2152	5.54
	Sub Total (1)				**33.74**
2.0	**Alignment and Formation**				
2.1	Elevated section excluding viaduct length in station	R. Km.	40.00	5.80	232.16
2.2	Third line for Mid-terminal	R. Km.	48.00	0.30	14.40
2.3	Special Span	Each	15.14	2.00	30.28
	Sub Total (2)				**276.84**
3.0	**Station Buildings**				

S. No.	Item	Unit	Rate	Qty.	Amount Without taxes
3.4	**Elevated Station Buildings (80mx21m)**				
a	Elevated station - Civil Works including Viaduct	Each	38.20	7.00	267.39
b	Elevated station - EM Works etc.	Each	4.95	7.00	34.65
3.6	**Elevated Station- Architectural Finishes**	Each	5.92	7.00	41.44
3.7	**Lifts & Escalators (Elevated and UG stations)**				
a	Lifts	Each	0.48	27.00	12.96
b	Escalators	Each	0.74	27.00	19.98
	Sub Total (3)				**376.42**
4.0	**Maintenance Depot**				
a	Civil works	LS			30.00
b	EM works + Machinery & Plant + General Works	LS			30.00
	Sub Total (4)				**60.00**
5.0	**P-Way**				
5.1	Ballastless track for main line	Route Km.	9.08	6.66	60.45
5.2	Ballasted track for Depot	Track Km.	4.54	0.80	3.63
5.3	Ballastless track for entry to Depot	Route Km.	9.08	0.00	0.00
	Sub Total (5)				**64.08**
6.0	**Traction & power supply incl. OHE, ASS etc. Excl. lifts & Escalators**				
6.2	Elevated section including SCADA	R. Km.	10.00	6.66	66.57
6.3	For Depot	R. Km.	10.00	0.80	8.00
6.4	For 220kV GIS and 220kV cable in RSS	Each	66.24	0.00	0.00
	Sub Total (6)				**74.57**
7.0	**Signalling and Telecom.**				
7.1	Signalling	R. Km.	8.35	6.66	55.59
7.2	Telecommunication	Per Station	5.23	7.00	36.61
7.3	Automatic fare collection	Per station	3.31	7.00	23.17
7.4	Central Clearing House System (CCHS)	Each	20.00	0.00	0.00
7.5	Platform Screen Doors	Per Station	3.64	7.00	25.48
	Sub Total (7)				**140.85**
8.0	**R & R incl. Hutments etc.**				
a	Environmental Cost	As per DPR chapter			20.43
b	R & R	As per DPR chapter			4.93
	Sub Total (8)				**25.36**

S. No.	Item	Unit	Rate	Qty.	Amount Without taxes
9.0	**Misc. Utilities, road works, Topographic Surveys, Geotechnical Investigation, Barricading, Tree Cutting and replanting, other civil works such as signage's, Environmental protection and traffic management**				
a	Civil works	R. Km.	4.51	6.657	29.99
b	Electrical Works	R. Km.	3.74	6.657	24.89
	Sub Total (9)				**54.89**
10.0	**Capital Expenditure on Security**				
a	Civil works	Per Station	0.30	7.00	2.12
b	EM works	Per Station	0.07	7.00	0.50
	Sub Total (10)				**2.63**
11.0	**Staff Quarters and OCC Building**				
a	Civil works	R. Km.	1.33	6.657	8.87
b	EM works	R. Km.	0.32	6.657	2.15
c	Cost of OCC Building - Civil Works	LS			0.00
d	Cost of OCC Building - E&M Works	LS			0.00
e	Cost for Green Building concept	LS			10.00
	Sub Total (11)				**21.02**
12.0	**Capital Expenditure on Inter modal integration including Footpath for pedestrians, Feeder Buses and Bicycles @2% of Total Cost excluding Land, R&R and Rolling Stock**				**21.83**
13.0	**Total of all items except Land, R&R and Rolling stock**				**1113.56**
14.0	**General Charges including Design charges @ 5% on all items except land, R&R and Rolling Stock**				**55.68**
15.0	**Total of all items including G. Charges**				**1169.24**
16.0	**Rolling Stock**	Each	10.86	3.00	32.58
17.0	**Total of 15 +16**				**1201.82**
18.0	**Contingencies @ 3 % on all items except land & R&R**				**36.05**
19.0	**Gross Total including Contingencies (excluding Land & R&R Cost)**				**1237.88**
20.0	**Gross Total including Contingencies (including Land & R&R Cost)**				**1276.54**
	Central Taxes & Duties				**100.58**
	State Taxes & Duties				**87.71**
	Total Cost including Taxes & Duties				**1464.83**

TABLE 17.10: CAPITAL COST ESTIMATE CORRIDOR-4A

April'2018, Price Level
CORRIDOR - 4: FROM PARDI TO TRANSPORT NAGAR
Total Length = 5.441 Km, From = (-) 580m to (-)6021m, UG = 0 Km & ELEV = 5.441 Km
Stations = 3, Elevated = 3 No's, U/G by Cut & cover = 0 No's
Rs. In Crores

S. No.	Item	Unit	Rate	Qty.	Amount Without taxes
1.0	**Land**				
a	Central Govt. Land -Permanent (without Solatium)	**Ha**	0.00	0.0000	0.00
	Central Govt. Land -Permanent (for Parking cum PD)	**Ha**	0.00	0.0000	0.00
b	Central Govt. Land -Temporary	**Ha**	0.00	0.0000	0.00
c	Central Govt. Structures- Permanent	**Ha**	0.00	0.0000	0.00
d	State Govt. Land -Permanent (for Alignment, Ancillary Bldgs, Misc., without Solatium)	**Ha**	15.51	0.1954	3.03
e	State Govt. Land -Permanent (for Parking cum PD)	**Ha**	15.51	0.2260	3.51
f	State Govt. Land -Temporary	**Ha**	0.78	10.0000	7.76
g	State Govt. Structures -Permanent (Depreciated cost)	**Ha**	25.7488	0.0456	1.17
h	Private Land -Permanent (for Alignment, Ancillary Bldgs, Misc., with 250% Solatium including R&R cost)	**Ha**	29.09	0.3248	9.45
i	Private Land -Permanent (for Parking cum PD)	**Ha**	29.09	0.0000	0.00
j	Private Structure - Permanent including Solatium as per LARRA	**Ha**	25.7488	0.0944	2.43
	Sub Total (1)				**27.35**
2.0	**Alignment and Formation**				
2.1	Elevated section excluding viaduct length in station	R. Km.	40.00	5.38	215.36
2.2	Third line for Mid-terminal	R. Km.	48.00	0.00	0.00
2.3	Special Span	Each	15.14	2.00	30.28
	Sub Total (2)				**245.64**
3.0	**Station Buildings**				
3.4	**Elevated Station Buildings (80mx21m)**				

S. No.	Item	Unit	Rate	Qty.	Amount Without taxes
a	Elevated station - Civil Works including Viaduct	Each	38.20	3.00	114.60
b	Elevated station - EM Works etc.	Each	4.95	3.00	14.85
3.6	**Elevated Station- Architectural Finishes**	Each	5.92	3.00	17.76
3.7	**Lifts & Escalators (Elevated and UG stations)**				
a	Lifts	Each	0.48	12.00	5.76
b	Escalators	Each	0.74	12.00	8.88
	Sub Total (3)				**161.85**
4.0	**Maintenance Depot**				
a	Civil works	LS			10.00
b	EM works + Machinery & Plant + General Works	LS			10.00
	Sub Total (4)				**20.00**
5.0	**P-Way**				
5.1	Ballastless track for main line	Route Km.	9.08	5.62	51.04
5.2	Ballasted track for Depot	Track Km.	4.54	0.00	0.00
5.3	Ballastless track for entry to Depot	Route Km.	9.08	0.00	0.00
	Sub Total (5)				**51.04**
6.0	**Traction & power supply incl. OHE, ASS etc. Excl. lifts & Escalators**				
6.2	Elevated section including SCADA	R. Km.	10.00	5.62	56.21
6.3	For Depot	R. Km.	10.00	0.00	0.00
6.4	For 220kV GIS and 220kV cable in RSS	Each	66.24	0.00	0.00
	Sub Total (6)				**56.21**
7.0	**Signalling and Telecom.**				
7.1	Signalling	R. Km.	8.35	5.62	46.94
7.2	Telecommunication	Per Station	5.23	3.00	15.69
7.3	Automatic fare collection	Per station	3.31	3.00	9.93
7.4	Central Clearing House System (CCHS)	Each	20.00	0.00	0.00
7.5	Platform Screen Doors	Per Station	3.64	3.00	10.92
	Sub Total (7)				**83.48**
8.0	**R & R incl. Hutments etc.**				
a	Environmental Cost	As per DPR chapter			16.05
b	R & R	As per DPR chapter			1.67
	Sub Total (8)				**17.72**

S. No.	Item	Unit	Rate	Qty.	Amount Without taxes
9.0	**Misc. Utilities, road works, Topographic Surveys, Geotechnical Investigation, Barricading, Tree Cutting and replanting, other civil works such as signage's, Environmental protection and traffic management**				
a	Civil works	R. Km.	4.51	5.621	25.33
b	Electrical Works	R. Km.	3.74	5.621	21.02
c	Additional cost for Utiity shifting near Kapsi Khurd station	LS			5.00
	Sub Total (9)				**51.35**
10.0	**Capital Expenditure on Security**				
a	Civil works	Per Station	0.30	3.00	0.91
b	EM works	Per Station	0.07	3.00	0.22
	Sub Total (10)				**1.13**
11.0	**Staff Quarters and OCC Building**				
a	Civil works	R. Km.	1.33	5.621	7.49
b	EM works	R. Km.	0.32	5.621	1.82
c	Cost of OCC Building - Civil Works	LS			0.00
d	Cost of OCC Building - E&M Works	LS			0.00
e	Cost for Green Building concept	LS			10.00
	Sub Total (11)				**19.31**
12.0	**Capital Expenditure on Inter modal integration including Footpath for pedestrians, Feeder Buses and Bicycles @2% of Total Cost excluding Land, R&R and Rolling Stock**				**14.12**
13.0	**Total of all items except Land, R&R and Rolling stock**				**720.16**
14.0	**General Charges including Design charges @ 5% on all items except land, R&R and Rolling Stock**				**36.01**
15.0	**Total of all items including G. Charges**				**756.17**
16.0	**Rolling Stock**	Each	10.86	3.00	32.58
17.0	**Total of 15 +16**				**788.75**
18.0	**Contingencies @ 3 % on all items except land & R&R**				**23.66**
19.0	**Gross Total including Contingencies (excluding Land & R&R Cost)**				**812.41**

S. No.	Item	Unit	Rate	Qty.	Amount Without taxes
20.0	**Gross Total including Contingencies (including Land & R&R Cost)**				**841.43**
	Central Taxes & Duties				**66.79**
	State Taxes & Duties				**58.08**
	Total Cost including Taxes & Duties				**966.30**

TABLE 17.11: CAPITAL COST ESTIMATE CORRIDOR-5

April 2018, Price Level
CORRIDOR - 3: FROM POLICE STATION MIDC TO DATTAWADI
Total Length = 4.489 Km, From = 15600m to 20089m, UG = 0 Km & ELEV = 4.489 Km
Stations = 3, Elevated = 3 No's, U/G by Cut & cover = 0 No's
Rs. In Crores

S. No.	Item	Unit	Rate	Qty.	Amount Without taxes
1.0	**Land**				
a	Central Govt. Land -Permanent (without Solatium)	**Ha**	0.00	0.0000	0.00
	Central Govt. Land -Permanent (for Parking cum PD)	**Ha**	0.00	0.0000	0.00
b	Central Govt. Land -Temporary	**Ha**	0.00	0.0000	0.00
c	Central Govt. Structures-Permanent	**Ha**	0.00	0.0000	0.00
d	State Govt. Land -Permanent (for Alignment, Ancillary Bldgs, Misc., without Solatium)	**Ha**	10.004	0.1079	1.08
e	State Govt. Land -Permanent (for Parking cum PD)	**Ha**	10.004	0.2900	2.90
f	State Govt. Land -Temporary	**Ha**	0.50	5.0000	2.50
g	State Govt. Structures -Permanent (Depreciated cost)	**Ha**	0.0000	0.0000	0.00
h	Private Land -Permanent (for Alignment, Ancillary Bldgs., Misc., with 250% Solatium including R&R cost)	**Ha**	20.13	0.5000	10.07
i	Private Land -Permanent (for Parking cum PD)	**Ha**	20.13	0.0000	0.00
j	Private Structure - Permanent including Solatium as per LARRA	**Ha**	25.7488	0.2217	5.71
	Sub Total (1)				**22.26**
2.0	**Alignment and Formation**				

S. No.	Item	Unit	Rate	Qty.	Amount Without taxes
2.1	Elevated section excluding viaduct length in station	R. Km.	40.00	4.25	170.08
2.2	Third line for Mid-terminal	R. Km.	48.00	0.00	0.00
	Sub Total (2)				**170.08**
3.0	**Station Buildings**				
3.4	**Elevated Station Buildings (80mx21m)**				
a	Elevated station - Civil Works including Viaduct	Each	38.20	3.00	114.60
b	Elevated station - EM Works etc.	Each	4.95	3.00	14.85
3.6	**Elevated Station- Architectural Finishes**	Each	5.92	3.00	17.76
3.7	**Lifts & Escalators (Elevated and UG stations)**				
a	Lifts	Each	0.48	12.00	5.76
b	Escalators	Each	0.74	12.00	8.88
	Sub Total (3)				**161.85**
4.0	**Maintenance Depot**				
a	Civil works	LS			10.00
b	EM works + Machinery & Plant + General Works	LS			10.00
	Sub Total (4)				**20.00**
5.0	**P-Way**				
5.1	Ballastless track for main line	Route Km.	9.08	4.49	40.76
5.2	Ballasted track for Depot	Track Km.	4.54	0.00	0.00
5.3	Ballastless track for entry to Depot	Route Km.	9.08	0.00	0.00
	Sub Total (5)				**40.76**
6.0	**Traction & power supply incl. OHE, ASS etc. Excl. lifts & Escalators**				
6.2	Elevated section including SCADA	R. Km.	10.00	4.49	44.89
6.3	For Depot	R. Km.	10.00	0.00	0.00
6.4	For 220kV GIS and 220kV cable in RSS	Each	66.24	0.00	0.00
	Sub Total (6)				**44.89**
7.0	**Signalling and Telecom.**				
7.1	Signalling	R. Km.	8.35	4.49	37.48
7.2	Telecommunication	Per Station	5.23	3.00	15.69
7.3	Automatic fare collection	Per station	3.31	3.00	9.93
7.4	Central Clearing House System (CCHS)	Each	20.00	0.00	0.00
7.5	Platform Screen Doors	Per Station	3.64	3.00	10.92
	Sub Total (7)				**74.02**
8.0	**R & R incl. Hutments etc.**				

S. No.	Item	Unit	Rate	Qty.	Amount Without taxes
a	Environmental Cost	As per DPR chapter			15.41
b	R & R	As per DPR chapter			2.30
	Sub Total (8)				**17.71**
9.0	**Misc. Utilities, road works, Topographic Surveys, Geotechnical Investigation, Barricading, Tree Cutting and replanting, other civil works such as signage's, Environmental protection and traffic management**				
a	Civil works	R. Km.	4.51	4.489	20.23
b	Electrical Works	R. Km.	3.74	4.489	16.79
c	Additional cost for Utiity shifting near MIDC PS station	LS			15.00
	Sub Total (9)				**52.01**
10.0	**Capital Expenditure on Security**				
a	Civil works	Per Station	0.30	3.00	0.91
b	EM works	Per Station	0.07	3.00	0.22
	Sub Total (10)				**1.13**
11.0	**Staff Quarters and OCC Building**				
a	Civil works	R. Km.	1.33	4.489	5.98
b	EM works	R. Km.	0.32	4.489	1.45
c	Cost of OCC Building - Civil Works	LS			0.00
d	Cost of OCC Building - E&M Works	LS			0.00
e	Cost for Green Building concept	LS			10.00
	Sub Total (11)				**17.43**
12.0	**Capital Expenditure on Inter modal integration including Footpath for pedestrians, Feeder Buses and Bicycles @2% of Total Cost excluding Land, R&R and Rolling Stock**				**11.95**
13.0	**Total of all items except Land, R&R and Rolling stock**				**609.54**
14.0	**General Charges including Design charges @ 5% on all items except land, R&R and Rolling Stock**				**30.48**
15.0	**Total of all items including G. Charges**				**640.01**
16.0	**Rolling Stock**	Each	10.86	6.00	65.16
17.0	**Total of 15 +16**				**705.17**
18.0	**Contingencies @ 3 % on all items except land & R&R**				**21.16**
19.0	**Gross Total including Contingencies (excluding Land & R&R Cost)**				**726.33**

S. No.	Item	Unit	Rate	Qty.	Amount Without taxes
20.0	**Gross Total including Contingencies (including Land & R&R Cost)**				**750.88**
	Central Taxes & Duties				**61.55**
	State Taxes & Duties				**52.41**
	Total Cost including Taxes & Duties				**864.84**

17.3.2. Taxes and Duties

Taxes and duties are worked out for each corridor separately. Current rates of GST (i.e. 12% on Metro projects) have been taken into consideration and have been applied as per prevalent practice. Taxes & duties for Corridor-1 to 5 have been worked out in **Table 17.13**,
Table 17.14**, Table 17.15**, **Table** 17.16, & **Table 17.17** respectively.

TABLE 17.12: TAXES AND DUTIES COMPONENTS

S.No.	Tax Component		%
1	Basic Customs duty	=	5.1500%
2	IGST (CGST portion)	=	9.4635%
3	IGST (SGST portion)	=	9.4635%
4	Total Customs Duty	=	24.0770%
5	General GST	=	12.0000%
6	General CGST	=	6.0000%
7	General SGST	=	6.0000%

TABLE 17.13: TAXES & DUTIES FOR CORRIDOR-1A

S. No.	Description	Total cost	Taxes and duties							
			Basic Customs Duty (Cr.)	IGST (CGST portion) (Cr.)	IGST (SGST portion) (Cr.)	Total Customs Duty (Cr.)	CGST (Cr.)	SGST (Cr.)	Total GST (CGST & SGST) (Cr.)	Total Taxes & Duties (Cr.)
1	**Alignment & Formation**									
	Underground	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Elevated	739.16	0.00	0.00	0.00	0.00	44.35	44.35	88.70	88.70
2	**Station Buildings**									
	Underground station-civil works	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Underground station-EM works	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Elevated station - civil works	441.19	0.00	0.00	0.00	0.00	26.47	26.47	52.94	52.94
	Elevated station-EM works	98.30	1.01	1.86	1.86	4.73	4.72	4.72	9.44	14.17
3	**Depot**									
	Civil works	30.00	0.46	0.85	0.85	2.17	1.26	1.26	2.52	4.69

S. No.	Description	Total cost	Taxes and duties							
			Basic Customs Duty (Cr.)	IGST (CGST portion) (Cr.)	IGST (SGST portion) (Cr.)	Total Customs Duty (Cr.)	CGST (Cr.)	SGST (Cr.)	Total GST (CGST & SGST) (Cr.)	Total Taxes & Duties (Cr.)
	EM and M&P works	30.00	0.31	0.57	0.57	1.44	3.36	3.36	6.72	8.16
4	**P-Way**	176.26	7.26	13.34	13.34	33.95	2.12	2.12	4.23	38.18
5	**Traction & power supply**									
	Traction and power supply	203.72	4.20	7.71	7.71	19.62	7.33	7.33	14.67	34.29
6	**S and T Works**									
	S & T	206.37	8.50	15.62	15.62	39.75	3.71	3.71	7.43	47.18
	AFC	33.10	1.28	2.35	2.35	5.98	0.74	0.74	1.49	7.47
	CCHS	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	PSD	36.40	1.50	2.76	2.76	7.01	0.66	0.66	1.31	8.32
7	**Environmental works**	44.10	0.00	0.00	0.00	0.00	2.65	2.65	5.29	5.29
8	**Misc.**									
	Civil works	83.14	0.00	0.00	0.00	0.00	4.99	4.99	9.98	9.98
	EM works	69.00	0.00	0.00	0.00	0.00	9.66	9.66	19.32	19.32
9	**Security**									
	Civil works	3.03	0.00	0.00	0.00	0.00	0.18	0.18	0.36	0.36
	EM works	0.72	0.00	0.00	0.00	0.00	0.10	0.10	0.20	0.20

S. No.	Description	Total cost	Taxes and duties							
			Basic Customs Duty (Cr.)	IGST (CGST portion) (Cr.)	IGST (SGST portion) (Cr.)	Total Customs Duty (Cr.)	CGST (Cr.)	SGST (Cr.)	Total GST (CGST & SGST) (Cr.)	Total Taxes & Duties (Cr.)
10	**Staff quarters**									
	Civil works	24.58	0.00	0.00	0.00	0.00	1.47	1.47	2.95	2.95
	EM works	5.97	0.00	0.00	0.00	0.00	0.84	0.84	1.67	1.67
11	**OCC Buildings**									
	Civil works	10.00	0.00	0.00	0.00	0.00	0.60	0.60	1.20	1.20
	EM works	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12	**Intermodal Integration**	44.70	0.00	0.00	0.00	0.00	2.68	2.68	5.36	5.36
13	**Rolling stock**	130.32	5.91	10.85	10.85	27.61	1.41	1.41	2.81	30.43
14	**Rent on Temporary Land**	4.12	0.00	0.00	0.00	0.00	0.37	0.37	0.74	0.74
15	**General Charges**	113.99	0.00	0.00	0.00	0.00	10.26	10.26	20.52	20.52
16	**Total**	**2528.18**	**30.43**	**55.92**	**55.92**	**142.27**	**129.93**	**129.93**	**259.86**	**402.13**
	Total taxes & Duties							**SAY**		**402.13**

TABLE 17.14: TAXES & DUTIES FOR CORRIDOR-2A

S. No.	Description	Total cost	Taxes and duties							
			Basic Customs Duty (Cr.)	IGST (CGST portion) (Cr.)	IGST (SGST portion) (Cr.)	Total Customs Duty (Cr.)	CGST (Cr.)	SGST (Cr.)	Total GST (CGST & SGST) (Cr.)	Total Taxes & Duties (Cr.)
1	**Alignment & Formation**									
	Underground	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.00**
	Elevated	514.76	0.00	0.00	0.00	0.00	30.89	30.89	61.77	**61.77**
2	**Station Buildings**									
	Underground station-civil works	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.00**
	Underground station-EM works	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.00**
	Elevated station - civil works	529.43	0.00	0.00	0.00	0.00	31.77	31.77	63.53	**63.53**
	Elevated station-EM works	117.96	1.21	2.23	2.23	5.68	5.66	5.66	11.32	**17.00**
3	**Depot**									
	Civil works	20.00	0.31	0.57	0.57	1.44	0.84	0.84	1.68	**3.12**

S. No.	Description	Total cost	Taxes and duties							
			Basic Customs Duty (Cr.)	IGST (CGST portion) (Cr.)	IGST (SGST portion) (Cr.)	Total Customs Duty (Cr.)	CGST (Cr.)	SGST (Cr.)	Total GST (CGST & SGST) (Cr.)	Total Taxes & Duties (Cr.)
	EM and M&P works	20.00	0.21	0.38	0.38	0.96	2.24	2.24	4.48	**5.44**
4	**P-Way**	118.04	4.86	8.94	8.94	22.74	1.42	1.42	2.83	**25.57**
5	**Traction & power supply**									
	Traction and power supply	196.24	4.04	7.43	7.43	18.90	7.06	7.06	14.13	**33.03**
6	**S and T Works**									
	S & T	171.31	7.06	12.97	12.97	33.00	3.08	3.08	6.17	**39.16**
	AFC	39.72	1.53	2.82	2.82	7.17	0.89	0.89	1.79	**8.96**
	CCHS	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.00**
	PSD	43.68	1.80	3.31	3.31	8.41	0.79	0.79	1.57	**9.99**
7	**Environmental Works**	33.87	0.00	0.00	0.00	0.00	2.03	2.03	4.06	**4.06**
8	**Misc.**									
	Civil works	63.57	0.00	0.00	0.00	0.00	3.81	3.81	7.63	**7.63**
	EM works	48.61	0.00	0.00	0.00	0.00	6.81	6.81	13.61	**13.61**

S. No.	Description	Total cost	Taxes and duties							
			Basic Customs Duty (Cr.)	IGST (CGST portion) (Cr.)	IGST (SGST portion) (Cr.)	Total Customs Duty (Cr.)	CGST (Cr.)	SGST (Cr.)	Total GST (CGST & SGST) (Cr.)	Total Taxes & Duties (Cr.)
9	**Security**									
	Civil works	3.64	0.00	0.00	0.00	0.00	0.22	0.22	0.44	**0.44**
	EM works	0.86	0.00	0.00	0.00	0.00	0.12	0.12	0.24	**0.24**
10	**Staff quarters**									
	Civil works	17.32	0.00	0.00	0.00	0.00	1.04	1.04	2.08	**2.08**
	EM works	4.21	0.00	0.00	0.00	0.00	0.59	0.59	1.18	**1.18**
11	**OCC Buildings**									
	Civil works	10.00	0.00	0.00	0.00	0.00	0.60	0.60	1.20	**1.20**
	EM works	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.00**
12	**Intermodal Integration**	39.06	0.00	0.00	0.00	0.00	2.34	2.34	4.69	**4.69**
13	**Rolling stock**	325.80	14.77	27.13	27.13	69.03	3.52	3.52	7.04	**76.07**
14	**Rent on Temporary Land**	4.32	0.00	0.00	0.00	0.00	0.39	0.39	0.78	**0.78**

S. No.	Description	Total cost	Taxes and duties							
			Basic Customs Duty (Cr.)	IGST (CGST portion) (Cr.)	IGST (SGST portion) (Cr.)	Total Customs Duty (Cr.)	CGST (Cr.)	SGST (Cr.)	Total GST (CGST & SGST) (Cr.)	Total Taxes & Duties (Cr.)
15	**General Charges**	99.61	0.00	0.00	0.00	0.00	8.97	8.97	17.93	**17.93**
16	**Total**	**2422.02**	**35.79**	**65.77**	**65.77**	**167.34**	**115.07**	**115.07**	**230.15**	**397.49**
	Total taxes & Duties							**SAY**		**397.49**

TABLE 17.15: TAXES & DUTIES FOR CORRIDOR-3A

S. No.	Description	Total cost	Taxes and duties							
			Basic Customs Duty (Cr.)	IGST (CGST portion) (Cr.)	IGST (SGST portion) (Cr.)	Total Customs Duty (Cr.)	CGST (Cr.)	SGST (Cr.)	Total GST (CGST & SGST) (Cr.)	Total Taxes & Duties (Cr.)
1	**Alignment & Formation**									
	Underground	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.00**
	Elevated	276.84	0.00	0.00	0.00	0.00	16.61	16.61	33.22	**33.22**
2	**Station Buildings**									
	Underground station-civil works	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.00**

S. No.	Description	Total cost	Taxes and duties							
			Basic Customs Duty (Cr.)	IGST (CGST portion) (Cr.)	IGST (SGST portion) (Cr.)	Total Customs Duty (Cr.)	CGST (Cr.)	SGST (Cr.)	Total GST (CGST & SGST) (Cr.)	Total Taxes & Duties (Cr.)
	Underground station-EM works	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.00**
	Elevated station - civil works	308.83	0.00	0.00	0.00	0.00	18.53	18.53	37.06	**37.06**
	Elevated station-EM works	67.59	0.70	1.28	1.28	3.25	3.24	3.24	6.49	**9.74**
3	**Depot**									
	Civil works	30.00	0.46	0.85	0.85	2.17	1.26	1.26	2.52	**4.69**
	EM and M&P works	30.00	0.31	0.57	0.57	1.44	3.36	3.36	6.72	**8.16**
4	**P-Way**	64.08	2.64	4.85	4.85	12.34	0.77	0.77	1.54	**13.88**
5	**Traction & power supply**									
	Traction and power supply	74.57	1.54	2.82	2.82	7.18	2.68	2.68	5.37	**12.55**
6	**S and T Works**									
	S & T	92.20	3.80	6.98	6.98	17.76	1.66	1.66	3.32	**21.08**
	AFC	23.17	0.89	1.64	1.64	4.18	0.52	0.52	1.04	**5.23**
	CCHS	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.00**

S. No.	Description	Total cost	Taxes and duties							
			Basic Customs Duty (Cr.)	IGST (CGST portion) (Cr.)	IGST (SGST portion) (Cr.)	Total Customs Duty (Cr.)	CGST (Cr.)	SGST (Cr.)	Total GST (CGST & SGST) (Cr.)	Total Taxes & Duties (Cr.)
	PSD	25.48	1.05	1.93	1.93	4.91	0.46	0.46	0.92	**5.83**
7	**Environmental Works**	20.43	0.00	0.00	0.00	0.00	1.23	1.23	2.45	**2.45**
8	**Misc.**									
	Civil works	29.99	0.00	0.00	0.00	0.00	1.80	1.80	3.60	**3.60**
	EM works	24.89	0.00	0.00	0.00	0.00	3.49	3.49	6.97	**6.97**
9	**Security**									
	Civil works	2.12	0.00	0.00	0.00	0.00	0.13	0.13	0.25	**0.25**
	EM works	0.50	0.00	0.00	0.00	0.00	0.07	0.07	0.14	**0.14**
10	**Staff quarters**									
	Civil works	8.87	0.00	0.00	0.00	0.00	0.53	0.53	1.06	**1.06**
	EM works	2.15	0.00	0.00	0.00	0.00	0.30	0.30	0.60	**0.60**
11	**OCC Buildings**									
	Civil works	10.00	0.00	0.00	0.00	0.00	0.60	0.60	1.20	**1.20**
	EM works	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.00**
12	**Intermodal Integration**	21.83	0.00	0.00	0.00	0.00	1.31	1.31	2.62	**2.62**
13	**Rolling stock**	32.58	1.48	2.71	2.71	6.90	0.35	0.35	0.70	**7.61**

S. No.	Description	Total cost	Taxes and duties							
			Basic Customs Duty (Cr.)	IGST (CGST portion) (Cr.)	IGST (SGST portion) (Cr.)	Total Customs Duty (Cr.)	CGST (Cr.)	SGST (Cr.)	Total GST (CGST & SGST) (Cr.)	Total Taxes & Duties (Cr.)
14	**Rent on Temporary Land**	1.77	0.00	0.00	0.00	0.00	0.16	0.16	0.32	**0.32**
15	**General Charges**	55.68	0.00	0.00	0.00	0.00	5.01	5.01	10.02	**10.02**
16	**Total**	**1203.59**	**12.86**	**23.64**	**23.64**	**60.14**	**64.07**	**64.07**	**128.15**	**188.29**
	Total taxes & Duties							**SAY**		**188.29**

TABLE 17.16: TAXES & DUTIES FOR CORRIDOR-4A

S. No.	Description	Total cost	Taxes and duties							
			Basic Customs Duty (Cr.)	IGST (CGST portion) (Cr.)	IGST (SGST portion) (Cr.)	Total Customs Duty (Cr.)	CGST (Cr.)	SGST (Cr.)	Total GST (CGST & SGST) (Cr.)	Total Taxes & Duties (Cr.)
1	**Alignment & Formation**									
	Underground	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.00**
	Elevated	245.64	0.00	0.00	0.00	0.00	14.74	14.74	29.48	**29.48**
2	**Station Buildings**									
	Underground station-civil works	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.00**

S. No.	Description	Total cost	Taxes and duties							
			Basic Customs Duty (Cr.)	IGST (CGST portion) (Cr.)	IGST (SGST portion) (Cr.)	Total Customs Duty (Cr.)	CGST (Cr.)	SGST (Cr.)	Total GST (CGST & SGST) (Cr.)	Total Taxes & Duties (Cr.)
	Underground station-EM works	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.00**
	Elevated station - civil works	132.36	0.00	0.00	0.00	0.00	7.94	7.94	15.88	**15.88**
	Elevated station-EM works	29.49	0.30	0.56	0.56	1.42	1.42	1.42	2.83	**4.25**
3	**Depot**									
	Civil works	10.00	0.15	0.28	0.28	0.72	0.42	0.42	0.84	**1.56**
	EM and M&P works	10.00	0.10	0.19	0.19	0.48	1.12	1.12	2.24	**2.72**
4	**P-Way**	51.04	2.10	3.86	3.86	9.83	0.61	0.61	1.22	**11.06**
5	**Traction & power supply**									
	Traction and power supply	56.21	1.16	2.13	2.13	5.41	2.02	2.02	4.05	**9.46**
6	**S and T Works**									
	S & T	62.63	2.58	4.74	4.74	12.06	1.13	1.13	2.25	**14.32**
	AFC	9.93	0.38	0.70	0.70	1.79	0.22	0.22	0.45	**2.24**
	CCHS	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.00**
	PSD	10.92	0.45	0.83	0.83	2.10	0.20	0.20	0.39	**2.50**

S. No.	Description	Total cost	Taxes and duties							
			Basic Customs Duty (Cr.)	IGST (CGST portion) (Cr.)	IGST (SGST portion) (Cr.)	Total Customs Duty (Cr.)	CGST (Cr.)	SGST (Cr.)	Total GST (CGST & SGST) (Cr.)	Total Taxes & Duties (Cr.)
7	**Environmental Works**	16.05	0.00	0.00	0.00	0.00	0.96	0.96	1.93	**1.93**
8	**Misc.**									
	Civil works	30.33	0.00	0.00	0.00	0.00	1.82	1.82	3.64	**3.64**
	EM works	21.02	0.00	0.00	0.00	0.00	2.94	2.94	5.89	**5.89**
9	**Security**									
	Civil works	0.91	0.00	0.00	0.00	0.00	0.05	0.05	0.11	**0.11**
	EM works	0.22	0.00	0.00	0.00	0.00	0.03	0.03	0.06	**0.06**
10	**Staff quarters**									
	Civil works	7.49	0.00	0.00	0.00	0.00	0.45	0.45	0.90	**0.90**
	EM works	1.82	0.00	0.00	0.00	0.00	0.25	0.25	0.51	**0.51**
11	**OCC Buildings**									
	Civil works	10.00	0.00	0.00	0.00	0.00	0.60	0.60	1.20	**1.20**
	EM works	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.00**
12	**Intermodal Integration**	14.12	0.00	0.00	0.00	0.00	0.85	0.85	1.69	**1.69**
13	**Rolling stock**	32.58	1.48	2.71	2.71	6.90	0.35	0.35	0.70	**7.61**
14	**Rent on Temporary Land**	7.76	0.00	0.00	0.00	0.00	0.70	0.70	1.40	**1.40**

S. No.	Description	Total cost	Taxes and duties							
			Basic Customs Duty (Cr.)	IGST (CGST portion) (Cr.)	IGST (SGST portion) (Cr.)	Total Customs Duty (Cr.)	CGST (Cr.)	SGST (Cr.)	Total GST (CGST & SGST) (Cr.)	Total Taxes & Duties (Cr.)
15	**General Charges**	36.01	0.00	0.00	0.00	0.00	3.24	3.24	6.48	**6.48**
16	**Total**	**796.51**	**8.71**	**16.01**	**16.01**	**40.73**	**42.07**	**42.07**	**84.14**	**124.87**
	Total taxes & Duties							**SAY**		**124.87**

TABLE 17.17: TAXES & DUTIES FOR CORRIDOR-5

S. No.	Description	Total cost	Taxes and duties							
			Basic Customs Duty (Cr.)	IGST (CGST portion) (Cr.)	IGST (SGST portion) (Cr.)	Total Customs Duty (Cr.)	CGST (Cr.)	SGST (Cr.)	Total GST (CGST & SGST) (Cr.)	Total Taxes & Duties (Cr.)
1	**Alignment & Formation**									
	Underground	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.00**
	Elevated	170.08	0.00	0.00	0.00	0.00	10.20	10.20	20.41	**20.41**
2	**Station Buildings**									
	Underground station-civil works	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.00**
	Underground station-EM works	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.00**
	Elevated station - civil works	132.36	0.00	0.00	0.00	0.00	7.94	7.94	15.88	**15.88**

S. No.	Description	Total cost	Taxes and duties							
			Basic Customs Duty (Cr.)	IGST (CGST portion) (Cr.)	IGST (SGST portion) (Cr.)	Total Customs Duty (Cr.)	CGST (Cr.)	SGST (Cr.)	Total GST (CGST & SGST) (Cr.)	Total Taxes & Duties (Cr.)
	Elevated station-EM works	29.49	0.30	0.56	0.56	1.42	1.42	1.42	2.83	**4.25**
3	**Depot**									
	Civil works	10.00	0.15	0.28	0.28	0.72	0.42	0.42	0.84	**1.56**
	EM and M&P works	10.00	0.10	0.19	0.19	0.48	1.12	1.12	2.24	**2.72**
4	**P-Way**	40.76	1.68	3.09	3.09	7.85	0.49	0.49	0.98	**8.83**
5	**Traction & power supply**									
	Traction and power supply	44.89	0.92	1.70	1.70	4.32	1.62	1.62	3.23	**7.56**
6	**S and T Works**									
	S & T	53.17	2.19	4.03	4.03	10.24	0.96	0.96	1.91	**12.16**
	AFC	9.93	0.38	0.70	0.70	1.79	0.22	0.22	0.45	**2.24**
	CCHS	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.00**
	PSD	10.92	0.45	0.83	0.83	2.10	0.20	0.20	0.39	**2.50**
7	**Environmental Works**	15.41	0.00	0.00	0.00	0.00	0.92	0.92	1.85	**1.85**
8	**Misc.**									
	Civil works	35.23	0.00	0.00	0.00	0.00	2.11	2.11	4.23	**4.23**

S. No.	Description	Total cost	Taxes and duties							
			Basic Customs Duty (Cr.)	IGST (CGST portion) (Cr.)	IGST (SGST portion) (Cr.)	Total Customs Duty (Cr.)	CGST (Cr.)	SGST (Cr.)	Total GST (CGST & SGST) (Cr.)	Total Taxes & Duties (Cr.)
	EM works	16.79	0.00	0.00	0.00	0.00	2.35	2.35	4.70	**4.70**
9	**Security**									
	Civil works	0.91	0.00	0.00	0.00	0.00	0.05	0.05	0.11	**0.11**
	EM works	0.22	0.00	0.00	0.00	0.00	0.03	0.03	0.06	**0.06**
10	**Staff quarters**									
	Civil works	5.98	0.00	0.00	0.00	0.00	0.36	0.36	0.72	**0.72**
	EM works	1.45	0.00	0.00	0.00	0.00	0.20	0.20	0.41	**0.41**
11	**OCC Buildings**									
	Civil works	10.00	0.00	0.00	0.00	0.00	0.60	0.60	1.20	**1.20**
	EM works	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.00**
12	**Intermodal Integration**	11.95	0.00	0.00	0.00	0.00	0.72	0.72	1.43	**1.43**
13	**Rolling stock**	65.16	2.95	5.43	5.43	13.81	0.70	0.70	1.41	**15.21**
14	**Rent on Temporary Land**	2.50	0.00	0.00	0.00	0.00	0.23	0.23	0.45	**0.45**
15	**General Charges**	30.48	0.00	0.00	0.00	0.00	2.74	2.74	5.49	**5.49**
16	**Total**	**707.67**	**9.14**	**16.80**	**16.80**	**42.74**	**35.61**	**35.61**	**71.22**	**113.96**
	Total taxes & Duties							**SAY**		**113.96**

17.4. SUMMARY OF CAPITAL COST

The abstract of capital cost estimate of Corridor-1 & 5 is given in **Table 17.18.**

TABLE 17.18: ABSTRACT OF COST ESTIMATE OF CORRIDOR-1 TO 5

(Rs. In Crores)

SN	ITEM	Corridor-1A	Corridor-2A	Corridor-3A	Corridor-4A	Corridor-5	Total
1	Land	99.43	33.59	33.74	27.35	22.26	216.36
2	Alignment and Formation	739.16	514.76	276.84	245.64	170.08	1946.49
3	Station Buildings incl. Civil works, EM works, ECS, TVS, Lift, escalators & Architectural Finishes etc	539.49	647.39	376.42	161.85	161.85	1887.00
4	Depot including civil, EM, Machinery & plants, general works	60.00	40.00	60.00	20.00	20.00	200.00
5	P-Way for main line, depot and depot connectivity	176.26	118.04	64.08	51.04	40.76	450.18
6	Traction & power supply for main line and depot incl. OHE, ASS, GIS etc.	203.72	196.24	74.57	56.21	44.89	575.63
7	Signalling and Telecom. Incl. AFC, Platform screen doors, CCHS etc.	275.87	254.71	140.85	83.48	74.02	828.93
8a	Environmental	44.10	33.87	20.43	16.05	15.41	129.86
8b	R & R incl. Hutments etc.	1.70	1.86	4.93	1.67	2.30	12.46
9	Misc. Utilities, road works, Topographic Surveys, Geotechnical Investigation, Barricading, Tree Cutting and replanting, other civil works such as signage's, Environmental protection and traffic management	152.14	112.19	54.89	51.35	52.01	422.58
10	Capital Expenditure on Security including civil and EM works	3.75	4.50	2.63	1.13	1.13	13.13
11	Staff Quarters and buildings including civil, electrical works and green building concept (Cost of OCC building is included in corridor-1 only)	40.56	31.53	21.02	19.31	17.43	129.85

SN	ITEM	Corridor-1A	Corridor-2A	Corridor-3A	Corridor-4A	Corridor-5	Total
12	Capital Expenditure on Inter modal integration including Footpath for pedestrians, Feeder Buses and Bicycles @2% of Total Cost excluding Land, R&R and Rolling Stock	44.70	39.06	21.83	14.12	11.95	131.67
13	Total of all items except Land, R&R and Rolling Stock	2279.76	1992.29	1113.56	720.16	609.54	6715.31
14	General Charges incl. Design charges, including Metro Bhawan, (Civil+EM works) @ 5% on all items except land, R&R and Rolling Stock. (Metro Bhawan is charged to coridor-1 only and it will cater to both the corridors)	113.99	99.61	55.68	36.01	30.48	335.77
15	Total of all items including G. Charges	2393.75	2091.90	1169.24	756.17	640.01	7051.07
16	Rolling Stock	130.32	325.80	32.58	32.58	65.16	586.44
17	Total of 15 + 16	2524.07	2417.70	1201.82	788.75	705.17	7637.51
18	Contingencies @ 3 %on all items except land and R&R	75.72	72.53	36.05	23.66	21.16	229.13
Gross Total including Contingencies (excluding Land and R&R Cost)		**2599.79**	**2490.23**	**1237.88**	**812.41**	**726.33**	**7866.64**
Gross Total including Contingencies (including Land and R&R Cost)		**2700.93**	**2525.68**	**1276.54**	**841.43**	**750.88**	**8095.46**
Central Taxes & Duties		**216.28**	**216.64**	**100.58**	**66.79**	**61.55**	**661.84**
State Taxes & Duties		**185.85**	**180.85**	**87.71**	**58.08**	**52.41**	**564.90**
Total Cost including Taxes & Duties		**3103.05**	**2923.16**	**1464.83**	**966.30**	**864.84**	**9322.19**

17.5. OPERATION AND MAINTENANCE COST

The Operation and Maintenance cost for Nagpur Metro Phase 2 Corridors is worked under three major heads:

- Staff cost
- Maintenance cost which includes expenditure towards upkeep and maintenance of the system and consumables and
- Energy cost

17.5.1. Staff Cost

The O&M staff is assumed to be provided @ 35 persons per kilometre. As per the experience of DMRC and BMRCL metros, the average annual salary of Rs. 7.77 lakh per annum is considered. Further, the average salary is increased by 15% to account for the impact of Pay commission. Thus, the average annual staff salary considered for Nagpur metro phase 2 corridors is Rs. 8.94 Lakhs in the year 2018. The escalation factor used for staff costs is 9% per annum to provide for growth in salaries. The staff cost for Phase 2 N-S corridors (i.e. Pili Nadi to Kanhan River and Eco Park to MIDC ESR corridors) is estimated to be **Rs 156.53 Crore** for the inception year i.e. 2024. The staff cost for Phase 2 E-W corridors (i.e. Hingna Mount View to Hingna, Police Station MIDC to Dattawadi and Pardi to Transport Nagar corridors) is estimated to be **Rs 65.67 Crore** for the inception year i.e. 2024.

17.5.2. Maintenance Expenses

Maintenance expenses are taken @ Rs. 1.45 Crore/km in the year 2018 based on MoUD Report Nov. 2013 (Operations & Maintenance Systems for Metro Railways). Maintenance cost for Phase 2 corridors is estimated to be **Rs 57.94 Crore** for N-S extensions and **Rs. 24.29 Crore** for E-W extensions in the inception year i.e. 2024 considering escalation @ 5% p.a. for every year of operation.

17.5.3. Energy Charges

The energy consumption to meet the traction and non-traction power requirement is based on traffic demand for different horizon years. The cost of electricity is a significant part of O&M charges. The traction power tariff is taken @ Rs. 5.8 per kVAh for year 2018, which is escalated @ 5% every year of operation. The annual energy consumption charges for Phase 2 N-S corridors have been estimated as **Rs 34.12 Crore** in 2024, **Rs 49.79 Crore** in 2031 and **Rs. 96.08 Crore** in 2041. Annual energy consumption charges for Phase 2 E-W corridors have been estimated as **Rs. 15.07 Crore** in year 2024, **Rs 23.73 Crore** in 2031 and **Rs. 47.09 Crore** in 2041.

Energy cost per unit and consumption units assumed for Phase 2 Corridors for the years 2024, 2031 and 2041 are indicated below in **Table 17.19**

TABLE 17.19: ENERGY COST PER UNIT AND CONSUMPTION UNITS

Corridor	Energy Cost Per Unit (in Rs.)			Consumption Units (in Million Units)		
	2024	2031	2041	2024	2031	2041
N-S Phase 2 Corridors	7.77	10.94	17.81	43.90	45.51	53.95
E-W Phase 2 Corridors	7.77	10.94	17.81	19.39	21.69	26.44

17.5.4. Additional Investment

To cater to increased traffic demand, additional investment will have to be made for purchase of additional coaches. The additional investment in Phase 2 N-S corridors in the year 2041 is **Rs 308.25 Crore** for purchase of 18 additional coaches. The additional investment in Phase 2 E-W corridors in the year 2031 is **Rs 126.44 Crore** for purchase of 9 additional coaches and in the year 2041 is **Rs 154.13 Crore** for purchase of 9 additional coaches. These additional investments have been worked out considering an escalation factor of 2% per annum.

17.5.5. Replacement Cost

The replacement costs are provided for meeting the cost on account of replacement of equipments due to wear and tear. With the nature of equipment proposed to be provided for the corridor, it is expected that about 25% of the equipment comprising Electrical, Rolling stock and 50% of Signalling & Telecom would require replacement/ rehabilitation after 20 years.

The replacement cost works out to be **Rs. 1832.00 Crore** for Phase 2 N-S corridors and **Rs. 806.64 Crore** for Phase 2 E-W corridors in the year 2044. The replacement cost has been worked out considering an escalation factor of 5% per annum.

The year wise total Operation and Maintenance cost for the corridors of Nagpur Metro Phase 2 is indicated in **Table 17.20** and **Table 17.21.**

TABLE 17.20: O&M COST FOR KANHAN RIVER TO MIDC ESR (PHASE 2 N-S CORRIDORS)

Year	Staff Cost	Maintenance Expenses	Energy Charges	Total O&M cost	Addition/ Replace - ment Cost (Cr.)	
	Esc @9%	Esc @5%	Esc @5%			
2024	156.53	57.94	34.12	248.59		
2025	170.62	60.84	36.01	267.47		
2026	185.98	63.88	38.02	287.88		
2027	202.72	67.07	40.13	309.92		
2028	220.96	70.42	42.35	333.73		
2029	240.85	73.94	44.69	359.48		
2030	262.53	77.64	47.18	387.35		
2031	286.16	81.52	49.79	417.47		
2032	311.91	85.60	53.26	450.77		
2033	339.98	89.88	56.92	486.78		
2034	370.58	94.37	60.82	525.77		
2035	403.93	99.09	64.97	567.99		
2036	440.28	104.04	69.37	613.69		
2037	479.91	109.24	74.09	663.24		
2038	523.10	114.70	79.08	716.88		
2039	570.18	120.44	84.40	775.02		
2040	621.50	126.46	90.07	838.03		
2041	677.44	132.78	96.08	906.30	308.25	Addition of 18 coaches
2042	738.41	139.42	102.46	980.29		
2043	804.87	146.39	109.27	1,060.53		
2044	877.31	153.71	116.47	1,147.49	1832.00	Replacement of 25% of Elec. & 50% S&T assets
2045	956.27	161.40	124.11	1,241.78		
2046	1042.33	169.47	132.22	1,344.02		
2047	1136.14	177.94	140.87	1,454.95		
2048	1238.39	186.84	150.00	1,575.23		
2049	1349.85	196.18	159.71	1,705.74		
2050	1471.34	205.99	170.05	1,847.38		
2051	1603.76	216.29	180.99	2,001.04		
2052	1748.10	227.10	192.61	2,167.81		
2053	1905.43	238.46	204.92	2,348.81		
2054	2076.92	250.38	218.01	2,545.31		
2055	2263.84	262.90	231.89	2,758.63		

TABLE 17.21: O&M COST FOR TRANSPORT NAGAR TO HINGNA (PHASE 2 E-W CORRIDORS)

Year	Staff Cost	Maintenance Expenses	Energy Charges	Total O&M cost	Addition/ Replace -ment Cost (Cr.)	
	Esc @9%	Esc @5%	Esc @5%			
2024	65.67	24.29	15.07	105.03		
2025	71.58	25.50	16.09	113.17		
2026	78.02	26.78	17.18	121.98		
2027	85.04	28.12	18.34	131.50		
2028	92.69	29.53	19.57	141.79		
2029	101.03	31.01	20.86	152.90		
2030	110.12	32.56	22.26	164.94		
2031	120.03	34.19	23.73	177.95	126.44	Addition of 9 coaches
2032	130.83	35.90	25.47	192.20		
2033	142.60	37.70	27.30	207.60		
2034	155.43	39.59	29.26	224.28		
2035	169.42	41.57	31.35	242.34		
2036	184.67	43.65	33.57	261.89		
2037	201.29	45.83	35.95	283.07		
2038	219.41	48.12	38.47	306.00		
2039	239.16	50.53	41.17	330.86		
2040	260.68	53.06	44.04	357.78		
2041	284.14	55.71	47.09	386.94	154.13	Addition of 9 coaches
2042	309.71	58.50	50.33	418.54		
2043	337.58	61.43	53.79	452.80		
2044	367.96	64.50	57.46	489.92	806.64	Replacement of 25% of Elec. & 50% S&T assets
2045	401.08	67.73	61.36	530.17		
2046	437.18	71.12	65.50	573.80		
2047	476.53	74.68	69.92	621.13		
2048	519.42	78.41	74.59	672.42		
2049	566.17	82.33	79.56	728.06		
2050	617.13	86.45	84.87	788.45		
2051	672.67	90.77	90.48	853.92		
2052	733.21	95.31	96.45	924.97		
2053	799.20	100.08	102.78	1,002.06		
2054	871.13	105.08	109.52	1,085.73		
2055	949.53	110.33	116.68	1,176.54		

Chapter – 18
TRANSIT ORIENTED DEVELOPMENT PLAN

18. TRANSIT ORIENTED DEVELOPMENT PLAN

18.1. NATIONAL TRANSIT ORIENTED DEVELOPMENT POLICY

National Transit Oriented Development (TOD) Policy provides guidelines on development along transit corridors. TOD integrates land use and transport planning and aims to develop planned sustainable urban growth centres, having walkable and liveable communes with high density mixed land-use. Citizens have access to open green and public spaces and at the same time transit facilities are efficiently utilized.

TOD focuses on creation of high density mixed land use development in the influence zone of transit stations, i.e. within the walking distance of (500-800 m) of transit station or along the corridor in case the station spacing is about 1 km. TOD advocates pedestrian trips to access various facilities such as shopping, entertainment and work.

TOD increases the accessibility of the transit stations by creating pedestrian and Non-Motorised Transport (NMT) friendly infrastructure that benefits large number of people, thereby increasing the ridership of the transit facility and improving the economic and financial viability of the system. Since the transit corridor has mixed land-use, where the transit stations are either origin (housing) or destination (work), the corridor experiencing peak hour traffic in both directions would optimize the use of the transit system.

18.2. OBJECTIVES OF TOD

The objectives of TOD include:

- To promote the use of public transport by developing high density zones in the influence area, which would increase the share of transit and walk trips.
- To provide all the basic needs of work/ job, shopping, public amenities, entertainment in the influence zone with mixed land-use development
- To establish a dense road network within the development area for safe and easy movement and connectivity of NMT and pedestrians between various uses as well as to transit stations.
- To achieve reduction in the private vehicle ownership, traffic and associated parking demand.
- To provide all kinds of recreational/entertainment/ open spaces, required for a good quality of life in the influence area.
- To prevent urban sprawl by accommodating the growing population in a

compact area with access to the transit corridor, this would also consolidate investments and bring down the infrastructure cost for development.

- To reduce carbon footprints by shifting towards environmentally friendly travel options for the line haul as well as for access and egress trips.

The study has been divided into following two components:

- Conceptual Urban Design Plans for TOD at identified typical Ph 2 metro stations
- Estimation of revenue potential from TOD along Ph 2 metro corridors

18.3. CONCEPTUAL URBAN DESIGN PLANS

18.3.1. Context

Transit Oriented Development (TOD) integrates land use & transportation to create compact, pedestrian-oriented, mixed-use communities centered around high quality transit station. TOD increases “location efficiency” so people can walk, bike and take transit, boosts transit ridership and minimizes the impacts of traffic and provides a rich mix of housing, jobs, shopping and recreational choices. It also provides value for the public and private sectors, and helps in creating a sense of community and of place. The concept of TOD with respect to transit stations is shown in **Figure 18.1**. TOD corridor level planning for various stakeholders is described in **Figure 18.2**.

FIGURE 18.1: CONCEPT OF TOD WITH RESPECT TO TRANSIT STATIONS

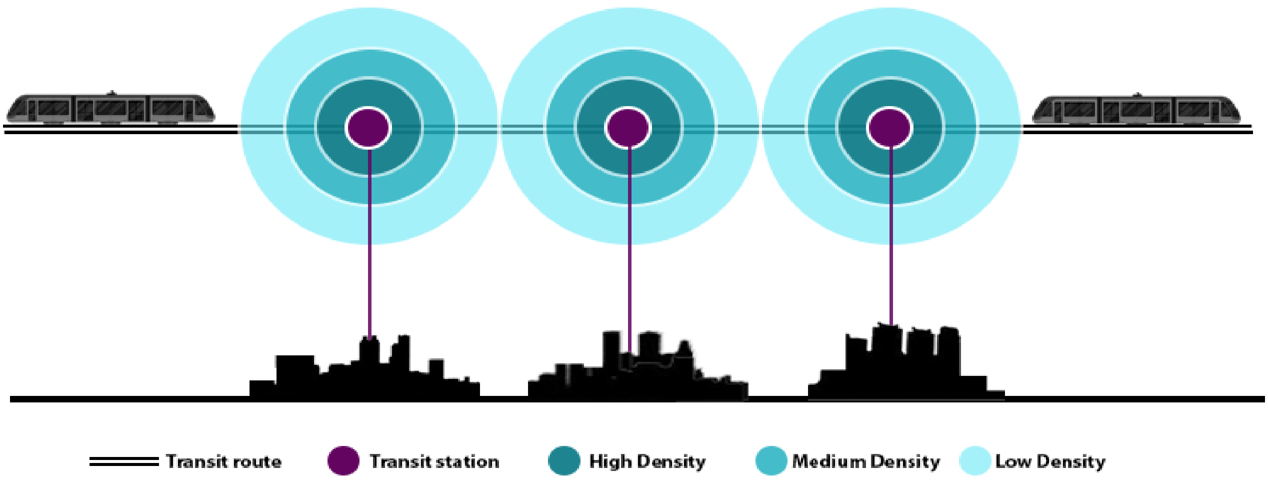
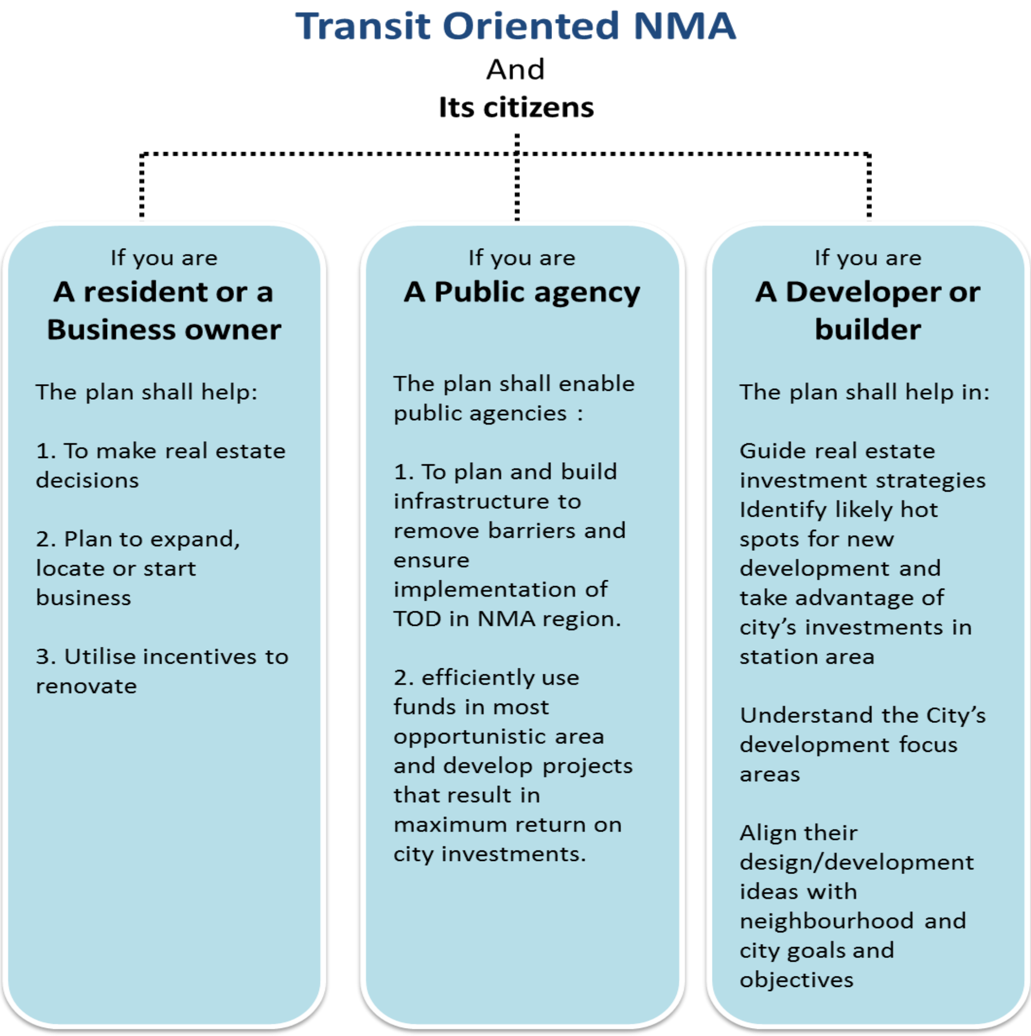


FIGURE 18.2: TOD TO VARIOUS STAKEHOLDERS



18.3.2. TODPrinciples

i. Promote Compact development in station area

Compact development can be promoted across the region by creating development with short commutes. By optimizing density and transit capacity by consciously placing homes, jobs, civic uses, shopping, entertainment, parks and other daily necessities close to transit stations, city can make possible short, walkable trips and reduce long, inefficient travel, at the same time contain sprawl in the region. A greater percentage of jobs and housing placed close together at Metro stations throughout the region can lead to better use of amount invested in infrastructure. The example of urban sprawl and compact development is shown in **Figure 18.3.**

FIGURE 18.3:MAP SHOWING URBAN SPRAWL & COMPACT DEVELOPMENT

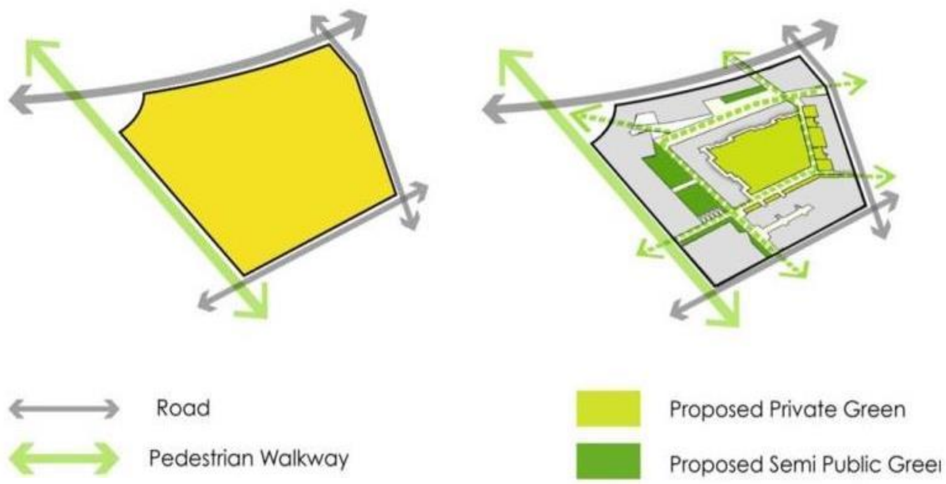
ii. Improve connectivity & Accessibility

Achieving high level of connectivity at station areas ensures a successful TOD. This is true in both stations that are located in areas with a strong market development potential, as well as stations that simply need to serve existing neighbourhoods. As each station increases its reach into the larger community, access to the region's economy is improved. It can be achieved through:

a. Develop neighbourhoods that promote walking
b. Prioritize non-motorized transport networks
c. Create dense networks of streets and paths

The network plan showing improved connectivity & accessibility is shown in **Figure 18.4.**

FIGURE 18.4:NETWORK PLAN SHOWING IMPROVED CONNECTIVITY



iii. Plan for mixed use

Planning for balanced mix of complementary uses and activities within close proximity, increases chances that people can reach a majority of their daily needs by foot, bicycle, or transit. A strong mix of uses keeps streets active and safe while making many daily trips walkable. Balanced mix of uses and activities provides residents a true choice of lifestyles, leading to a more resilient place to live, work, and play. Mix of use can be done both horizontally as well as vertically.

Figure 18.5shows the example of mixed use planning for TOD.

FIGURE 18.5:EXAMPLE OF MIXED USE PLANNING FOR TOD

iv. Enhance mobility

A true multi-modal city goes beyond needed transit improvements. A complete network needs high-ease-of-use bike and pedestrian facilities, car sharing, bike sharing, and other new ways to make getting around without the use of a car a reality. A shift from being a cardependent city to a multi-modal city is essential.

Travel demand strategies like regulating parking and road use are also required to regulate mobility. Successful TODs utilize reduced total parking numbers, and incorporate central shared parking between different uses, thereby reducing overall parking numbers further compared to conventional development.

v. High Quality Public realm

Great public spaces are the living rooms of the city - An activated public place becomes a destination, strengthening the livability of the community. Great public spaces with easy access encourage people to come outdoors, promoting a feeling of safety and visual interest for pedestrians. Public spaces range from grand central plazas and squares, to small, local neighbourhood parks.

Successful public spaces have a sense of enclosure by attractive, human-scaled buildings. Therefore to ensure a successful TOD it is essential to make places not just to travel through, but rather to stop, linger, converse, and generally live life.

Figure 18.6 shows the form and scale of public spaces created by built form.

FIGURE 18.6:FORM & SCALE OF PUBLIC SPACES

18.3.3. Final Site Selection

On the basis of site study and TOD site assessment, the recommended two sites have been finalised in consultation with the client to develop typical urban design conceptual plans.

i. TOD Independent of Metro Station: Maharashtra State Road Transport Corporation (MSRTC) Workshop Land

The site is along proposed Vasudev Nagar - Wadi Corridor. Site is situated 650 m away from proposed Metro Station Police Station MIDC. MSRTC workshop is currently operational at the site. The total area of the plot is approx 8.8 Ha. The land actually belongs to Maharashtra Industrial Development Corporation (MIDC) which has been leased for 100 years to MSRTC.

ii. TOD Integrated with Metro Station: Kamptee Police Station Land

The site is along proposed Automotive Square –Kanhan River corridor opposite to proposed metro station at Kamptee Police Station. The site is situated on National Highway 7 and the land belongs to Kamptee Police Station. The total area of the plot is approx 1 Ha.

18.3.4. Policies and Guidelines

Following policies, guidelines & byelaws were referred for the developing the urban design framework for the above selected sites.

i. Nagpur Metropolitan Area, Development Control and Promotion Regulations, Development Plan 2012-2032

Following guidelines have been referred to for developing the conceptual framework:

- FSI= maximum permissible 4.0, including base permissible FSI allowed on plots with area greater than 2,000 sqm. FSI shall be calculated on the net plot area.
- Minimum open spaces for area more than 0.4 Ha = 15% of the entire holding area
- Permissible land uses: Mixed use in the form of residential and commercial may be permissible on the plot in NMRC fronting on road width of 12 m.

ii. Marginal spaces to be left around building in the TOD zone shall be H/4, where ‘H’ is height of the proposed building provided that the marginal space shall be minimum 6m for the building above 15 m height.

iii. Draft National Mission on Sustainable Habitat (NMSH)

- Area of blocks surrounded by public access pedestrian/cyclist streets or pathways not to exceed 2 ha. In existing built-up areas, statutory planning to be done for breaking up blocks with an area of more than 2 Ha, to provide publicly accessible pedestrian thoroughfare.
- Vehicle access network should be set on a grid with no side exceeding (C/C) 250m with additional public access pedestrian thoroughfares cutting through the block, where possible.

18.3.5. UrbanDesign Framework for MSRTC Workshop Site

i. Site Characteristics & analysis

- The site selected is land owned by MIDC leased out to MSRTC, which is presently using the land as a workshop for managing city wide buses. The two key factors that govern the development parameters of this site is the need of residential units by MSRTC and need for a bus depot & workshop.
- Key parameters that framed requirements and help strategize
  - Strategic location- lies close to junction between Hingna road and ring road.
  - Need of residential units by MSRTC
  - Proposed mixed use development in proximity.
  - Frontage available on site
  - Improving access to metro stations

MSRTC Workshop site is shown in **Figure 18.7.**

FIGURE 18.7:MSRTC WORKSHOP SITE

ii. Vision

TOD in this area, aims at fostering more coordinated development around transit area nodes with more FAR and encourage a mix of residential, commercial, and special industrial uses (media and entertainment) that shall make this dead and quite district into an otherwise vibrant urban quarter of the city.

iii. Conceptual Plan with Urban Design Frame work

- Site Area =88750 Sq.m. (22acres)
- Floor area ratio =3.37
- Built up area = 299516 Sq.m.

The proposed planning and zoning of uses on the site is shown in **Figure 18.8** and conceptual plan of the proposed transit oriented development is shown in**Figure 18.9.**

FIGURE 18.8: PROPOSED PLANNING AND ZONING OF USES ON MSRTC WORKSHOP SITE

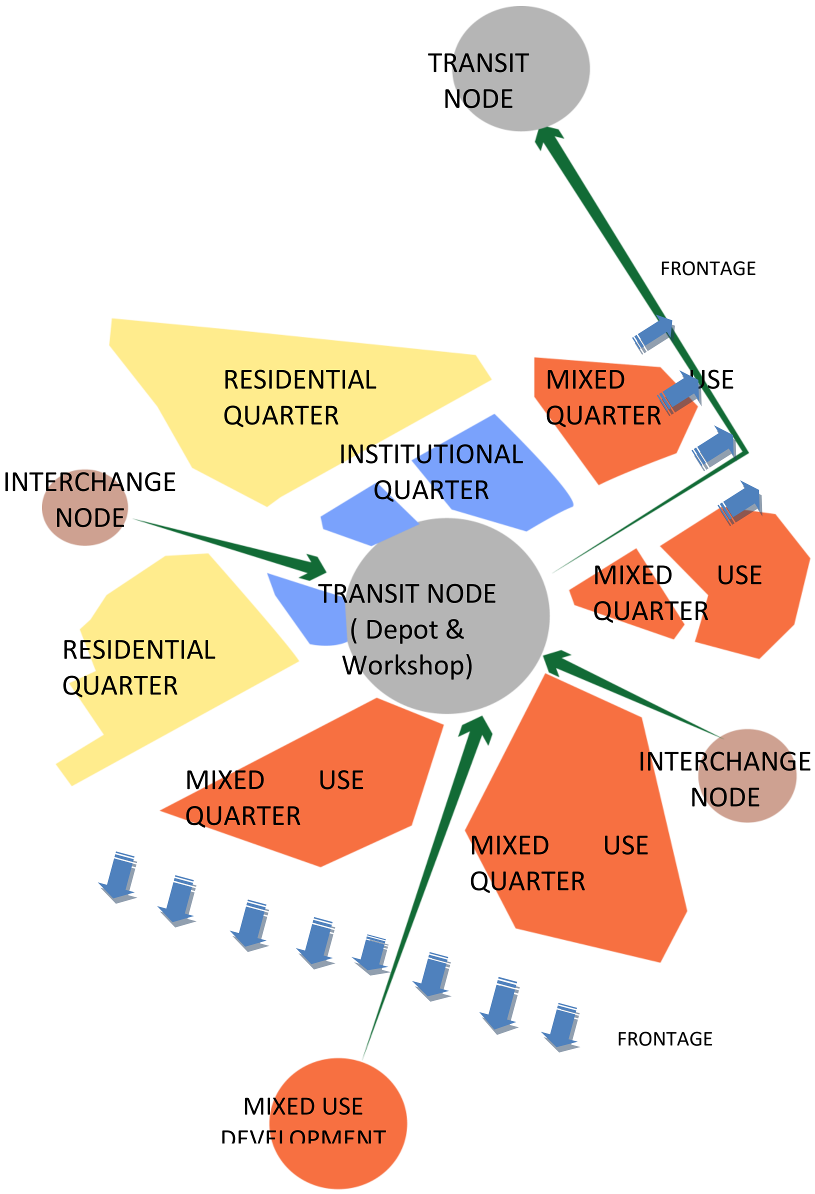


FIGURE 18.9: CONCEPTUAL PLAN OF PROPOSED TRANSIT ORIENTED DEVELOPMENT

The Conceptual details of individual blocks are listed below:

	Block size (Sq. m.)	No. of floors	Total BUA (Sq. m.)	Mix use
Block 1	1591	4	6364	Commercial
	642	6	3852	Commercial
Block 2	1958	4	7832	Commercial
	732	11	8052	Commercial
Block 3	785	4	3140	Institutional
Block 4	1956	4	7824	Institutional
Block 5	845	26	21970	Institutional
Block 6	590	8	4720	Institutional
Block 7	699	4	2796	Institutional
Block 8	509	4	2036	Residential
	910	4	3640	Residential
Block 9	422	15	6330	Residential
	922	4	3688	Residential +
	402	10	4020	Residential +
	524	4	2096	Residential
Block 10	727	4	2908	Residential +

	Block size (Sq. m.)	No. of floors	Total BUA (Sq. m.)	Mix use
	2005	4	8020	Residential
	800	4	3200	Residential
Block 11	1395	4	5580	Commercial
	698	26	18148	Commercial +
	906	35	31710	Commercial +
Block 12	3000	4	12000	Commercial +
	2050	40	82000	Commercial +
	914	35	31990	Commercial +
Bus Depot/Workshop			15600	Institutional
			299516	

Mix of use

Mix of uses proposed in order to ensure a vibrant and an economically viable development are as follows:

Mix of uses

Residential (50%) 149576 Sq.m.

70% tenements shall be less than 60 sqm. 1310 units

15% remaining shall be 80sq.m. 280 Units

15% remaining shall be 120sq.m. 280 units

Density **498/pph**

Commercial (29%)= 87890 Sq.m.

- Type of commercial
- Office space
- Retail Flagship Stores, Malls,
- hotels,
- public houses, restaurants,
- cafes,
- boutiques
- serviced offices
- Service apartments

Institutional (21%)= 62050 Sq.m.

- MSTRC office
- MSRTC Workshop & Depot
- Institutional
- requirements like nursery and school for residential population
- Fire Fighting Depot
- Recreational Club
- Nursery
- Maternity Hospital
- Old age home

Open space provision

16% Green Open Space i.e. 14772 sqmhas been provided.

Parking provision

- 2995 ECS for Car Parking which shall be provided in 3 basements
- 5990 Two wheeler parking
- 2995 Cycle parking

Other requirement for Multimodal integration

- 26 Auto rickshaw parking
- 10 Taxi parking
- 15 cycle rickshaw parking

Conceptual view of the proposed transit oriented development is shown in**Figure 18.10.**

18.3.6. URBAN DESIGN FRAMEWORK FOR KAMPTEE POLICE STATION SITE

i. Site Characteristics & analysis

- Site selected is owned by Kamptee Police department on which there is a police station with some small residential quarters. It is right next to the proposed metro station and hence forth gives a perfect opportunity for integrated development.
- The site is also located in the central core of the city, which when developed shall act as a catalyst and shall give an opportunity to transform the image of the city.
- Since the development is an integrated development with the station, the setback norms of h/4 have therefore not been met. Also the requirement of the greens cannot be met. Therefore it is recommended to revisit the design code regulations for such integrated development along road side.

Kamptee Police Station site is shown in **Figure 18.11.**

ii. Conceptual Plan with Urban Design Frame work

- Site Area =11887 Sq.m. (2.93acres)
- Floor area ratio =3.85
- Built up area = 45868Sq.m.

The proposed planning and zoning of uses on the site is shown in**Figure 18.12** and conceptual plan of the proposed transit oriented development as in **Figure 18.13.**

FIGURE 18.10: CONCEPTUAL VIEW OF PROPOSED TRANSIT ORIENTED DEVELOPMENT

FIGURE 18.11: KAMPTEE POLICE STATION SITE

FIGURE 18.12: PROPOSED PLANNING AND ZONING OF USES ON KAMPTEE POLICE STATION SITE

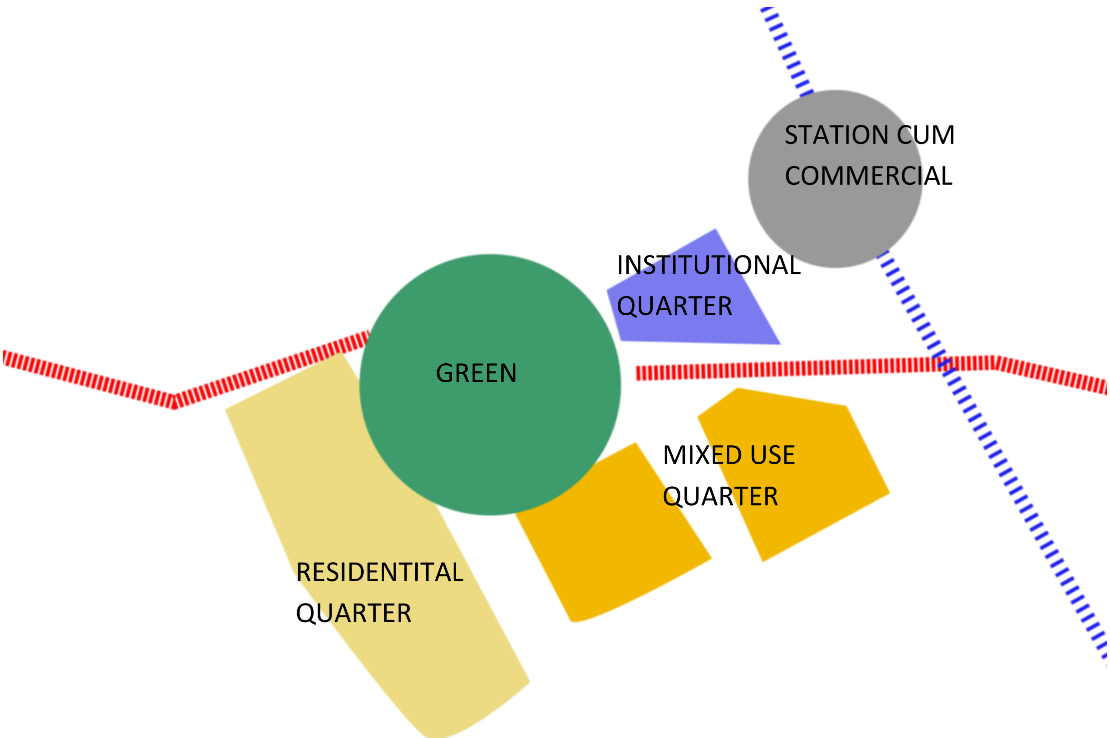
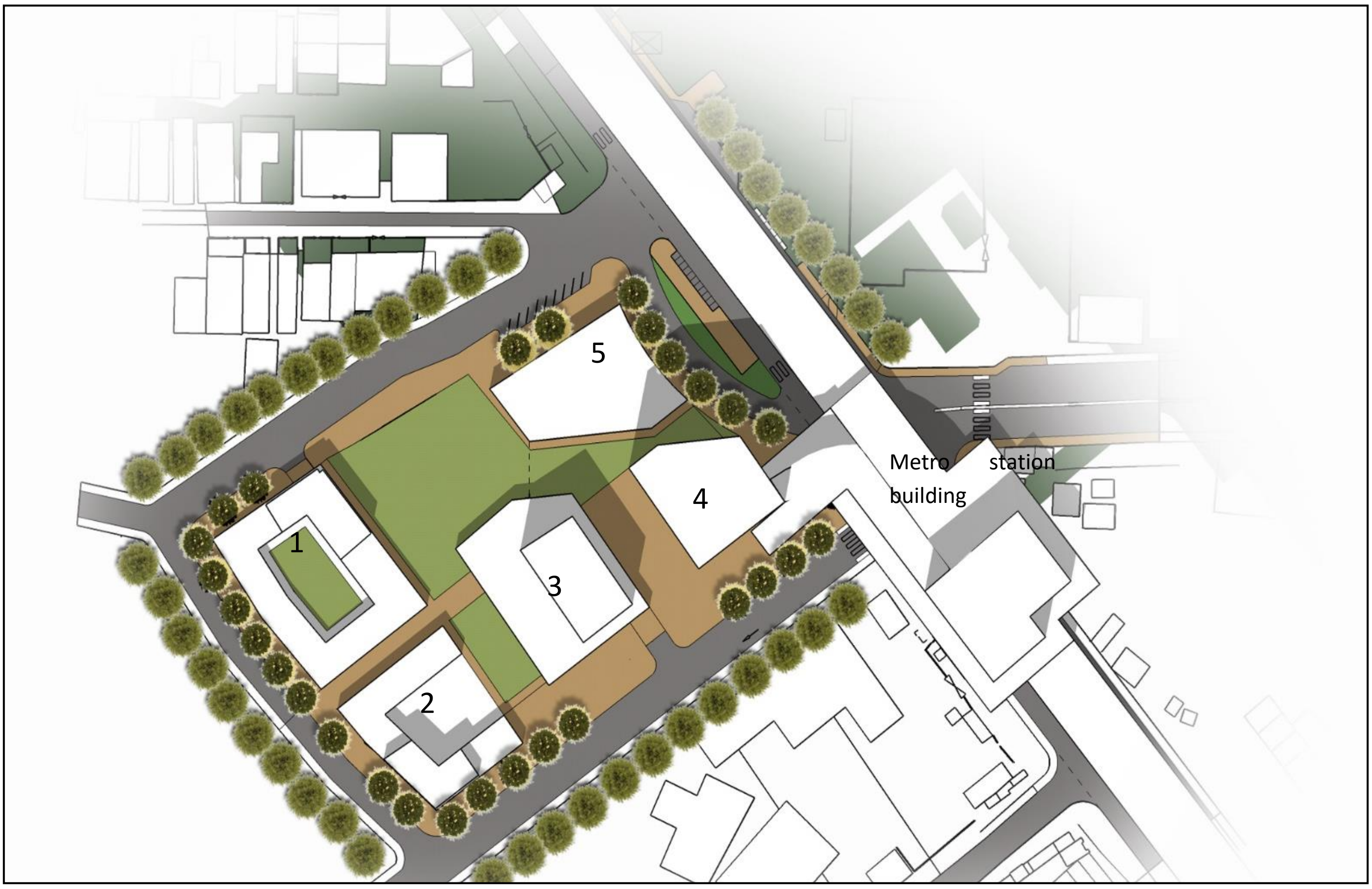


FIGURE 18.13: CONCEPTUAL PLAN OF PROPOSED TRANSIT ORIENTED DEVELOPMENT



The Conceptual details of individual blocks are listed below:

Police Station Block

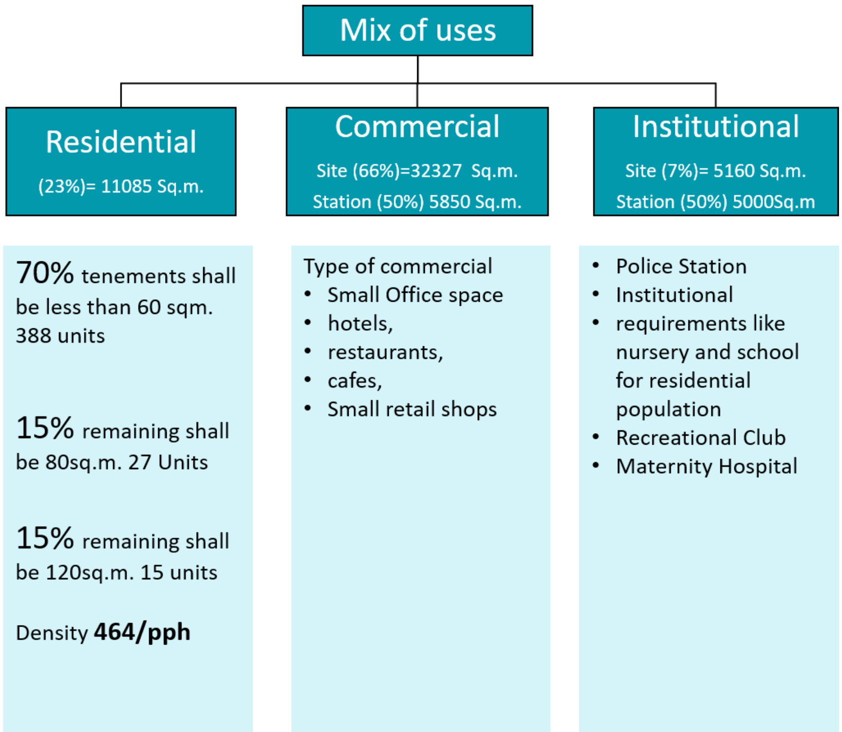
	Block size	No.of floors	Total BUA	Mix use
Block 1	400	8	3200	Residential
	755	4	3020	Commercial + residential
Block 2	430	4	1720	Commercial + residential
	300	8	2400	Residential
Block 3	785	4	3140	Residential
	386	18	6948	Commercial
Block 4	676	10	6760	Commercial
	676	20	13520	Residential
Block 5	860	6	5160	Institutional
			45868	

Metro station block

	Block Size	No.of floors	Total BUA	Mix use
Station Block	2500	2	5000	Transportation
	450	13	5850	Commercial
			10850	

Mix of use:

Mix of uses proposed are as follows



Open space provision

24% Green open space that is 2868sq.m. has been provided.

Parking provision

Total parking provision

458 ECS +**108** ECS for which shall be provided in **3** basements

916 + 216 Scooterparking

458 + 108 Cycle parking

10 Auto rickshaw parking

10 cycle rickshaw parking

Conceptual views of the proposed transit oriented development are shown in **Figure 18.14**.

FIGURE 18.14: CONCEPTUAL VIEW OF PROPOSED TRANSIT ORIENTED DEVELOPMENT

18.4. ASSESSMENT OF DEVELOPMENT POTENTIAL

An assessment of theexisting & proposed Land Use distribution as per DP remarks and Development Control & Promotion Regulations has been conducted as per Development Plan 2012-32 incorporated for Nagpur Metropolitan Region in January, 2018. The said analysis has been conducted for only the land parcels falling within the jurisdiction of Transit Oriented Development (TOD) Influence Zone (250m on both sides of metro) as defined in the new DCPR.

The extents of the TOD Influence area & special DCPR provisions for promoting densification of urban development along the corridors have been referred from thesaid DCPR and the stipulations pertaining to FSI cap based on plot size & road frontage, have been considered to arrive at the total development potential from land component of the TOD Influence area.

In addition, a detailed corridor-wise market assessment has been conducted to encapsulate prevalent real estate dynamics along the proposed Phase II metro corridors. A wide range of relevant asset classes have been studied, such as residential, commercial (including retail, commercial office, hospitality) etc.– which arepotentialavenues of developmentthat are touted to consume additionalFSI. The market assessment exerciseascertains a quantum (in terms of pricing & absorption trends) to the potential demand that shall catalyzedevelopment / redevelopment along the corridors and the inputs received from the same are incorporated to calculate the revenue contribution from the stipulated TOD Influence Zone.

In consonance with the objectives outlined for the study, the assessment of development potential has been undertaken across the following modules:

i. Real Estate Market Assessment Exercise

A detailed real estate market study has been undertaken for the relevant micro-markets, to identify key growth vectors and prevalent market trends with respect to residential and commercial (IT/ITeS, Non-IT Office, Retail, Hospitality, Logistics) segments. This market study formulates a basis for further analysis.

ii. Assessment of supply potential and estimation of demand

A) <u>Review of the TOD Policy & subsequent DCPR to be followed for the TOD Influence Area of Nagpur Metro Phase II</u>

A detailed review of current Nagpur Land Use and Development Control Regulations for the proposed Metro Corridor is undertaken considering the following parameters:

- On ground survey along the Phase II corridors
- Desktop review of the latest sanctioned DP 2012-32 of Nagpur Metropolitan Area
- Review & incorporation of modifications in DP pertaining to change in Land Use (as per additional Notification SM & EPattached with the said DP)
- Review of the latest sanctioned DCPR for assessment of guidelines pertaining to delineation of TOD buffer zone for Nagpur Metro Phase II Corridors and eligibility criteria of plots (complete or part thereof) which fall within the stipulated TOD Influence area for additional FSI
- Understanding the ProposedLand use across the phase II TOD Influence and scrutiny of other relevant development bye laws

B) <u>Estimation of Consumed FSI by Existing Buildings and Built vs. Vacant/Under-developed Analysis</u>

- A rough estimate of built versus vacant land parcels along the Phase II of Nagpur Metro has been conducted to summarize the existing land utilizationand to ascertain the proportion of developed vis-à-vis vacant or under-developed properties

  – As a start point, a broad mapping exercise incorporating visual inspection of existing buildings & structures falling within the TOD Corridor was conducted for a broad estimation of typical number of floors, land area covered and typical height of buildings. This provides a rough estimation of existing FSI utilisation along the stipulated TOD corridors.

  – The same has been represented with an AutoCAD reconstruction of cadastre maps of plots falling within the TOD influence area. Additionally, with an overlay of satellite imagery on the reconstructed vectors, a rough estimation of vacant land parcels is also accumulated. As an outcome, area statements for all the 5 studied corridors are prepared enumerating the total land area under various designated land uses and total area of vacant land parcels.

  – Further, eligibility of the respective plots for applicability of maximum permissible FSI (as per the TOD Policy) was derived through a sample-size analysis considering blocks of 40-80 plots at a distance of every 100-200 metres along each corridor. The same also involved due consideration given to plots which are land-locked at the moment & therefore shall be subjected to a cutting of 30-35% land area towards development of roads.

C) ProjectingPotential for FSI Utilization

In continuation to above sections, a review of allthe previous version & the latest sanctioned TOD Notification for Nagpur Metro (Phase II) corridors has been conducted. Following are the key highlights:

- Review of the TOD Notification enlists the FSI incentives that are extended towards potential developments in the earmarked TOD Influence area. The stipulated eligibility criterions for applicability of the incentives, such as size of a plot, width of the main access road and tenement & population density etc. have also been referred from the latest notified document.

- The evaluation of existing FSI utilization is based upon the on-ground survey conducted by RITES, encompassing trends pertaining to existing Demand and Supply dynamics of Nagpur city's peri-urban fringes.

- Further, the said estimation of demand-supply gap, combined with summarization of upcoming developments across various asset classes, verifies the projected FSI utilization.

iii. Assessment of Revenue Contribution from TOD

Based on findings of the market assessment exercise, thorough review of the existing & proposed land use plan and scrutiny of the Nagpur Metro TOD Notification, an estimation of maximum realizable revenue has been made considering the following non-fare box avenues:

- **Supply Side Assessment :**Total Development Potential on land parcels falling within TOD Influence area, considering various revenue yielding asset classes such as residential and commercial

- **Demand Side Assessment :** projection of probable year-on-year demand trends (across asset classes) considering a regression analysis of organic population increment, to be projected till 2048-49

Methodology for estimation of maximum realizable revenue

After analyzing the potential for FSI Utilization, the maximum realizable revenue is estimated from various sources, such as:

➔ **Levy of Premiums for Additional FSI**

– Establishing applicable base & premium FSI for the various identified revenue yielding uses of land (Residential 1 & 2 and Commercial)

– Understanding applicable premium for purchasing additional FSI in congested & Non-congested areas

– Scrutiny of Ready Reckoner values for the various Talukas & villages falling within the TOD influence area of Phase II alignments

– **Estimation of maximum potential of revenue generation on supply side** : Calculation of total purchasable FSI along each corridor, which is calculated as per the equation below,

$$(FSI_{(max)} - FSI_{(base)}) \mathbf{X} A_{(vacant)} \mathbf{X} RR_{(weighted\ Average)}$$

where,

$FSI_{(max)}$ =*Maximum permissible FSI (as per TOD policy)*

$FSI_{(base)}$ =*Base FSI (as per DCPR, 2018)*

$RR_{(weighted\ Average)}$ = W*eighted average Ready Reckoner value of land along the corridor*

– **Estimation of maximum potential of revenue generation on demand side** : Calculation of total Built-up potential (R & C) along each corridor on the basis of population projection approach (till 2048) and similar computation of revenue through sale of additional FSI (as computed on the supply side)

➔ **Additional Surcharge towards Metro in Property Transactions**

– The levy on property transactions is a standard share of the transaction / Guideline value, whichever is more. The study reflects an estimate of revenues from levy of an additional surcharge on the property transactions dedicated towards Metro project. The same shall apply to the transactions arising out of sale / purchase of transfer of land / property. The applicability of the additional surcharge is considered to only be applicable to transactions related to assets situated within the earmarked TOD Influence area. -

– The phase II of the project is touted for peripheral locations falling under the jurisdiction of NMRDA and parts of NMC / NIT. In case of Phase I, an additional surcharge of 1% is incurred towards Nagpur Metro Project. The same is levied basis notification (No. MRD-3316/C.R.24/ (2)/UD7, dated 30th June 2016) published in Government of Maharashtra's Gazetteer dated 07th July, 2016. The notification establishes the Nagpur Metro Phase I Project as "Essential Public Project and Vital Urban Transport Project" status. Phase II of the project does not have the status at the moment, however on lines of phase I, the same may be incorporated.

– As established in the Government of Maharashtra Notification No. MRD – 3316/ C.R. / 24 / (2) / UD 7, dated 06th July 2016 & G.R. dated 30th of January 2014, an additional surcharge of 1% is approved to be levied for Nagpur Metro Phase I, the same having status of a "Essential Public Transport Project". The additional surcharge is also to be retained by the SPV so formed for execution & development of the project. Hence, following similar lines as the Phase I, the Phase II of the said Metro project shall achieve a surcharge of 1% over and above the base Stamp Duty as 100% revenue (given the project also achieves the "Essential Public Transport Project"). The revenue estimation, so projected in the report are based on the above assumption.

➔ **Additional levies ~External Development Charges / Infrastructure Development Charges on properties being developed along the corridor**

– The areas falling under the TOD Influence area of the Phase II alignments are divided by a number of Institutional / administrative bodies such as Gram Panchayats, Nagar Panchayats &Zila Parishads, which may present further complexities to the process of revenue collection & retrieval of the same as an income for Nagpur Metro. However, since the project is being developed within the Nagpur Metropolitan Area notified to be under jurisdiction of NIT (the Special Planning Authority for the region incorporated as per UDD Notification No. TPS 2409/2890/C.R. 356 / UD-9, dated 31st August 2010), the same comes under the applicability of Section 124B of the Maharashtra Region and Town Planning Act, 1966.

– As per sub-section 2 of the said act, development charges are to be levied & collected by the nodal authority (NIT / NMRDA) at rates specified in column (4) of the second schedule. The schedule is annexed as **Annexure I**.

– As per the clause 2-1A of the said section of the act, for consideration of a Vital Urban Transport Project, the development charges levied and collected under the provision of the sub-section (2) shall be increased by one hundred percent. This report considers the additional 100% only as the revenue to be accrued towards Nagpur Metro Phase II project.

– However, an application has to be made to the UDD for the inclusion of the Phase II alignments in the 'Special status project', for revenue through this avenue to be realised as an income from TOD Influence area of Phase II.

The aforementioned assessment serves a two-sided presentation of comparative scenarios; On one hand, the supply side scenario presents themaximum potential of revenue earnings from the overall areafalling within the TOD influence zone of Nagpur Metro Phase II and on the other, the demand side perspective optimally represents a realistic picture of realizable revenue earning basis evaluation of a Y-o-Y demand trend.

18.4.1. Real Estate Market Assessment along Metro Corridors

A. CORRIDOR - AUTOMOTIVE SQUARE TO KANHAN RIVER

This particular extension of the Metro project is planned on the Kamptee Road till Kanhan River. Automotive Square is a prime retail destination for automobile agencies. A number of 4 wheeler agencies such as Maruti Suzuki and Toyota have their dealerships retail showrooms in the area. Major established developers of the city had recently launched their residential projects along the stretch and market interactions reveal that a number of such development have gained velocity over the past 2 years. However, the southern vector i.e. Vardha Road has been better in terms of attracting developers as well as buyers along the stretch due to proximity to the airport. This has caused slower absorption trends along the Kamptee Road and hence the supply side dynamics have also remained stagnant over recent years.

The upcoming of Delhi Public School and Novotel Hotel on the Kamptee road has re-instated investors' interest for residence along the corridor. As observed during the field visits, the typical typology of residential developments has been a mix of low rise plotted type along with a portion in the form of high rise apartments.

Major locations along this stretch include, Sangharsh Nagar, Kamgar Nagar, K.G.N. Society (all under the jurisdiction of NMC), Shivkrupa Nagar, Suman Vihar, Gokuldham Colony (under NIT) and Kamptee (a Class IV municipal corporation). A portion of the Kamptee Cantonment is situated along the Kamptee Municipalcorporation area and a part of which is also situated in the 500m buffer of the Metro (Ph – 2 alignment). Some of the key real estate features of this area are:

– Automotive Square is a major landmark on the Kamptee Road due to the presence of a number of 4-wheeeler retail agencies such as Maruti Suzuki, Toyota etc. A Transport Plaza owned by Nagpur Improvement Trust (NIT) is also situated on this stretch.

– Only a limited number of Industries are observed along this stretch with most being standalone (freehold) plotted developments. There are no major organised commercial or retail developments on this stretch. Most of the residential developments are being constructed with designated basic convenience shopping areas within the development premises.

– A number of group housing projects have been developed recently along the Kamptee Road. However, the building typology is a mix of developed plots, standalone detached/semi-detached or bungalows and apartment (high rise).

– The residential density in these areas is not as high as other three stretches, as developments along Kamptee road have picked pace recently and the normal organic growth of the city has been majorly southwards on Wardha Road.

– However with recent development of Delhi Public School and upcoming Novotel (Grand Bhagwati) Hotel on Kamptee Road, residential developments have picked pace in this area since past 5-7 years.

– SDPL Greens and Nilgiri, Suman Vihar and Lok Vihar Orange City, Shivkrupa Nagar and Kalpatru Colony are some of the key recent residential projects to have been established in this area along with a number of other residential colonies. The approximate cumulative inventory of the afore-listed developments is nearly 595 units and interactions with developers reflect that as many as 600 new units are under proposition along the corridor.

– The average price of developed residential property towards Automotive square is approx. INR 3,300 – 4,350 per sft. Towards Suman Vihar (approx. 6 km from Automotive square) the average quoted price for developed residential property is INR 2,200 – 2,800 per sft. Most of the dwelling units on offer are available in the configurations of 2 BHK (approx. 800 – 1,100 sft), 3 BHK (approx. 1,350 – 1,800 sft) and 4 BHK (approx. 1,850 – 2,050 sft). The property prices are observed to be increasing steadily.

– Most of the aforementioned properties are sold out to a tune of 55-70%.

– Independent Non–Agriculture (NA) use converted plots are available for standalone residential / commercial developments between the range of INR 1,450 to2,200 per sft. Agricultural land parcels are quoted in a range of INR 45 -

70 lacs per Bigha, i.e. INR 1.1 – 1.75 Crores per acre approximately. The quotes depend upon the proximity to Automotive square and frontage towards Kamptee Road.

B. CORRIDOR - LOKMANYA NAGAR TO HINGNA

Lokmanya Nagar in Hingna is also a low-medium density residential location near Police Nagar (CRPF) towards the south-west of Nagpur City is a medium density residential area on Hingna Road. This stretch is further more proximate to key educational institutions in Hingna such as VSPM Dental College, Priyadarshini Group of Institutions, Yashvantrao Chavan College of engineering etc. and hence is an older residential location. Recently there have been no major residential projects to have come up (in the 500m buffer of the Metro alignment). However, peripheral villages such as Isasani are emerging locations for residential developments in the region. Hingna road, forms the backdrop of the Nagpur Airport, however, there is no direct access to the same from this side. Hence, the capital prices pertaining to residential developments are quite lower in comparison to core residential areas within the city. Also, since Hingna is proximate to the Airport, major height restrictions pertain to the newer developments. During the market study, no major Commercial office space establishments were noticed along the corridor.

Major locations along this stretch include, Lokmanya Nagar, Rajgruhanagar, Police Nagar, Rajiv Nagar, Wanadongri and Anand Nagar. The complete stretch of this corridor is situated beyond the limits of NMC. Similar to Wadi, a majority of land under this TOD influence area in this stretch is owned by MIDC. Some of the key real estate features of this area are:

– Lokmanya Nagar and Ashish Nagar towards Nagpur City on Hingna Road are old and established residential localities also situated in the TOD influence zone of this corridor. A State Reserve Police Camp in also situated along this corridor.

– Presence of Yeshwantrao Chavan College of Engineering and Shree VidyarthiSudharsangha College of Engineering and Research (SVSSCER) near Wanadongri is one of the prime attractions situated in this stretch. In past 7 - 8 years, a number of standalone residential developments and row housing projects have been established around the area.

– CRPF road near Lokmanya Nagar, is a more developed stretch in consideration of real estate developments. A number of new group housing projects have been developed in the past 4-5 Years. SumangalVihar, Pioneer Woods in Wanadongri are few of the recent projects.

- The average Price of developed residential property in this area is approx. INR 2,950 – 3,300 per sft. Towards Pioneer Woods (approx. 3.5 km from Lokmanya Nagar) the average quoted price for developed residential property is INR 3,200 – 3,450 per sft. However, there are limited properties available in the latter project and the quoted values are resale values. The property prices are observed to be increasing steadily.
- The MIDC areas lying under this stretch have number of industrial sheds and godown facilities are also present along the corridor on lease. The prevalent rentals for the same are in the range of INR 9-14 per sft of leased space. Land for setting up industries is also available on lease at rental of INR 5-7 per sft of leased land.
- Independent land parcels in this location are mostly occupied and hence, land price value quotes are only available for resale of land which is in the range of 1.2 – 1.8 Crores per acre.

C. CORRIDOR - VASUDEV NAGAR TO DATTAWADI

Vasudev Nagar in the south-west of Nagpur City is a medium density residential area on Hingna Road. Owing to the presence of a number of educational institutions in Hingna and the Industrial estates, Hingna Road has been a preferred residential location which forms an extension to the core residential areas such as Trimurtee Nagar, Shantinekatan Colony and Pratap Nagar, which are situated towards the centre of the city. However, SH 260 - along which the corridor is planned - is a rather industrial location with the presence of MIDC Hingna Estate along the corridor. A transition from core residential (and commercial) to a contrasting Industrial use can be observed along this stretch of Metro Phase 2.

Major locations along this stretch include, Rajendra Nagar, Vasudev Nagar and Sanjay Nagar (lying under the jurisdiction of NMC) and MIDC Estate (Hingna) in Wadi. A majority of area lying under the TOD influence zone along this stretch is under the jurisdiction of MIDC and hence, a number of small, medium and large scale manufacturing units are located on the corridor. Approx. 59% of the land area lying under the TOD Influence zone is earmarked as Industrial. On one side of the metro alignment, a row of large scale manufacturing units is situated and on the other, there is a vacant parcel of land reserved under the catchment area of Ambazari Lake. Some of the key real estate features of this area are:

- MIDC Hingna is one of the premiere industrial estate in Nagpur with 100% occupancy and presence of large scale manufacturing and warehousing units.
- MIDC leases land parcels for the duration of 99 years the title for which is transferable upon payment of transfer charges to MIDC. At present, MIDC plots are completely occupied. However, the same are available at resale of lease deeds.
- Industries include steel moulding and metal fabrication units, metal forging units, automobile spare parts manufacturing units, chemical processing units etc.
- Some of the major industrial companies situated in MIDC Hingna are Mahindra and Mahindra, AIA Engineering Limited, VIP Industries, FACOR Steels Limited, MetalfabHighTech Limited, GMMCO and Gansons Limited etc.
- A number of industrial sheds and godown facilities are also present along the corridor on lease. The prevalent rentals for the same are in the range of INR 9-14 per sft of leased space. Land for setting up industries is also available on lease at rental of INR 5-7 per sft.
- Independent land parcels in this location are mostly occupied and hence, land price value quotes are only available for resale of land which is in the range of 1.2 – 1.8 Crores per acre.
- MIDC land parcels available on resale of lease deed are quoted in the range of 1,750 – 2,050 per sft.

D. CORRIDOR - PRAJAPATI NAGAR TO TRANSPORT NAGAR

This particular extension of the Metro project is planned on Bhandara Road till KapsiBuzurg village. Kapsi is one of the major industrial locations around the periphery of the city. Land parcels along the metro Phase 2 alignments on the Nagpur Metro are largely Industrial and residential. However, Industrial domination along the corridor has left large plots completely vacant with very low organised residential development. The MaaUmiya Industrial Estate is one of the largest private industrial estates around the city having a number of warehousing and godown facilities.

Major locations along this stretch include, Surya Nagar, Pardi Chowk, Subhan Nagar, Netaji Nagar, Bhandewadi and Ghatate Nagar (lying under the jurisdiction of NMC)

Bidgaon and KhapsiBuzurg villages under NIT jurisdiction. Some of the key real estate features of this area are:

– HB town near Pardi Chowk is one of the few organised residential developments situated along this stretch. Located within the Nagpur Municipal Corporation (NMC) boundary, this is a mixed typology residential township with high rise apartment type and semi-detached bungalow type built up options. The township project was developed in 2007 is completely sold out at present.

– The Centre Point School near Pardi Chowk is one of the main attractions situated within 500 meters TOZ influence zone of the proposed metro corridor towards Kapsi. The presence of one of the major schools of the city opens up this stretch for a multitude of residential and associated developments in the area.

– Bidgaon and KapsiBuzurg are two major village settlements with a considerable presence of medium and large scale manufacturing units and godowns. Apart from the industries, the stretch has negligible presence of organised residential or commercial developments.

– MaaUmiya Industrial estate in KapsiBuzurg village is one of the largest private industrial parks in Nagpur City spread across an area of approximately 130 Hectares.

– The typical land prices pertaining to this stretch are in the range of 25-40 lacs per bigha (INR 62 lacs to 1 Crore per acre) for Agricultural land.

– Non Agricultural (NA) converted Industrial land is available in this area at INR 800 – 1,450 per sft and the typical rental for land for construction of warehousing/ Industrial development ranges between INR 4-5 per sft. Developed godown space is rented in the range of INR 8 – 10 per sft.

E. CORRIDOR - MIHAN TO MIDC ESR

Major locations located along this stretch include MIHAN, Khapri, Jamtha, Bothali, Buti Bori (MIDC), Satgaon, & Indo Rama Colony. The complete stretch of this corridor is situated beyond the limits of NMC. The stretch is planned along Wardha Road emanating from MIHAN leading upto the centre of the MIDC estate. This stretch is constituted by a variety of land uses, of which R2, Commercial & Industrial being the dominant designated uses. Wardha road is one of the most steeply transforming vector of Nagpur city, however the development has remained constricted within 4-5 km of the NMC limits. The rest of the corridor is majorly undeveloped. Butibori MIDC, being one of the largest Industrial estates of Asia (by virtue of land) contains a number of large, mega & Ultra mega scale industries such as CEAT Tyres, Morarjee Textiles, KEC International, Superior Drinks Private Limited, Calderys India Refractories, to name a few. Some of the key real estate features of this area are:

- MIHAN, amongst other major locations (falling under this corridor), has been one of the most sought after activity hubs of the city, with a number of FMCG, Defence, MRO, Pharmaceutical companies having established operations or under the process of construction. Additionally, the SEZ is house a number of regional offices of major IT companies such as Infosys, Tech Mahindra, TCS, GlobalLogic etc. The area is also touted to be developed as a regional centre of education considering the advent of AIIMS, IIM Nagpur, National Law University, Delhi Public School & a few other education institutions. MIHAN also constitutes a considerable allocation of land towards development of group housing projects, a number of which are already developed or planned over the next 2-3 years. MIHAN (along with the Nagpur Airport) is touted to be the highest ridership generating locations of the city, especially considering the supply of upcoming IT office space & establishment of a major manufacturing & logistics base at the location.
- The average Price of developed residential property in Jamtha area is approx. INR 3,300 – 3,500 per sft. Within MIHAN the upcoming developments are quoting 4,700 – 6,000 per sft on saleable area for 1,2 BHK compact units. Going forward, the prices are expected to increase marginally over a short term of 3-5 year (by approx. 3-5% annually) considering a heavily supplied Nagpur market. Once the manufacturing & IT operations commence on a full swing, the demand is expected to increase around the vector, which may induce developer activity on the vacant land parcels located along Wardha Road. Connectivity by Metro, shall play a vital role in expanding developer activity to as south of Nagpur as Butibori.
- Prices for Industrial & commercial land in and around Buti Bori MIDC have remained on a premium. Developed land parcels within the estate is available at INR 800 – 1,200 per sft, while bulk vacant land is quoted at approx. INR 1.4 – 2 Crores in the location.

The following **Table 18.1** summarizes the real estate scenario pertaining to all the corridors.

TABLE 18.1:REAL ESTATE SCENARIO ALONG NAGPUR METRO PHASE 2 CORRIDORS

Corridor	Use	Micro-market	Typology of Buildings	Prevailing built configurations / Building types	Typical Unit Sizes (in sft)	Total Supply (in sft) / No. of units	Avg. Capital Price (in INR/ sft)	Avg. Rental Price (in INR/ sft / `X C`month)	Observed Y-o-Y escalation in prices over past 3 years	Absorption / Sales Velocity
Automotive Square - Kanhan River	Residential	Automotive Square	Residential group housing	Mid-rise Apartment type	2 BHK : 883 - 1,130 3 BHK : 1,062 -1,460	120 (Approx.)	3,200- 4,395 (resale)	-	13%	65%
	Commercial	Automotive Square	Retail Sohwroom	Standalone building	Carpet Area of 8,000	28,000 sft	5,400 -6,050 (resale value)	58-72	12%	100%
	Residential	New Khasala	Residential group housing	Mid-rise Apartment type	2 BHK : 800 -1,000	98	3,250 - 3,400	-	8-10%	55%
	Commercial	New Khasala	Retail within group housing	Retail shops	650-2,250	20	5,000	30	8%	25%
	Residential	Yerkheda	Group Housing	Mixed type residential project with components of apartment type and row houses	2 BHK : 850 -900 3BHK : 1,350 -1,610 (duplex) 4 BHK: 2,200 (duplex)	300	2,200 - 2,285	-	10%	80%
Lokmanya Nagar - Hingna	Residential	Isasani	Residential group housing	Mixed type residential project with components of apartment, row houses	2 BHK : 760 - 1,092 3 BHK : 1,143 -1,200 4 BHK: 1,375 - 1,500	600 (Approx.)	3,050- 3,650	-	10 - 12%	40%
	Residential	Wanadongri	Residential Aprartment	Medium Rise	2 BHK : 850 - 1,200 3 BHK : 980-1,290	550	3,400 - 4,200 (resale value)	-	10%	95%
Vasudev Nagar - Wadi	Industrial	MIDC Hingna on Amrawati Road	Warehousing sheds and godowns	Grade B warehousing sheds of typical concrete structure	4,000 8,000 12,000	Approximate supply of 1.2 Mn sft of warehousing space	800-1050	14-Dec	10-12%	35%
	Residential	Vasudev nagar	Residential Aprartment	Medium Rise	2 BHK : 850 - 1,175 3 BHK : 1,150-1,375	800	5,400 - 6,800	-	10%	95%
Prajapati Nagar - Transport Nagar	Industrial	Kapsi (Nagpur Rural Tehsil)	Industrial shed	Grade A warehousing sheds of typical pre-fabricated structure and rubber base flooring	8,000 12,000 20,000	140,000 sft	1,250 - 1,500	12-Aug	9-10%	50%

Corridor	Use	Micro-market	Typology of Buildings	Prevailing built configurations / Building types	Typical Unit Sizes (in sft)	Total Supply (in sft) / No. of units	Avg. Capital Price (in INR/ sft)	Avg. Rental Price (in INR/ sft / `X C`month)	Observed Y-o-Y escalation in prices over past 3 years	Absorption / Sales Velocity
	Industrial	Kapsi (Buzurg)	Industrial shed	Grade A warehousing sheds of typical prefabricated structure and rubber base flooring	8,000 12,000 20,000	0.8 Mn sft	900 - 1,250	10-Sep	8%	67%
MIHAN to MIDC ESR	Residential	MIHAN	Residential group housing	Mid-rise Apartment type	1 BHK: 650 - 725 2 BHK: 950 - 1,150 3 BHK: 1,360 - 1,700	Approx. 3,000	3,800 - 4,180	-	8%	65%
	Residential	Jamtha	Residential group housing	High-rise apartment type	1 BHK: 650 - 700 2 BHK: 850 - 1,150 3 BHK: 1,260 - 1,650	Approx. 5,000	2,400 - 2,800		5%	55%
	Non-Agricultural	Jamtha	Land	Land	-	-	~ 18.5 - 25 Mn per Acre	-	4%	-
	Commercial	MIHAN	Commercial office space in MADC building	IT (SEZ) Building	1,250 - 4,800	200	NA	45 - 60	4%	~58%
	Land	MIHAN	Land (Lease)	IT (SEZ) Building	1 - 10 Acres	NA	950 - 1,250	10	5%	NA
	Industrial Land	Butibori	Land (MIDC)	Land	2,000 - 40,000	NA	850 - 975	8	3%	NA
	Industrial Land	Butibori	Land (Non-MIDC)	Land	1 - 10 Acres	NA	~6.5 - 14.5 Mn per acre	NA	3%	NA

18.4.2. Assessment of Supply Potential and Estimation of Demand

A. Review of Existing Land Use and Development Control Regulations

The existing Land Use Plan (Revised Draft DP 1986 – 2011) of Nagpur City was prepared in the year 1986 by Nagpur Improvement Trust (NIT) and handed over to Nagpur Municipal Corporation upon a resolution passed by the Government of Maharashtra. Nagpur is the only Municipal Corporation in the district with a jurisdiction area of about 225.08 sq. km. The Draft Development Plan of Nagpur Metropolitan Area (NMA) is prepared by NIT and was approved in 2015 by the state government of Maharashtra.

Residential

Existing residential in the NMA includes urban land uses categorized as residential under the particular use. Concentrations of the residential areas are majorly observed along the major transportation corridors on the periphery of Nagpur city.

Commercial

Land uses that include retail shopping and general business have been classified as commercial use. Commercial areas amount to 6.82 sq.km which is 0.19% of the entire NMA.

Industrial

This area is the second largest developed land use component of the NMA region. Presence of major transport corridors such as NH-6 and NH-7 has facilitated the growth of the industrial area. The MIDC Industrial Estate at Butibori is one of the largest Industrial Areas in Asia. Hingna MIDC towards the south-west of Nagpur City and some other private industrial estates inKapsi (due east of Nagpur City along NH – 6) are prime Industrial areas.

B. Proposed Land Use Plan

The Proposed Land Use (PLU) as described under the Draft DP of NIT (2016) contains provision of 381 sq.km (50.53% of the total urban uses. Additionally sub-listed Residential uses are enumerated as follows:

Residential R1:

Residential R1 Zone is allocated to areas close to existing employment centres such as Nagpur City which are witnessing major development activities.Residential Zone (R1) consists of all plots situated along roads having existing or proposed width of less than 12 m in non-congested area and less than 9 m in congested area.The gross average density in this zone is considered to be 35 – 55 dwelling units per Hectare (du / Ha) or approx. 150 – 220 persons per Ha.

Residential R2:

The residential R2 zone is intended to be characterized with relatively higher intensity development, but lower than R1. Residential Zone (R2) consists of all plots abutting roads having existing or proposed width of 12 m and above in non-congested area and 9 m & above in congested area, respectively. It will also allow a wide range of non-residential compatible uses resulting in a mixed-use character, including hotels and service industries with certain conditions/limitations. The gross average density in this zone is considered to be around 110 – 150 persons per Ha or 25 – 35 du / Ha.

C. Asper Development Control Promotion Regulations notified in January 2018, the definition of NMRC is stated as:

'It is the area falling within 250 mt. distance on either side of the Nagpur Metro Rail measured from its Centre line and also includes the area falling within 250 mt. distance from the longitudinal end of the last Metro Railway Station as shown on development plan.

D. Synopsis of TOD Notification

Notification No.TPS-2414/477/CR-248 (Part 1)/2014/UD-9 dated 14th March 2018 – Urban Development Department, Government of Maharashtra

i. Maximum Permissible FSI:

The maximum permissible total FSI in NMRC shall be 4.0 including the base permissible FSI, subject to condition that the additional FSI over and above the base permissible FSI shall be allowed within the overall limit of maximum permissible FSI, as given in the Table 18.2 below:

TABLE 18.2:CONDITIONS FOR ELIGIBILITY OF MAXIMUM PERMISSIBLE FSI

Minimum Road Width (in meters)	Plot Area (in sqm)	Maximum Permissible FSI
9.00	Below 1,000 sqm	2.00
9.00	1,000 sqm or above	3.00
12.00	2,000 sqm and above	3.50
15.00	2,000 sqm or above	4.00

The maximum permissible FSI shall be determined by satisfaction of both the criteria viz. minimum road width and plot area, simultaneously. However, in case, both these criteria are not satisfied simultaneously, the maximum permissible FSI shall be the minimum of that permissible against each of the two criteria.

The maximum permissible FSI as given in the table above, shall be calculated on the Gross Plot Area.

ii. **Payable Premium:**

Additional FSI over and above base premium FSI of respective land use zones as per the sanctioned DCR of 2000 may be permitted on payment of premium as may be decided by the government from time to time.

- The premium towards availing additional FSI, in case of development / redevelopment proposed in the NMRC, shall be decided on the basis of tenement density per hectare of the Gross plot area, which may be calculated as ~

  Minimum Number of Tenements = (Gross Plot Area) *(maximum Proposed FSI for residential use) *(200 tenements per Hectare)

  A notification (No. 2416/176/2016/UD-1, dated 24.07.2017 stipulates the sale of additional FSI (within the NMRC Area) at a premium chargeable as 30% of Annual Statement of rates (ASR) values for developments which meets the above stipulated Tenement Density. The same is chargeable at 40% of ASR values for development which do not meet the stipulated tenement density.

- However, subject to the provisions of the permissible mixed use in the form of commercial and residential, the premium to be paid as may be decided by the Government from time to time and such premium shall be chargeable on the total additional FSI to be availed beyond the base permissible FSI.

iii. Eligibility of Plot for Premium FSI(same as initial notification dated 09/06/2017 with addition of points (d) to already existing points (a), (b) & (c)):

Notwithstanding anything contained in any other provisions of these regulations, Parking, Double height terraces up to 20% & 15%, balconies not enclosed, Staircases, Lift Wells with machine rooms, Refuge Areas, Voids, Service Floor & Entrance Lobbies of the buildings in NMRC shall be free of FSI.

iv. Non-applicability of TDR in NMRC Zones:

TDR shall not be allowed to be either received or on the plots lying within NMRC, irrespective of its location in congested area / non-congested area as per the sanctioned Development Plan of Nagpur.

v. Permissibility of Mixed Use in NMRC:

Mixed Use in the form of residential and commercial may be permissible on the residential plot in NMRC fronting on the road width of 12 meters and above and mixed use on plot (s) in commercial zone in NMC Area shall be permissible as per principal DCR and the maximum permissible FSI under these regulations shall be allowed in payment of premium.

Notes

1. If owner / developer of plot(s) falling within radius of 200 meters from Metro Station is willing to provide public parking space over and above the parking spaces required as prescribed under the new Notification dated 09th June 2017, the premium to be paid by such developer / owner shall be reduced to an amount equal to the premium worked out for 25% of the area earmarked for such additional Public Parking space, subject to certain conditions.

2. Large wholesale stores, car dealer showrooms, warehouses/storages, auto service centres, Garages etc. **shall not be permissible** in NMRC.

3. Provision of inclusive housing shall not be permissible in NMRC.

18.4.3. Land Use under respective TOD Influence Zones

A. CORRIDOR 2A- AUTOMOTIVE SQUARE TOKANHAN RIVER

The total land area under different land uses within TOD influence zone is shown in**Table 18.3**. The average FSI utilization of the corridor is ~0.82.

TABLE 18.3:LAND AREA WITHIN TOD ZONE ALONG CORRIDOR-2A

S. No.	Land Use	Total Land Area under TOD (Sq.m)	Total Land with Built Up Structures (sqm)	Total Vacant Land (sqm)	Total FSI Utilized
1	Industrial (Non-MIDC)	804,518.38	613,907.08	190,611.30	0.50
2	Public / Semi Public	457,018.07	300,144.38	156,873.69	1.00
3	Residential 1	258,299.93	212,266.93	46,033.00	1.10
4	Residential 2	994,628.24	620,775.10	373,853.14	1.00
5	Notified Slums (R4)	-	-	-	0.80
6	Residential on Agricultural Use	-	-	-	-
7	Commercial	752,703.97	464,546.03	288,157.94	1.00
8	Amenities, parks and waterbodies	222,930.90	153,995.84	68,935.06	-
9	Agricultural	25,943.07	-	25,943.07	-
10	Transportation	291,729.69	220,233.19	71,496.50	0.30
Grand Total		**3,807,772.25**	**2,585,868.55**	**1,221,903.70**	**0.82**

Figure 18.15shows the land use map within TOD zone and **Figure 18.16**shows the villages and census towns falling within TOD Influence Zone.

FIGURE 18.15:LAND USE WITHIN TOD ZONE ALONG CORRIDOR-2A

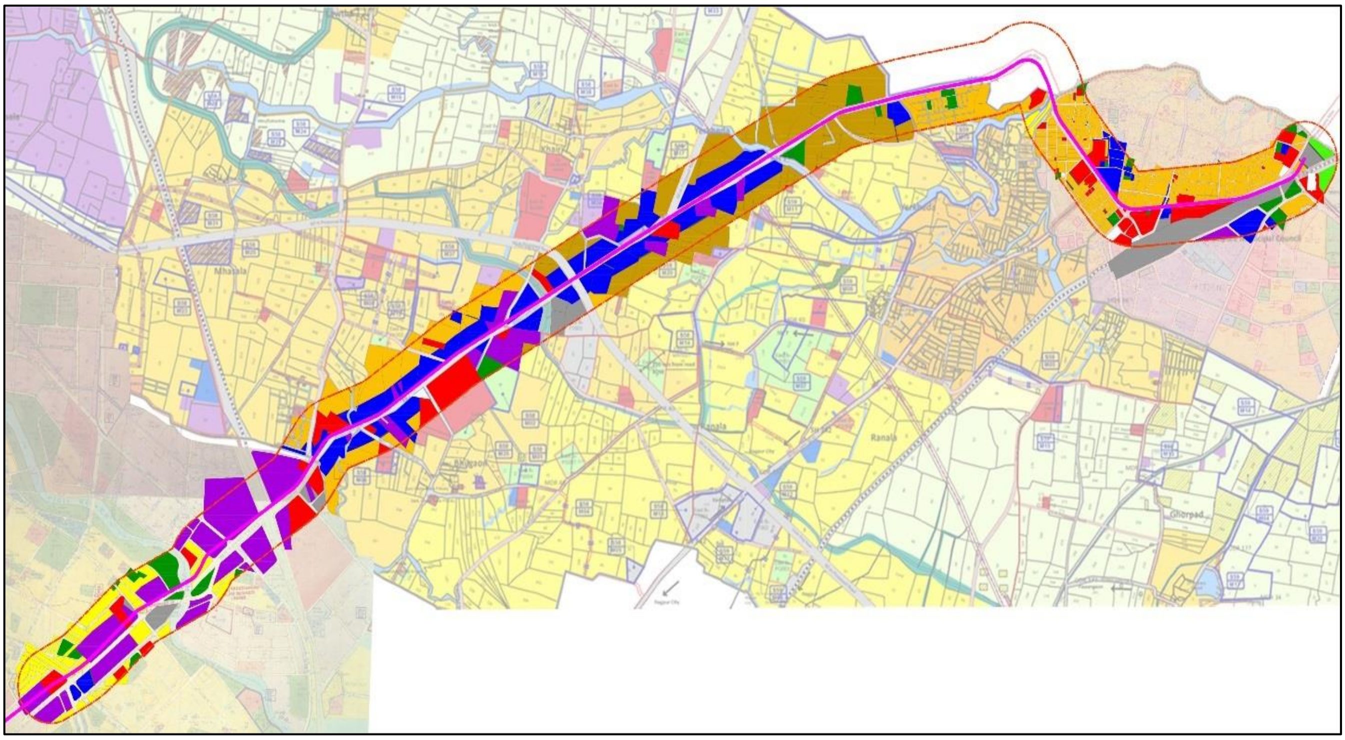
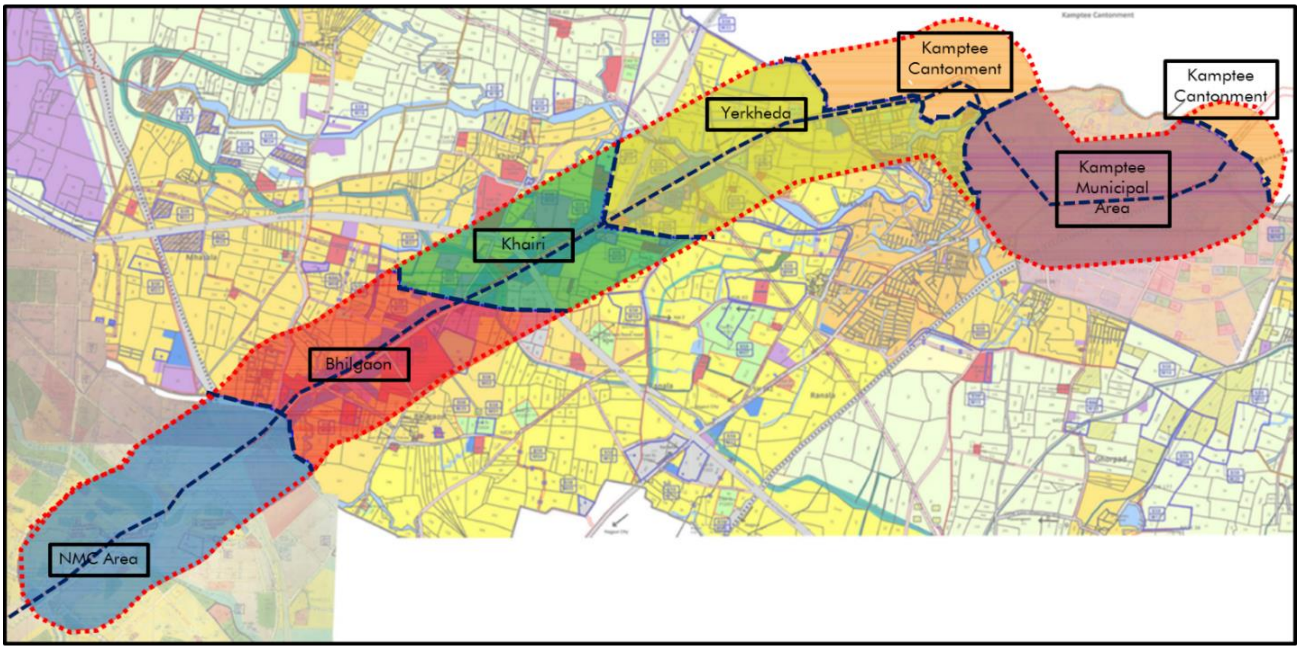


FIGURE 18.16:VILLAGES FALLING WITHIN TOD ZONE ALONG CORRIDOR-2A



B. CORRIDOR 3A - LOKMANYA NAGAR TO HINGNA

The total land area under different land uses within TOD influence zone is shown in **Table 18.4.**The average FSI utilization of the corridor is ~0.91.

TABLE 18.4:LAND AREA WITHIN TOD ZONE ALONG CORRIDOR-3A

S. No.	Land Use	Total Land Area under TOD (in Sq.m)	Total Land with Built Up Structures (in	Total Vacant Land (in sqm)	Total FSI Utilized
1	Industrial MIDC	406,630.26	406,630.26	-	0.55
2	Public / Semi Public	441,141.27	416,187.90	24,953.37	1.00
3	Residential 1	121,160.75	121,160.75	-	1.00
4	Residential 2	1,411,105.25	1,033,387.14	377,718.11	1.00
5	Residential 4	112,699.08	59,381.90	53,317.18	1.00
6	Residential on Industrial Use	22,876.75	22,876.75	-	0.80
7	Residential on Agricultural Use	1,940.81	1,940.81	-	1.00
8	Residential on Recreational	27,784.70	25,142.65	2,642.05	1.00
9	Commercial	293,263.17	253,319.52	39,943.65	1.00
10	Recreational, Amenities and waterbodies	131,463.49	-	20,111.75	0.00
11	Agricultural	337.65	-	337.65	0.20
12	Transportation (Metro Depot)	122,018.24	18,760.31	103,257.93	0.20
Grand Total		3,092,421.42	**2,358,788.0**	**622,281.69**	**0.91**

Figure 18.17shows the land use map within TOD zone and**Figure 18.18** shows the villages and census towns falling within TOD Influence Zone.

FIGURE 18.17: LAND USE WITHIN TOD ZONE ALONG CORRIDOR-3A

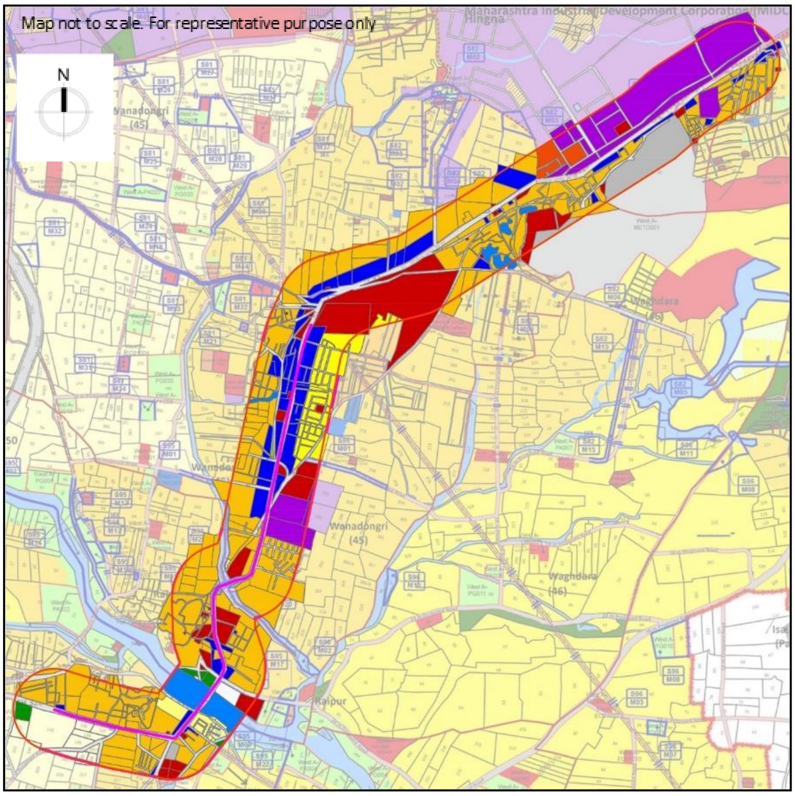
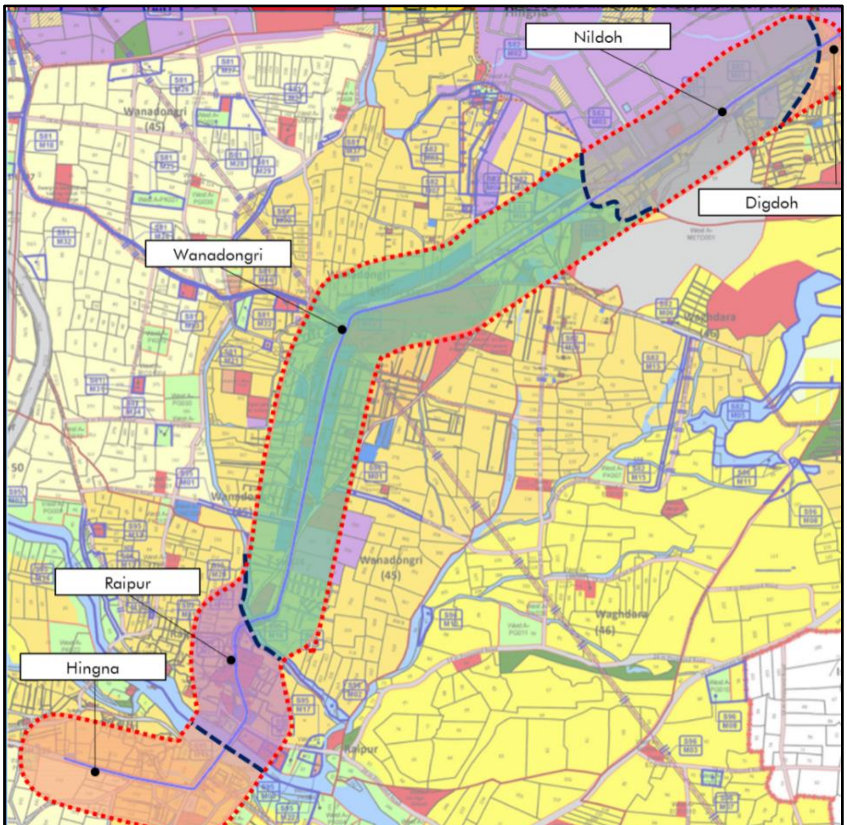


FIGURE 18.18:VILLAGES FALLING WITHIN TOD ZONE ALONG CORRIDOR-3A



C. CORRIDOR 5 - VASUDEV NAGAR TO WADI CORRIDOR

The total land area under different land uses within TOD influence zone is shown in**Table 18.5.** The average FSI utilization of the corridor is ~0.64.

TABLE 18.5:LAND AREA WITHIN TOD ZONE ALONG CORRIDOR-5

S. No.	Land Use	Total Land Area under TOD (in sqm)	Total Land with Built Up Structures (sqm)	Total Vacant Land (sqm)	Total FSI Utilized
1	Industrial MIDC*	1,915,482.43	1,915,482.43	-	0.55
2	Public Utilities	62,330.50	62,330.50	-	0.80
3	Residential 1	157,797.25	130,200.10	27,597.15	1.00
4	Residential 2	10,546.28	10,546.28	-	1.00
5	Residential on Industrial	3,857.12	3,857.12	-	1.00
6	Residential on Agricultural	-	-	-	1.00
7	Commercial	210,973.53	210,973.53	-	1.25
8	Amenities and waterbodies	29,263.86	-	-	-
9	Agricultural	210,227.87	-	-	-
10	Transportation (Railways)	-	-	-	-
Grand Total		**2,600,478.84**	**2,333,389.96**	**27,597.15**	**0.64**

***** The portion falling within jurisdiction of MIDC has been enumerated in the report for reflecting the quantum of Land area under the Influence of TOD for Phase II alignments of Nagpur Metro. MIDC land has however, been not considered for analysis / calculation of developable area or revenue estimations.

Figure 18.19shows the land use map within TOD zone and **Figure 18.20**shows the villages and census towns falling within TOD Influence Zone.

D. CORRIDOR4A - PRAJAPATI NAGAR TO TRANSPORT NAGAR

The total land area under different land uses within TOD influence zone is shown in **Table 18.6.** The average FSI utilization of the corridor is ~0.70.

TABLE 18.6:LAND AREA WITHIN TOD ZONE ALONGCORRIDOR-4A

S. No.	Land Use	Total Land Area under TOD (in sqm)	Total Land with Built Up Structures (sqm)	Total Vacant Land (sqm)	Total FSI Utilized
1	Industrial (Non- MIDC)	1,061,003.99	436,825.74	624,178.25	0.40
2	Public / Semi Public	103,911.50	43,957.49	59,954.01	0.80
3	Residential 2	126,565.78	17,188.52	109,377.26	1.00
4	Residential 1	639,780.52	475,351.89	164,428.63	1.10
5	Vacant	149,203.83	88,368.54	60,835.29	-
6	Commercial	346,212.83	188,955.10	157,257.73	1.00
7	Amenities and waterbodies	85,251.43	67,965.73	17,285.70	0.2
8	Agricultural	6,006.33	6,006.33	-	-
9	Public Utilities	77,113.20	54,873.51	22,239.69	0.40
Grand Total		**2,595,049.41**	**1,379,492.85**	**1,215,556.**	**0.70**

Figure 18.21 shows the land use map within TOD zone and **Figure 18.22**shows the villages and census towns falling within TOD Influence Zone.

FIGURE 18.19:LAND USE WITHIN TOD ZONE ALONG CORRIDOR-5

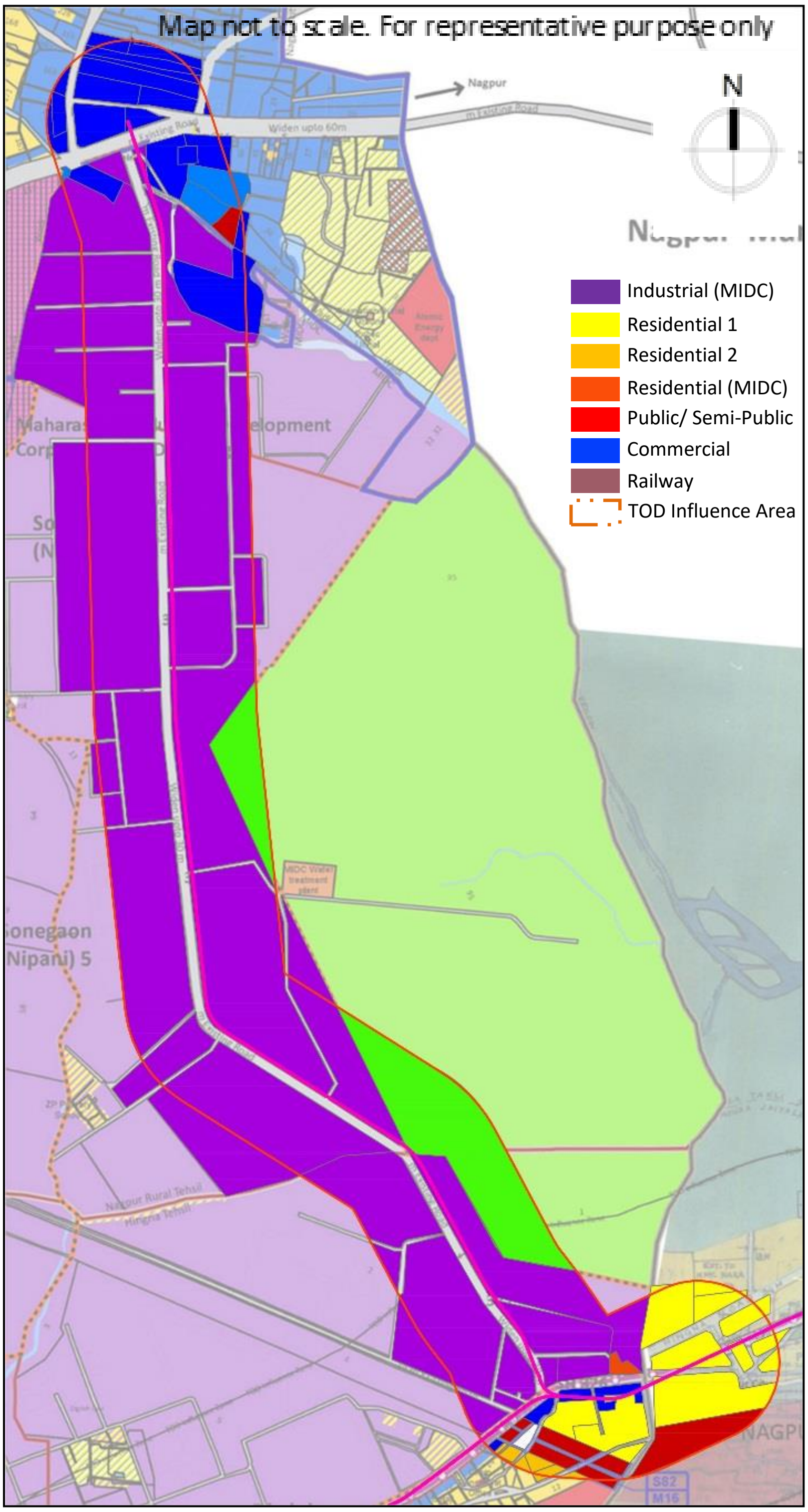


FIGURE 18.20:VILLAGES FALLING WITHIN TOD ZONE ALONG CORRIDOR-5

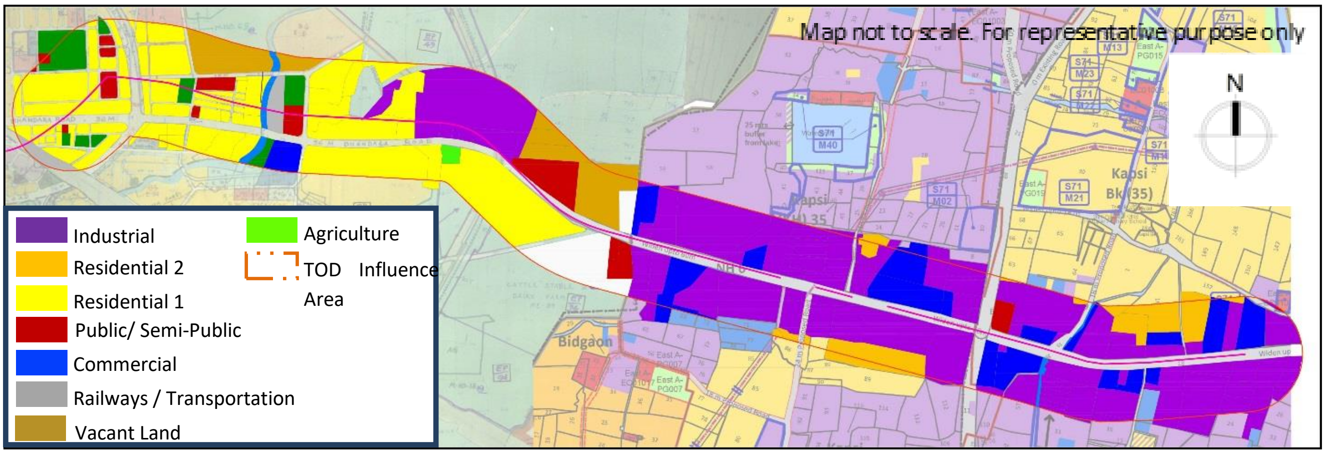


FIGURE 18.21:LAND USE WITHIN TOD ZONE ALONG CORRIDOR-4A

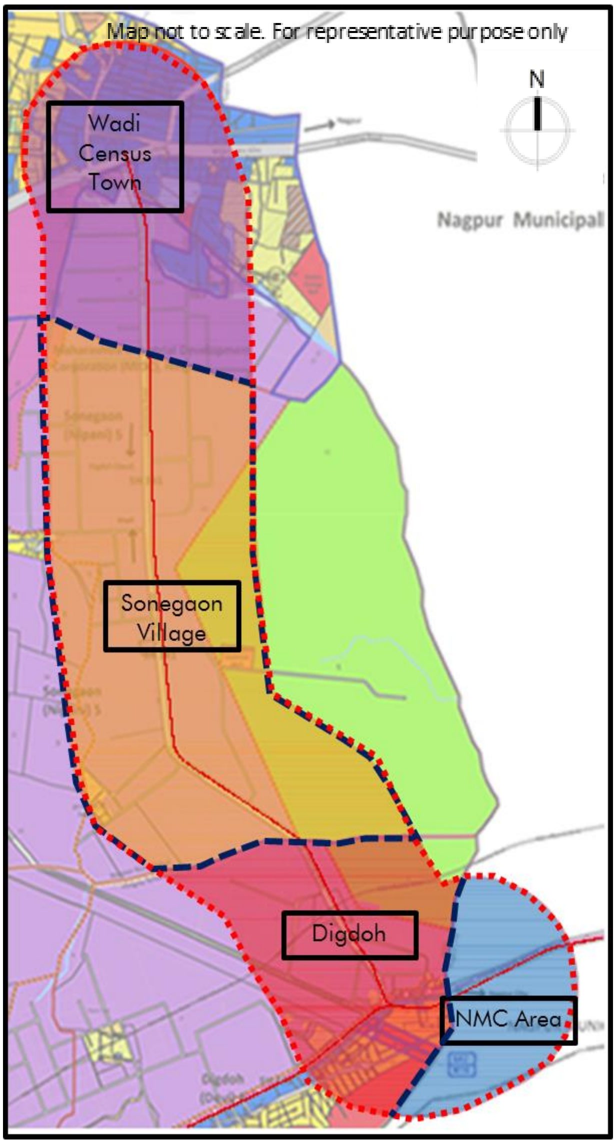
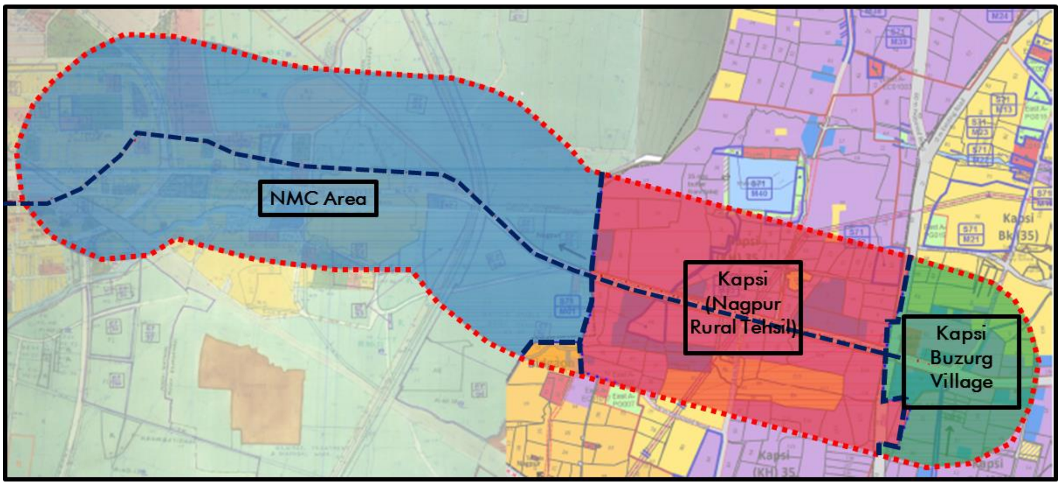


FIGURE 18.22:VILLAGES FALLING WITHIN TOD ZONE ALONG CORRIDOR-4A



E. CORRIDOR 1A - MIHAN TO MIDC ESR

The total land area under different land uses within TOD influence zone is shown in**Table 18.7**.The average FSI utilization of the corridor is ~0.55.

TABLE 18.7:LAND AREA WITHIN TOD ZONE ALONG CORRIDOR-1A

S. No.	Land Use	Total Land Area under TOD (in Sq.m)	Total Land with Built Up Structures (in sqm)	Total Vacant Land (in sqm)	Total FSI Utilized
1	Industrial (MIDC)	2,002,636.38	1,235,748.33	766,888.05	0.45
2	Industrial (Non-MIDC)	338,241.22	147,411.22	190,830.00	0.45
3	Public / Semi Public	219,179.74	49,609.08	169,570.66	0.80
4	Residential 2	3,150,628.60	757,722.44	2,392,906.16	0.80
5	Residential 1	295,969.90	99,059.06	196,910.84	0.80
6	Residential 3	65,283.46	-	65,283.46	0.00
7	Residential 4	481,423.98	7,914.23	473,509.75	0.80
8	Residential on Agricultural	77,007.87	4,599.33	72,408.54	0.20
9	Commercial	883,761.97	194,460.66	689,301.31	1.00
10	Transportation	520,642.34	312,180.62	208,461.72	0.20
11	Forests	95,404.56	38,825.24	56,579.32	0.00
12	Amenities &Recreational Open	184,781.02	91,221.05	93,559.97	0.20
Grand Total		**8,314,961.04**	**2,938,751.26**	**5,376,209.78**	**0.55**

Figure 18.23shows the land use map within TOD zone and **Figure 18.24**shows the villages and census towns falling within TOD Influence Zone.

FIGURE 18.23:LAND USE WITHIN TOD ZONE ALONG CORRIDOR-1A

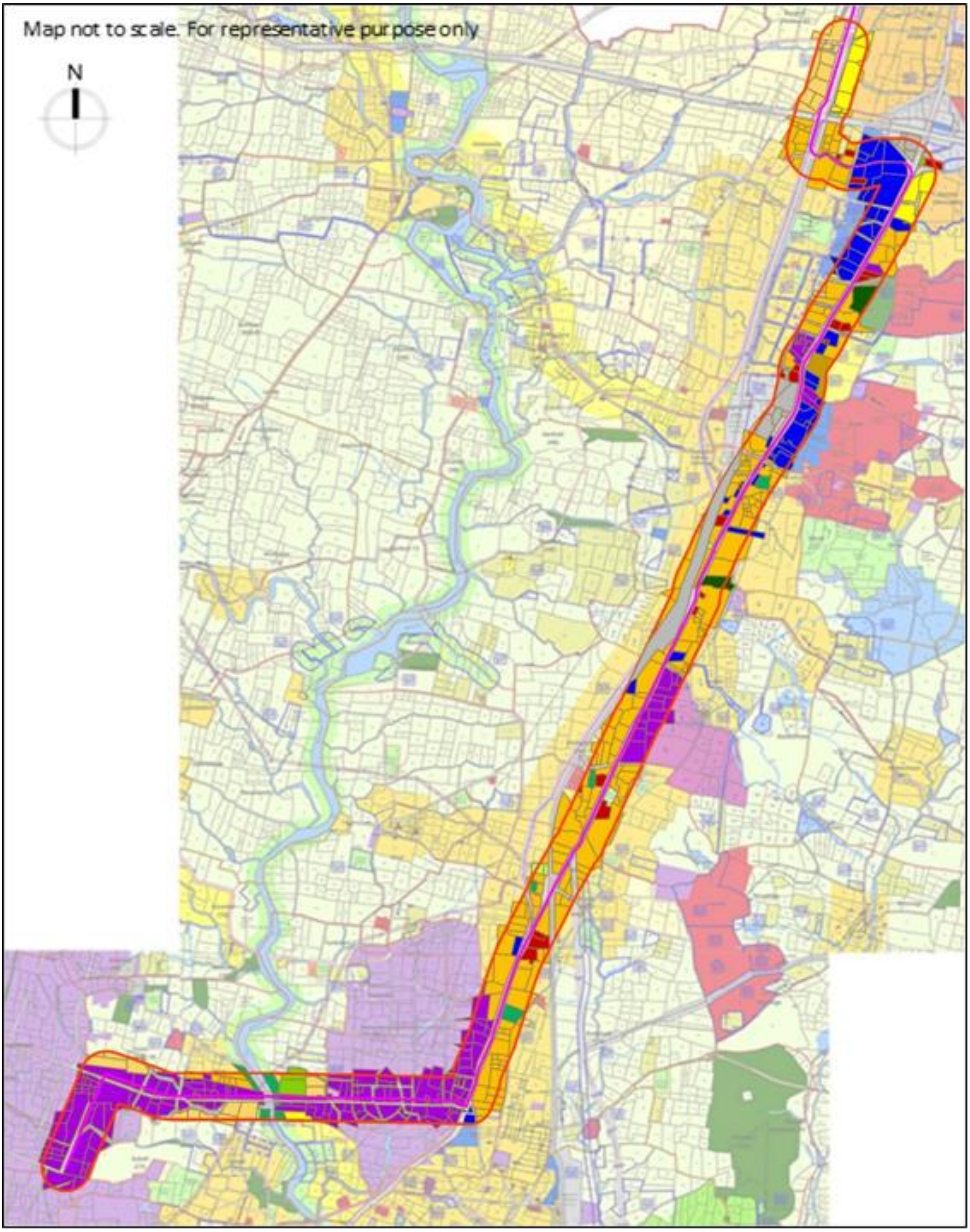
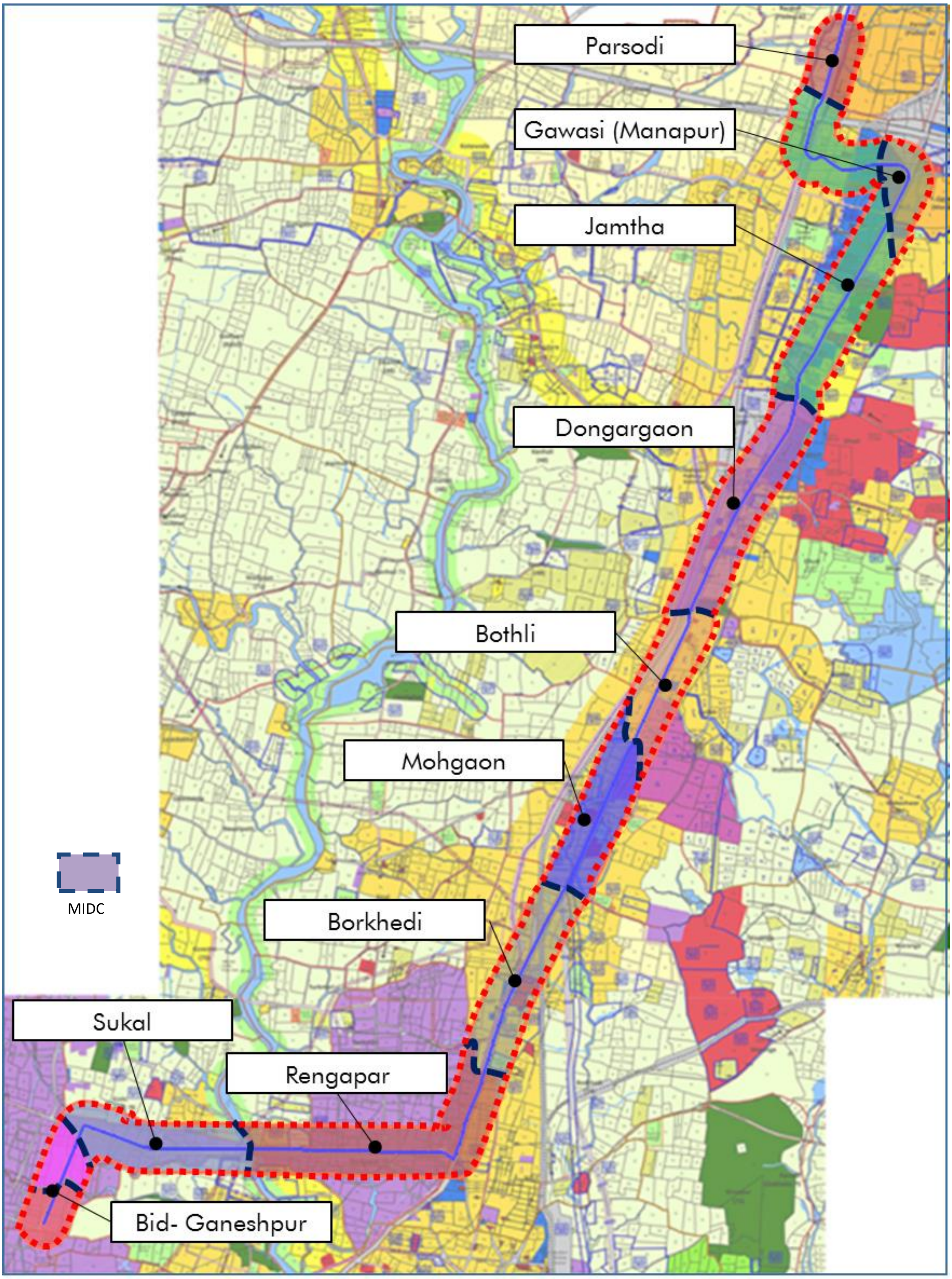


FIGURE18.24:VILLAGES FALLING WITHIN TOD ZONE ALONG CORRIDOR-1A



18.4.4. Revenue Estimation from TOD

For consideration of understanding the supply - demand dynamics pertaining to the TOD Influence area, we have assumed two scenarios – one for estimating the total development potential from the supply side, i.e. assessment of net built - up potential as per the maximum FSI cap, applicable as per the sanctioned TOD Policy, encapsulated in the NMA DCPR (2018).

The second approach is a demand side assessment which is based on projecting achievable utilisation of land for real estate development along all the Metro Phase II TOD Corridors till 2048. The same has been enumerated basisa Y-o-Y population projection method, which is extrapolated to derive the net housing & relative commercial demand. This two-way analysis approach shall provide a range of comparative analysis between a net development potential within the NMRC viz. a viz. a realistic absorption scenario basis Y-o-Y absorption projection till 2048.

A. Supply Side Dynamics

The study of the supply side dynamics includes a comprehensive area assessment of the total land areaencompassedwithin the earmarked 250-meter bufferof the phase IIMetro alignments. The same also includes an analysis of the various designated land uses as per the sanctioned NMA DP for Nagpur (2012-32). To initiate the study, we have assumed a methodology involving desktop analysis of the Proposed Land Use Plan of Nagpur Metropolitan Area and reconstruction of the NMRC Corridor on AutoCAD. This enabled an estimation of the approximate land area under the various, which is further used to estimate the total Built-up potential of the corridor as per the maximum FSI cap established as per the TOD Policy.A desktop analysis, combined with findings of the primary survey,is also incorporated determine a built vs. vacant area matrix along the corridors to envisage a green-field development potential on vacant plots in the stipulated area. Our findings for the respective metro corridors are enumerated as follows:

i. Built up Area Estimation and Land Supply

For the estimation of built up area, base FSI as per DCR 2018 have been taken as under:

- Residential R1 - 1.1
- Residential R2 - 1.1
- Commercial - 1.25

The estimation of built up area along all the corridors are shown in following **Table 18.8.**

TABLE 18.8:LAND & BUILT UP AREA SUPLY FOR RESIDENTIAL & COMMERCIAL DEVELOPMENT

S. No.	Corridor	Average Premium FSI Available*	Residential		Commercial	
			Land Supply in 2048 (sq. m)	Built up Area Supply in 2048 (sq. m)	Land Supply in 2048 (sq. m)	Built up Area Supply n 2048 (sq. m)
1	Automotive Square - Kanhan River	3.04	4,19,886	12,78,372	2,88,158	8,77,317
2	Lokmanya Nagar - Hingna	2.69	4,31,035	11,58,610	39,944	1,07,367
3	Vasudev Nagar - Dattawadi	3.20	27,597	88,327	-	-
4	Prajapati Nagar - Transport Nagar	3.32	2,73,806	9,09,093	1,57,258	5,22,129
5	MIHAN - MIDC ESR	3.20	31,28,610	1,03,87,655	6,89,301	22,02,371

* Average premium FSI is calculated by taking weighted average of plot sizes falling within the TODInfluence Areas and respective road frontages to the plots, thus providing an average value of eligible FSI. Vasudev Nagar – Wadi & Lokmanya Nagar to Hingna corridors both have a considerable portion of land under the jurisdiction of MIDC. For enumeration of revenue estimation, the MIDC land parcels have been excluded duly.

ii. Revenue Estimation from TOD Influence Area – Supply Side

To calculate Revenues from additional surcharge on property transactions, we have referred the Annual Statement of Rates (ASR) 2018 -19 pertaining to different locations (Talukas, Villages) falling within the 5 respective TOD influence corridors to assimilate a weighted average ready reckoner (RR)value. The weights have been assigned as per the percentage of each land use zoning within the corridor. For example, if in a stretch of 1 Hectare, 50% area is residential, 35% is industrial and 15% commercial, the respective weights for the RR values for residential properties have been adjusted within a sum of 50%. Similarly, for all the RR values for Land with Industrial property, the respective weights have been adjusted within a sum of 35%.

However, for consideration of ASR or RR values for computation of premium towards additional purchasable FSI, we have only considered the ASR land values (for residential, commercial and industrial properties). Hence, for each stretch we have deduced two sets of ASR weighted average values, one for computation of additional surcharge on property transactions (land + property) and other for computation of premium on additional FSI (Land only – converted to Non-Agricultural use (residential/commercial)).

The weighted average RR (ASR) values considered for each of the corridor are assumed at Year 0 (2018).For consideration of this report, we have assumed a2% annual escalation scenario. We consider that a 2% escalation on Ready Reckoner

(ASR) values is nominal & has increased at a similar rate in the past. The ready reckoner values assumed at Year 0 (2018) are as follows:

Automotive Square to Kanhan River Corridor:

- RR (ASR) 2018-19 weighted average value (of land with residential / commercial / industrial property) for computation of additional surcharge on property transactions: **INR 19,678 per sqm**
- RR (ASR) 2018-19 weighted average value (of commercial / industrial / residential land) for computation of Premium on Additional FSI: **INR 5010 per sqm**

Lokmanya Nagar to Hingna Corridor:

- RR (ASR) 2018-19 weighted average value (of land with residential / commercial / industrial property) for computation of additional surcharge on property transactions: **INR 16,072 per sqm**
- RR (ASR) 2018-19 weighted average value (of commercial/ industrial/ residential land) for computation of Premium on Additional FSI: **INR 8,016 per sqm**

Vasudev Nagar to DattawadiCorridor:

- RR (ASR) 2018-19weighted average value (of land with residential / commercial / industrial property) for computation of additional surcharge on property transactions: **INR 11,261 per sqm**
- RR (ASR) 2018-19 weighted average value (of commercial/ industrial / residential land) for computation of Premium on Additional FSI: **INR 7,368 per sqm**

Prajapati Nagar to Transport Nagar Corridor:

- RR (ASR) 2018-19 weighted average value (of land with residential / commercial / industrial property) for computation of additional surcharge on property transactions: **INR 12,354 per sqm**
- RR (ASR) 2018-19 weighted average value (of commercial / industrial / residential land) for computation of Premium on Additional FSI: **INR 7,830 per sqm**

MIHAN to MIDC ESR Corridor:

- RR (ASR) 2018-19 weighted average value (of land with residential / commercial / industrial property) for computation of additional surcharge on property transactions: **INR 18,275 per sqm**

- RR (ASR) 2018-19 weighted average value (of non-agricultural commercial / industrial / residential land) for computation of Premium on Additional FSI: **INR 7,025 per sqm**

Property Transaction Charges:

Phase II of the project is touted for peripheral locations falling under the jurisdiction of NMRDA and parts of NMC / NIT. In case of Phase I, an additional surcharge of 1% is incurred towards Nagpur Metro Project. The same is levied basis notification (No. MRD-3316/C.R.24/ (2)/UD7, dated 30th June 2016) published in Government of Maharashtra's Gazetteer dated 07th July, 2016. The notification establishes the Nagpur Metro Phase I Project as "Essential Public Project and Vital Urban Transport Project" status. Phase II of the project does not have the status at the moment, however on lines of phase I, the same may be incorporated.

As established in the Government of Maharashtra Notification No. MRD – 3316/ C.R. / 24 / (2) / UD 7, dated 06th July 2016 & G.R. dated 30th of January 2014, an additional surcharge of 1% is approved to be levied for Nagpur Metro Phase I, the same having status of a "Essential Public Transport Project". The additional surcharge is also to be retained by the SPV so formed for execution & development of the project. Hence, following similar lines as the Phase I, the Phase II of the said Metro project shall achieve a surcharge of 1% over and above the base Stamp Duty as 100% revenue (given the project also achieves the "Essential Public Transport Project"). The revenue estimation, so projected in the report are based on the above assumption.

The surcharge upon transactions of developed properties are charged at varying rates for different jurisdiction areas.

Key excerpts from the Section 149 B concern the provision of levying & collection of a surcharge amounting to an additional 1% over and above the stipulated surcharge on property transactions. It is also duly mentioned, that for the purpose of this section, section 28 of the Maharashtra Stamp Act shall be read and enforced as if, it specifically requires the particulars therein referred to be set forth separately in respect of, -

- Properties situated in the City having Notified project (s); and
- Property situated in any other area

Sub-section 3 of Section 149 B state that the State Government shall, every year, after due appropriation made by the law in this behalf, pay to the Corporation or the agency which has undertaken the notified project, pay a grant-in aid approx. equal to the amount of additional duty realized on account of surcharge levied and collected under this section in respect of immovable properties situated in the 'City' having Notified projects. Such grant-in-aid shall be utilized for the notified projects in the manner specified by the government.

Sub-section 4 of section 149B reads, "The sum of money required to meet the expenditure by the State Government under sub-section (3), shall be charged on the Consolidated Fund of the State'.

RITES Recommendations-

1. **Concerning the second phase of Nagpur Metro Project, a Notification from the State Government of Maharashtra has to be drawn for extension of "Vital Urban Transport Project" status for the Nagpur Metro Phase II alignments, for levying of any additional surcharges, either on Property Transactions or other Development Charges.**
2. On lines of Nagpur Metro Phase I, a mechanism of revenue sharing from proposed additional surcharge (to be levied in NMRDA jurisdiction areas) can be instated for the Phase II of the project, according to the directives of the above Notification.
3. Also considering that the jurisdiction area of NMRDA is much larger than that of NMC and that the Nagpur Metro Phase II Project can function service to a limited portion of the NMA area, the contribution of surcharge towards the Phase II project shall be raised from the land parcels situated within the stipulated NMRC TOD Influence area.

Premium on Additional FSI

Regulations & guidelines pertinent to the latest sanctioned TOD Policy and other general by-laws, enumerated in the sanctioned DCPR (January 2018) of the Nagpur Metropolitan Area have been referred to for computation of premium FSI area, pertinent to the NMRC / TOD Influence area of Metro Phase II alignments.

Computation of premium chargeable towards the purchase of additional FSI has been followed as per Notification No. *TPS–2416/C.R.176/2016/UD–1,* dated

24/07/2017. As per Clause 38.2.1(a) of the NMA DCPR, the premium to be paid towards additional FSI is computed basis satisfaction of a minimum tenement density per hectare of gross plot area, which is given as follows:

Minimum number of Tenements = Gross Plot Area X Maximum Proposed FSI for Residential Use X 200 Tenements per Hectare

Developments / Redevelopment projects that fulfil the above parameter are liable to pay the premium at 30% of ASR Value of the land. For projects which do not meet the minimum density criterion, the premium is charged at 40% of ASR value of land. **For ease of computation, we have assumed an average of the two figures, i.e. 35% for consideration of our report.**

As per Government of Maharashtra G.R. dated 30th January, 2014, from the total revenue so accrued from sale of additional FSI, only a 50% shall be accounted as revenue towards the Phase II Metro Project.

<u>**Development Charges**</u>

The areas falling under the TOD Influence area of the Phase II alignments are divided by a number of Institutional / administrative bodies such as Gram Panchayats, Nagar Panchayats &Zila Parishads, which may present further complexities to the process of revenue collection & retrieval of the same as an income for Nagpur Metro. However, since the project is being developed within the Nagpur Metropolitan Area notified to be under jurisdiction of NIT (the Special Planning Authority for the region incorporated as per UDD Notification No. TPS 2409/2890/C.R. 356 / UD-9, dated 31st August 2010), the same comes under the applicability of Section 124B of the Maharashtra Region and Town Planning Act, 1966.

As per sub-section 2 of the said act, development charges are to be levied & collected by the nodal authority (NIT / NMRDA) at rates specified in column (4) of the second schedule. The schedule is annexed as **Annexure I**.

As per point (c) of column 3 of the second Schedule, projects involving development of land for residential or institutional use, also involving building or construction operations shall imply development charge fee as follows:

- For land component – 0.5% of rates of developed land as mentioned in the Stamp Duty Reckoner
- For the built up component – 2.0% of the rates of developed land mentioned in the Stamp Duty Reckoner

As per the clause 2-1A of the said section of the act, for consideration of a Vital Urban Transport Project, the development charges levied and collected under the provision of the sub-section (2) shall be increased by one hundred percent. This report considers the additional 100% only as the revenue to be accrued towards Nagpur Metro Phase II project.

As mentioned in the previous sections, an application has to be made to the UDD for the inclusion of the Phase II alignments in the ‘Special status project’, for revenue through this avenue to be realised as an income from TOD Influence area of Phase II. Also, the process requires a robust revenue collection mechanism, may be at the level of Nagar / Gram Panchayats and Zila Parishads falling under the NMA jurisdiction. Also, the process requires an automated funds transfer mechanism of the collected revenues to the Special Planning Authority, i.e. NIT / NMRDA. An operational challenge that may be a major road-block for the avenue is the fact that the Metro Phase II alignments facilitate connectivity for a limited fraction of NMA area and thus levying of Development Charges to the overall jurisdiction area may not be justified.

The total estimated revenues from sale of additional FSI, additional surcharge on property transactions and development charges for all the corridors of Nagpur Metro Ph -2 are shown in following**Table 18.9.**

TABLE 18.9:SUPPLY SIDE REVENUE ESTIMATION (2024-2048) (In Crore)

S. No.	Corridor	Revenue from Sale of additional FSI	Revenue from 1% Surcharge on Property Transactions	Revenue from Development Charge	Total	Total Revenue towards Mahametro*
1	Automotive Square - Kanhan River	219.58	39.83	21.95	281.36	**171.56**
2	Lokmanya Nagar - Hingna	197.0	19.25	21.00	237.25	**138.75**
3	Vasudev Nagar - Wadi	14.40	0.96	1.35	16.71	**9.51**
4	Prajapati Nagar - Transport Nagar	246.38	19.25	26.03	291.66	**168.47**
5	MIHAN - MIDC ESR	474.05	74.67	60.72	609.44	**372.41**

* 50% of revenue from sale of additional FSI and 100% of revenue from 1% surcharge on property transactions and development charges will accrue to Mahametro.

Year wise breakup of revenue for all the corridors combined has been shown in**Table 18.10** below.

TABLE 18.10:YEAR WISE REVENUE BREAK UP FOR SUPPLY SIDE FOR ALL CORRIDORS

Year	Revenue (Rs. In Crores)			
	Premium on Additional FSI	1% Surcharge on Property Transactions	Development Charge	Total
2024-25	10.26	3.20	2.75	16.21
2025-26	13.38	4.00	3.45	20.83
2026-27	14.11	4.20	3.60	21.91
2027-28	14.89	4.50	3.80	23.19
2028-29	15.72	4.70	4.05	24.47
2029-30	18.57	5.30	4.50	28.37
2030-31	19.65	5.60	4.80	30.05
2031-32	20.79	5.90	5.05	31.74
2032-33	16.91	5.00	4.20	26.11
2033-34	17.67	5.20	4.40	27.27
2034-35	19.66	5.30	4.50	29.46
2035-36	20.55	5.60	4.70	30.85
2036-37	21.48	5.80	4.90	32.18
2037-38	22.44	6.10	5.15	33.69
2038-39	23.46	6.30	5.35	35.11
2039-40	25.43	6.40	5.45	37.28
2040-41	26.58	6.70	5.70	38.98
2041-42	27.8	7.00	5.95	40.75
2042-43	28.95	7.30	6.20	42.45
2043-44	30.27	7.60	6.50	44.37
2044-45	30.52	7.70	6.60	44.82
2045-46	31.91	8.10	6.85	46.86
2046-47	33.37	8.40	7.20	48.97
2047-48	34.9	8.80	7.50	51.20
2048-49	36.5	9.20	7.85	53.55

B. Demand Side Dynamics

The estimation of real estate demand has been established upon the population growth trends of the city. On the basis of zone-wise projected population figures along the areas lying within the TOD influence zone, we have incorporated a Compounded Annual Growth Rate (CAGR) to project a Year-on-Year increment in the population.

The Y-o-Y incremental trend in population figures is considered to calculate the housing demand for the increased population. To calculate the number of dwelling units required to accommodate the increased population, the Nagpur district census data is referred to observe the number of households in 2011 viz-a-viz the population of district at the time.

An average household size of **4.47**has been assumed to calculate the number of household units required to accommodate the Y-O-Y increment in the population.

i. Population and household trends pertaining to Metro Corridors (Phase 2)

It is assumed that only a portion of the projected population in the analysis zones shall be residing in the areas falling within the 250 meters buffer of the metro alignment. Hence, we have assigned a co-efficient to total population along each corridor to calculate a tentative requirement of housing within the 250m buffer zone.

Based on the zone-wise CAGR, the net population for influence area of five corridors are projected in **Table 18.11.**

TABLE 18.11:INFLUENCE AREA WISE POPULATION PROJECTION

Corridor	2021	2031	2041
Automotive Square - Kanhan River	45,581	56,546	69,552
Lokmanya Nagar - Hingna	11,331	14,385	18,045
Vasudev Nagar - Wadi	9,954	12,639	15,526
Prajapati Nagar - Transport Nagar	16,629	20,868	24,568
MIHAN - MIDC ESR	8,234	12,598	16,836

By dividing the Population with the assumed average household size of 4.47 – the total number of dwellings units required to accommodate the Y-o-Y growth of population is achieved. To assume the size of an average size of dwelling unit, a weighted average of typical DU size (based upon primary market research) is established at 84.10 sq m as shown in**Table 18.12.**

TABLE 18.12:WEIGHTED AVERAGE OF TYPICAL DWELLING UNIT SIZE

Area calculation for average dwelling unit size (in sqm) in prevailing apartment type / group housing developments								
Type	I	II	III	IV	V	VI	VII	VIII
Unit Area (in sqm)	45	65	85	115	135	150	180	200
Weight	23%	22%	26%	16%	9%	2%	1%	1%
Weighted Average Area (in sqm)	**84.10**							

Corridor-wise calculation of residential and commercial demand

Based on the typical dwelling size assumed, the residential Built-up area requirement is calculated by direct multiplication with the annual additional housing requirement (no. of dwelling units). The net weighted average eligible FSI for the corridor (additional FSI under NMRC Influence zone with respect to size and width of access road to the plot) as assumed while assessing the supply side dynamics has been retained for the demand estimation.

The total land area demand and net Built Up area requirement till 2048 for residential development on all corridors is presented in **Table 18.13.**

TABLE 18.13:LAND & BUILT UP AREA REQUIREMENT FOR RESIDENTIAL DEVELOPMENT

S. No.	Corridor	Average Weighted Premium FSI	Land Area Demand in 2048 (sq. m)	Built up Area Required in 2048 (sq. m)
1	Automotive Square - Kanhan River	3.04	209,185	636,876
2	Lokmanya Nagar - Hingna	2.69	66,188	177,911
3	Vasudev Nagar - Dattawadi	3.2	44,916	143,758
4	Prajapati Nagar - Transport Nagar	3.05	63,692	194,261
5	MIHAN - MIDC ESR	3.20	69,068	220,676

Methodology for computation of commercial space requirement:

For calculation of commercial demand, a similar population projection method is incorporated. For computation of a per capita commercial built –up space (sqm / person) for Nagpur city, we had considered the per capita commercial absorption co-efficient of 6 Major Indian Tier I cities such as Mumbai, Pune, Hyderabad, Kolkata and Delhi NCR by analysing the population growth trends and absorption in commercial office space sector since 2011. The respective per capita commercial co-efficient of the respective cities were 0.59, 1.05, 0.41, 0.48 and 0.37 respectively. A co-efficient of 0.7 was achieved by assigning due weights to the co-efficient of the studied cities, depending upon their respective size and scale in comparison to Nagpur City. Assuming that Nagpur is a Tier 2 city, only a 20% of the achieved per capita commercial demand co-efficient is considered, i.e. 0.14sqm per person. Considering the same Additional FSI figure of 3.20, the land area requirement is calculated as follows.

The total land area demand and net Built Up area requirement till 2048 for commercial development on all corridors is presented in **Table 18.14.**

TABLE 18.14:LAND & BUILT UP AREA REQUIREMENT FOR COMMERCIAL DEVELOPMENT

S. No.	Corridor	Average Weighted Premium FSI	Land Area Demand in 2058 (sq. m)	Built up Area Required in 2058 (sq. m)
1	Automotive Square - Kanhan River	3.04	72,108	219,537
2	Lokmanya Nagar - Hingna	2.69	20,526	55,174
3	Vasudev Nagar - Wadi	3.2	14,944	47,829
4	Prajapati Nagar - Transport Nagar	3.05	16,153	49,266
5	MIHAN - MIDC ESR	3.20	68,711	219,537

Conclusion (Demand Side BUA and Developable Land area requirement):

Cumulatively, the demand side residential estimate projects that by the year 2048, a sum total of **16,322 units** shall be required across price and affordability segments to accommodate the population demand basis organic growth. **The net cumulative residential BUA** required to accommodate the tentatively projected demand shall be **approx. 14.78 Mn sft**, with a **land area requirement of 45.30 Hectares**.

Similarly, the **subsequent commercial space requirement to accommodate office space, retail & hospitality segments** (basis population growth trends) within the TOD Influence area of all the 4 Metro alignments of Phase II combined, shall be **approx. 6.37 Mn sft.**The net **land area required** to consume the demand is estimated to **approx. 19.24Hectares.**

Thus, demand side projections reflect a cumulative BUA requirement of approx. 21.15Mn sft of BUA for revenue yielding asset classes with a net developable land requirement of 64.55 Hectares. This shall also trigger demand for other asset classes as well as land area requirement for accommodation of support amenities and infrastructure (both physical and social).

Demand Side Revenue Estimation

For computation of Revenue from Surcharge on Property Transactions and Sale of additional FSI, the assumptions relating to the weighted average value of Annual Statement of Rates / Ready Reckoner are same as those adopted while computing the revenues from supply side. Since, the demand is projected for a duration of 25years from 2024 onwards (till 2048), the ASR values for have also been escalated to 2% on an Y-o-Y basis. Following are the corridor-wise revenue figures from surcharge on property transactions, development charges and sale of additional FSI respectively.

TABLE 18.15:DEMAND SIDE REVENUE (2024-48)

Description	Particulars (Rs. in Crores)				
	Automotive Sq. - Kanhan River	Lokmanya Nagar - Hingna	Vasudev Nagar - Wadi	Prajapati Nagar - Transport Nagar	MIHAN - MIDC ESR
Total Revenue from sale of additional FSI	140.51	56.77	47.60	62.16	101.35
Total Revenue from 1% Surcharge on Property Transactions	25.18	5.63	3.23	4.45	11.91
Revenue from Development Charge	13.88	6.14	4.55	6.11	9.88
Total	179.57	68.54	55.38	72.72	123.14
Total Revenue towards Maha Metro*	**109.32**	**40.16**	**31.58**	**41.64**	**72.47**

* 50% of revenue from sale of additional FSI and 100% of revenue from surcharge on property transactions and development charges will accrue to Mahametro.

The year wise breakup of revenue estimation for all corridors combined is shown in **Table 18.16** below.

TABLE 18.16:YEAR WISE REVENUE BREAK UP FOR DEMAND SIDE FOR ALL CORRIDORS

Year	Revenue (Rs. In Crores)			
	Premium on Additional FSI	1% Surcharge on Property Transactions	Development Charge	Total
2024-25	4.20	1.02	0.83	6.05
2025-26	5.48	1.33	1.08	7.89
2026-27	5.76	1.40	1.14	8.29
2027-28	6.05	1.46	1.20	8.71
2028-29	6.36	1.54	1.26	9.15
2029-30	6.69	1.62	1.32	9.62
2030-31	7.03	1.70	1.39	10.12
2031-32	7.40	1.78	1.46	10.64
2032-33	6.34	1.57	1.26	9.17
2033-34	6.61	1.64	1.31	9.56
2034-35	6.90	1.71	1.37	9.98
2035-36	7.20	1.78	1.43	10.41
2036-37	7.51	1.86	1.49	10.86
2037-38	7.84	1.94	1.56	11.33
2038-39	8.18	2.03	1.62	11.83
2039-40	8.53	2.11	1.70	12.34
2040-41	8.90	2.21	1.77	12.88
2041-42	9.29	2.30	1.85	13.44
2042-43	9.75	2.42	1.94	14.11
2043-44	10.18	2.53	2.02	14.73
2044-45	10.63	2.64	2.11	15.38

Year	Revenue (Rs. In Crores)			
	Premium on Additional FSI	1% Surcharge on Property Transactions	Development Charge	Total
2045-46	11.10	2.76	2.21	16.06
2046-47	11.59	2.88	2.30	16.77
2047-48	12.10	3.01	2.40	17.52
2048-49	12.64	3.15	2.51	18.29

C. Comparison of Revenue Under Two Scenarios

It has been observed that demand for absorbing the market is only 35% of the supply. The comparison between Supply side revenue potential and Demand Side Revenue Estimate is given in **Table 18.17.**

TABLE 18.17: COMPARISON OF SUPPLY SIDE & DEMAND SIDE REVENUE (2024, 2031 & 2041)

Description	Supply Side Revenue (in Cr)			Demand Side Revenue (in Cr)		
	2024-25	2031-32	2041-42	2024-25	2031-32	2041-42
Total Revenue from sale of additional FSI	10.26	20.79	27.8	4.20	7.40	9.29
Total Revenue from 1% Surcharge on Property Transactions	3.20	5.90	7.00	1.02	1.78	2.30
Total Revenue from Development Charge	2.75	5.05	5.95	0.83	1.46	1.85
Total realisable revenue towards MahaMetro	**16.21**	**31.74**	**40.75**	**6.05**	**10.64**	**13.44**

The supply and demand side revenue figures are estimated in terms of present day value i.e. 2018-19 Annual Statement of Rates (escalated at 2% annually). The supply side, on one end highlights the total revenue potential of land situated within the NMRC buffer zone, the demand side highlights a more realisable organic growth in demand for Built up area. The demand side estimation takes into account the population growth trends of the city prevailing over the past and hence is a more realistic approach towards demand estimation.

D. Revenue from 1% Surcharge on Property Transactions in NMA Region

As advised by Maha Metro, another option for assessment of revenue from surcharge on property transactions based on existing revenue collection has been explored. To minimise the collection hurdles, Maha Metro desires that the surcharge should be applied on whole of Nagpur Metropolitan Area (NMA) as done in Nagpur Municipal Area for Metro Phase-I . It was also suggested that the present rate of 0.5% surcharge on property transactions in NMA area as detailed under section 77 of

NIT Act, 1936 may be increased to 1% as adopted in the case of Nagpur Metro Ph I. The data of surcharge on property transactions has been collected from Nagpur Improvement Trust (NIT) for the past 5 years i.e. 2012-13 to 2016-17 (**Table 18.18**).

TABLE 18.18: COLLECTION OF SURCHARGE ON PROPERTY TRANSACTIONS IN NMA AREA DURING 2012-17

Sr. No.	Year	Surcharge Received by NIT @0.50% of transaction value in NMA Region (Rs in Cr)
1	2012-13	5.42
2	2013-14	5.97
3	2014-15	7.24
4	2015-16	6.66
5	2016-17	6.88

It is observed that surcharge collection has grown at an average growth rate of 7% in past five years. To project the revenue collection, the growth rate has been moderated to 5%. The estimated revenue from surcharge on property transactions @1% is shown in**Table 18.19.**

TABLE 18.19: REVENUE FROM SURCHARGE ON PROPERTY TRANSACTIONS IN NMA AREA

Sr. No.	Year	Revenue from 1% surcharge on Property Transactions in NMA Area (Rs in Cr)
1	2024-25	20.33
2	2031-32	28.61
3	2041-42	46.60

E. Proposals

Based on above analysis two options for assessment of revenue from TOD (Value Capture Finance) are being proposed for consideration of Maha Metro.

- Option 1: Revenue from sale of FSI & development charge based on Demand Scenario and 1% surcharge on property transactions based on existing collection in NMA.
- Option 2: Revenue from sale of FSI, development charge and 1% surcharge on property transactions in TOD Influence Area based on Demand Scenario.

Year wise revenue from TOD from year 2024 - 2048 in Option 1 & 2 are shown in **Table 18.20** and**Table 18.21**. A decision on which option to be adopted may be taken by Mahametro at the project approval/ implementation stage.

TABLE 18-20 ESTIMATION OF REVENUE FROM TOD (OPTION 1)

Year	Revenue (Rs. In Crores)			
	Premium on Additional FSI	1% Surcharge on Property Transactions in NMA	Development Charge	Total
2024-25	4.20	20.33	0.83	25.36
2025-26	5.48	21.35	1.08	27.91
2026-27	5.76	22.41	1.14	29.31
2027-28	6.05	23.53	1.20	30.78
2028-29	6.36	24.71	1.26	32.32
2029-30	6.69	25.95	1.32	33.95
2030-31	7.03	27.24	1.39	35.66
2031-32	7.40	28.61	1.46	37.46
2032-33	6.34	30.04	1.26	37.64
2033-34	6.61	31.54	1.31	39.46
2034-35	6.90	33.11	1.37	41.39
2035-36	7.20	34.77	1.43	43.40
2036-37	7.51	36.51	1.49	45.51
2037-38	7.84	38.33	1.56	47.73
2038-39	8.18	40.25	1.62	50.05
2039-40	8.53	42.26	1.70	52.49
2040-41	8.90	44.38	1.77	55.05
2041-42	9.29	46.60	1.85	57.73
2042-43	9.75	48.93	1.94	60.61
2043-44	10.18	51.37	2.02	63.58
2044-45	10.63	53.94	2.11	66.68
2045-46	11.10	56.64	2.21	69.94
2046-47	11.59	59.47	2.30	73.36
2047-48	12.10	62.44	2.40	76.95
2048-49	12.64	65.57	2.51	80.71

TABLE 18-21 ESTIMATION OF REVENUE FROM TOD (OPTION 2)

Year	Revenue (Rs. In Crores)			
	Premium on Additional FSI	1% Surcharge on Property Transactions in TOD Influence Area	Development Charge	Total
2024-25	4.20	1.02	0.83	6.05
2025-26	5.48	1.33	1.08	7.89
2026-27	5.76	1.40	1.14	8.29
2027-28	6.05	1.46	1.20	8.71
2028-29	6.36	1.54	1.26	9.15
2029-30	6.69	1.62	1.32	9.62
2030-31	7.03	1.70	1.39	10.12
2031-32	7.40	1.78	1.46	10.64

Year	Revenue (Rs. In Crores)			
	Premium on Additional FSI	1% Surcharge on Property Transactions in TOD Influence Area	Development Charge	Total
2032-33	6.34	1.57	1.26	9.17
2033-34	6.61	1.64	1.31	9.56
2034-35	6.90	1.71	1.37	9.98
2035-36	7.20	1.78	1.43	10.41
2036-37	7.51	1.86	1.49	10.86
2037-38	7.84	1.94	1.56	11.33
2038-39	8.18	2.03	1.62	11.83
2039-40	8.53	2.11	1.70	12.34
2040-41	8.90	2.21	1.77	12.88
2041-42	9.29	2.30	1.85	13.44
2042-43	9.75	2.42	1.94	14.11
2043-44	10.18	2.53	2.02	14.73
2044-45	10.63	2.64	2.11	15.38
2045-46	11.10	2.76	2.21	16.06
2046-47	11.59	2.88	2.30	16.77
2047-48	12.10	3.01	2.40	17.52
2048-49	12.64	3.15	2.51	18.29

F. Caveats and Limitations

The present report is based on broad comprehensive market study of the overall market for the possible situations given the limited nature of the scope of the assignment. RITEShas reliedupon secondary sources of information for a macro-level analysis.

RITES endeavours to develop forecasts on demand, supply and pricing on assumptions that would be considered relevant and reasonable at that point of time. All of these forecasts will be in the nature of likely or possible events/occurrences and the Report will not constitute a recommendation to adopt a particular course of action. The use of the Report at a later date may invalidate the assumptions and bases on which forecasts have been generated.

Changes in land use, planning as envisaged in Development Plan 2032 and socio-economic conditions could result in a substantially different situation than those presented at the stated effective date.

Annexure18.1: Government of Maharashtra G.R. Dated 30.01.2014

नागपूर मेट्रो रेल्वे प्रकल्पांतर्गत (१) ऑटोमोटीव्ह चौक ते मिहान व (२) प्रजापतीनगर ते लोकमान्यनगर या उन्नत मेट्रो मार्ग प्रकल्पास मान्यता देण्याबाबत.

महाराष्ट्र शासन

नगर विकास विभाग

शासन निर्णय क्रमांक : नासुप्र-३३१३/प्र.क्र.४१/नवि-७,
मंत्रालय, मुंबई ४०० ०३२.
दिनांक : ३० जानेवारी, २०१४.

संदर्भ : शासन निर्णय क्रमांक : एनआयटी-२२११/प्र.क्र.६४/नवि-७,
मंत्रालय, मुंबई ४०० ०३२, दिनांक २९ नोव्हेंबर, २०१२.

प्रस्तावना :

परिशिष्ट- ३

[I] नागपूर मेट्रो रेल्वे प्रकल्पासाठी निधी उभारण्यासाठी निश्चित करण्यात आलेले आर्थिकस्त्रोत -

(i) मेट्रो मार्गिकाच्या दोन्ही बाजूस ५०० मी. अंतरापर्यंत येणा-या जमीनीवर अधिमुल्य आकारुन ४ चटईक्षेत्र निर्देशांकाच्या मर्यादेत अतिरिक्त चटईक्षेत्र निर्देशांक (एफ.एस.आय.) देण्याची तरतूद विकास नियंत्रण नियमावलीत करुन त्यानुसार अधिमुल्याची रक्कम संबंधीत नियोजन प्राधिकरणाने वसूल करणे व त्यापैकी ५०% रक्कम पायाभूत सुविधांच्या सुधारणांसाठी स्वत:कडे ठेवून घेऊन उर्वरित ५०% रक्कम सदर प्रकल्पासाठी नियुक्त एसपीव्ही यांस देणे.

(ii) शासन अधिसूचित करेल असे महत्वपूर्ण नागरी वाहतूक प्रकल्प राबविण्यात येणाऱ्या शहरात महाराष्ट्र प्रादेशिक नियोजन व नगररचना अधिनियम, १९६६ च्या तरतूदीनुसार आकारण्यात येणारे विकास शुल्क १००% पर्यंत वाढ करून आकारण्याविषयी कायद्यात तरतूद करणे व त्यानुसार वसूल होणारी वाढीव रक्कम अशा प्रकल्पासाठी वापरणे.

(iii) शासन अधिसूचित करेल असे महत्वपूर्ण नागरी वाहतूक प्रकल्प राबविण्यात येणाऱ्या महानगरपालिका क्षेत्रात मुंबई मुद्रांक अधिनियम, १९५८ अन्वये स्थावर मालमत्तेचे अनुक्रमे विक्री, देणगी व फलोपभोग गहाण यावरील संलेखावर बसवायच्या मुद्रांक शुल्कासोबतच जमीनी व इतर स्थावर मालमत्तेचे विक्री किंवा देणगीच्या बाबतीत अशा रितीने स्थित असलेल्या मालमत्तेच्या मुल्यांवर व फलोपभोग गहाणाच्या संलेखाच्या बाबतीत संलेखात मांडण्यात आलेल्या संलेखाद्वारे सुरक्षित रक्कमेवर १% अधिभार लावण्याची तरतूद महाराष्ट्र महानगरपालिका अधिनियमात करुन अशा प्रत्यक्ष जमीनी व इतर स्थावर मालमत्तेचे अनुक्रमे विक्री, देणगी व फलोपभोग गहाण संलेखाच्या नोंदणीच्या वेळी सदर अधिभाराची रक्कम संबंधित जिल्हा उपनिबंधकांनी वसूल करणे व शासनाने यामाध्यमातून वसूल झालेल्या रक्कमेएवढे अनुदान संबंधित महानगरपालिका किंवा संबंधित महत्वपूर्ण नागरी वाहतूक प्रकल्पासाठी नियुक्त एसपीव्ही यांस देणे.

(iv) मेट्रो रेल्वे स्टेशन व कार डेपोंच्या जागेंचे व्यावसायिक वापरास परवानगी देणे व त्यानुसार विकसनाद्वारे प्राप्त होणारे उत्पन्न प्रस्तुत प्रकल्पासाठी वापरणे.

(v) मेट्रो रेल्वे स्टेशन येथील जाहिरात व पार्कींगपासून मिळणारे उत्पन्न सदर प्रकल्पासाठी वापरणे.

Chapter – 19

FINANCIAL ANALYSIS & NON FARE BOX REVENUE ASSESSMENT

19. FINANCIAL ANALYSIS &NON FARE BOX REVENUE ASSESSMENT

19.1. INPUT FOR THE ANALYSIS

19.1.1. Previous approvals

Ministry of Urban Development (MoUD) vide letter No. No. K-14011/1(N-1)/2014-MRTS-lll dated 21.8.2014 granted approval to the Nagpur Metro Rail Project with following main conditions:

A. The complete cost of land acquisition, resettlement and rehabilitation (including escalation) shall be met by the State Government. The State Government would ensure that land acquisition does not become reason for delay in implementation of the project.

B. Cost Escalation: Government of India support shall be ring fenced to 20% of the project cost. Any cost escalation due to changes in the statutory central duties/levies shall be shared equally between the project promoters. Any other cost escalation due to price escalation, exchange rate variation , and change in scope or avoidable delay within and beyond the approved time cycle as well as inclusion of essential items not reflected in DPR shall be entirely borne by the State Government. The state/local taxes shall be entirely waived/reimbursed by the State Government and will not be included in the project cost.

C. Taxes
   1. The State Government will either exempt the SPV from its State/local taxes and duties/levies or reimburse the same.
   2. The State/local taxes would not form part of the project cost to be shared by the Government of India.
   3. There will be no waiver of Central taxes/duties by the Government of India.

D. Repayment of Loan: In case of SPV not being able to repay the loan (as and when it becomes due), the responsibility for the same shall be borne by the State Government, and not by the Government of India.

E. The State Government is also advised to rework the DPR on realistic basis with adequate deliberation on the issues, if any, raised by various stakeholders before going ahead with implementation to ensure sustainability of the project.

F. Dedicated Urban Transport Fund: The State Government should set up a dedicated urban transport fund at the state level as well as at the city/metropolitan area level to create pool of resources for replacement of assets and providing operational subsidies, if any, not only for this project but other Urban Transport projects as well.

G. Land Use Densification: Land Use densification around the stations also needs to be done to increase the rider-ship and decrease the overall travel demand.

H. Periodic Fare Revision: A suitable arrangement, independent of the SPV formed to implement the Metro Rail project, shall be provided for periodic fare revision for the Metro Rail as well as other competing modes. A mutually agreed schedule for periodic revision of fares for the metro rail as well as other modes of transport will also be incorporated by the Ministry of Urban Development, Government of India in the Memorandum of Understanding to be signed with the State Government.

Nagpur Metro Rail Project (Phase -I) is approved by Government of Maharashtra Government Resolution No: NIT-3313/Letter No. -41/UD-7dated 30th January 2014 with following main approvals.

1. Approval is accorded to funding structure for raising fund wherein Central Government shall contribute 20% fund, State Government shall contribute 20% fund and Nagpur Municipal Corporation and Nagpur Improvement Trust shall contribute 5% each (thus total 10% jointly) and remaining 50% fund shall be raised from other sources for Nagpur Metro Rail Project.

2. Approval is accorded to transfer to “Nagpur Metro Railway Corporation Limited” i.e. the SPV Company, the Government lands required for this project at the prevailing rate and the cost of the Government land shall be included in the 20% contribution of State Government in the said Metro Railway Project.

3. Approval is accorded to the plan of financial sources of the said project as mentioned in Appendix-3. Similarly, approval is accorded to Nagpur Improvement Trust and Nagpur Municipal Corporation to keep the fund so received by them from the said sources in one separate “Urban Transport Fund” at their level and transfer that fund to S.P.V. Company formed for the said project to utilize that fund for making

payments in the form of financial aid to be given for the said project as well as for repayment of the loan of the project.

4. As the Nagpur Metro Railway Project is going to be implemented under the provisions of the Central Metro Act, in principal approval is accorded to the rate of passenger fare for the said Metro Railway Service as mentioned in the Appendix-4 enclosed herewith. Similarly, approval is accorded to empower the "Fare Fixation Committee" to be constituted under the provisions of the Central Metro Act, for revising the fare after certain period as per requirement.

5. Approval is accorded to declare the said project as essential public project and an important urban transport project.

19.1.2. Input for Analysis

The financial analysis has been carried out combined for all extensions of Nagpur Metro Phase 2. Accordingly, the capital costs and O&M costs for all the Phase 2 corridors have been added to arrive at the total capital and O& M costs. The financial analysis considers the following:

- Ridership - The incremental ridership considering the difference of estimated daily trips on full network (Phase 1 & 2) to that of Phase 1 (taken from DPR, 2013). The ridership for the year 2024 has been derived by using extrapolation between the ridership of 2021 and 2031.
- Average Metro Passenger Trip Length has been taken as combined for Phase 1 and 2.
- Capital Cost has been considered for Phase 2 Corridors. However, rake requirement/ replacement has been considered for incremental travel demand on Phase 1 along with Phase 2 extension i.e., for full network.
- O&M Cost including staff, energy & maintenance requirements have been considered for incremental travel demand on Phase 1 along with Phase 2 extension i.e., for full network.

19.2. Capital Cost

The combined Construction cost of the Phase II Extension of Nagpur metro corridors at April 2018 prices is estimated at Rs. 7867 Crore. The Central, State GST and duties amount to Rs. 1227 Crore with Rs 662 Cr towards Central GST and basic Custom duties and Rs 565 Cr towards State GST. The cost of land including R&R is estimated at Rs. 229

Crore including Rs.168 Crore for private land and the cost of government land has been estimated at Rs 48 Crore. Land cost has been estimated on the basis of Circle Rates (Ready Recknor Rate of 2018). Cost of Private land required for acquisition has been worked out as per the Direct Purchase Method Policy of Govt. of Maharashtra.

The construction cost including and central taxes is estimated at Rs 8528Crore. The total cost of project including land & R&R and all taxes is estimated at Rs. 9322Crore. The capital cost components at April'18 prices are given in **Table 19.1.**

TABLE 19.1: CAPITAL COSTS (RS. IN CRORE)

S.No	Cost Component	Total
1	Construction Cost without Land & R&R	7867
2	Central GST and Basic Custom Duties	662
3	**Construction Cost without land & R&R but with Central GST**	**8528**
4	Land Cost & R&R	229
5	State GST	565
6	**Total Construction Cost with Land, R&R, central GST and State GST**	**9322**

19.2.1. Completion Cost

Escalation rate has been assumed @ 5%. It has been calculated on the basis of growth in Whole Sale Price index for last 12 years.

TABLE 19.2: ESTIMATION OF ESCALATION RATE

Financial Year	WPI Index
2016-17	183.2
2015-16	176.67
2014-15	181.19
2013-14	177.64
2012-13	167.62
2011-12	156.13
2010-11	143.32
2009-10	130.81
2008-09	126.02
2007-08	116.63
2006-07	111.35
2005-06	104.47
Growth over 12 years	**1.0479 ~1.05**

Source: Govt. of India, Ministry of Commerce & Industry

With escalation factor of 5% p.a., the Completion Cost of the project excluding land & R&R is estimated to be **Rs.9,490 Crore (Table 19.3)** and with central taxes it is estimated at **Rs 10288 Crore (Table 19.3).** The Completion cost of the project including land, R&R, Central Taxes and State Taxes is estimated at **Rs. 11,216 Crore.** It is proposed to start land acquisition prior to Year 2019 and complete the same by Year 2021. Land cost have been escalated to estimate land rates applicable at the time of transfer. The details of completion cost under different scenarios are as per **Table 19.3.**

TABLE 19.3: DETAILS OF COMPLETION COSTS (RS IN CRORE)

Completion Cost	Amount
Cost without taxes & Land & R&R	**9490**
Cost With Central Taxes and without Land & R&R	**10288**
Cost with all taxes and Land & R&R	**11216**

19.2.2. Phasing of Construction

Considering the lengths of MRTS network, it is expected that the construction of Phase II extension of Nagpur metro will take 5-6 years but the operation can start after 5 years. **Table 19.4** gives the % distribution of costs during the construction period based on typical construction schedule.

TABLE 19.4: % DISTRIBUTION OF COSTS DURING CONSTRUCTION

Year	% Distribution of Cost
2019-2020	5%
2020-2021	15%
2021-2022	20%
2022-2023	25%
2023-2024	25%
2024-2025	10%

19.2.3. Requirement of Funds

The year wise requirement of funds under different scenarios has been given in **Table 19.5** (Without any Taxes), in **Table 19.6** (With Central Taxes only) and **Table 19.7** (With Central and State Taxes). The cost of land is divided into two initial years during which it is expected that the land acquisition work would be over and related payments would be released.

TABLE 19.5: YEAR WISE FUND REQUIREMENTS WITHOUT TAXES (RS. IN CRORE)

Year	Completion Cost	Land &R&R Cost	Total Completion Cost
2019-2020	413	120	533
2020-2021	1,301	126	1,427
2021-2022	1,821		1,821
2022-2023	2,390		2,390

Year	Completion Cost	Land &R&R Cost	Total Completion Cost
2023-2024	2,510		2,510
2024-2025	1,054		1,054
Total	**9,490**	**246**	**9,736**

TABLE 19.6: YEAR WISE FUND REQUIREMENTS WITH CENTRAL TAXES WITHOUT LAND & R&R (RS IN CRORE)

Year	Completion Cost	Central Taxes	Total Completion Cost
2019-2020	413	35	448
2020-2021	1,301	109	1,410
2021-2022	1,821	153	1,975
2022-2023	2,390	201	2,592
2023-2024	2,510	211	2,721
2024-2025	1,054	89	1,143
Total	**9,490**	**798**	**10,288**

TABLE 19.7: YEAR WISE FUND REQUIREMENTS WITH ALL TAXES (RS IN CRORE)

Year	Completion Cost	Land & R&R Cost	Central Taxes	State Taxes	Total Completion Cost
2019-2020	413	120	35	30	598
2020-2021	1,301	126	109	93	1,630
2021-2022	1,821		153	131	2,105
2022-2023	2,390		201	172	2,763
2023-2024	2,510		211	180	2,901
2024-2025	1,054		89	76	1,219
Total	**9,490**	**246**	**798**	**682**	**11,216**

19.2.4. Operation & Maintenance Costs Estimates

➢ **Basis of O&M Cost Estimates**

The O&M Cost has three major components which include:

- Manpower Cost
- Energy Cost
- Maintenance Cost

The manpower cost and the maintenance expenses have been calculated considering the operating costs of DMRC and BMRCL projects for years 2007-2012 as mentioned in Operations and Maintenance report, November 2013, by Ministry of Urban Development.

The per km manpower deployment for DMRC and BMRCL projects is 35.3 per route km and 38.4 persons per route km respectively. For Nagpur Metro Phase 2 project, this has been considered as 35 persons per route km. The average salary of the staff is assumed to be 5.47 lakh per annum for the year 2018considering the revised pay scales of Maha-Metro. The maintenance expenses for the Nagpur Phase 2 project have been considered as Rs. 1.45 Cr/km. The energy cost has been calculated as per the train operation plan (explained in detail in Chapter 8).

The operations and maintenance expenses for DMRC has been considered as the basis for the estimations of the Nagpur Metro Phase 2 project. DMRC has the least operating cost per passenger journey as compared to the metros which are the member of NOVA/CoMET. As per the operating cost details of Delhi metro project for the year 2012, the staff cost is around 44% of the total O&M cost and energy cost is around 33% of the total O&M cost. The estimated staff and energy cost of the Nagpur Metro Phase 2 project for the year 2024 i.e. the inception year has been calculated as 51% and 18% respectively.

Several measures have been proposed for the Nagpur Metro Phase 2 project which will help in reduction of O&M cost. These include:

- Use of energy efficient LED lights in place of conventional lights.
- Installation of solar panels on the rooftops of all elevated stations and the sheds of the depot. The solar energy harnessing is proposed with RESCO model as adopted in various metro projects. Fixed tariff as per the power purchase agreement shall be applicable for a period of 20-25 years. This shall result in savings in energy cost due to use of solar energy.
- Preventive maintenance schedule as given in Maintenance depot chapter shall be followed so as to reduce the number of breakdowns. This will ensure the smooth operation of the trains.
- CBTC (Communication Based Train Control) Signalling system has been proposed which will enable the trains to operate with high frequency and improve the operational capability of the system.
- Outsourcing of various activities like ticketing, crowd control, housekeeping etc.

➢ **O&M Cost Estimates**

Based on above principles, O&M Cost for Nagpur Metro has been worked out. Corridor wise details of O&M cost are given in **Chapter 17**. The combined O&M cost for all the corridors is given in **Table 19.8**. The total O&M cost in the year **2024** is estimated at

Rs. 267 Crore. The total O&M cost in the year **2031** is estimated at **Rs. 438 Crore**. The Table also gives the requirement of Additional and Replacements costs as well.

To cater to increased traffic demand additional Rolling Stock would be required. Additional investment of **Rs.126 Crore** and **Rs.462 Crore** have been estimated in the Year **2031** and the year **2041** respectively. The replacement cost for the corridors is estimated to be **Rs. 2639 Crore** in the year **2044**.

TABLE 19.8: OPERATION AND MAINTENANCE COSTS (RS IN CRORE)

Year	Staff Cost	Maintenance Expenses	Energy Charges	Total O&M Cost	Additional/ Replacement Cost
	Esc @9%	Esc @5%	Esc @5%		
2024	**135.95**	**82.23**	**49.19**	**267.37**	
2025	148.19	86.34	52.10	286.63	
2026	161.53	90.66	55.20	307.39	
2027	176.07	95.19	58.47	329.73	
2028	191.91	99.95	61.92	353.78	
2029	209.18	104.95	65.55	379.68	
2030	228.00	110.20	69.44	407.64	
2031	**248.52**	**115.71**	**73.52**	**437.75**	**126.44**
2032	270.89	121.50	78.73	471.12	
2033	295.27	127.58	84.22	507.07	
2034	321.84	133.96	90.08	545.88	
2035	350.81	140.66	96.32	587.79	
2036	382.38	147.69	102.94	633.01	
2037	416.80	155.07	110.04	681.91	
2038	454.31	162.82	117.55	734.68	
2039	495.20	170.97	125.57	791.74	
2040	539.77	179.52	134.11	853.40	
2041	**588.35**	**188.49**	**143.17**	**920.01**	**462.38**
2042	641.31	197.92	152.79	992.02	
2043	699.02	207.82	163.06	1069.90	
2044	761.93	218.21	173.93	1154.07	**2,638.64**
2045	830.50	229.13	185.47	1245.10	
2046	905.25	240.59	197.72	1343.56	
2047	986.72	252.62	210.79	1450.13	
2048	1075.53	265.25	224.59	1565.37	

19.3. MEANS OF FINANCE

The Revenue for Nagpur metro will mainly consists of fare box collection and revenue from other non-fare box sources such as property development, advertisement, parking, taxes etc. Estimation of revenue from fare box and non-fare box source has been made.

19.3.1. Fare Box Revenue

➢ **Projected Traffic Demand**

The ridership on the proposed Phase 2 extensions has been estimated considering the impact of Phase 2 Metro on the ridership on Phase 1 corridors. The travel demand has been estimated considering the incremental travel demand on Phase 1 along with Phase 2 extension i.e., for full network. It is estimated that the Phase 2 MRTS Corridors will cater to 2.89 Lakh passenger trips per day by the year 2024 when the system gets operational. The ridership figures for key horizon years are given in **Table 19.9**. After 2041, the traffic has been assumed to grow @ of 2% per annum.

TABLE 19.9: EXPECTED METRO RIDERSHIP IN HORIZON YEARS

Year	Passenger Trips per day (Lakh)
2024	2.89
2031	3.39
2041	4.08

➢ **Trip Length Distribution**

Average trip length on the Phase 2 corridors is 10.35 km. However, it includes the incremental effect of ridership on Phase-1 network. The trip length distribution is given in **Table 19.10.**

TABLE 19.10: TRIP LENGTH DISTRIBUTION

Distance Slab	2021	2031	2041
0-2	13.5%	12.3%	11.7%
2-4	16.4%	17.1%	17.1%
4-6	14.7%	15.1%	13.7%
06 – 09	12.8%	12.1%	12.2%
09 – 12	10.0%	9.8%	10.3%
12 – 15	8.0%	7.8%	8.1%
15 – 18	7.4%	7.4%	7.6%
18 – 21	3.3%	3.4%	3.9%
21 – 24	3.4%	3.3%	3.2%
24 – 27	2.6%	3.2%	3.4%
27 – 31	2.7%	2.6%	2.8%
31 – 35	2.1%	2.4%	2.6%
35 – 39	1.6%	1.7%	1.6%
39 – 44	0.9%	1.1%	1.1%
>44	0.4%	0.5%	0.5%

- **Fare Structure**

Government of Maharashtra vide its GR no.NIT-3313/CR41/UD-7 dated 30-01-2014 approved a fare structure for Nagpur metro for the year 2018-19. This fare structure was based on DMRC fare structure of 2009 **(Table 19.11**) with escalation of 15% every two years**.** The fare has been rounded off to nearest 5.

TABLE 19.11: FARE STRUCTURE - PH IINAGPUR METRO BASED ON GOVT OF MAHARASHTRAAPPROVED FARE

Fare Stage	Govt of Maharashtra approved fare for in 2018-19	Fare in 2024-2025
0-2	15	25
2-4	19	30
4-6	23	35
6-9	28	45
9-12	30	45
12-15	34	50
15-18	36	55
18-21	39	60
>21	41	65

DMRC revised its fare structure in 2017with revision @ 7% per year as proposed by DMRC Fare Fixation Committee 2016.DMRC fare in 2017-18and Nagpur metro fare for first year of operation in the year 2024-25 on the same basis is given in (**Table 19.12**). The fare has been rounded off to nearest 5.

TABLE 19.12: FARE STRUCTURE - PH IINAGPUR METRO BASED ON REVISED DMRC FARE

Fare slabs	DMRC Fare in 2017-18	NMRC Fare in 2024
0-2	10	15
2-5	20	30
5-12	30	50
12-21	40	65
21-32	50	80
>32	60	95

DMRC revised its fares in 2017 after a gap of 8 years. The increase is in fares is almost 7% per annum. Considering the fact that DMRC has been operating MRTS systems since 2002 and the current fares reflects the better picture of fares in relation to operational cost. In view of above, adoption of the revised fare structure of DMRC for Nagpur Metro Phase-II is recommended.

Table 19.13 gives the year wise fare structure for Nagpur metro in horizon years. **Table 19.14** shows year wise revenue generated from fare box.

TABLE19.13: FARE STRUCTURE FOR NAGPUR METROBASED ON REVISED DMRC FARES

Year		0-2	2-5	5-12	12-21	21-32	>32
2019	**2020**	11	23	34	46	57	69
2020	**2021**	12	25	36	49	61	74
2021	**2022**	13	27	39	52	65	79
2022	**2023**	14	29	42	56	70	85
2023	**2024**	15	31	45	60	75	91
2024	**2025**	16	33	48	64	80	97
2025	**2026**	17	35	51	68	86	104
2026	**2027**	18	37	55	73	92	111
2027	**2028**	19	40	59	78	98	119
2028	**2029**	20	43	63	83	105	127
2029	**2030**	21	46	67	89	112	136
2030	**2031**	22	49	72	95	120	146
2031	**2032**	24	52	77	102	128	156
2032	**2033**	26	56	82	109	137	167
2033	**2034**	28	60	88	117	147	179
2034	**2035**	30	64	94	125	157	192
2035	**2036**	32	68	101	134	168	205
2036	**2037**	34	73	108	143	180	219
2037	**2038**	36	78	116	153	193	234
2038	**2039**	39	83	124	164	207	250
2039	**2040**	42	89	133	175	221	268
2040	**2041**	45	95	142	187	236	287
2041	**2042**	48	102	152	200	253	307
2042	**2043**	51	109	163	214	271	328
2043	**2044**	55	117	174	229	290	351
2044	**2045**	59	125	186	245	310	376
2045	**2046**	63	134	199	262	332	402
2046	**2047**	67	143	213	280	355	430
2047	**2048**	72	153	228	300	380	460
2048	**2049**	77	164	244	321	407	492

TABLE 19.14: YEAR WISE REVENUE FROM FARE BOX (RS IN CRORE)

YEAR		0-2	2-5	5-12	12-21	21-32	>32	TOTAL
2024	**2025**	20	70	148	120	74	41	474
2025	**2026**	20	83	151	132	80	46	511
2026	**2027**	27	84	169	143	86	49	558

YEAR		0-2	2-5	5-12	12-21	21-32	>32	TOTAL
2027	2028	28	98	187	155	97	54	619
2028	2029	28	100	205	168	103	57	661
2029	2030	29	114	209	180	110	63	704
2030	2031	37	128	228	193	122	68	777
2031	2032	35	142	255	226	149	88	895
2032	2033	36	159	277	241	157	96	966
2033	2034	44	177	317	268	172	106	1085
2034	2035	45	195	341	284	187	114	1168
2035	2036	46	214	366	313	209	126	1274
2036	2037	54	234	392	342	226	138	1386
2037	2038	55	254	437	373	249	150	1519
2038	2039	65	275	484	404	267	162	1658
2039	2040	74	297	513	450	292	175	1801
2040	2041	75	320	563	484	318	192	1951
2041	2042	82	333	613	560	362	208	2159
2042	2043	83	374	667	613	391	226	2355
2043	2044	93	399	723	668	429	249	2561
2044	2045	104	442	803	725	467	272	2813
2045	2046	115	487	863	784	508	296	3052
2046	2047	126	534	948	860	557	324	3348
2047	2048	138	582	1036	938	608	354	3656
2048	2049	150	632	1127	1020	661	384	3974

19.3.2. Non Fare Box Revenue

Non-fare box revenue streams for Phase -I of Nagpur Metro Rail are already approved by Government of Maharashtra Government Resolution No: NIT-3313/Letter No. -41/UD-7 dated 30th January 2014. The identified sources of non- fare box revenue are enlisted in Appendix-3 of the said Govt of Maharashtra resolution contents of which are reproduced as under:

A. The revenue Sources finalized for raising fund for Nagpur Metro Railway Project

1. Recovery of premium amount by the Planning Authorities by incorporating provision in the Development Control Regulations for grant of additional Floor Space Index (FSI) to the extent of 4 upto 500m on the both sides of the metro corridor by charging premium and retaining 50% of the amount recovered with it for improvement of basic infrastructure facilities and remitting the remaining 50% amount to the appointed SPV.
2. Making provision in the Maharashtra Regional Town Planning Act 1966 to increase Development charge to the extent of 100% for important Urban

Transport Project in such cities and the additional amount recovered shall be utilized for such Project.

3. Provision in the Mumbai Stamp Duty Act 1958 shall be incorporated for the city notified by the Govt. Resolution for important Urban Transport Project shall be eligible to recover 1% surcharge on stamp duty for transaction on sale, donation, Mortgage of land and other immovable properties. The surcharge amount shall be recovered by the concerned district sub-registrar and through Govt. it shall be transferred to the respective Municipal Corporation or SPV appointed for the said Project.
4. Permission to be given for Metro Railway Station and Car depot land for Commercial use and the amount so generated shall be utilized for this Project.
5. The revenue generated from the advertisement and parking at stations shall be utilized for the said project.

B. Planning authorities shall deposit the revenue from the sources mentioned above into a separate account in the name of "Urban Transport Fund" at their level. This fund shall be transferred to SPV Company on a regular basis for funding of this project and refund of the loan raised for this project. In case of any shortage of "Urban Transport Fund" for project and repayment of loan, additional fund if any required shall be arranged by the Nagpur Improvement Trust and Nagpur Municipal Corporation from other sources.

Subsequent to the approval of Nagpur Metro Rail Project, Government of Maharashtra has taken following steps:

1. Amendment in MRTP act.

Amended section 124(B) MRTP Act, 1976in the year 2014 and inserted new sub section 2-1A as under

[(2-1A) In respect of the area under the jurisdiction of any Planning Authority or a New Town Development Authority under this Act, where State Government declares its intention to undertake one or more Vital Urban Transport Projects, the development charges levied and collected under the provisions of sub-section (2) shall be increased by one hundred per cent.

Explanation.—For the purpose of this section, the term "Vital Urban Transport Project" means a project related to Mass Rapid Transport System such as Metro Rail, Mono Rail Bus Rapid Transport System and includes Freeway, Sea link, Etc., in respect of which the State Government has by notification in the Official Gazette, declared the intention to undertake such project either on its *own behalf or through the Planning Authority, a New Town Development Authority, any other statutory authority, an agency owned and controlled by the Central Government or State Government, or a Government company incorporated under the provisions of the Companies Act, 2013 or any other law relating to companies for the time being in force.]*

2. Amendment in Municipal Corporation Act.

   Section 149(B) of Municipal Corporation Act in the year 2015 is as under:

   > [*149B. (1) Without prejudice to the provisions of section 149A, the stamp duty leviable under the Maharashtra Stamp Act, on the instruments of sale, gift and usufructuary mortgage, respectively, of immovable property shall, in the case of any such instrument relating to immovable property situated in the City in which one or more Vital Important Urban Transport Projects (hereinafter in this section referred to as ‘‘ City having notified projects ’’) and executed on or after such date as may be specified by the State Government, by notification in the Official Gazette, be increased by a surcharge at the rate of one per cent., in case of instrument of sale or gift, on the value of the property so situated and in case of an instrument of usufructuary mortgage, on the amount secured by the instrument as set forth in the instrument and shall be collected accordingly under the said Act.*
   >
   > *(2) For the purposes of this section, section 28 of the Maharashtra Stamp Act shall be read and enforced as if, it specifically requires the particulars therein referred to be set forth separately in respect of,— (a) the property situated in the City having notified projects ; and (b) the property situated in any other area.*
   >
   > *(3) The State Government shall, every year, after due appropriation made by law in this behalf, pay to the Corporation or the agency which has undertaken the notified project, a grant-in-aid approximately equal to the amount of additional duty realized on account of surcharge levied and collected under this section in respect of the immovable properties situated in the City having notified projects and such grant-in-aid shall be utilised on such notified projects in the manner specified by the Government.*]

   Vide GR No. MRD-3316/C.R.24/(2)/UD-7 dated 30th June 2016, the Government of Maharashtra declares the Metro Rail Project consisting two corridors (1) Automotive Square to MIHAN (North – South Corridor) and (2) Prajapati Nagar to Lokmanya Nagar (East – West Corridor) in Nagpur Metropolitan Region as “Vital Important

Urban Transport Project" for the purpose of Section 149B of the Maharashtra Municipal Corporation Act.

3. TOD Policy.

Vide GR No. TPS-2414/447/CR-248/2014/UD-9 dated 09th June 2017, Government of Maharashtra has issued special regulations for Development / Redevelopment of building falling within Nagpur Metro Rail Corridor (NMRC). The area falling within 500 mt. distance on either side of the Nagpur Metro Rail is subjected to maximum permissible FSI of 4.00 depending upon Road Width and Plot Area.(Annexure- 18.1)

The sources of non-fare box revenue identified for Nagpur Phase II Metro are divided into two heads:

1. Value Capture Finance (VCF) tools
2. Property Development
3. Other sources like Advertisement etc.

a) In view of above policy decisions taken by Government of Maharashtra regarding 1% additional stamp duty, development fund under MRTP act & premium from additional FSI in NMRC corridor, the same source of revenue are proposed for Phase II of Nagpur Metro Rail Project:

The assessment of revenue from VCF tools has been detailed in Chapter 18.

b) Property Development

Property Development has been considered as a source of revenue for Nagpur Metro Ph I. Maha Metro has carried out the study of property development for Nagpur Metro Phase-I through E&Y. The expected revenue from the property development of Phase I will accrue to Maha Metro by the time Phase II becomes operational. Accordingly, expected revenue from property development of Phase I has been assumed as a part of non-fare box revenue of Phase II. The results of the study giving the estimated revenue stream are reproduced below:

"Nagpur Metro, at present owns a total 17 land parcels, spread across the city along Ph I corridors. Overall revenue potential from Property Development has been estimated with a cumulative area of 428,201 sqm. **Figure 19.1** shows the identified land parcels and the details are presented in **Table 19.15**.

FIGURE 19.1: IDENTIFIED LAND PARCELS FOR PROPERTY DEVELOPMENT

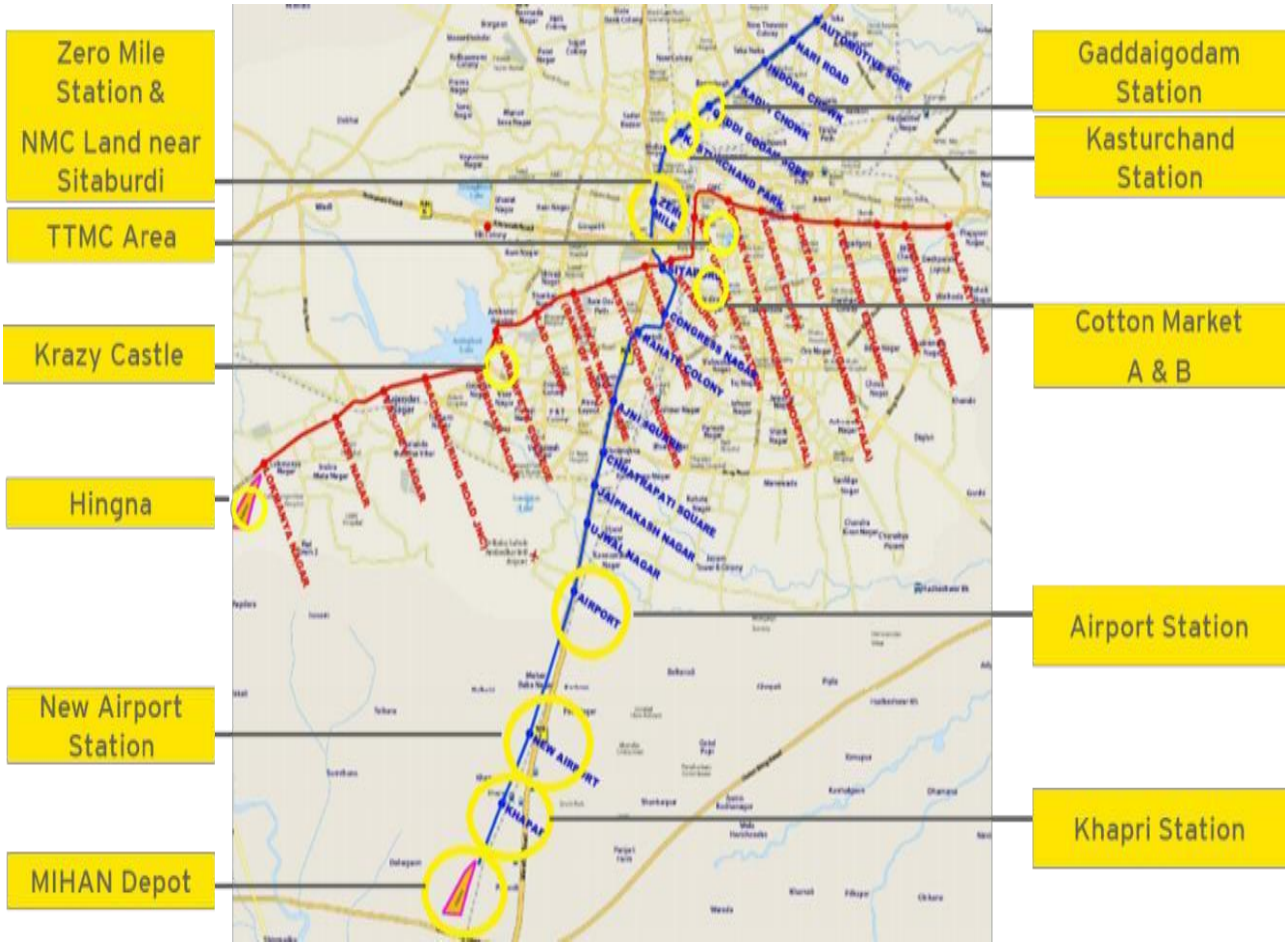


TABLE 19.15: IDENTIFIED LAND PARCELS FOR PROPERTY DEVELOPMENT

S. No.	*Land Parcel Location*	*Area (sq. M)*
1	*Zero Mile*	*12,829*
2	*NMC Land near Sitabuldi*	*6,189*
3	*Sitabuldi, TTMC*	*19,890*
4	*Kasturchand Park*	*7,220*
5	*Cotton Market A*	*70,425*
6	*Cotton Market B*	*5,177*
7	*Prajapati Nagar*	*1,875*
8	*Hingna*	*44,601*
9	*Krazy Castle*	*26,193*
10	*Gaddi Godam*	*3,644*
11	*Ajni (Neeri)*	*70,425*
12	*Ujjwal Nagar*	*6,570*
13	*Jaiprakash Nagar*	*68,085*
14	*Old Airport*	*2,899*
15	*New Airport*	*305*
16	*Khapri (MIHAN City)*	*937*
17	*Metro Depot (MIHAN Depot)*	*80,937*
	Total	***428,201***

The overall development suitability of each site has been examined with respect to its location setting, land use pattern and catchment potential. The revenue estimation has been strictly based on the prevailing Annual Statement of Rates applicable to NIT to arrive at a base revenue expectation. The rates do not capture the overall market sensitivity which could be on a higher side even upto a range of upto 15-20% over and above the base prevailing ASR.

*The available and potential Built up Area (BUA) has been computed at each site on the basis of applicable DCR norms. An indicative site development suitability has been worked out, in order to comprehend the 1) development timeframe; 2) development phasing; and 3) phasing pattern, in terms of number of phases. The areas and development phasing of all identified land parcels is presented in **Table 19.16**. **Table 19.17** shows the likely revenue estimation from the identified land parcels over a horizon period of next 25-30 years.*

TABLE 19.16: IDENTIFIED LAND PARCELS FOR PROPERTY DEVELOPMENT

Land Parcel	Area (sqm)	FSI	BUA (sqm)	Phasing Pattern	Development Timeframe	Phasing Strategy	Phase 1	Phase 2	Phase 3	Phase 4
Zero Mile	12829	4	51312	2	Immediate	Gradual	2020	2026		
NMC Land near Sitabuldi	6189	4	24756	1	Mid Term	NA	2029			
Sitabuldi, TTMC	19890	4	79560	2	Immediate	Gradual	2020	2026		
Kasturchand Park	7220	4	28880	1	Immediate	NA	2026			
Cotton Market A	70425	4	281699	4	Long term	Aggressive	2035	2041	2047	2050
Cotton Market B	5177	4	20709	1	Mid term	NA	2029			
Prajapati Nagar	1875	1	1875	1	Long Term	NA	2035			
Hingna	44601	1	44601	3	Mid Term	Aggressive	2029	2033	2036	2039
Krazy Castle	26193			NA	NA	NA				
Gaddi Godam	3644	4	14576	1	Long Term	NA	2032			
Ajni (Neeri)	70425	4	281699	4	Mid Term	Gradual	2021	2031	2041	
Ujjwal Nagar	6570	1	6570	1	Long Term	NA	2035			
Jaiprakash Nagar	68085	1	68085	4	Long Term	Gradual	2031	2034	2037	
Old Airport	2899	1	2899	1	Mid Term	NA	2030			
New Airport	305	1	305	1	Mid Term	NA	2030			
Khapri (MIHAN City)	937	1	937	1	Mid Term	NA	2030			
Metro Depot (MIHAN Depot)	80937	4	299467	4	Immediate	Aggressive	2023	2027	2030	
Total Area	428,201		674538							

TABLE 19.17: ESTIMATED REVENUE FROM PROPERTY DEVELOPMENT

Year	Land area (as per Phasing Plan)	Potential Revenue (INR Crore)
2020	16360	372.88
2021	0	0
2022	0	0
2023	26979	129.12
2024	0	0
2025	0	0

Year	Land area (as per Phasing Plan)	Potential Revenue (INR Crore)
2026	23580	601.03
2027	26979	156.95
2028	0	0
2029	22516	265.05
2030	31120	232.94
2031	22695	342.36
2032	3644	75.76
2033	11150	86.93
2034	22695	396.32
2035	0	559.23
2036	11150	100.63
2037	22695	458.79
2038	0	0
2039	11150	116.49
2040	0	0
2041	17606	567.82
2042	0	0
2043	0	0
2044	17606	657.32
2045	0	0
2046	0	0
2047	17606	760.93
Total	**305531**	**5881**

The development suitability has been analysed purely on the basis of site context. The overall market absorption trend for the horizon period has not been considered in totality. Hence the results indicate the potential of the land irrespective of forecasted market appetite. The actual expected sale ability shall depend on the market demand supply dynamics at any given point of time".

The other sources of Non-fare box revenue considered for Nagpur Metro Ph II are:

- Advertisement a) in stations, b) inside trains and c) external train wrap , other prospective areas of advertisements are assumed @ 10% of the total advertisement revenue;
- Parking charges for 4 wheeler vehicles at stations;

- Film shooting Charges
- Telecom cable & Tower license fee
- Rental from Kiosks inside the stations
- Semi-Naming Rights of Station building

Advertising is proposed at following locations with areas as mentioned in **Table 19.18.**

TABLE 19.18: ADVERTISING AREA

S. No.	Place of Advertisement	Area of Advertising (in Sqm)
1	Elevated Stations Advt. (35 Stations)	14,300
2	10% Extra Advertisement for rest of Advt. possibilities (i.e. total advertisement revenues including Train Rap revenues)	

The assumptions of unit rates and rates of increase are tabulated in **Table 19.19.** The basis for assumption of rates is detailed as under:

- For advertisement rates, comparative analysis of advertisement rates of metro in 3 Tier I cities viz. Kolkata, Hyderabad and Chennai has been done. The prevailing rates of advertisement in these cities are found as Rs. 2500/ sq.m, Rs. 3000/ sq.m and Rs. 4000/ sq.m respectively. Since Nagpur is Tier II city, the minimum rates among all three i.e. Rs. 2500/ sq.m has been assumed as advertisement rates.

TABLE 19.19: ASSUMPTIONS OF RATES FOR NON FARE BOX REVENUES

Type of Revenue	Unit Rate (Rs)	Rate of Increase (%)
Advertising panels inside stations and train coach	2500 per sqm per month	5% every year
Advertisement on external train wrap	Rs. 3.3 lakh/coach/month	5% every year
Parking charges at stations	Average of 4 hrs. @ rate for 3-6 Hrs i.e. Rs. 20/- & 8 hrs for 6-12 Hrs i.e. Rs. 30/- Plus 20% for time slots and vehicle variations	15% every 3 years
Film shooting charges	Rs. 2 Lakh/ hour for inside Train/Station assumed for 8 hrs and once in 8 months i.e. 12 hrs in a year	5% every year
Telecom cable license fee	2000 per month for entire track length	10% every 2 year
Telecom Tower license fee	15000 per month for elevated stations	10% every 2 year
Kiosk rentals	700 per sqm per month	5% every year
Semi Naming Rights of Station Building	1.5 Crore per year per station	25% every 5 years

- The train wrapping price varies from Rs 25 lakh/ month per 6-8 coach train In Delhi. The rate varies from route to route also. In Mumbai and Chennai metro, the rate varies from Rs 14 - 15 Lakh /train/ month. An average of Rs 3.3 Lakh/ coach/ month has been assumed for Nagpur Metro.

- The rates assumed for parking charges, film shooting charges, telecom cable and tower license fee have been taken as 20% discounted rates from the prevailing rates of Chennai Metro.

- For estimating revenue from leasing out rental space of kiosks inside the stations, prevailing rates of Jaipur Metro i.e. Rs. 700 per sqm per month have been taken considering Jaipur and Nagpur are comparable cities.

- For estimating revenue from semi-naming rights of station building, prevailing rates of Rapid Metro Gurgaon have been taken. The rates of semi-naming rights of stations in Rapid Metro vary from Rs. 1.5 Crore - 5 Crore per year per station. Being on lower side, the figure of Rs. 1.5 Crore per year per station has been assumed for Nagpur Metro.

Based on above parameters, revenue estimation from other sources of non fare box revenue has been made. For revenue projection, 5% annual escalation has been taken. The summary of non-fare revenue under the heads of advertisement receipts, rentals from Kiosks, parking receipts, Film Shooting, Telecom Cable & Tower (License fees) and semi-naming rights of stations is presented in **Table 19.20.**

TABLE 19.20: ESTIMATION OF NON FARE BOX REVENUE FROM OTHER SOURCES

Revenue Stream	Total Revenue (Rs. in Crore)			
	2024-25	2031-32	2041-42	2048-49
Advertisement Receipts	92.9	140.1	257.3	359.5
Rentals from Kiosks	3.2	4.4	7.2	10.2
Parking Receipts	5.1	7.1	11.6	16.4
Film Shooting	0.3	0.5	0.7	1.0
Telecom Cable & Tower (License fees)	1.0	1.4	2.3	3.2
Semi-Naming Rights of Stations	70.4	99.0	161.3	226.9
Total	**172.8**	**252.5**	**440.5**	**617.2**

As revenue from VCF tools is expected to be shared for other infrastructure projects, it is expected that among VCF tools, 50% of the revenue earned from sale of additional FSI and 100% of revenue from cess on stamp duty and development charge will come to Nagpur metro. Revenue from other sources such as advertisement, parking etc., all 100% has been assumed to accrue to Nagpur metro.

Year wise revenue from all the sources of non-fare box revenue from year 2024 - 2048 is shown in **Table 19.21.**

TABLE 19.21: ESTIMATION OF NON FARE BOX REVENUE (2024-48)

Year	Revenue (Rs. In Crore)						
	VCF (TOD)				Property Development Phase-I	Other Sources	Grand Total
	Premium on Additional FSI	Cess on Stamp Duty in NMA	Development Charge	Total			
2024-25	4.20	20.33	0.83	25.36	0	172.80	198.16
2025-26	5.48	21.35	1.08	27.91	0	181.45	209.36
2026-27	5.76	22.41	1.14	29.31	601.03	190.52	820.86
2027-28	6.05	23.53	1.20	30.78	156.95	200.04	387.77
2028-29	6.36	24.71	1.26	32.32	0	210.05	242.37
2029-30	6.69	25.95	1.32	33.95	265.05	220.55	519.55
2030-31	7.03	27.24	1.39	35.66	232.94	231.58	500.18
2031-32	7.40	28.61	1.46	37.46	342.36	252.52	632.34
2032-33	6.34	30.04	1.26	37.64	75.76	265.14	378.54
2033-34	6.61	31.54	1.31	39.46	86.93	278.40	404.79
2034-35	6.90	33.11	1.37	41.39	396.32	292.32	730.03
2035-36	7.20	34.77	1.43	43.40	559.23	301.21	903.84
2036-37	7.51	36.51	1.49	45.51	100.63	316.27	462.41
2037-38	7.84	38.33	1.56	47.73	458.79	332.08	838.60
2038-39	8.18	40.25	1.62	50.05	0	348.69	398.74
2039-40	8.53	42.26	1.70	52.49	116.49	366.12	535.10
2040-41	8.90	44.38	1.77	55.05	0	384.43	439.48
2041-42	9.29	46.60	1.85	57.73	567.82	440.46	1066.01
2042-43	9.75	48.93	1.94	60.61	0	462.48	523.09
2043-44	10.18	51.37	2.02	63.58	0	485.61	549.19
2044-45	10.63	53.94	2.11	66.68	657.32	509.89	1233.89
2045-46	11.10	56.64	2.21	69.94	0	533.14	603.08
2046-47	11.59	59.47	2.30	73.36	0	559.80	633.16
2047-48	12.10	62.44	2.40	76.95	760.93	587.79	1425.67
2048-49	12.64	65.57	2.51	80.71	0	617.18	697.89

19.3.3. Total Revenue

The total annual revenue through the fare box and other sources for the study corridors is given in **Table 19.22.**

TABLE 19.22: TOTAL REVENUE COLLECTION (RS. IN CRORE) - DMRC REVISED FARES

Source of Revenue	2024	2031	2041
Fare Box Revenue	474	895	2159
Non Fare Box Revenue	198	632	1066
Total Revenue	**672**	**1527**	**3225**

19.4. OPERATIONAL VIABILITY/FINANCIAL INTERNAL RATE OF RETURN (FIRR)

The FIRR for the project with capital costs including all taxes and revenue from fare box and non-fare box sources works out to be **7.72%** and FIRR with capital cost including central taxes is **8.21%** is presented in **Table 19.24** and **Table 19.25.**

19.5. SENSITIVITY ANALYSIS

The FIRR of the project is sensitive to revenues, and capital costs. The sensitivity of the project FIRR with all taxes cost with respect to above capital cost and ridership is given in **Table 19.23.** It can be seen that the project FIRR is more sensitive to ridership variations than to variations in costs.

TABLE 19.23: PROJECT FIRR SENSITIVITY W.R.T COST AND RIDERSHIP

Parameter	+5%	+10%	-5%	-10%
Capital Cost	7.35	7.00	8.12	8.55
Ridership	8.13	8.51	7.31	6.86

TABLE 19.24: NAGPUR MRTSFIRR BASED ON DMRC REVISED FARES- COST WITH ALL TAXES (RS. IN CRORE)

Year	Project Construction Costs					Project Revenues								Project O&M Costs		Operational
								TOD								
	Completion Cost	Land Cost	Central Taxes	State taxes	Total Cost	Fare Box	Advertisement	Premium on Addl FSI	Cess on Stamp Duty	Development Charges	Total TOD Rev	PD Revenue-Ph-I	Gross Revenue	O&M Cost	Addl Capital	Surplus
2019-2020	413	120	35	30	598	0	0						0			-598
2020-2021	1301	126	109	93	1630	0	0						0			-1630
2021-2022	1821		153	131	2105	0	0						0			-2105
2022-2023	2390		201	172	2763	0	0						0			-2763
2023-2024	2510		211	180	2901	0	0									-2901
2024-2025	1054		89	76	1219	474	173	10	20	3	33	0	680	267	0	-806
2025-2026						511	181	13	21	3	38	0	731	287	0	444
2026-2027						558	191	14	22	4	40	601	1390	307	0	1083
2027-2028						619	200	15	24	4	42	157	1018	330	0	688
2028-2029						661	210	16	25	4	44	0	916	354	0	562
2029-2030						704	221	19	26	5	49	265	1239	380	0	859
2030-2031						777	232	20	27	5	52	233	1293	408	0	885
2031-2032						895	253	21	29	5	54	342	1544	438	126	980
2032-2033						966	265	17	30	4	51	76	1358	471	0	887
2033-2034						1085	278	18	32	4	54	87	1504	507	0	997
2034-2035						1168	292	20	33	5	57	396	1914	546	0	1368
2035-2036						1274	301	21	35	5	60	559	2195	588	0	1607
2036-2037						1386	316	21	37	5	63	101	1866	633	0	1233
2037-2038						1519	332	22	38	5	66	459	2376	682	0	1694
2038-2039						1658	349	23	40	5	69	0	2076	735	0	1341

Year	Project Construction Costs					Project Revenues								Project O&M Costs		Operational
								TOD								
	Completion Cost	Land Cost	Central Taxes	State taxes	Total Cost	Fare Box	Advertisement	Premium on Addl FSI	Cess on Stamp Duty	Development Charges	Total TOD Rev	PD Revenue-Ph-I	Gross Revenue	O&M Cost	Addl Capital	Surplus
2039-2040						1801	366	25	42	5	73	116	2357	792	0	1565
2040-2041						1951	384	27	44	6	77	0	2413	853	0	1559
2041-2042						2159	440	28	47	6	80	568	3247	920	462	1865
2042-2043						2355	462	29	49	6	84	0	2902	992	0	1910
2043-2044						2561	486	30	51	7	88	0	3134	1070	0	2064
2044-2045						2813	510	31	54	7	91	657	4071	1154	2639	278
2045-2046						3052	533	32	57	7	95	0	3680	1245	0	2435
2046-2047						3348	560	33	59	7	100	0	4008	1344	0	2665
2047-2048						3656	588	35	62	8	105	761	5109	1450	0	3659
2048-2049						3974	617	37	66	8	110	0	4701	1565	0	3136
Total	**9490**	**246**	**798**	**682**	**11216**	**41925**	**8740**	**576**	**970**	**131**	**1677**	**5379**	**57721**	**18317**	**3227**	**24961**
															IRR	**7.72%**

TABLE 19.25: NAGPUR MRTSFIRR BASED ON DMRC REVISED FARES- COST WITH CENTRAL TAXES (RS. IN CRORE)

Year	Project Construction Costs				Project Revenues								Project O&M Costs		Operational
							TOD								
	Completion Cost	Land Cost	Central Taxes	Total Cost	Fare Box	Advertisement	Premium on Addl FSI	Cess on Stamp Duty	Development Charges	Total TOD Rev	PD Revenue-Ph-I	Gross Revenue	O&M Cost	Addl Capital	Surplus
2019-2020	413	120	35	568	0	0						0			-568
2020-2021	1301	126	109	1537	0	0						0			-1537
2021-2022	1821		153	1975	0	0						0			-1975
2022-2023	2390		201	2592	0	0						0			-2592
2023-2024	2510		211	2721	0	0									-2721
2024-2025	1054		89	1143	474	173	10	20	3	33	0	680	267	0	-731
2025-2026					511	181	13	21	3	38	0	731	287	0	444
2026-2027					558	191	14	22	4	40	601	1390	307	0	1083
2027-2028					619	200	15	24	4	42	157	1018	330	0	688
2028-2029					661	210	16	25	4	44	0	916	354	0	562
2029-2030					704	221	19	26	5	49	265	1239	380	0	859
2030-2031					777	232	20	27	5	52	233	1293	408	0	885
2031-2032					895	253	21	29	5	54	342	1544	438	126	980
2032-2033					966	265	17	30	4	51	76	1358	471	0	887
2033-2034					1085	278	18	32	4	54	87	1504	507	0	997
2034-2035					1168	292	20	33	5	57	396	1914	546	0	1368
2035-2036					1274	301	21	35	5	60	559	2195	588	0	1607
2036-2037					1386	316	21	37	5	63	101	1866	633	0	1233
2037-2038					1519	332	22	38	5	66	459	2376	682	0	1694

Year	Project Construction Costs				Project Revenues								Project O&M Costs		Operational
							TOD								
	Completion Cost	Land Cost	Central Taxes	Total Cost	Fare Box	Advertisement	Premium on Addl FSI	Cess on Stamp Duty	Development Charges	Total TOD Rev	PD Revenue-Ph-I	Gross Revenue	O&M Cost	Addl Capital	Surplus
2038-2039					1658	349	23	40	5	69	0	2076	735	0	1341
2039-2040					1801	366	25	42	5	73	116	2357	792	0	1565
2040-2041					1951	384	27	44	6	77	0	2413	853	0	1559
2041-2042					2159	440	28	47	6	80	568	3247	920	462	1865
2042-2043					2355	462	29	49	6	84	0	2902	992	0	1910
2043-2044					2561	486	30	51	7	88	0	3134	1070	0	2064
2044-2045					2813	510	31	54	7	91	657	4071	1154	2639	278
2045-2046					3052	533	32	57	7	95	0	3680	1245	0	2435
2046-2047					3348	560	33	59	7	100	0	4008	1344	0	2665
2047-2048					3656	588	35	62	8	105	761	5109	1450	0	3659
2048-2049					3974	617	37	66	8	110	0	4701	1565	0	3136
Total	**9490**	**246**	**798**	**10535**	**41925**	**8740**	**576**	**970**	**131**	**1677**	**5379**	**57721**	**18317**	**3227**	**25642**
														IRR	**8.21%**

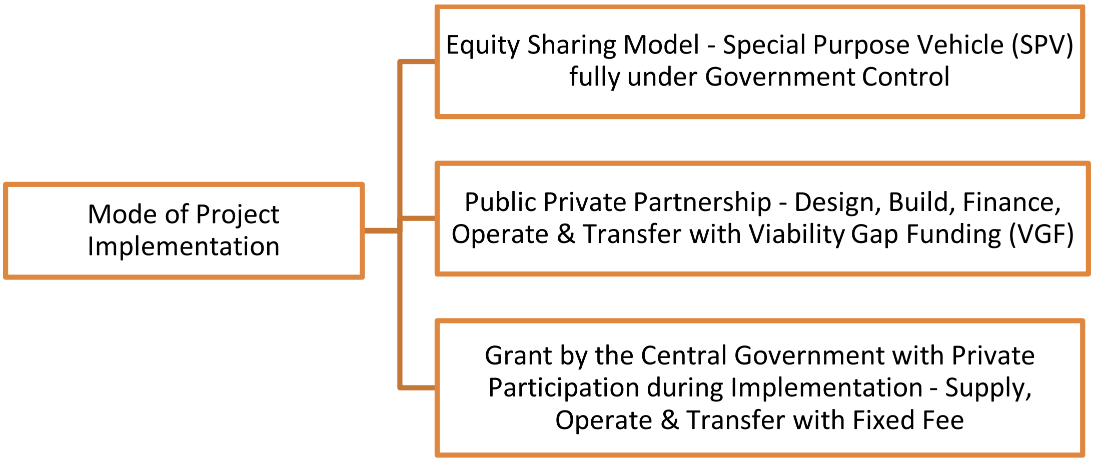
19.6. ALTERNATE MEANS OF FINANCING

The financing option for metro implementation depends upon selection of the dedicated agency created to implement the project. As per Metro Rail Policy '2017, the prominent models are:

- Equity Sharing Model- Special Purpose Vehicle (SPV) fully under Government Control
- Public Private Partnership (PPP)
- Grant by the Central Government

Figure 19.2 presents the implementation models graphically.

FIGURE 19.2: MODEL OF IMPLEMENTATION OF MRTS PROJECTS



19.6.1. Equity Sharing Model (SPV Model)

Under this model, a Special Purpose Vehicle (SPV) is set up as a joint venture between Central Government and State Government for the implementation of the project and for its subsequent Operation & Maintenance. Under this arrangement Government of India and State Government make equal equity contribution and run SPV as a commercial enterprise. As per the prevalent practice, Central Government contribute 20% of the project cost as their equity contribution. An equal amount can be contributed by State Government aggregating the total equity to 40%. Remaining 60% is arranged as soft loan from funding agencies. Delhi Metro Rail Corporation, Bangalore Metro Rail Corporation, Chennai Metro Rail Corporation & Kolkata Metro Rail Corporation are some of the examples of success of such a SPV. Under implementation Nagpur metro Phase-I has also been planned on Equity Sharing Model only.

19.6.2. Public Private Partnership

As per Metro Rail Policy 2017, it is essential to explore private participation either for complete provisioning of metro rail or for some unbundled components of operations and maintenance costs of metro rail.

The fundamental principle underlying Public Private Partnerships (PPP's) as a development option for any infrastructure project is to combine the strengths of the private sector with those of the public sector in order to overcome challenges faced during construction & operation and to achieve better outcomes. The private sector can be expected to contribute to efficiency gains in the development of land, construction, operations and maintenance through the use of technology, better management and construction practices. In addition, the private sector should be expected to bring economies of scale from large projects and by involving a larger number of private partners.

However, the success of PPP will depend critically on designing PPP structures that make an appropriate allocation of risks, responsibilities, rewards and penalties, and create the incentives for value creation. Indeed, this risk allocation is the defining feature of the PPP strategy. The golden principle is that risks should be allocated to the entity best equipped to manage each risk. The expectation is that such an allocation of risks will not only produce the best possible program and project outcomes but also optimize costs. This should lead to good quality outcomes at optimum prices.

19.6.3. Grant by Central Government

Under this option Central Government would fund 10% of the project completion cost excluding private investment Land, R&R and state taxes. Remaining costs are to be borne by state with Private sector participation. These models have been explored for implementation of Nagpur Metro Rail.

19.6.4. Case Studies of Private Sector Participation in MRTS in Indian Cities

Metro systems being planned in the cities of India have majorly adopted equity sharing model. Some of the cities have gone for private sector participation also. **Exhibit 19.1** to **Exhibit 19.4** give the examples of PPP in construction and operation of MRT system. Some of the metro companies have involved private sector in O&M also. **Exhibit 19.5** to **Exhibit 19.7** give the examples of PPP in some of the O&M activities.

The involvement of private sector in O&M activities in case of Nagpur Metro, can be finalized at the time of operation.

EXHIBIT 19.1 DELHI AIRPORT LINE UNDER PPP MODEL

DMRC has implemented a High Speed Airport Link from New Delhi Railway Station to IGI Airport and further extension to Sector-21, Dwarka covering a distance of 22.7 KM with private sector participation. The project with an estimated cost of Rs. 3869 Crore has been implemented under a unique model of PPP where in the DMRC has undertaken the civil works with the funds being contributed by GoI, GNCTD, Delhi International Airport Limited and DDA (54%) and the cost of systems and Rolling Stock (46%) is being met by the private operator who will operate the system for 30 years, after which the system will revert back to DMRC. The approved funding pattern of the line is depicted in ***Figure 19.3. There have been some issues with the concessionaire and DMRC is now operating the system.***

FIGURE 19.3: APPROVED FUNDING PATTERN OF DELHI AIRPORT LINE

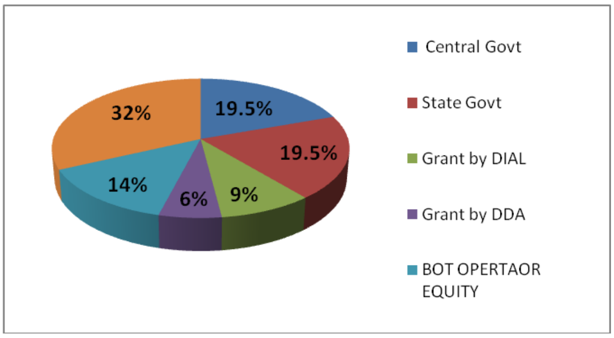


EXHIBIT 19.2 HYDERABAD METRO UNDER PPP MODEL

Hyderabad Metro is the first PPP Metro Rail Project that has been sanctioned by Government of India. GoAP has undertaken the Hyderabad Metro Rail Project under Viability Gap Funding (VGF) scheme of GoI. The MRTS network include three high density traffic corridors with total length of about 71 km. The Project is being executed by L&T on design, build, and finance, operate and transfer (DBFOT) basis. GoAP will spend another ₹ 1,980 Crore towards land acquisition, R&R package, shifting of utilities and GoI will support the project with grant of ₹ 1,458 Crore as VGF. ***Figure 19.4*** *gives the funding plan of Hyderabad metro.*

FIGURE 19.4: FUNDING PATTERN OF HYDERABAD METRO

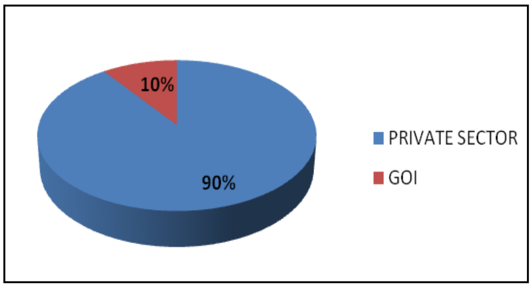


EXHIBIT 19.3 GURGAON METRO UNDER PPP MODEL

Gurgaon's Rapid Metro project is India's first fully privately financed metro. With the project cost of Rs 1100 Crore, it has a network of 5.1 km connecting Cyber City, NH-8 & Sikanderpur Station (DMRC) in Phase I. The planned route for Rapid Metro acts as a feeder to the MRC's Jahangirpuri-Central Secretariat-HUDA City Centre (Yellow Line). A special purpose vehicle (SPV), Rapid Metro Rail Gurgaon Limited (RMGL) was formed to construct, operate and maintain the metro.

EXHIBIT 19.4 MUMBAI METRO LINE 1 & 2 UNDER PPP MODEL

In contrast to the SPV model adopted for construction of metro rail system in the city of Delhi, Bangalore, Chennai & Kolkata, the Maharashtra government has opted Build Own, Operate & Transfer (BOOT) model in the city of Mumbai.

So far, 2 lines covering a distance of 44 KMs (Line 1 of 11.07 KMs from Versova – Andheri - Ghatkopar with a total cost of Rs. 2356 Crore and Line 2 of 32 KMs from Charkop – Bandra – Mankurd with an estimated cost of Rs. 8250 Crore) have been awarded to private operator for construction and operation by giving Viability Gap Funding by GoI& Maharashtra State Government to the extent of Rs. 650 Crore and Rs. 1532 Crore for Line 1 & Line 2 respectively.

Mumbai Metro One Private Limited is a Joint Venture Company formed by Reliance Energy Limited, a Reliance ADA Group Company, Veolia Transport, France and Mumbai Metropolitan Region Development Authority (MMRDA) incorporated under the Companies Act, 1956 to implement this project. ***Figure 19.5*** *gives the funding pattern of Mumbai Metro Line 1. Line 1 is now operational. There are some issues with the concessionaire and the implementation mechanism for Line 2 is being revisited.*

FIGURE 19.5: FUNDING PATTERN OF MUMBAI METRO LINE 1

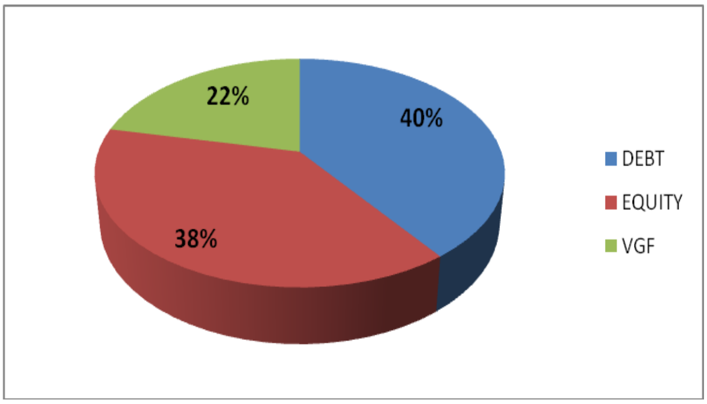


EXHIBIT 19.5 PPP IN O&M ACTIVITIES IN BANGALORE METRO

Bangalore Metro Rail Corporation Ltd (BMRCL) has signed a memorandum of understanding (MoU) with the Embassy Group to build the Kadubeesanahalli Metro station. Embassy Group will pay Rs 100 Crore to BMRCL in installments. The group is the first corporate to sign the agreement under the public-private partnership scheme. The station, to be located just outside the Embassy Tech Village on the Outer Ring Road, will be on the recently approved 17-km North-South Metro corridor linking Silk Board Junction with Krishnarajapuram.

The construction will be done in accordance with the façade designs and specifications approved by BMRCL. The period of concession and permission granted to Embassy Group will be for 30 years starting from the date of commencement of commercial operations and could be extended further on mutual terms. The agreement mandates that the group will maintain Kadubeesanahalli Metro station, including housekeeping and maintenance, along with all the equipment, according to specifications laid down by the corporation.

The partnership also means the group will be entitled to utilize the pre-determined spaces for advertisements. Embassy can also use the leasable retail space measuring approximately 3,000 sq. ft at the Metro station. Embassy will also have the advantage of leveraging the linear zone of 250 metres around the Kadubeesanahalli Metro station.

EXHIBIT 19.6 PPP IN O&M ACTIVITIES IN LUCKNOW METRO - AFC

LMRC has tied up with M/s HDFC Bank for Fare Collection System and Provision of Allied Banking Application for Phase I (21 stations of North South Corridor of the project). The Bank was offered two options for partnership
Option 1 – Annual royalty payable by bidder to LMRC (including provisions of TVMs and RCTMs)
Option 2 – Annual royalty payable by bidder to LMRC (excluding provisions of TVMs and RCTMs)
The Royalty Shall increase by 20% on completion of every 3 years on a compounding basis.
M/s HDFC Bank opted for Option 2 i.e. Annual Royalty payable by Bidder to LMRC (excluding provisions of TVMs and RCTMs). HDFC Bank pays Rs. 1000 as Annual Royalty under option 2 to LMRC. While opting for option 2, following cost is being incurred by HDFC Bank in discharging the obligation.
Annual Manpower Cost (including dress) – Rs. 101.17 Lakh
Annual Cash Management Charges – Rs. 53.4 Lakh
Annual Maintenance Charges – Rs. 3.00 Lakh
Total - Rs. 157.54 Lakh
The above cost will be increased by approx. 9% annually considering the inflation and other cost.

EXHIBIT 19.7 PPP IN O&M ACTIVITIES IN KOCHI METRO - AFC

Kochi Metro Rail Limited (KMRL) has signed a public-private partnership (PPP) act with Axis Bank for the automated fare collection (AFC) system. Under the agreement, investment for the entire funding required for the AFC system will be undertaken by Axis Bank, which will also maintain it for 10 years. The bank will pay a royalty of Rs 209 Crore over the next 10 years for the right to be KMRL's partner in this endeavor. In return, Axis Bank will get the right to issue co-branded cards, which will function as a smart card as well as a ticket, to the users of the metro. In addition to this, 0.2 per cent of Axis Bank's gross revenue, from the utilization of this card outside KMRL's ecosystem in various mercantile outlets and internet transactions, will also accrue to KMRL over the next 10 years.

The AFC system is a critical core component of any metro system. It includes complex hardware and software installed at entry points of metro stations as well as buses and boats. It uses radio frequency identification devices (RFID) to collect fares from the users. In such a system, the metro ticket can be in the form of a co-branded card or an NFC-enabled smart phone or a 'patch' on a mobile device or any other surface with NFC stickers or QR code, or even as a paper-coupon. The smart card can be linked with any bank account of the user, in any bank.

KMRL is planning a 'click and collect' system whereby the commuter will be able to order goods and services using this card, which can be delivered at all metro stations. It is also planning to start a drive for including a variety of local and national goods and services that can be accessed using the KMRL-Axis Bank co-branded card. In addition to the co-branded card, the bank will also develop a mobile app, which can be used for ticketing as well as e-commerce. This initiative is unique in that it is for the first time that 'open-loop' smart cards are being

19.6.5. Equity Sharing Model (SPV Model) for Nagpur Metro

Under this model, a Special Purpose Vehicle (SPV) will be set up as a joint venture between Central Government and Government of Maharashtra for the implementation of the project and for its subsequent Operation & Maintenance. As per the prevalent practice, Central Government contribute 20% of the project cost excluding land and state taxes as its equity contribution. An equal amount will be contributed by State Government aggregating the total equity to 40%. In addition to equity, Govt of Maharashtra will also fund the cost of land and state taxes. During Stake holder consultations, it was agreed that local bodies in the city would contribute towards funding of the metro in the city by giving land for the project free of cost. Remaining amount shall be arranged as soft loan from funding agencies.

Soft loan (ODA Loan) from three funding agencies namely JICA, AFD and KFW has been considered. **Table 19.26** gives the loan conditions of these agencies.

TABLE 19.26: LOAN CONDITIONS OF FUNDING AGENCIES

S.N	Agency	Loan period	Moratorium period	Interest rate	Commitment fee
1	JICA	30	10	0.3%	0.2% of loan to be paid in 1st year
2	KFW	20	5	1.25%+6 monthly Euribor	Nil
3	AFD	20	5	0.6%+6 monthly Euribor	

In case of KFW and AFD, the loan interest rate has fixed and floating components, Euribor rate is floating component in the interest rate. A positive Euribor rate gets added to the interest rate to determine final loan interest rate whereas negative Euribor has no effect on fixed rate of interest. 6 monthly Euribor rate has been negative since 2015.

The funding pattern developed under this model is placed in **Table 19.27, Table 19.28** and **Table 19.29.**

Equity Cash Flows (after repayment of Loan and excluding cost towards hedging of exchange rate risk) is placed at Annexure 1,2,3.

TABLE 19.27: FUNDING PATTERN UNDER EQUITY SHARING MODEL (PROJECT COST WITH CENTRAL TAXES) - JICA LOAN

Particulars	Amount (Rs in Cr)	% Share
Equity by GoI	1658	16.12%
Equity by GoM	1658	16.12%
SD for CT by GoI	399	3.88%
SD for CT by GoM	399	3.88%
Grant by MADC	194	1.88%
Soft Loans	5980	58.12%
Total	**10288**	**100%**
Grant by MIDC for Land and R&R	246	
Grant by MIDC towards State Taxes	315	
Grant by MADC towards State Taxes	367	
IDC by State Government for JICA Step Loan @0.1% &Front End Fee @0.2%	23	
Total Cost	**11239**	**-**

SD: Subordinate Debt, CT: Central Taxes, IDC: Interest During Construction

TABLE 19.28: FUNDING PATTERN UNDER EQUITY SHARING MODEL(PROJECT COST WITH CENTRAL TAXES) - KFW LOAN

Particulars	Amount (Rs in Cr)	% Share
Equity by GoI	1658	16.12%
Equity by GoM	1658	16.12%
SD for CT by GoI	399	3.88%
SD for CT by GoM	399	3.88%
Grant by MADC	194	1.88%
Soft Loans	5980	58.12%
Total	**10288**	**100%**
Grant by MIDC for Land and R&R	246	
Grant by MIDC towards State Taxes	315	
Grant by MADC towards State Taxes	367	
IDC for KFWODA Loan @1.25%	130	
Total Cost	**11239**	**-**

SD: Subordinate Debt, CT: Central Taxes, IDC: Interest During Construction

TABLE 19.29: FUNDING PATTERN UNDER EQUITY SHARING MODEL (PROJECT COST WITH CENTRAL TAXES) - AFD LOAN)

Particulars	Amount (Rs in Cr)	% Share
Equity by GoI	1658	16.12%
Equity by GoM	1658	16.12%
SD for CT by GoI	399	3.88%
SD for CT by GoM	399	3.88%
Grant by MADC	194	1.88%
Soft Loans	5980	58.12%
Total	**10288**	**100%**
Grant by MIDC for Land and R&R	246	
Grant by MIDC towards State Taxes	315	
Grant by MADC towards State Taxes	367	
IDC for AFD ODA Loan @0.6%	62	
Total Cost	**11278**	**-**

SD: Subordinate Debt, CT: Central Taxes, IDC: Interest During Construction

Total cost of the project is comparable in all the cases but JICA loan with lowest interest rate and higher moratorium period has lowest project cost. It is, therefore, recommended that soft loans may be procured from JICA.

19.6.6. Public Private Partnership in Nagpur Metro

In this model, the private firm may be responsible for designing, building, operating and maintaining of the entire project. Government of Maharashtra will bear the cost towards land including R&R and state taxes irrespective of the model of PPP. The metro rail being a social sector project not many private parties are available to bid for such a project. Besides quite expectedly the private operator may demand assured rate of return in the range of 16% to 18% or a comfort of guaranteed ridership.

The operation period by a private entity is considered as 30 years, Debt: Equity ratio for all financing by private entity is considered as 70:30, with long term cost of debt as 12% p.a. The Private Partner will develop the infrastructure with its own funds and funds raised from lenders at its risk (that is, it will provide all or the majority of the financing). Private Partner is also responsible for operating (supply and running of rolling stock) and managing the infrastructure life cycle (assuming life-cycle cost risks) for a specified number of years. To carry out these tasks, the Private Partner, will usually create an SPV.

The bid parameter in such projects is either Premium (as percentage of revenues) if the funds coming from users are sufficient to cover O&M expenses and long-term maintenance with a surplus that can then be used as a source to repay the financing of the construction of the asset, and where no Bidder is offering a Premium, bidding parameter is the Grant required (as per VGF scheme of Government of India which is at present is maximum of 20% of the project cost).The Grant/ Premium is computed for a target pre-tax equity IRR of private entity as 18%. Based on above, the funding pattern without additional income from PD is provided in **Table 19.30.** Equity Cash Flows to Concessionaire is provided in **Annexure 4.**

TABLE 19.30: FUNDING PATTERN UNDER PPP – BOT WITH VGF

Particulars	Amount (Rs in Cr)	% of Contribution
VGF by GoI	2058	20.00%
VGF by Govt. of Maharashtra	3107	30.20%
Equity by Concessionaire	1537	14.94%
Concessionaire's Debt @ 12% p.a.	3587	34.86%
Total	**10288**	100.00%
Land& R&R by Govt. of Maharashtra	246	
State Taxes by Govt. of Maharashtra	682	
Total Project Cost	**11216**	
IDC	924	
Total Cost including Funding Charges	**12140**	

VGF: Viability Gap funding, IDC: Interest during Construction

19.6.7. Grant by the Central Government – Supply of System and O&M by Private Party

Under this model, Government of Maharashtra will bear the cost towards land including R&R and state taxes. Central Government shall provide a grant of 10% and post-construction of civil assets by State Government, the Private Partner installs the system (signaling and electrical assets), procures rolling stock and operates and maintains all these assets. The State Government collects all the revenue and pays the Private Partner a monthly/ annual payment for operations and maintenance of the system. The remuneration given could comprise of a fixed fee and a variable component, which would depend on the quality of service provided and the fixed fee is computed for a target pre-tax equity IRR of private entity as 18% which will be financed through the revenue generated in the project. For our analysis, a fixed fee escalated at long-term WPI i.e. 4% p.a. is considered. Equity Cash Flows to Private Partner is provided in Annexure 5. Based on above, the funding pattern is provided in **Table 19.31.**

TABLE 19.31: FUNDING PATTERN UNDER GRANT BY CENTRAL GOVERNMENT MODEL

Particulars	Amount (Rs in Cr)	% of Contribution
Capital Contribution by GoI	1029	10.00%
Capital Contribution by Govt. of Maharashtra	6173	60.00%
Equity by Concessionaire	926	9.00%
Concessionaire's Debt @ 12% p.a.	2161	21.00%
Total	**10288**	100.00%
Land& R&R by Govt. of Maharashtra	246	
State Taxes by Govt. of Maharashtra	682	
Total Project Cost	**11216**	
IDC	502	
Total Cost including Funding Charges	**11718**	

VGF: Viability Gap funding, IDC: Interest during Construction

The total fund contribution of GoI & Govt of Maharashtra under various alternatives excluding land and state taxes is tabulated in **Table 19.32.**

It can be seen from the above table that the contribution of Governments under SPV model is less than that of VGF and Grant by Central Govtmodel. Moreover, under the VGF model, the entire revenues for the Concession Period are accruing to the Private Partner with no return on Government’s contribution. Accordingly, it is proposed that Nagpur Metro Phase-II project may be implemented on SPV Model with soft loans from JICA.

TABLE 19.32: COMPARISON OF THREE IMPLEMENTATION MODELS (RS. CRORE)

Particulars	Equity Sharing Model (SPV)	BOT (VGF) Model	Grant by Central Govt Model
Contribution by GoI	2058	2058	1029
Contribution by Govt of Maharashtra (excluding land & State Taxes)	2058	3107	6318
Sub-Total	**4115**	**5165**	**7347**
Land & State Taxes by Govt of Maharashtra	928	928	928
Total	**5043**	**6092**	**8274**
Present Value @8% of Operating Cash Flow to Public Entity (Revenue less Expenses)	8583	0	4651

However, as per new Metro Rail Policy 2017, it is essential to explore private participation either for complete provisioning of metro rail or for some unbundled components of operations and maintenance costs of metro rail. Accordingly, under SPV model for implementation of Nagpur Metro project following activities have been identified for private participation:

i. Private sector participation in Automatic Fare System by completely outsourcing operation of Ticket Operating Machines (TOMs), Ticket Vending Machines (TVMs) and Card Recharge Machines including Smart Cards provisions and Merchant Acquirer functions on similar lines as Lucknow Metro.

ii. Maintenance contracts with System suppliers for Rolling Stock and Signaling systems in place of in house maintenance.

iii. Station Civil and E&M maintenance and parking management.

iv. Exploring long term lease of Elevators at Metro Stations

ANNEXURE 1: EQUITY CASH FLOWS TO GOVERNMENT (PROJECT COST WITH CENTRAL TAXES) - JICA LOAN

Year			Construction Cost	Front End Fee	Net Revenue	Loan Opening Balance	Withdrawn	Interest	Principal Repayment	Interest Repayment	Closing Balance
2019	-	20	568	12	0	0	0	0	0	0	0
2020	-	21	1537	0	0	0	0	0	0	0	0
2021	-	22	1975	0	0	0	0	0	0	0	0
2022	-	23	2592	0	0	0	2309	1	0	0	2310
2023	-	24	2721	0	0	2310	2721	4	0	0	5035
2024	-	25	1143	0	412	5035	1143	6	0	0	6183
2025	-	26	0	0	444	6183	0	6	0	6	6183
2026	-	27	0	0	1083	6183	0	6	0	6	6183
2027	-	28	0	0	688	6183	0	6	0	6	6183
2028	-	29	0	0	562	6183	0	6	0	6	6183
2029	-	30	0	0	859	6183	0	6	309	6	5874
2030	-	31	0	0	885	5874	0	6	309	6	5565
2031	-	32	0	0	980	5565	0	5	309	5	5256
2032	-	33	0	0	887	5256	0	5	309	5	4947
2033	-	34	0	0	997	4947	0	5	309	5	4638
2034	-	35	0	0	1368	4638	0	4	309	4	4328
2035	-	36	0	0	1607	4328	0	4	309	4	4019
2036	-	37	0	0	1233	4019	0	4	309	4	3710
2037	-	38	0	0	1694	3710	0	4	309	4	3401
2038	-	39	0	0	1341	3401	0	3	309	3	3092

Year			Construction Cost	Front End Fee	Net Revenue	Loan Opening Balance	Withdrawn	Interest	Principal Repayment	Interest Repayment	Closing Balance
2039	**-**	**40**	0	0	1565	3092	0	3	309	3	2783
2040	**-**	**41**	0	0	1559	2783	0	3	309	3	2473
2041	**-**	**42**	0	0	1865	2473	0	2	309	2	2164
2042	**-**	**43**	0	0	1910	2164	0	2	309	2	1855
2043	**-**	**44**	0	0	2064	1855	0	2	309	2	1546
2044	**-**	**45**	0	0	278	1546	0	1	309	1	1237
2045	**-**	**46**	0	0	2435	1237	0	1	309	1	928
2046	**-**	**47**	0	0	2665	928	0	1	309	1	618
2047	**-**	**48**	0	0	3659	618	0	0	309	0	309
2048	**-**	**49**	0	0	3136	309	0	0	309	0	0
Total			**10535**	**12**	**36177**		**6173**	**97**		**87**	

ANNEXURE 2: EQUITY CASH FLOWS TO GOVERNMENT (PROJECT COST WITH CENTRAL TAXES) - AFD LOAN

Year			Construction Cost	Front End Fee	Net Revenue	Loan Opening Balance	Withdrawn	Interest	Principal Repayment	Interest Repayment	Closing Balance
2019	-	20	568	0	0	0	0	0	0	0	0
2020	-	21	1537	0	0	0	0	0	0	0	0
2021	-	22	1975	0	0	0	0	0	0	0	0
2022	-	23	2592	0	0	0	2309	7	0	0	2316
2023	-	24	2721	0	0	2316	2721	22	0	0	5059
2024	-	25	1143	0	412	5059	1143	33	390	0	5845
2025	-	26	0	0	444	5845	0	34	390	34	5455
2026	-	27	0	0	1083	5455	0	32	390	32	5066
2027	-	28	0	0	688	5066	0	29	390	29	4676
2028	-	29	0	0	562	4676	0	27	390	27	4286
2029	-	30	0	0	859	4286	0	25	390	25	3897
2030	-	31	0	0	885	3897	0	22	390	22	3507
2031	-	32	0	0	980	3507	0	20	390	20	3117
2032	-	33	0	0	887	3117	0	18	390	18	2728
2033	-	34	0	0	997	2728	0	15	390	15	2338
2034	-	35	0	0	1368	2338	0	13	390	13	1948
2035	-	36	0	0	1607	1948	0	11	390	11	1559
2036	-	37	0	0	1233	1559	0	8	390	8	1169
2037	-	38	0	0	1694	1169	0	6	390	6	779
2038	-	39	0	0	1341	779	0	4	390	4	390
2039	-	40	0	0	1565	390	0	1	390	1	0

Year			Construction Cost	Front End Fee	Net Revenue	Loan Opening Balance	Withdrawn	Interest	Principal Repayment	Interest Repayment	Closing Balance
2040	**-**	**41**	0	0	1559	0	0				
2041	**-**	**42**	0	0	1865	0	0				
2042	**-**	**43**	0	0	1910	0	0				
2043	**-**	**44**	0	0	2064	0	0				
2044	**-**	**45**	0	0	278	0	0				
2045	**-**	**46**	0	0	2435	0	0				
2046	**-**	**47**	0	0	2665	0	0				
2047	**-**	**48**	0	0	3659	0	0				
2048	**-**	**49**	0	0	3136	0	0				
Total			**10535**	**0**	**36177**		**6173**	**325**	**6235**	**263**	

ANNEXURE 3: EQUITY CASH FLOWS TO GOVERNMENT (PROJECT COST WITH CENTRAL TAXES) - KFW LOAN

Year			Construction Cost	Front End Fee	Net Revenue	Loan Opening Balance	Withdrawn	Interest	Principal Repayment	Interest Repayment	Closing Balance
2019	-	20	568	0	0	0	0	0	0	0	0
2020	-	21	1537	0	0	0	0	0	0	0	0
2021	-	22	1975	0	0	0	0	0	0	0	0
2022	-	23	2592	0	0	0	2309	15	0	0	2323
2023	-	24	2721	0	0	2323	2721	46	0	0	5091
2024	-	25	1143	0	412	5091	1143	69	394	0	5909
2025	-	26	0	0	444	5909	0	71	394	71	5515
2026	-	27	0	0	1083	5515	0	66	394	66	5121
2027	-	28	0	0	688	5121	0	62	394	62	4727
2028	-	29	0	0	562	4727	0	57	394	57	4333
2029	-	30	0	0	859	4333	0	52	394	52	3939
2030	-	31	0	0	885	3939	0	47	394	47	3545
2031	-	32	0	0	980	3545	0	42	394	42	3151
2032	-	33	0	0	887	3151	0	37	394	37	2757
2033	-	34	0	0	997	2757	0	32	394	32	2363
2034	-	35	0	0	1368	2363	0	27	394	27	1970
2035	-	36	0	0	1607	1970	0	22	394	22	1576
2036	-	37	0	0	1233	1576	0	17	394	17	1182
2037	-	38	0	0	1694	1182	0	12	394	12	788
2038	-	39	0	0	1341	788	0	7	394	7	394
2039	-	40	0	0	1565	394	0	2	394	2	0

Year			Construction Cost	Front End Fee	Net Revenue	Loan Opening Balance	Withdrawn	Interest	Principal Repayment	Interest Repayment	Closing Balance
2040	**-**	**41**	0	0	1559	0	0	0			
2041	**-**	**42**	0	0	1865	0	0	0			
2042	**-**	**43**	0	0	1910	0	0	0			
2043	**-**	**44**	0	0	2064	0	0	0			
2044	**-**	**45**	0	0	278	0	0	0			
2045	**-**	**46**	0	0	2435	0	0	0			
2046	**-**	**47**	0	0	2665	0	0	0			
2047	**-**	**48**	0	0	3659	0	0	0			
2048	**-**	**49**	0	0	3136	0	0	0			
Total			**10535**	**0**	**36177**		**6173**	**684**		**554**	

ANNEXURE 4: EQUITY CASH FLOWS TO CONCESSIONAIRE IN DBFOT WITH VGF MODEL

Year			Capital Cost	Revenue	O&M Cost	Cash Flow before debt	Equity Withdrawn	Loan Opening Balance	Withdrawn	Interest	Principal Repayment	Interest Repayment	Closing Balance	Equity Cash Flow
2019	-	20	448	0	0	-448	448	0	0	0	0	0	0	-448
2020	-	21	1221	0	0	-1221	1089	0	132	17	0	0	148	-1089
2021	-	22	809	0	0	-809	0	148	809	113	0	0	1070	0
2022	-	23	1062	0	0	-1062	0	1070	1062	204	0	0	2336	0
2023	-	24	1115	0	0	-1115	0	2336	1115	292	0	0	3743	0
2024	-	25	468	680	267	-56	0	3743	468	299	0	0	4510	0
2025	-	26	0	731	287	444	0	4510	0	271	0	271	4510	174
2026	-	27	0	1390	307	1083	0	4510	0	259	196	259	4314	628
2027	-	28	0	1018	330	688	0	4314	0	247	196	247	4118	245
2028	-	29	0	916	354	562	0	4118	0	235	196	235	3922	131
2029	-	30	0	1239	380	859	0	3922	0	224	196	224	3726	439
2030	-	31	0	1293	408	885	0	3726	0	212	196	212	3530	477
2031	-	32	0	1544	564	980	0	3530	0	200	196	200	3334	584
2032	-	33	0	1358	471	887	0	3334	0	188	196	188	3138	503
2033	-	34	0	1504	507	997	0	3138	0	176	196	176	2941	624
2034	-	35	0	1914	546	1368	0	2941	0	165	196	165	2745	1007
2035	-	36	0	2195	588	1607	0	2745	0	153	196	153	2549	1258
2036	-	37	0	1866	633	1233	0	2549	0	141	196	141	2353	896
2037	-	38	0	2376	682	1694	0	2353	0	129	196	129	2157	1368
2038	-	39	0	2076	735	1341	0	2157	0	118	196	118	1961	1027
2039	-	40	0	2357	792	1565	0	1961	0	106	196	106	1765	1263
2040	-	41	0	2413	853	1559	0	1765	0	94	196	94	1569	1269
2041	-	42	0	3247	1382	1865	0	1569	0	82	196	82	1373	1587
2042	-	43	0	2902	992	1910	0	1373	0	71	196	71	1177	1643
2043	-	44	0	3134	1070	2064	0	1177	0	59	196	59	980	1810
2044	-	45	0	4071	3793	278	0	980	0	47	196	47	784	35
2045	-	46	0	3680	1245	2435	0	784	0	35	196	35	588	2204

Year			Capital Cost	Revenue	O&M Cost	Cash Flow before debt	Equity Withdrawn	Loan Opening Balance	Withdrawn	Interest	Principal Repayment	Interest Repayment	Closing Balance	Equity Cash Flow
2046	**-**	**47**	0	4008	1344	2665	0	588	0	24	196	24	392	2445
2047	**-**	**48**	0	5109	1450	3659	0	392	0	12	196	12	196	3451
2048	**-**	**49**	0	4701	1565	3136	0	196	0	0	196	0	0	2940
Total			**5124**	**57721**	**21544**	**31053**	**1537**		**3587**	**4171**	**4510**	**3247**		**26470**
													Equity IRR	**18.00%**

ANNEXURE 5: EQUITY CASH FLOWS TO PRIVATE ENTITY IN GRANT BY CENTRAL GOVERNMENT MODEL

Year			Capital Cost	Fixed Fee	O&M Cost	Cash Flow before debt	Equity Withdrawn	Loan Opening Balance	Loan Withdrawn	Interest	Principal Repayment	Interest Repayment	Closing Balance	Equity Cash Flow
2019	**-**	**20**	134	0	0	-134	134	0	0	0	0	0	0	-134
2020	**-**	**21**	423	0	0	-423	423	0	0	0	0	0	0	-423
2021	**-**	**22**	592	0	0	-592	369	0	224	29	0	0	252	-369
2022	**-**	**23**	777	0	0	-777	0	252	777	115	0	0	1145	0
2023	**-**	**24**	816	0	0	-816	0	1145	816	177	0	0	2139	0
2024	**-**	**25**	343	763	267	152	0	2139	343	180	0	0	2662	152
2025	**-**	**26**	0	793	287	506	0	2662	0	160	0	160	2662	347
2026	**-**	**27**	0	825	307	517	0	2662	0	153	116	153	2546	249
2027	**-**	**28**	0	858	330	528	0	2546	0	146	116	146	2431	266
2028	**-**	**29**	0	892	354	538	0	2431	0	139	116	139	2315	284
2029	**-**	**30**	0	928	380	548	0	2315	0	132	116	132	2199	300
2030	**-**	**31**	0	965	408	557	0	2199	0	125	116	125	2083	316
2031	**-**	**32**	0	1003	564	439	0	2083	0	118	116	118	1968	205
2032	**-**	**33**	0	1044	471	572	0	1968	0	111	116	111	1852	346
2033	**-**	**34**	0	1085	507	578	0	1852	0	104	116	104	1736	358
2034	**-**	**35**	0	1129	546	583	0	1736	0	97	116	97	1620	370
2035	**-**	**36**	0	1174	588	586	0	1620	0	90	116	90	1505	380
2036	**-**	**37**	0	1221	633	588	0	1505	0	83	116	83	1389	389
2037	**-**	**38**	0	1270	682	588	0	1389	0	76	116	76	1273	396
2038	**-**	**39**	0	1320	735	586	0	1273	0	69	116	69	1157	401
2039	**-**	**40**	0	1373	792	581	0	1157	0	63	116	63	1042	403

Year			Capital Cost	Fixed Fee	O&M Cost	Cash Flow before debt	Equity Withdrawn	Loan Opening Balance	Loan Withdrawn	Interest	Principal Repayment	Interest Repayment	Closing Balance	Equity Cash Flow
2040	**-**	**41**	0	1428	853	575	0	1042	0	56	116	56	926	403
2041	**-**	**42**	0	1485	1382	103	0	926	0	49	116	49	810	-61
2042	**-**	**43**	0	1545	992	553	0	810	0	42	116	42	694	395
2043	**-**	**44**	0	1606	1070	537	0	694	0	35	116	35	579	386
2044	**-**	**45**	0	1671	3793	-2122	0	579	0	28	116	28	463	-2265
2045	**-**	**46**	0	1738	1245	492	0	463	0	21	116	21	347	356
2046	**-**	**47**	0	1807	1344	464	0	347	0	14	116	14	231	334
2047	**-**	**48**	0	1879	1450	429	0	231	0	7	116	7	116	307
2048	**-**	**49**	0	1955	1565	389	0	116	0	0	116		0	273
Total			**3087**	**31755**	**21544**	**7124**	**926**		**2161**	**2418**	**2662**	**1917**		**4363**
													Equity IRR	**18.01%**

Chapter – 20
ECONOMIC ANALYSIS

20. ECONOMIC ANALYSIS

20.1 APPROACH AND METHODOLOGY FOR ECONOMIC ANALYSIS

The economic appraisal has been carried out within the broad framework of Social Cost – Benefit Analysis Technique. It is based on the incremental costs and benefits and involves comparison of project costs and benefits in economic terms under the “with” and “without” project scenario. In the analysis, the cost and benefit streams arising under the above project scenarios have been estimated in terms of market prices and economic values have been computed by converting the former using appropriate shadow prices.

This has been done to iron out distortions due to externalities and anomalies arising in real world pricing systems. The annual streams of project costs and benefit have been compared over the analysis period of 30 years to estimate the net cost / benefit and to calculate the economic viability of the project in terms of EIRR & ENPV.

20.1.1 Evaluation Assumptions

Project horizon comprises of the construction and operation period of the rail based transit project. The annual streams of project costs and benefit have been compared over the analysis period of 30 years to estimate the net cost / benefit and to calculate the economic viability of the project in terms of EIRR. The key assumptions used in the evaluation are listed in **Table 20.1.**

TABLE 20.1: KEY EVALUATION ASSUMPTIONS

Parameter	Assumption
Price Level	April ’2018
Construction period	2019-2024
First year of operation of MRTS	2024
Daily to annual factor	340

20.1.2 Development of 'With' and 'Without' Scenarios

The development of the two scenario starts with estimating the traffic and the modal share in these scenarios for the system. **Table 20.2** gives the estimated traffic and modal share in different horizon years for Metro.

The travel demand on Phase 2 MRTS corridors has been estimated for various years considering the fact that the implementation of Phase 2 Metro will enhance the ridership on Phase 1 corridors as well. Further, the train operation plan, rake requirement and O&M will have to be planned considering this incremental travel demand on Phase 1 along with Phase 2 extension i.e., for full network. Accordingly, the incremental daily passenger trips for Phase 1 and Phase 2 have been estimated considering the difference of estimated daily trips on full network (phase 1 & 2) to that of Phase 1 (taken from DPR, 2013) (**Table13.10**). **Table 20.2** give total daily trip details in the city.

It can be seen that the total estimated demand in the year 2024 is about 52.27 Lakh which is expected to rise to about 73 Lakh in the year 2041. In the year 2024, Nagpur Metro Phase I+II combined is expected to cater to about 5.5 Lakh trips / day which is expected to rise to about 8lakhs in the year 2041.

TABLE 20.2: ESTIMATED DEMAND & MODAL SHARE IN "WITH" AND "WITHOUT SCENARIO"

Mode	Trips Without Phase II MRTS Extension (Lakh)			Trips with Phase II MRTS Extension (Lakh)		
	2024	**2031**	**2041**	**2024**	**2031**	**2041**
Bus	4.84	5.28	5.82	3.78	4.13	4.60
Car	4.80	5.66	7.00	4.59	5.42	6.68
2-Wheelers	32.66	37.72	43.53	31.61	36.50	42.04
Auto Rickshaw	5.39	6.41	9.12	5.25	6.25	8.89
Shared Auto	1.98	2.84	3.88	1.54	2.23	3.06
MRTS	2.60	2.94	3.66	5.49	6.33	7.75
Total	**52.27**	**60.86**	**73.02**	**52.27**	**60.86**	**73.02**

20.2 ESTIMATION OF ECONOMIC COST OF MRTS

The economic costs of the capital works and annual operation and maintenance costs have been calculated from the financial cost estimates by excluding:

- Price contingencies/price escalations
- Import duties and taxes
- Sunk costs
- Interest payment, principal payment and interest during construction

The economic costs (**Table 20.3**) have been derived from financial costs using following shadow price factor for each component to take care of the distortions brought by above factors.

TABLE 20.3: FACTORS USED FOR CONVERTING PROJECT COSTS TO ECONOMIC COSTS

S. No	Item	Factor
1	Capital Cost	0.83
2	Operations & Maintenance Cost	0.87

Table 20.4 and **Table 20.5** give the capital and O&M costs of the MRTS in financial and economic terms at April'18 price levels respectively.

TABLE 20.4: FINANCIAL COSTS OF METRO - CAPITALAND O&M (RS. IN CRORE)

Cost Component	Metro
Construction Cost Including Land and R&R	**8095**
Taxes @18% FOR GST	**1227**
O&M Costs	
2024	234
2031	237
2041	245

TABLE 20.5: ECONOMIC COSTS OF METRO- CAPITAL AND O&M (RS IN CRORE)

Cost Component	Metro
Construction Cost Including land and R&R	6719
O&M Costs	
2024	204
2031	206
2041	213

20.3 ECONOMIC BENEFITS OF MRTS

Nagpur Metro will yield tangible and non-tangible savings due to equivalent reduction in road traffic and certain socio-economic benefits. **Table 20.6** gives reduced passenger trips due to Nagpur Metro Phase II extensions.

TABLE 20.6: REDUCED PASSENGER TRIPS DUE TO NAGPUR MRTS

Mode	Reduced pass Trips Due to Nagpur Metro (Trips in Lakh)		
	2024	**2031**	**2041**
Bus	1.07	1.15	1.23
Car	0.20	0.24	0.33
2-Wheelers	1.05	1.22	1.49
Auto Rickshaw	0.14	0.16	0.22
Shared Auto	0.44	0.62	0.82
MRTS	2.89	3.39	4.08

Shifting of passenger trips from road to metro would lead to reduction in number of mini buses, IPT, usage of private vehicles, air pollution and increase in the speed of road-based vehicles. This, in turn, will result in significant social benefits due to reduction in fuel consumption, vehicle operating cost and travel time of passengers. Reduction in accidents, pollution and road maintenance costs are the other benefits to the society in general. The benefit stream includes:

- Savings in Capital and operating cost (on present congestion norms) of carrying the total volume of passenger traffic by existing modes in case MRTS project is not taken up.
- Savings in operating costs of different modes due to de-congestion including those that would continue to use the existing transport network even after the MRTS is introduced.
- Savings in time of commuters using the MRTS over the existing transport modes because of faster speed of MRTS.
- Savings in time of those passengers continuing on existing modes, because of reduced congestion on roads.
- Savings on account of prevention of accidents and pollution with introduction of MRTS.
- Savings in road infrastructure and development costs that would be required to cater to increase in traffic, in case MRTS is not introduced.

The Quantification of some of the social benefits has not been attempted because universally acceptable norms do not exist to facilitate such an exercise. However, it has been considered appropriate to highlight the same, as given below:

- Reduced road stress
- Better accessibility to facilities in the influence area
- Economic stimulation in the micro region of the infrastructure
- Increased business opportunities
- Overall increased mobility
- Facilitating better planning and up-gradation of influence area
- Improving the image of the city

20.3.1 Input Parameters

Inputs used for Economic analysis have been collected from primary and secondary data sources. Vehicle Operating cost (VOC) and Value of Travel Time (VOT) are the two important parameters of Economic Analysis.

Vehicle Operating Cost (VOC): VOC is a function of speed, road roughness, carriageway, width/capacity, rise and fall per unit. The VOC unit cost have been taken from the "Manual on Economic Evaluation of Highway Projects in India, 2009" by the Indian Road Congress (IRC). The VOC has been adjusted for Nagpur according to the traffic, road conditions in the city as recommended in the manual. **Table 20.7** gives the mode wise VOC to estimate benefits accruing to the society from the project.

TABLE 20.7: MODE WISE VOC FOR NAGPUR

Mode	VOC* Rs /Km
Bus	17.84
Car	7.35
2 Wheeler	2.75
Auto	5.51
Shared Auto	6.89

**Source IRC SP 30 (2009) Values brought to 2018 level using factor of 5%*

Value of Travel Time (VOT): VOT is another important parameter of Economic Analysis. It refers to the cost of time spent on transport. It includes costs of both work and non-work trips. Mode wise value of time has also been taken from IRC SP-30 (2009) Values brought to 2018 level using factor of 5%. The value of travel time for MRTS passengers has been taken as that of deluxe bus. **Table 20.8** gives the mode wise VOT to estimate benefits accruing to the society from the project.

TABLE 20.8: MODE WISE VOT FOR NAGPUR MRTS

Mode	Value of Travel Time**Passenger/ Hour
Bus	67.48
Car	89.20
2 Wheeler	41.89
Auto	41.89
Shared auto	41.89

**Source IRC SP 30 (2009) Values brought to 2018 level using factor of 5%*

Other operational parameters required to assess the savings in VOC and VOT, accidents, pollution for the system in year 2041 is presented in **Table 20.9**.

TABLE 20.9: MODE WISE OPERATIONAL PARAMETERS –METRO

Mode	Average Lead KM	Veh-KM/ Day	Average Speed (Km/Hr)*		Occupancy
			Without MRTS	With MRTS	
Bus	11	200	18	20	60
Car	11	27	23	25	2.8

Mode	Average Lead KM	Veh-KM/ Day	Average Speed (Km/Hr)*		Occupancy
			Without MRTS	With MRTS	
2-Wheelers	9	22	22	24	1.3
Auto Rickshaw	6	70	20	22	1.8
Shared Auto	7	100	18	20	5

*Source: RITES Field Studies 2017, * Derived from Transport Demand model*

Other benefits that will accrue to the society include reduction in emission, savings due to reduction in accidents. The input for the benefit estimation from these parameters includes the emission factors by vehicle category as given by CPCB (**Table 20.10**), vehicle and accident statistics **(Table 20.11)** and cost of accidents (**Table 20.12**).

TABLE 20.10: MODE WISE EMISSION FACTORS (GRAM/KM)

Vehicle Type/ Pollutant	CO	HC	NOX	PM	CO2
2-wheeler	1.4	0.7	0.3	0.05	28.58
Auto	2.45	0.75	0.12	0.08	77.89
Cars (incl. cabs)	1.39	0.15	0.12	0.02	139.52
Bus (incl. BRT)	3.72	0.16	6.53	0.24	787.72
Treatment Cost (Rs. /ton)	1,00,000	1,00,000	1,00,000	1,00,000	500

Source: Appraisal guidelines for Metro Rail Project Proposals MoHUA, GOI 2017

TABLE 20-11: ROAD ACCIDENTS IN NAGPUR

Year	Registered Vehicles	Total Accidents	Fatal Accidents	Injury
2014	1,310,344	1,149	281	1094
2015	1,378,051	1254	260	1203
2016	1,426,694	1242	232	1285
2017	1,475,217	1373	310	1510

Source: Year-wise Statistics on Road Accidents in Nagpur, Traffic Police, 2017

TABLE 20.12: COST OF ACCIDENTS

Type of Accident	Accident Cost (Rs.)	
	(2004 prices)*	(2018 prices)**
Cost of fatal accident	437342	824674
Cost of major accident	64256	121164
Cost of damage to Two wheelers	2286	18410
Cost of damage to Car	9763	61883
Cost of damage to buses in road accidents	32818	4311

*Source: *Appraisal guidelines for Metro Rail Project Proposals MoHUA, GOI 2017*
***derived using escalation factor of 5%*

20.3.2 Estimation of Project Benefits

The methodology adopted to quantify benefits that will accrue to the society owing to implementation of the metro project include:

- **Travel time savings**- travel time savings will accrue on two accounts:
  - Travel time savings for passenger trips that are shifted to MRTS from other modes due to higher speed of MRTS project as compared to 'without' project scenario.
  - Travel time savings for trips remaining on road due to reduction in congestion due to shift on metro leading to fewer vehicles on roads.
  - Passenger time savings = time savings of modal shift passenger + time savings of passenger travelling on other mode.
  - Time savings of modal shift passengers = (time spent by modal shift passengers on metro rail project - time spent by modal shift diverted passenger on alternate transport mode in do nothing/alternative scenario) x value of passenger time.
  - Time savings of passengers travelling on other modes = (time spent by passengers travelling on other mode in with project scenario - time spent by passengers travelling on other mode in do nothing/alternative scenario) x value of passenger time.

- **Savings in Vehicle Operating Cost**- Shifting of passenger trips from road to MRTS will result in lesser vehicles on roads resulting in saving in VOC. Savings in VOC will also accrue on two accounts:
  - VOC savings of mode wise vehicle trips which have shifted from road to MRTS.
  - VOC savings due to reduced congestion on roads of vehicles trips remaining on road.
  - The VOC savings are calculated by multiplying the unit VOC cost with the number of vehicle trips and with the average lead distance for the particular vehicle category. VOC savings = VOC [Rs. /km] x Average Lead [km] x no. of vehicle trips
  - The VOC savings are calculated for the vehicle types and then added. The difference of cost in "with" and "without" project is taken to estimate savings in Vehicle Operating Cost.

- **Accident reduction-**These savings are also based on reduction in no of vehicles on roads due to shift of passengers of different modes on MRTS.

  reduction in fatal and injury accidents due less no of vehicles on roads.

- Savings in damage cost to vehicles involved in accidents.

- Based on trends of last 3-year data of vehicles and relationship with fatal and damage accidents data, the reduction in no of accidents is estimated for reduced no of vehicles on roads due to modal shift of passengers. reduced number of fatal and damage accidents are then multiplied by the cost of accident to arrive at savings due to metro.
- Savings from pollution reduction - the reduction in no of vehicles on roads due to shift of passengers of different modes on MRTS will reduce the air pollution.
- Absence of vehicles on road due to modal shift passengers on MRTS will save pollution from modes that would have continued on road in "without MRTS scenario"
- Savings from pollution are estimated by using the following method
- Vehicle km saved = [no. of trips shift to metro from other mode] x [average lead of the mode]
- Total volume of pollutant= [volume of pollutant released per km] x [daily vehicle km saved]
- Annual treatment cost = [volume of pollutant] x [treatment cost/ton]

  savings in road infrastructure maintenance

  with less no of vehicles on roads, expenditure on road maintenance is expected to go down. in the absence of data, a lump-sum expenditure of Rs. 60 cr/ year has been assumed.
- following the above methodology socio-economic benefits of Nagpur metro have been estimated in monetary terms. following factors have been used for converting project benefits to economic costs (**Table 20.13**).

TABLE 20.13: FACTORS FOR CONVERTING PROJECT BENEFITS IN ECONOMIC COSTS

S. No	Item	Factor
1	Savings in Capital & Operating Cost of Buses	0.83
2	Savings in Capital & Operating cost of Private Vehicles	0.9
3	Savings in Passenger Time	1.0
4	Savings in VOC	0.9
5	Savings in Accident Costs	0.9
6	Savings in Pollution Costs	1.0
7	Infrastructure Maintenance Cost Savings	0.87

With input from above tables, the accrued economic benefits for Nagpur metro in the horizon year 2041-42 has been summarized in **Table 20.14.**

TABLE 20.14: ECONOMIC RETURN PARAMETERS OF NAGPUR MRTS

S.NO	BENEFITS	MRTS	
		Amount	% Share
1	Travel Time Savings	1217	71
2	Savings in Vehicle Operating Cost	432	25
3	Savings from Accident , Pollution & Road maintenance Reduction	69	4
	Total	**1718**	**100**

It is clear from the Table that benefits are mainly come from saving of Travel Time by MRTS (71%), and VOC savings (25%), and benefit from emission reduction, accident reduction and road maintenance cost (together 4%).

EIRR for 30 years for deriving the values of economic indicators (EIRR, ENPV), cost and benefit stream for the system has been constructed in terms of money value. The toolkit on finance and financial analysis 2013 by MOHUA, suggests that ENPV to be calculated on social cost of capital or government security rate. Accordingly, ENPV for the system have been calculated on both the rates. metro rail policy 2017 prescribes 14% as acceptable EIRR rate for metro project, same has been considered as the social cost of capital. The government security rate in May '2018 is 7.76%. accordingly, ENPV for the system has been calculated based on these rates. The summary of the ENPV and EIRR is presented in **Table 20.15.** The cost and benefit streams for metro system is presented in **Table 20.16.**

TABLE 20.15: ECONOMIC RETURN PARAMETERS OF NAGPURMETRO

S.NO	PARAMETER	Metro
1	EIRR	14.40%
2	ENPV - Social cost of capital @14% - Government Security Rate@ 7.76%	 142.4 5261

20.3.3 Outcome On Economic Viability

The project has EIRR more than 14%, indicating that the benefits to the society are more than the social cost of capital of 14%. It also meets the acceptable norm of MOUD. Thus the project is economically viable and should be implemented.

20.3.4 Sensitivity Analysis

The sensitivity analysis has been carried out to see the impact of change in critical parameters in the range of 5% to 15% on EIRR and is presented in **Table 20.16.**

TABLE 20.16: SENSITIVITY ANALYSIS

S. No.	Factor	Range		
		5%	10%	15%
1	Cost overruns due to delay or other factors	13.81	13.25	12.73
2	Increase in Maintenance Cost	14.30	14.19	14.09
3	Reduction in Ridership	14.08	13.75	13.41
4	Reduction in benefits	13.67	12.92	12.14
5	Combination of reduction in benefits and increase in cost	13.09	11.83	10.61

TABLE 20.17: COST AND BENEFIT STREAM FOR METRO SYSTEM (IN CRORE)

YEAR	COSTS			SAVINGS					NET CASH
	CAPITAL	O&M	TOTAL	TIME	VOC	POLLUTION	INFRASTRUCTURE	TOTAL	FLOW
2019-20	421	0	421	0	0	0		0	-421
2020-21	1074	0	1074	0	0	0		0	-1074
2021-22	1306	0	1306	0	0	0		0	-1306
2022-23	1632	0	1632	0	0	0		0	-1632
2023-24	1632	0	1632	0	0	0		0	-1632
2024-25	653	204	857	844	252	13	52	1161	304
2025-26	0	204	204	857	372	13	52	1294	1090
2026-27	0	204	204	871	377	13	52	1314	1109
2027-28	0	205	205	885	383	13	52	1334	1129
2028-29	0	205	205	899	389	13	52	1354	1149
2029-30	81	205	287	913	396	14	52	1374	1088
2030-31	0	206	206	927	402	14	52	1395	1190
2031-32	0	206	206	1008	418	16	52	1495	1289
2032-33	0	207	207	1027	435	16	52	1530	1324
2033-34	0	207	207	1047	443	17	52	1558	1351
2034-35	0	208	208	1066	451	17	52	1587	1379
2035-36	0	209	209	1087	460	17	52	1616	1407
2036-37	0	210	210	1107	469	18	52	1646	1436
2037-38	0	210	210	1128	477	18	52	1676	1465
2038-39	0	211	211	1149	487	18	52	1706	1495
2039-40	0	212	212	1171	496	19	52	1738	1526
2040-41	243	213	456	1193	505	19	52	1770	1314
2041-42	0	213	213	1217	515	19	52	1804	1590

YEAR	COSTS			SAVINGS					NET CASH
	CAPITAL	O&M	TOTAL	TIME	VOC	POLLUTION	INFRASTRUCTURE	TOTAL	FLOW
2042-43	0	214	214	1242	525	20	52	1839	1625
2043-44	616	215	831	1266	536	20	52	1875	1044
2044-45	0	216	216	1292	547	20	52	1911	1695
2045-46	0	216	216	1318	558	21	52	1948	1732
2046-47	0	217	217	1344	569	21	52	1986	1769
2047-48	0	218	218	1371	580	22	52	2025	1807
2048-49	0	218	218	1398	592	22	52	2064	1846
								IRR	**14.40%**
								NPV@14%	142
								NPV@7.76%	5261

Chapter – 21
IMPLEMENTATION PLAN

21 IMPLEMENTATION PLAN

21.1 PROJECT IMPLEMENTATION PLAN

The appointment of Interim and General Consultants may be initiated for project management including preparation of tender documents – as soon as DPR is approved by Government of Maharashtra (GoM), and Maha Metro. The possible dates of important milestones are given in **Table 21.1** and **Figure 21.1**.

TABLE 21.1: PROJECT IMPLEMENTATION SCHEDULE

S. No.	Tasks	Timelines
1	Final DPR	July, 2018
2	State Government Approval of DPR	November, 2018
3	Final Approval by GoI	January, 2019
4	Appointment of Interim Consultant	February, 2019
5	Appointment of DDC for Civil Works	March, 2019
6	Packaging and Invitation of Bids	April, 2019
7	Appointment of General Consultants	June, 2019
8	Commencement of Civil Works	July, 2019
9	Commencement of Operation	April, 2024

The commercial operation on Phase 2 corridors may start from April 2024 after providing about 4.5 years for construction and 4 months for safety audit and certification.

21.2 IMPLEMENTATION STRUCTURE

Maharashtra has a successful example of metro operation in Mumbai on SPV model by Mumbai Metro Rail Corporation Limited (MMRCL). Nagpur Metro Rail Phase-1 project is also implemented on SPV model by Maha Metro. Similarly, Nagpur Metro Phase 2 project may also be implemented on SPV model. However, some subcomponents of operations & maintenance may be taken up with private sector participation (PPP) model.

The PPP model to be adopted and implementation structure shall be decided at the time of implementation.

FIGURE 21.1: IMPLEMENTATION SCHEDULE FOR MONITORING OF PROJECT

Key Performance Indicators	2018	2019				2020				2021				2022				2023				2024	
	Oct - Dec	Jan - Mar	Apr - June	July - Sept	Oct - Dec	Jan - Mar	Apr - June	July - Sept	Oct- Dec	Jan - Mar	Apr - June	July - Sept	Oct- Dec	Jan - Mar	Apr - June	July - Sept	Oct- Dec	Jan - Mar	Apr - June	July - Sept	Oct- Dec	Jan - Mar	Apr - June
Approval of DPR by State Government																							
Appointment of Interim Consultant																							
Appointment of DDC for Civil Works																							
Final Approval of GoI																							
Packaging & Invitation of Bids																							
Process of Land Acquisition																							
Shifting of Utilities																							
GT Survey																							
Viaduct Construction																							
Elevated Station																							
Track Linking																							
OHE Fixing Testing																							
S&T Works																							
Trial Run Testing																							
CRS Inspection and Commissioning																							

21.3 LEGAL AND INSTITUTIONAL FRAMEWORK FOR IMPLEMENTING THE PROJECT

21.3.1 Legal Framework

Construction of Nagpur Metro Phase 2 should commence soon. The legislation for construction of Phase -1 may also provide legal cover for construction of Nagpur Metro Phase 2. Implementation of proposed Extension of Nagpur Metro can be done under "The Metro Railways (Amendment) Act 2009".

21.3.2 Institutional Arrangements

Metro construction is a very specialized and multi-disciplinary job. It is therefore, impossible to have a single organizational set up which can be responsible for all aspects of metro implementation, namely investigation, planning, design, drawing up of specifications, preparation of tender documents, fixing of contractors, supervising the contractors' works, ensuring interface fusion between different contractors, ensuring quality and safety during constructions, planning and supervising integration system trials and getting the project commissioned in time.

Effective institutional arrangement is needed to enable the Metro project to be implemented without any loss of time and cost over-run. The details of possible arrangements are discussed in following sections. Experience of implementing Delhi, Mumbai and Nagpur Phase 1 metro projects has shown that a Special Purpose Vehicle (SPV), vested with adequate powers, is an effective organizational arrangement to implement and subsequently operate and maintain a metro rail project.

It is suggested to have a two tier organization with well-defined responsibilities for getting this project executed. At the apex will be the Maha Metro - the organization with full mandate and total power. The second level will be a project management team called "General Consultants" who will be engaged by the Maha Metro on contract basis and who will be fully responsible for planning, design and project management. In fact they will be the "Engineers" for the Maha Metro, who is the "Client". The detailed design consultants as required may be engaged by General Consultants as their Sub-Consultants within their own contract responsibilities. Since most of the alignment length is elevated, it is recommended that the contracts be made on "design and build" basis, based on broad technical specifications and performance requirements drawn up by the General Consultants.

21.3.3 High Power Committee

During the implementation of the project several problems with regard to acquisition of land, diversion of utilities, shifting of structures falling on the project alignment, rehabilitation of project affected persons, etc. are likely to arise. For expeditious resolution of these problems, an institutional mechanism needs to be set up at the State Government level. Towards this end, it is recommended that a High Power Committee under the chairmanship of Chief Secretary, Maharashtra may be set up. Other members of this Committee may be the Secretaries of concerned Departments of State Government and Heads of civic bodies who are connected in one way or the other with the implementation of the project. Nagpur Municipal Commissioner may also be the member of this committee.

21.3.4 Empowered Committee

At the Central Government level an Empowered Committee, under the chairmanship of Cabinet Secretary, is presently functioning for Delhi Metro project. Other members of this Committee are Secretaries of Planning Commission, Ministry of Home Affairs, Ministry of Housing and Urban Affairs, Ministry of Road Transport and Highways, Ministry of Environment and Forests, Department of Expenditure, Chief Secretary of Delhi and a representative from the PMO. The Empowered Committee meets regularly and takes decisions on matters connected with inter-departmental coordination and overall planning, financing and implementation of the Delhi Metro project.

It is suggested that the role of this Empowered Committee is enlarged to include Nagpur Metro Phase-2 project also and the Chief Secretary, Maharashtra is inducted as a member of this Committee.

21.4 ROLE, RESPONSIBILITY AND INVOLVEMENT OF CITY GOVERNMENT

21.4.1 Unified Metropolitan Transport Authority (UMTA)

The National Urban Transport Policy 2014 has recommended setting up of Unified Metropolitan Transport Authorities (UMTA’s) in million plus cities. The policy document stipulates following on UMTA.

“The current structure of governance for the transport sector is not equipped to deal with the problems of urban transport. These structures were put in place well before

the problems of urban transport began to surface in India and hence do not provide for the right coordination mechanisms to deal with urban transport. The central government will, therefore, recommend the setting up of Unified Metropolitan Transport Authorities (UMTA's) in all million cities to facilitate more coordinated planning and implementation of urban transport programs & projects and integrated management of urban transport systems. Such Metropolitan Transport Authorities would need statutory backing in order to be meaningful."

The metro rail policy - 2017 makes it mandatory for the cities which are planning to have MRTS to address their mass transport requirements to have city level UMTA.

For integrated approach in planning and management of urban transport in the city, State Government shall constitute Unified Metropolitan Transport Authority (UMTA) as a statutory body. This Authority would implement various proposals as per CMP for the city, organize investments in urban transport infrastructure, establish effective coordination among various urban transport agencies, manage the Urban Transport Fund (UTF) etc. UMTA will have to play active role in the implementation of Nagpur Metro being a city government authority.

21.4.2 Steering Committee

Apart from a High Power Committee under the chairmanship of Chief Secretary, Maharashtra, a 'Steering Committee' may be set up under the chairmanship of Commissioner of Nagpur Municipal Corporation. Other members of this Committee may be District Collector, Municipal Commissioner, and other heads of civic bodies who will be connected in one way or the other with the implementation of the project.

During the implementation of the project several problems with regard to acquisition of land, diversion of utilities, shifting of structures falling on the project alignment, rehabilitation of project affected persons, etc. are likely to arise. The steering committee will work for expeditious resolution of these problems at local level. This Committee may meet regularly to sort out all problems brought before it by Maha Metro.

21.4.3 Way Forward

On acceptance of the Detailed Project Report, following actions may be initiated for implementing of Nagpur Metro Phase-2 project:

- Approval of State Government to the Detailed Project Report
- Issue of notifications for the project, alignment and setting up of UMTA
- DPR to be forwarded to the Ministry of Housing and Urban Affairs, Niti Aayog and Finance Ministry with request for approving the Metro project and for financial participation through equity contribution to the SPV
- Appointment of Interim Consultants (IC)
- Appointment of Detailed Design Consultants (DDC)
- Packaging and invitation of bids for various contracts
- Appointment of General Consultants (GC)
- Land acquisition
- Examination and appraisal of DPR by bilateral/multilateral funding agencies for possible funding
- Stakeholder consultation on environmental and social impact of the project
- Signing of an MOU between Maharashtra State Government and Government of India giving all details of the Joint Venture bringing out the financial involvement of each party, liability for the loans raised, the administrative control in the SPV, policy in regard to fare structure etc.
- Agreement between the State and Central Government for financing the debt portion of the project along with the setting up of time frame for completing the Project
- Loan approval
- Providing legal cover for construction as well as O&M stages of the Project
- Memorandum of Understanding between various service providers to provide seamless integration between various transport modes.

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नागपूर मेट्रो रेल प्रकल्प टप्पा-२ या उन्नत मेट्रो मार्गास मान्यता देण्याबाबत.

महाराष्ट्र शासन
नगर विकास विभाग
शासन निर्णय क्रमांक : एनएमआर-३३१८/प्र.क्र.१४५/नवि-७,
मंत्रालय, मुंबई ४०० ०३२.
दिनांक : १४ जानेवारी, २०१९.

प्रस्तावना :-

नागपूर शहराची वाढती लोकसंख्या आणि वाहनांची संख्या या अनुषंगाने निर्माण झालेल्या वाहतुक समस्या लक्षात घेता, सार्वजनिक वाहतुक व्यवस्था सक्षम करणे गरजेचे आहे. नागपूर महानगर क्षेत्र ३५७७.१६ वर्ग कि.मी. व नागपूर महानगरपालिकेचे क्षेत्र २१७ वर्ग कि.मी. आहे. आजमितीस सन २०११ च्या जनगणनेप्रमाणे महापालिका क्षेत्राची लोकसंख्या सुमारे २४.०५ लक्ष असून सन २०४१ पर्यंत ही लोकसंख्या ३६.१७ लक्ष पर्यंत पोहचेल असा अंदाज आहे. महानगर क्षेत्रात ९ तहसिल मधील ७२६ गावांचा समावेश असून त्याची लोकसंख्या ३२.७२ लक्ष आहे आणि सन २०३२ पर्यंत ही लोकसंख्या ५१.१० लक्ष इतकी होण्याची शक्यता आहे. वाढती लोकसंख्या व वाहने लक्षात घेता नजीकच्या काळामध्ये अस्तित्वात असलेले रस्ते अपुरे पडून गर्दी होईल हे लक्षात घेवून शासनाने शासन निर्णय क्रमांक दिनांक नासुप्र ३३१३/प्र.क्र.४१/ नवि-७, दिनांक ३०.०१.२०१४ ला नागपूर मेट्रो रेल प्रकल्प राबविण्यास मान्यता दिली. केंद्र शासनाने दि. २१.०८.२०१४ ला या प्रकल्पास मान्यता दिली व त्याकरीता महाराष्ट्र मेट्रो रेल कॉर्पोरेशन लि. या विशेष उद्देश वाहन ची निर्मिती करण्यात आली असून उक्त विशेष उद्देश वाहनाद्वारे मेट्रो मार्गाची उभारणी करण्यात येत आहे. सदर टप्पा-१ मार्गिकांची कामे प्रगतीपथावर असून ती लवकरच पूर्ण होणे अपेक्षित आहे.

सदर मार्गिकांचा विस्तार करण्यासाठी महाराष्ट्र मेट्रो रेल कॉर्पोरेशन लि. नागपूर यांनी सादर केलेल्या नागपूर मेट्रो रेल प्रकल्प टप्पा-२ या उन्नत मेट्रो मार्गीकांकरीता रु.११२३९ कोटी खर्चाचा महाराष्ट्र मेट्रो रेल कॉर्पोरेशन लि. नागपूर यांच्यामार्फत अंमलबजावणी करण्याबाबतचा प्रस्ताव शासनाच्या मान्यतेसाठी सादर केला आहे. त्यानुषंगाने सदर प्रकल्पाच्या प्रस्तावास राज्य शासनाकडून मान्यता देण्याची बाब शासनाच्या विचाराधीन होती. त्यानुषंगाने शासन पुढीलप्रमाणे निर्णय घेत आहे.

०२. **शासन निर्णय :-**

महाराष्ट्र मेट्रो रेल कॉर्पोरेशन लि. नागपूर यांनी सादर केलेल्या नागपूर मेट्रो रेल प्रकल्प टप्पा-२ या उन्नत मेट्रो मार्गीकेकरीता रु.११२३९ कोटी खर्चास महाराष्ट्र मेट्रो रेल कॉर्पोरेशन लि. नागपूर यांच्यामार्फत अंमलबजावणी करण्यास पुढीलप्रमाणे मान्यता देण्यात येत आहे.

(१) नागपूर मेट्रो रेल प्रकल्प फेज-२ च्या करिता रू. ११२३९ कोटीच्या खर्चास व खालील मार्गिकांना मान्यता देण्यात येत आहे.

अ.क्र.	फेज-२ मार्गिका	लांबी (कि.मी.)
१अ	MIHAN ते MIDC ESR	१८.७६८
२अ	ऑटोमोटिव्ह चौक ते कन्हान नदी	१२.९२५
३अ	लोकमान्य नगर ते हिंगणा	६.६५७
४अ	प्रजापती नगर ते ट्रान्सपोर्ट नगर	५.४४१
५	वासुदेव नगर ते दत्तवाडी	४.४८९
एकूण		४८.२९

(२) सदर प्रकल्पासाठी प्रस्तावित प्रकल्प निधी उभारणी खाली नमूद केलेल्या ढाचास धरून तत्वतः मान्यता देण्यात येत आहे.

अ. क्र.	तपशील/संस्था	आर्थिक सहभाग निधी (कोटीत)	आर्थिक खर्चातील हिस्सा
१.	केंद्र शासनाचा समभाग	१६५८	१६.१२%
२.	महाराष्ट्र शासनाचा समभाग	१६५८	१६.१२%
३.	राज्य शासनाकडून केंद्रीय कराकरीता दुय्यम कर्ज	३९९	३.८८%
४.	केंद्र शासनाकडून केंद्रीय कराकरिता दुय्यम कर्ज	३९९	३.८८%
५.	एमएडीसीकडून अनुदान	१९४	१.८८%
६.	द्विपक्षीय/बहुपक्षीय वित्तीय संस्थांकडून कर्ज	५९८०	५८.१२%
	एकूण	१०२८८	१००%
७.	एमआयडीसीमार्फत भुसंपादन आणि पुनर्वसन व पुनर्वासाकरीता अनुदान (भूसंपादन रु.२३३ कोटी व पुनर्वसन व पुर्नवसाहत रु.१३ कोटी)	२४६	
८.	एमआयडीसीमार्फत राज्य कराकरीता अनुदान	३१५	
९.	एमएडीसीमार्फत राज्य कराकरीता अनुदान	३६७	
	एकूण	११२१६	
१०.	बांधकाम कालावधी दरम्यानचे व्याजाकरिता (द्विपक्षीय/बहुपक्षीय वित्तीय संस्थांकडूनच्या कर्जावरील व्याज) राज्यशासनाचा सहभाग.	२३	
	एकूण रक्कम	११२३९	

(३) मेट्रो सेवेसाठी खाली नमूद केल्यानुसार प्रवासी भाडे दरास तत्वतः मान्यता देऊन या भाड्यामध्ये ठराविक कालावधीनंतर आवश्यकतेप्रमाणे सुधारणा करण्याचे अधिकार सदर कंपनीस देण्यास मान्यता देण्यात येत आहे.

अ.क्र.	अंतर (कि.मी.)	डीएमआरसीचे सन २०१७-१८ चे भाडे	नागपूर मेट्रो रेल प्रकल्प फेज-२ चे सन २०२४-२५ चे प्रस्तावित भाडे
१	०-२	१०	१५
२	२-५	२०	३०
३	५-१२	३०	५०
४	१२-२१	४०	६५
५	२१-३२	५०	८०
६	>३२	६०	९५

(४) सदर प्रकल्प खर्चाच्या २० टक्के हिस्सा इक्विटी आणि राज्य कर यासाठी खालीलप्रमाणे राज्यशासन, महाराष्ट्र औद्योगिक विकास महामंडळ लि. (एमआयडीसी), महाराष्ट्र विमानतळ विकास कंपनी लि. (एमएडीसी) यांच्यामार्फत निधी देण्यास मान्यता देण्यात येत आहे.

अ.क्र.	संस्था	आर्थिक सहभाग (कोटीत)
१.	महाराष्ट्र शासनाचा समभाग	१६५८
२.	राज्य शासनाकडून केंद्रीय कराकरीता दुय्यम कर्ज	३९९
३.	एमएडीसीकडून अनुदान	१९४
४.	एमआयडीसीमार्फत भुसंपादन आणि पुनर्वसन व पुनर्वासाकरीता अनुदान (भूसंपादन रु.२३३ कोटी व पुनर्वसन व पुर्नवसाहत रु.१३ कोटी)	२४६
५.	एमआयडीसीमार्फत राज्य कराकरीता अनुदान	३१५
६.	एमएडीसीमार्फत राज्य कराकरीता अनुदान	३६७
७.	बांधकाम कालावधी दरम्यानचे व्याजाकरिता (द्विपक्षीय/बहुपक्षीय वित्तीय संस्थांकडूनच्या कर्जावरील व्याज). राज्यशासनाचा सहभाग	२३
	एकूण रक्कम	३२०२

(५) वरील परिच्छेद क्रमांक ४ मधील तक्त्यात नमूद केल्याप्रमाणे सदर प्रकल्पाकरिता एमआयडीसीमार्फत रु. ५६१ कोटी व एमएडीसीमार्फत रु.५६१ कोटी इतके अनुदान महामेट्रोला देण्यासाठी एमआयडीसी व एमएडीसी यांना निदेश देण्यात येत आहेत.

(६) वरील परिच्छेद क्रमांक ४ मधील तक्त्यात नमूद केल्याप्रमाणे सदर प्रकल्पाकरिता राज्यशासनाकडून रु.१६५८ कोटी समभाग म्हणून, केंद्रीय कराकरीता रु.३९९ कोटी राज्यशासनाचे बिनव्याजी दुय्यम कर्ज म्हणून व बांधकाम कालावधी दरम्यानचे व्याज रु.२३ कोटी राज्यशासनाचा सहभाग म्हणून देण्यास देण्यास मान्यता देण्यात येत आहे.

(७) नागपूर मेट्रो रेल प्रकल्पाचा दुसरा टप्पा - Vital Important Urban Transport Project म्हणून घोषित करण्यास मान्यता देण्यात येत आहे.

(८) महा-मेट्रो फेज-२ चे विस्तारित मार्गिकेमध्ये येणारे क्षेत्र तसेच स्टेशन, पार्कींग व संपत्ती विकास याकरीता महाराष्ट्र मेट्रो रेल कॉर्पोरेशन लि. ला हस्तांतरीत करण्यात आलेल्या क्षेत्रासाठी एसपीए म्हणून मान्यता देण्यात येत आहे.

(९) महाराष्ट्र प्रादेशिक व नगर रचना अधिनियम, १९६६ च्या अंतर्गत नागपूर मेट्रो रेल फेज-२ च्या टीओडी कॉरिडॉरचे विस्तारिकरण करण्यास मान्यता देण्यात येत आहे.

(१०) सदर प्रकल्प अंमलबजावणीच्या दृष्टीकोनातून धोरणात्मक निर्णय घेण्यासाठी शासनातर्फे खालीलप्रमाणे उच्चाधिकार समिती (High Power Committee) गठित करून समितीच्या कार्यक्षेत्रास मान्यता देण्यात येत आहे.

a. उच्चाधिकार समितीची रचना

प्रकल्प अंमलबजावणीच्या दृष्टीकोनातून धोरणात्मक निर्णय घेण्यासाठी शासनातर्फे खालीलप्रमाणे उच्चाधिकार समिती (High Power Committee) स्थापन करण्यास मान्यता देण्यात येत आहे.

i.	अध्यक्ष	:	मा. मुख्य सचिव
ii.	सदस्य	:	प्रधान सचिव(१), नगर विकास विभाग
iii.	सदस्य	:	प्रधान सचिव(२), नगर विकास विभाग
iv.	सदस्य	:	प्रधान सचिव, वित्त विभाग.
v.	सदस्य	:	प्रधान सचिव, विधी व न्याय विभाग
vi.	सदस्य	:	जिल्हाधिकारी, नागपूर
vii.	सदस्य	:	आयुक्त, नागपूर महानगर प्रादेशिक विकास प्राधिकरण
viii.	सदस्य	:	व्यवस्थापकीय संचालक, महा-मेट्रो

b. सदर समितीची कार्यकक्षा पुढीलप्रमाणे राहील :-

i. नागपूर मेट्रो फेज-२ उभारणे व परिचलन करणे या संबंधातील धोरणात्मक बाबींवर निर्णय घेणे.

ii. नागपूर मेट्रो रेल प्रकल्पाच्या फेज-२ संदर्भात जमीन वापर बदल, वाढीव चटई क्षेत्र निर्देशांक व तद्नुषंगिक सवलती देण्यासंदर्भात निर्णय घेणे.

iii. नागपूर मेट्रो रेल प्रकल्पाच्या फेज-२ ला राज्य शासनाचा देय हिस्सा वितरित करण्यासाठी निर्देश देणे.
iv. नागपूर मेट्रो रेल प्रकल्प फेज-२ च्या सविस्तर प्रकल्प अहवालात नमूद केल्याप्रमाणे अथवा आवश्यकतेप्रमाणे इतर आर्थिक पर्यायाच्या अंमलबजावणीसाठी निर्देश देणे व त्यासाठी कालबध्द कार्यक्रम ठरवून देणे.
v. राज्य शासनास वाटतील असे तसेच स्पेशल पर्पज व्हेईकल कंपनीच्या अखत्यारित नसलेल्या बाबींवर निर्णय घेणे.
vi. केंद्र व राज्य शासनाने वेळोवेळी दिलेल्या निर्देशानुसार नागपूर मेट्रो प्रकल्प फेज-२ मध्ये आवश्यक त्या सुधारणा/ बदल करून अंमलबजावणीस मान्यता देणे.

(११) सध्या महानगरपालिका अधिनियम, १९६६ च्या कलम १४९-बी अंतर्गत नागपूर म्युनिसिपल हद्दीमध्ये १% अधिभार आकारला जातो. सदर प्रकल्पाचे संरेखन विचारात घेता महाराष्ट्र जिल्हा परिषद व पंचायत समिती कायदा, १९६१ मध्ये ही दुरूस्ती करण्यास मान्यता देण्यात येत आहे.

(१२) नागपूर मेट्रो रेल्वे टप्पा-१ ला दिनांक ३० जानेवारी २०१४ रोजी मान्यता देताना मेट्रो मार्गिकेच्या दोन्ही बाजूस ५०० मी. पर्यंत अतिरिक्त चटईक्षेत्र निर्देशांक देताना आकारण्यात येणाऱ्या अधिमूल्यातील रक्कम, सदर प्रकल्प क्षेत्राच्या शहरात १०० टक्के वाढीव विकास शुल्कातून जमा होणारी रक्कम व सदर प्रकल्प क्षेत्राच्या शहरात १ टक्के वाढीव मुद्रांक शुल्क अधिभारातून जमा होणारी रक्कम संबंधित एसपीव्हीला देण्यास मान्यता दिली आहे. त्याधर्तीवर मेट्रो प्रकल्पाच्या विस्तारित क्षेत्रात जमा होणारी अशी रक्कम प्रकल्पाची एसपीव्ही म्हणून महामेट्रोस देण्यास संबंधित संस्थाना निदेश देण्यास मान्यता देण्यात येत आहे.

(१३) केंद्र सरकारकडून जमीन अधिग्रहण खर्चासाठी आणि राज्य करासाठी योगदान प्राप्त होणार नाही त्यामुळे सदर प्रकल्पासाठी अशा शासकीय जमिनी नाममात्र रूपये १/- मूल्य आकारून महाराष्ट्र मेट्रो रेल कॉर्पोरेशन लि. ला हस्तांतरित करण्यास मान्यता देण्यात येत आहे.

(१४) नागपूर व पुणे मेट्रो रेल्वे प्रकल्पांतर्गत येणाऱ्या प्रकल्प बाधितांचे (PAP) पुनर्वसन व पुनर्वसाहत करण्याकरिता गृहनिर्माण व विशेष सहाय्य विभाग, शासन निर्णय क्रमांक प्रकल्प-१७००/सीआर-३१/स्लम-२, दिनांक १२.१२.२००० अन्वये लागू केलेले "मुंबई नागरी परिवहन प्रकल्प पुनर्वसन व पुनर्वसाहत धोरण (MUTP-R & R Policy)" लागू करण्यास मान्यता देण्यात येत आहे.

हा शासन निर्णय नियोजन विभाग अनौपचारीक संदर्भ क्र. १/१९/१४४४ दिनांक ७.१.२०१९ व वित्त विभाग अनौपचारीक संदर्भ क्र. १०/व्यय-३, दिनांक १४.०१.२०१९ अन्वये प्राप्त अभिप्रायांचा विचार करुन निर्गमित करण्यात येत आहे.

सदर शासन निर्णय महाराष्ट्र शासनाच्या www.maharashtra.gov.in या संकेतस्थळावर उपलब्ध करण्यात आला असून त्याचा सांकेतांक २०१९०११४१५४७३५८६२५ असा आहे. हा आदेश डिजीटल स्वाक्षरीने साक्षांकित करुन काढण्यात येत आहे.

महाराष्ट्राचे राज्यपाल यांच्या आदेशानुसार व नावाने,

Digitally signed by Shriram Dattatray Yadav
DN: c=IN, o=Government Of Maharashtra, ou=Urban Development Department, postalCode=400032, st=Maharashtra, 2.5.4.20=9da0e03bd84c1e17d78ad320814d003150fbf7d2abd36f924e5705145bf0e270, cn=Shriram Dattatray Yadav
Date: 2019.01.15 17:49:14 +05'30'

(श्रीराम यादव)
उपसचिव, महाराष्ट्र राज्य

प्रति,

१. मा. राज्यपाल, महाराष्ट्र राज्य, यांचे सचिव.
२. मा. मुख्यमंत्री यांचे प्रधान सचिव, मंत्रालय, मुंबई ४०० ०३२.
३. मा. राज्यमंत्री (नवि) यांचे खाजगी सचिव, मंत्रालय, मुंबई ४०० ०३२.
४. मा. मुख्य सचिव, महाराष्ट्र शासन, मंत्रालय, मुंबई ४०० ०३२.
५. अपर मुख्य सचिव (महसूल), महसूल व वन विभाग, मंत्रालय, मुंबई ४०० ०३२.
६. अपर मुख्य सचिव, गृह विभाग, मंत्रालय, मुंबई ४०० ०३२.
७. अपर मुख्य सचिव (वित्त), वित्त विभाग, मंत्रालय, मुंबई ४०० ०३२.
८. अपर मुख्य सचिव, नियोजन विभाग, मंत्रालय, मुंबई ४०० ०३२.
९. प्रधान सचिव, विधी व न्याय विभाग, मंत्रालय, मुंबई ४०० ०३२.
१०. प्रधान सचिव (नवि-१), नगर विकास विभाग, मंत्रालय, मुंबई ४०० ०३२.
११. प्रधान सचिव (परिवहन), गृह विभाग, मंत्रालय, मुंबई ४०० ०३२.
१२. प्रधान सचिव (नवि-२), नगर विकास विभाग, मंत्रालय, मुंबई ४०० ०३२.
१३. प्रधान सचिव, ग्राम विकास विभाग, मंत्रालय, मुंबई ४०० ०३२.
१४. प्रधान सचिव (उद्योग), उद्योग, ऊर्जा व कामगार विभाग, मंत्रालय, मुंबई ४०० ०३२.
१५. प्रधान सचिव (ऊर्जा), उद्योग, ऊर्जा व कामगार विभाग, मंत्रालय, मुंबई ४०० ०३२.
१६. अपर मुख्य सचिव, सामान्य प्रशासन विभाग, मंत्रालय, मुंबई ४०० ०३२.
१७. सचिव (विशेष प्रकल्प), सामान्य प्रशासन विभाग, मंत्रालय, मुंबई ४०० ०३२.
१८. सचिव, सार्वजनिक बांधकाम विभाग, मंत्रालय, मुंबई ४०० ०३२.
१९. व्यवस्थापकिय संचालक, महाराष्ट्र मेट्रो रेल कॉर्पोरेशन लि. (महामेट्रो) नागपूर.
२०. उपाध्यक्ष तथा व्यवस्थापकीय संचालक, महाराष्ट्र विमानतळ विकास कंपनी लि., मुंबई.
२१. मुख्य कार्यकारी अधिकारी, महाराष्ट्र औद्योगिक विकास महामंडळ लि., मुंबई.
२२. विभागीय आयुक्त, नागपूर विभाग, नागपूर.
२३. पोलिस आयुक्त, नागपूर.
२४. सभापती, नागपूर सुधार प्रन्यास, नागपूर
२५. आयुक्त, नागपूर महानगरपालिका, नागपूर.
२६. महानगर आयुक्त, नागपूर महानगर प्रदेश विकास प्राधिकरण, नागपूर.
२७. जिल्हाधिकारी, नागपूर.
२८. महाव्यवस्थापक, मध्य रेल्वे, मुंबई.
२९. विभागीय रेल्वे प्रबंधक, मध्य रेल्वे, नागपूर.

३०. विभागीय रेल्वे प्रबंधक, दक्षिण-पूर्व मध्य रेल्वे, नागपूर.
३१. महाव्यवस्थापक, नागपूर महानगर परिवहन महामंडळ मर्यादित, पुणे.
३२. सह सचिव, नगर रचना, नगर विकास विभाग, मंत्रालय, मुंबई ४०० ०३२.
३३. संचालक, नगर रचना, मध्यवर्ती प्रशासकीय इमारत, पुणे.
३४. उप सचिव, वित्त विभाग, मंत्रालय, मुंबई ४०० ०३२.
३५. कार्यासन अधिकारी (नवि-२६), नगर विकास विभाग, मंत्रालय, मुंबई.
३६. निवड नस्ती (नवि-७).