No. K-14011/37/2022-MRTS-II
Government of India
Ministry of Housing and Urban Affairs
(Urban Transport)

Nirman Bhawan, New Delhi
Dated, the 04th September, 2024

To

The Chief Secretary, Government of Maharashtra,
CS Office, Main Building, Mantralaya, 6th Floor,
Madame Cama Road, Mumbai-400032

Subject: Approval of Pune Metro Phase-1 project extension line towards south from Swargate to Katraj.

Sir,

I am directed to convey the approval of the Government of India (GoI) for implementation of Pune Metro Phase-1 project extension line towards south **from Swargate to Katraj** covering a length of 5.464 km at a completion cost of ₹2954.53 crore with contribution of GoI in form of Equity and Subordinate Debt as per the details given in para 3 and subject to the conditions as given in para 6 below. The cost break-up of the project has been given in the **Annexure-I**. The project will be completed in four years and six months from the date of sanction of the project.

2. **Corridor:** Swargate – Katraj Metro project (extension of Pune Metro Phase-1 line towards south) will cover 5.464 km with 3 underground stations.

3. **Project Financing:** The cost of the project as stated in Para 1 above will be financed as per the financing plan given below:

Particulars	Amount (in ₹ Cr)	Percentage
Equity by GoI	397.83	15.50%
Equity by GoM	397.83	15.50%
SD for Central Taxes by GoI(50%)	115.52	4.5%
SD for Central Taxes by GoM(50%)	115.52	4.5%
Soft Loan from bilateral/ multilateral funding agencies	1540.04	60.00%
Sub – Total	**2,566.74**	**100%**
Subordinate Debt (SD) for State Taxes by GoM	206.58	
Contribution / Grant for Land, R&R and IDC by Pune Municipal Corporation	181.21	
Total	**2,954.53**	

4. **Legal Framework:** Legal coverage of the project shall be under The Metro Railways (Construction of Works) Act, 1978, The Metro Railways (Operation & Maintenance) Act, 2002 as amended through the Metro Railways (Amendment) Act, 2009 and the Railways Act, 1989 as amended from time to time.

5. **Institutional Arrangement**

(i) The project will be implemented by the existing Special Purpose Vehicle (SPV) namely Maharashtra Metro Rail Corporation Limited (Maha Metro), which is a 50:50 jointly owned company of GoI and GoM. The promoters, the GoI and the State Government shall nominate five Directors each to the Board of Directors (BoD), totalling 10 nominees Directors. The ex-officio Chairman of BoD will be among the five nominee Directors from GoI. The full-time Managing Director with adequate administrative experience, will be the nominee of the State Government and will be appointed or removed by the BoD only with the prior written permission of GoI. The Managing Director shall not be given any other/additional assignment by the State Government without the prior written permission of GoI. The BoD shall also have Functional Directors, in addition to the 10 nominee Directors.

(ii) **High Powered Committee:** During implementation of the project, the existing High Powered committee under the chairmanship of the Chief Secretary to the Government of Maharashtra, with other Secretaries concerned as members, will take expeditious decisions on matters relating land acquisition, shifting of utilities and other structures in project alignment, rehabilitation of Project Affected Persons, multimodal integration and such other matters where the State Government has to facilitate quick action including various conditions of sanction of this project.

6. **The conditions of sanction of the project are as under:**

(i) A Memorandum of Understanding (MoU) shall be signed amongst the GoI, GoM and Maha-Metro to ensure effective implementation of the project and conditions of sanction.

(ii) GoM would ensure price-based measures to promote and facilitate ridership, as part of an integrated traffic rationalization plan and Development Plan, 2017 for Pune Municipal Corporation (PMC) with a view to ensure that the projected ridership is realized.

(iii) Integration of various modes of transport which would act as feeder/evacuation systems to the proposed Metro for improved ridership including adequate parking space at Stations, National common mobility card being introduced by Ministry of Housing and Urban Affairs and integrated ticketing across all modes and all operators would be given high priority by the GoM and Maha-Metro.

(iv) A suitable arrangement shall be provided by GoM for periodic and automatic fare revision for other competing modes.

(v) The GoM would set up a dedicated Urban Transport Fund (UTF) at State level in consultation with Ministry of Housing and Urban Affairs, Government of India through levy of dedicated taxes/levies etc., capturing the increased land and property value from sale proceeds/rental (as well as increased FAR) all along the corridors in Maharashtra as envisaged in National Urban Transport Policy, 2006 to create pool of resources for replacement of assets, interest subsidy and providing operational subsidies, if any, not only for this project but other Urban Transport projects as well. Amount realized from the increased land and property value capture from sale/rental proceeds would be credited to Dedicated Urban Transport Fund at State level.

(vi) Ministry of Housing and Urban Affairs (MoHUA), Government of India will take necessary steps in regard to standardization and indigenization across all MRTS.

(vii) MoHUA, Government of India will get safety certification for all Metro systems done through Commissioner of Metro Railway Safety.

(viii) The Maha-Metro, a joint venture of Government of India and GoM, which will implement the project shall generally adopt the guidelines of Department of Public Enterprises, the Department of Economic Affairs and the Central Vigilance Commission as necessary to strengthen the Corporate Governance and shall be subject to Parliamentary scrutiny.

(ix) Maha-Metro and GoM along with Pune Municipal Corporation (PMC), would ensure development of facilities for pedestrians and cyclists in the catchment area of all the Metro stations in PMC. A modern ITS enabled cycle sharing facility (like Velib in Paris) would be set up and maintained by Maha-Metro in the catchment area of all the Metro stations in the network to promote green and clean transport.

(x) In order to promote indigenization, the growth of industry and employment in India, the Maha-Metro would insist on manufacturing facilities in India for majority of its procurement.

(xi) The Maha-Metro shall generally be bound by such directions on question of policy, as the Central Government may give in writing from time to time after giving due opportunity to the Maha-Metro to express its views before giving any direction.

(xii) **Cost Escalation**: GoI's proposed funding in the form of Equity and Subordinate Debt will be ring fenced to ₹513.35 Cr i.e. 20% of the total project cost excluding private investment, land, R&R and taxes. Any other cost escalation due to price escalation or exchange rate variation leading to increase in the cost of the project within or beyond the approved project time limit, inclusion of any essential item not referred to in the DPR, and also any other cost escalation due to change in scope occurred within/beyond the approved project time limit or delays beyond the approved time cycle shall be borne/met/arranged by the SPV and/or GoM.

(xiii) **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 Government of Maharashtra and not by the Government of India.

(xiv) Hedging cost and exchange rate fluctuation shall be borne by GoM.

(xv) Expenditure on O&M and debt servicing should be the responsibility of the SPV. In case the SPV fails to bear the liabilities, these will be borne by GoM in terms of Para (D) (iv) (d) of Metro Rail Policy, 2017.

(xvi) Keeping in view overarching fiscal consolidation path, the respective State Governments should ensure flow of realisable Value Capture Finance (VCF) in the SPV account in terms of Para (D) (vii) (b) of Metro Rail Policy, 2017 for meeting O&M, escalation, debt servicing etc. of the project in a manner that will reduce burden on the State exchequer.

(xvii) The external funding will be on back to back basis as per the Standard arrangement of Department of Economic Affairs.

(xviii) Central Laws, i.e., the Metro Railways (Construction of Works) Act, 1978, the Metro Railways (Operation & Maintenance) Act, 2002 as amended through Metro Railways (Amendment) Act, 2009 and the Railways Act, 1989 would be applicable.

(xix) The Joint Venture, shall be bound by such directions on question of policy, as the Central Government may give in writing from time to time after giving due opportunity to the Joint Venture to express its views before giving any direction.

8. This issues with the concurrence of the Integrated Finance Division of this Ministry vide their Notes#267-270 dated 29.08.2024.

Yours faithfully,

(Sunil Kumar)
Deputy Secretary to the Govt. of India
Ph. 23061294

Copy to:

1. Principal Secretary to Prime Minister, Prime Minister's Office, South Block, New Delhi- 110001
2. CEO, NITI Aayog, NITI Bhavan, Sansad Marg, New Delhi-110001.
3. Secretary, Department of Expenditure, Ministry of Finance, North Block, New Delhi-110001.
4. Secretary, Department of Economic Affairs, Ministry of Finance, North Block, New Delhi-110001.
5. Chairman, Railway Board, Rail Bhawan, New Delhi-110001.
6. The Secretary, Ministry of Environment, Forest and Climate Change, Indira Paryavaran Bhawan, Prithvi Block, Jor Bagh, New Delhi-110003.
7. Secretary, Ministry of Statistics and Programme Implementation, Sardar Patel Bhavan, Sansad Marg, New Delhi-110001.
8. Secretary, Ministry of Housing and Urban Affairs, New Delhi.

Copy also forwarded, for information to:

1. Director, Cabinet Secretariat, Rashtrapati Bhawan, New Delhi- 110004 with reference to their communication D.O. No. 22/CM/2024(i) dated 19.08.2024
2. The Principal Secretary (UD-1), Urban Development Department, Government of Maharashtra, Mantralaya, 6th Floor, Madame Cama Road, Mumbai-400032.
3. The Managing Director, Maharashtra Metro Rail Corporation Limited (Maha-Metro), Metro Bhawan, East High Court Road (VIP Road), In front of Dr. Babasaheb Ambedkar College, Near Dikshabhoomi, Nagpur-440010.
4. Resident Commissioner, Government of Maharashtra, New Maharashtra Sadan, New Delhi- 110001.
5. PS to Hon'ble Minister (HUA).
6. OSD (UT), MoHUA, New Delhi.
7. JS & FA, MoHUA, New Delhi.
8. All Directors & Deputy Secretaries in UT Division of MoHUA, New Delhi.

(Sunil Kumar)
Deputy Secretary to the Govt. of India
Ph. 23061294

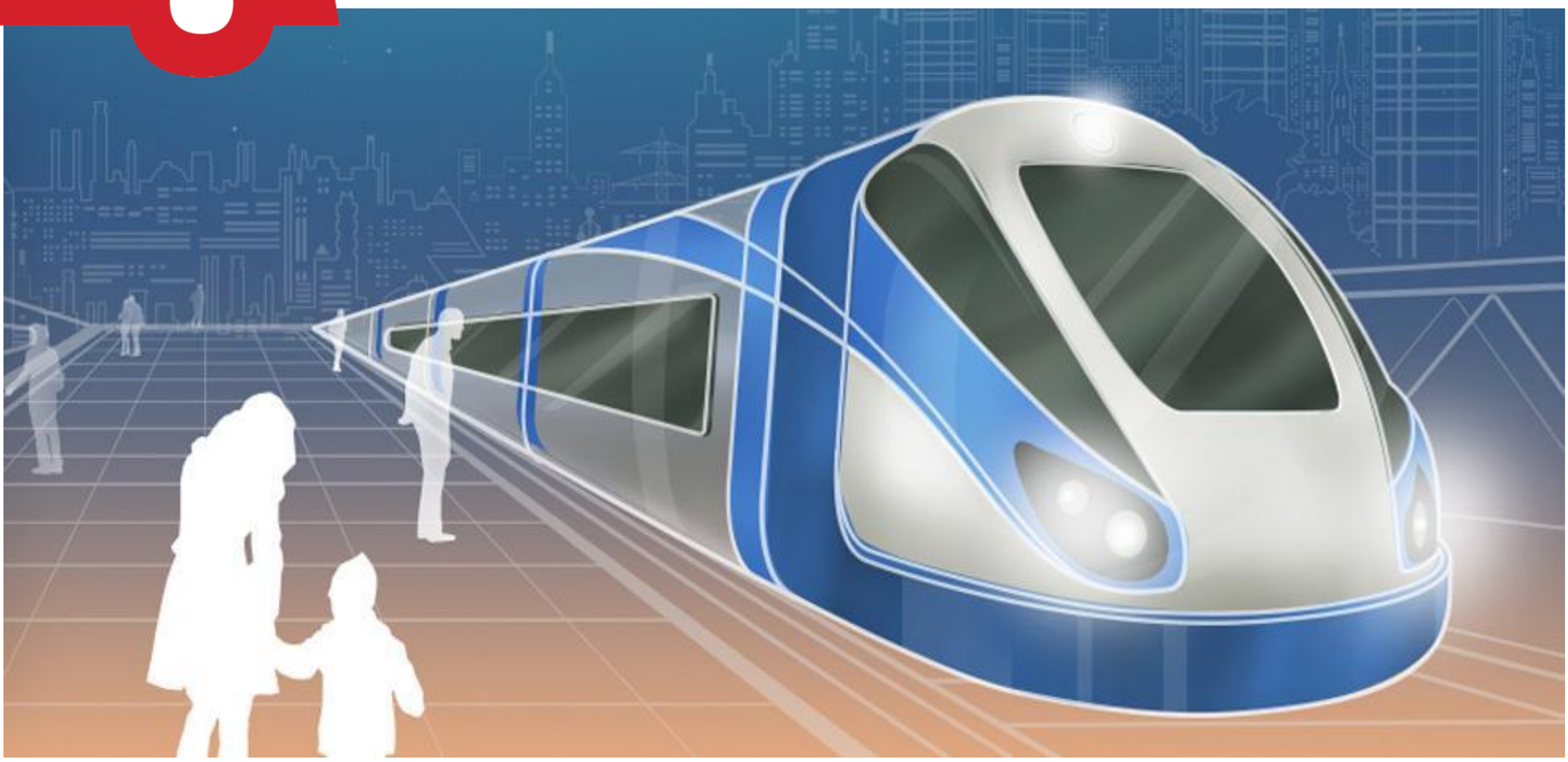
Annexure- I

Component Wise Cost Break-up of the project

S. No	Description	Total cost (₹ in Cr.)
1	Alignment & Formation	
a	Underground Section - Twin Tunnel	751.50
b	Viaduct for Stabling Line/Depot	37.63
2	Station Buildings	
a	Station Building - Cut & Cover	441.00
b	E&M tunnel ventilation incl. Lifts & Escalators	169.51
c	Ventilation Shaft between Station 2 & Station 3	41.09
3	Stabling Lines	11.72
4	P-Way for main line and Stabling Line/Depot	47.47
5	Traction and Power Supply	147.28
6	Signaling	54.06
7	Telecommunication	15.26
8	Rolling Stock	120.00
9	Automatic Fare Collection (AFC)	11.87
10	Platform Screen Doors (PSD)	10.17
11	Multi Modal Integration	10.17
12	Cost of Security	1.25
13	Environment cost	3.32
14	Utility Shifting	37.05
15	Total Cost at July '21 price level (Excluding Land, R&R, General Charges, Contingencies, Central & State Taxes)	**1,910.35**
16	General Charges @ 5%	95.52
17	Contingencies @ 3% on Sr. No.14 i.e. on basic cost	57.31
18	Total Cost at July '21 price levels incl. General Charges and Contingencies (Excluding Land, R&R, Central & State Taxes)	**2,063.17**
19	Central and State Taxes @ July '21 Price Level	386.55
20	**Total Cost incl. General Charges, Contingencies, Central and state Taxes @ July '21 Price Levels (Excl. Land and R&R)**	**2,449.73**
21	Land	111.30
22	R&R	45.52
23	Total Cost incl. General Charges, Contingencies, Central and state Taxes @ July '21 Price Levels (Incl. Land and R&R)	**2,606.55**
24	Escalation at 5% per annum on the above	323.60
25	**Total Completion Cost incl. Land and R&R Costs**	**2,930.14**
26	Interest During Construction (IDC)	24.39
27	**Total Completion cost including IDC**	**2,954.53**

X-X-X-X-X

REVISED FINAL DETAILED PROJECT REPORT (SWARGATE – KATRAJ)



EXTENSION OF PUNE METRO PHASE-I

REVISED FINAL DETAILED PROJECT REPORT (SWARGATE – KATRAJ)

IDENTIFICATION TABLE

Client/Project owner	Maharashtra Metro Rail Corporation Limited
Project	Extension of Pune Metro Phase-I
Type of document	Revised Final Detailed Project Report (SWARGATE – KATRAJ)
Study	Detailed Project Report
Framework	Systra India
Reference number	IN01T18A03
Confidentiality	Confidential
Language	English
Number of pages	523

APPROVAL

Version	Name		Position	Date	Signature	Modifications
4	Production	Divya Dahiya	Urban Planner	10/12/2021		
	Check	Rishi Gupta	Project Manager	10/12/2021		
	Establishment of liability for the entity	Praveen Goyal	Project Director	10/12/2021		
5				21/12/2022		Cost Estimate

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ABBREVIATIONS TABLE

AAC	All Aluminium Conductor
AAI	Airport Authority of India
AAQ	Ambient Air Quality
ABD	Area Based Development
ADB	Asian Development Bank
ADB	Asian Development Bank
AFC	Automatic Fare Collection
ALG	Advanced Launching Girder
APHA	American Public Health Association
ASHRAE	American Society of Heating, Refrigerating and Air-Conditioning Engineers
ASR	Annual Statement of Rates
ATD	Anti-Tensioning Device
ATO	Automatic Train Operation
ATP	Automatic Train Protection
ATS	Automatic Train Supervision
BAU	Business as Usual
BCD	Basic Custom Duty
BEC	Buried Earth Conductor
BHLS	Bus with a High Level of Service
BIS	Bureau of Indian Standard
BOCC	Backup Operation Control Centres
BOH	Back of House
BOT	Build Operate Transfer
BRT	Bus Rapid Transit
BS	British Standard
CBD	Central Business District
CBTC	Communication based Train Control System
CENELEC	European committee for Electrotechnical standardization
CMP	Comprehensive Mobility Plan
CO	Carbon Monoxide
COI	Corridor of Impact
CPCB	Central Pollution Control Board
CPR	Community Property Resource
CTTS	Comprehensive Traffic and Transportation Study
CVRS	Central Voice Recording System
CWR	Continuous Welded Rail

DCF	Discounted Cash Flow
DG Set	Diesel Generating Set
DMC	Driving Motor Car
DMRC	Delhi Metro Rail Corporation
DP	Development Plan
EFO	Excess Fare Office
EGOM.	Empowered Group of Ministers
EIA	Environmental Impact Assessment
EIRR	Economic Internal Rate of Return
EMDB	Emergency Main Distribution Board
EMP	Environmental Management Plan
ENPV	Economic Net Present Value
EOCC	Economic Opportunity Cost of Capital
FAR	Floor Area Ratio
FC	Forest Conservation
FCU	Fan Coil Unit
FIRR	Financial Internal Rate of Return
FOB	Foot Over Bridge
FRP	Fire Resistance Period
FSI	Floor Space Index
GC	Generalized Cost
GOA	Grade of Operation
GOI	Government of Maharashtra
GOM	Government of India
GPR	Ground-penetrating radar
GPS	Global Positioning System
HCMTR	High Capacity Mass Transit Route
HDM	Highway Design and Maintenance Standards Mode
HMI	Human Machine Interface
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronics Engineers
IMD	India Meteorological Department
IPTs	Intermediate Public Transport
IRR	Internal Rate of Return
ISM	Industrial Scientific Medical Radio Band
IT	Information Technology
ITDP	Institute for Transportation and Development Policy
ITES	Information Technology Enabled Services
ITU-T	International Telecommunication Union – Telecommunication Standardisation sector

JICA	Japan International Cooperation Agency
LAA	Land Acquisition Act
LAP	Land Acquisition Plan
LBT	Local Body Tax
LCCA	Life Cycle Cost Analysis
Loss	Levels of Service
LoS	Level of Service
LRT	Light Rail Transit
LULC	Land-use Land-Cover
LWR	Long Welded Rail
MIDC	Maharashtra Industrial Development Corporation
MOHUA	Ministry of Housing and Urban Affairs
MOU	Memorandum of Understanding
MoUD	Ministry of Urban Development
MSRTC	Maharashtra State Road Transport Corporation
NFPA	National Fire Protection Association
NLO	National Labour Organisation
NMS	Network Management System
NMT	Non-Motorised Transport
NMV	Non-Motorised Vehicle
Nox	Oxides of Nitrogen
NPV	Net Present Value
OCC	Operational Control Centre
OD	Origin-Destination
ODA	Official development assistance
OHE	Overhead Equipment
OPC	Overhead Protection Cable
OTE	Over Trackway Exhaust
PBS	Public Bike Sharing
PCMC	Pimpri-Chinchwad Municipal Corporation
PCMT	Pimpri Chinchwad Municipal Transport
PCNTDA	Pimpri Chinchwad New Town Development Authority
PCTR	Per Capita Trip Rate
PCU	Passenger Car Unit
PD	Property Development
PD	Property Development
PF	Platform
PHPDT	Per Hour Per Direction Traffic
PM	Particulate Matter

PMPML	Pune Mahanagar Parivahan Mahamandal Limited
PMT	Pune Municipal Transport
PPE	Personal Protective Equipment's
PRT	Personalised Rapid Transport
PSD	Platform Screen Doors
PSG	Platform Screen Gates
PST	Power Supply & Traction
PT	Public Transport
R&M	Repairs and Maintenance
R&R	Rehabilitation and Resettlement
RAP	Resettlement Action Plan
RAP	Rehabilitation Action Plan
RCTM	Recharge Card Terminal Machine
REJ	Rail Expansion Joint
RH	Relative Humidity
ROW	Right of Way
SC	Schedule Caste
SCADA	Supervisory Control and Data Acquisition
SCR	Station Control Room
SERF	Shadow Exchange Rate Factor
SOx	Oxides of Sulphur
SPV	Special Purpose Vehicle
ST	Schedule Tribe
TAZ	Traffic Analysis Zone
TC	Trailer Car
TDM	Transportation Demand Management
TES	Trackway Exhaust System
TVC	Traffic Volume Count
TVM	Ticket Vending Machine
UPE	Under Platform Exhaust
UPS	Uninterrupted Power at Stations
URDPFI	Urban and Regional Development Plan formulation and Implementation
UV	Ultra Violet
ULB	Urban Local Body
VOC	Vehicle Operating Cost
WB	World Bank

I. SALIENT FEATURES

GAUGE – 1435 mm

Corridor & Route Length

CORRIDOR	UNDERGROUND (KM)	ELEVATED	TOTAL LENGTH KM)
Swargate to Katraj (Phase 2A)	5.464	0	5.464

Number of Stations

CORRIDOR	UNDERGROUND	ELEVATED	TOTAL
Swargate to Katraj (Southward Extension of Corridor-1 of Phase 1) - Phase -2A	3	NIL	3

Traffic Forecast

Maximum Ridership and PHPDT

CORRIDORS	Station	2027	2037	2047	2057
Nigdi to Katraj	Peak Hour	64100	85200	98700	102900
	Daily	668000	888000	1028000	1072000
	PHPDT	18070	22980	27020	28170
Nigdi to Swargate	Peak Hour	55000	70100	80700	84000
	Daily	573000	730000	841000	875000
	PHPDT	16610	21300	24830	25840

Station Planning

A typical design has been suggested for the corridor which will form basis for planning of the stations.

Sr. No.	Size (sq. m)	Levels	No. of stations	Construction Type
1	153.4 x 23.73	3	3	Underground (Cut and Cover)

Intermodal Integration

Feeder bus service, Public Bicycle sharing, Parking and Pedestrian facilities have been proposed for all the stations for intermodal connectivity.

Train Operation Plan

The total number of Train car requirement to satisfy the traffic demand is given in the table below:

Year	Total Car Requirement	Total Trains Required	
		3-Car	6-Car
2027	108	36	0
2037	132	36	4
2047	150	30	10
2057	156	28	12

* Note: Total Car Requirement' includes 90 cars already planned for earlier phases.

Speed

(A) Maximum Design speed : 90 kmph
(B) Maximum Operating Speed : 80 kmph
(C) Scheduled Speed : 33 kmph

Traction Power Supply

(A) Voltage: 25KV OHE and 25 KV ROCS [1]
(B) Power Demand (MVA)

Corridor		Year			
		2027	2037	2047	2057
PCMC-NIGDI	Traction	0.9 MVA	1.0 MVA	1.0 MVA	1.0 MVA
	Auxiliary	1.1 MVA	1.1 MVA	1.1 MVA	1.1 MVA
PCMC-SWARGATE	Traction	8.5 MVA	9.9 MVA	10.9 MVA	11.1 MVA
	Auxiliary	21.9 MVA	21.9 MVA	21.9 MVA	21.9 MVA
SWARGATE - Katraj	Traction	1.1 MVA	1.2 MVA	1.2 MVA	1.2 MVA
	Auxiliary	9.9 MVA	9.9 MVA	9.9 MVA	9.9 MVA
Total Power Demand	**Traction**	**10.5 MVA**	**12.1 MVA**	**13.1 MVA**	**13.3 MVA**

[1] ROCS is recommended for phase 2A whereas OHE is only used as a reference for calculation purpose.

Corridor		Year			
		2027	2037	2047	2057
(NIGDI-SWARGATE)	Auxiliary	32.9 MVA	32.9 MVA	32.9 MVA	32.9 MVA

Incremental requirement of RSS

The implementation of Nigdi – PCMC & Swargate-Katraj metro corridor will increase the Power supply Load requirement on Phase 1 corridors as well. It is necessary to duly consider the incremental power supply load requirement while doing the Power load calculations. The incremental load requirement due to the extension of the corridor, viz. Nigdi – PCMC & Swargate-Katraj have been estimated considering the traction power requirement and Auxiliary power requirements for elevated & underground section from NIGDI to KATRAJ. To cater this incremental requirement with reliability of the Power Supply for traction as well as auxiliary load, One RSS is Proposed near Swargate to cater the Power supply load requirements for Phase 1 corridor from Nigdi to Katraj.

(C) Sources of Power Supply

Corridor	Grid sub-station (with Input voltage)	Location of RSS of Metro Authority	Approx. length of cables
NIGDI - KATRAJ	132 kV Chinchwad SS	Near PCMC	4.5 km approx. from Chinchwad to PCMC
	132 kV Ganeshkhind SS	Near Agri. College	3 km approx. from ganeshkhind to Range hill
	200 kV Parvati SS	Near Swargate	3 km Approx. from Parvati GSS to swargate

Rolling stock

S. No.	Parameter	Rolling Stock
1	Basic Unit	3 Car basic unit 2DMC and 1 TC. Every coach should be fully interchangeable with any other coach of same type.
2	Train Composition	3- Car: DMC+TC+DMC 6- Car: DMC +TC +MC + MC + TC + DMC Capable of GoA4 operation
3	Coach Dimensions	L= 22.6m, W=2.9m, H= 3.9m
4	Coach construction	Light weight Stainless Steel/Aluminium body
5	Axle load	≤16 T
6	Braking System	Regenerative Braking
7	Propulsion system	3 phase drive system with VVVF control

S. No.	Parameter	Rolling Stock
8	Type of traction supply	25kV AC OHE/ROCS system[2]

Stabling lines

Phase-II augmentation of the Range Hill depot is planned to accommodate 22 numbers of 6-car trains or equivalent number of 3-car and 6-car trains which is sufficient for planned Phase-2A requirement up to year 2037.
However, for planned requirement in Phase-2A in year 2047 & 2057, i.e. additional 4 number of 6-car trains, additional stabling facility is required.
For Phase -2A in year 2047 & 2057, elevated stabling lines are proposed at the terminal point of PCMC – Nigdi Corridor. 4 stabling lines are proposed for stabling of 6-car train on each line.

Signalling & Telecommunication

- Type of Signalling: adopting 'CATC' (Continuous Automatic Train Control System) based on "CBTC" (Communication Based Train Control System) which includes ATP (Automatic Train Protection), ATO (Automatic Train Operation) and ATS (Automatic Train Supervision) sub-systems using radio communication between Track side and Train.
- Telecommunication system includes Fibre Optic System - Main Telecommunication Bearer, Telephone System, Mobile Radio Communication, Centralized Clock System, Passenger Announcement System, Centralized Clock System, Passenger Information Display System, CCTV System, Access Control System, Network Monitoring and Management

Fare Collection

The AFC system for this phase shall be of contactless smart card & token type which will also allow easy accounting. The System shall be capable for open loop transactions as well to further integrate the mobility solution with the advancements in technology and to allow for seamless transition from dedicated cards to common multi-use stored value fare media that can be used for financial transactions such as making purchases at shops etc. as well as a fare media in the system.

Environment and Social Impact Assessment

- Both negative and positive impacts associated with the proposed metro corridor during various phases of project cycle have been identified. Metro will provide

[2] ROCS is recommended for phase 2A whereas OHE is only used as a reference for calculation purpose.

commuter friendly and efficient transport system, thus will bring positive impact on the environment.

- Along with that, few negative impacts would also take place during the pre-construction (design) and construction phase e.g. Approx. 146 Trees are falling within the propose Right of Way/at the station locations.
- The total estimated environmental management cost for the proposed project is about **Rs. 3.32 Crore.**
- The project will involve acquisition of 2.63 Ha Hectare of land. Total of 52 structures will be affected out of which 45 are private properties, 5 are government owned and one is religious in nature.
- Estimated cost of implementation of R&R Plan is **INR 45.52 Cr.**
- Total Land Acquisition cost works out to **INR 111.3 Cr.**

Detailed Cost Estimate

The detailed cost estimate of the proposed extension line is given below,

CAPITAL COST ESTIMATE (JULY 2021 PRICE LEVEL)

S. No	Description	Total cost (Cr.)
1	Alignment & Formation	
a	Underground Section - Twin Tunnel	1,052.10
b	Viaduct for Stabling Line/Depot	37.63
2	Station Buildings	
a	Station Building - Cut & Cover	570.00
b	E&M tunnel ventilation incl. Lifts & Escalators	169.51
c	Ventilation Shaft between Station 2 & Station 3	50.00
3	Stabling Lines	11.72
4	P-Way for main line and Stabling Line/Depot	47.47
5	Traction and Power Supply	147.28
6	Signaling	54.06
7	Telecommunication	15.26
8	Rolling Stock	162.73
9	Platform Screen Doors (PSD)	10.17
10	Multi Modal Integration	10.17
11	Cost of Security	1.25
12	Environment cost	3.32
13	Utility Shifting	37.05
14	**Total Cost at July '21 price level (Excluding Land, R&R, General Charges, Contingencies, Central & State Taxes)**	**2,379.72**
15	General Charges @ 5%	118.99

16	Contingencies @ 3 % on Sr. No.14 i.e. on basic cost	71.39
17	**Total Cost at July '21 price levels incl. General Charges and Contingencies (Excluding Land, R&R, Central & State Taxes)**	**2,570.10**
18	**Central and State Taxes @ July '21 Price Level**	**376.96**
19	**Total Cost incl. General Charges, Contingencies, Central and state Taxes @ July '21 Price Levels (Excl. Land and R&R)**	**2,947.05**
20	Land	111.30
21	R&R	45.52
22	**Total Cost incl. General Charges, Contingencies, Central and state Taxes @ July '21 Price Levels (Incl. Land and R&R)**	**3103.87**
23	Escalation at 5 % per annum on the above	512.44
24	**Total Completion Cost incl. Land and R&R Costs**	**3,616.31**
25	Interest During Construction (IDC)	30.29
26	**Total Completion cost including IDC**	**3,646.60**
27	PPP component (AFC) incl. escalation & taxes	17.26
28	**Total Completion Cost**	**3,663.86**

Note: July '21 Price Level is considered and the prices are escalated till the completion period to arrive at the completion cost.

Economic Analysis

EIRR in economic term is 19.80 % for proposed extension of Phase 2A i.e. Swargate to Katraj. The evaluation has indicated that the proposed MRTS extension in Pune City with a total length of 5.464 km, considered under the investment proposals is found to be economically viable, with the calculated EIRR value exceeding the economic opportunity cost of capital.

Sensitivity analysis of the EIRR with Capital cost increase by 15%, O&M costs increased by 15%, Target beneficiaries reduced by 15%, Delay in accrual of benefit by 1 year has also been carried out.

Financial Analysis

FIRR with project cost including all taxes, estimated fare and non-fare box revenue is estimated at 14.45%

Implementation plan

S. No	Tasks	Anticipated Timelines
1	Approval of DPR by PMC	Septemeber 2021
2	Approval of DPR by GoM	February 2022
3	Final Approval by GoI	May 2022
4	Packaging & Invitation of Bids	August 2022
5	Commencement of Civil Works	November 2022
6	Commencement of Operation	April 2027

II. EXECUTIVE SUMMARY

0.1 Introduction

Study area for the assignment is the administrative boundary of Pune Municipal Corporation which forms part of core urban area of Pune Metropolitan Region (PMR) with an area of 170 sq. km. As per Census 2011, the population of PMC area is 31.24 Lakh. There is a growth of more than six times in the city's population in the last 60 years. (Source: City Development Plan, PMC)

Large-scale urbanization in IT/ITES and industrialization with rapid growth of vehicular population has laid severe stress on urban transport system in city over the years. The City has a total of about 23 lakhs vehicles as per Maharashtra government vehicle statistics. The growth in mechanized vehicles was around 10 percent per annum in Pune City as per City Development Plan, 2041 (PMC). The usage of private modes is increasing unabated mainly due to inadequate public transport facilities.

With a view of developing effective and efficient mass transit system towards improving the share of public transport trips, the Government of Maharashtra conceived and implemented Metro rail system covering 17.8 km (Line 1, Phase 1) with an extension of 4.413 km as part of Phase-IA in the north and further extension of 5.464 km in the south.

There is a need for extension of Phase 1 in order to meet the future traffic demand. Nationally and globally it is seen that the metro network expands progressively to serve the entire City.

0.2 Existing Transportation System

City level transportation demand is catered predominantly by PMPML, Intermediate Public Transport System (IPT) in the form of shared services along major arterials and Commuter Rail System. Phase-I of Pune Metro covering 33.5 km in two corridors is being implemented– Corridor 1: PCMC to Swargate (17.8 km) and Corridor 2: Vanaz to Ramwadi (15.7 km). An extension from PCMC to Nigdi (about 4.413 km), Swargate to Katraj (5.464 km) also has been planned in Corridor 1 (PCMC to Swargate).

0.3 Travel Demand Forecast

The peak hour peak direction traffic (PHPDT) and daily ridership for horizon years up to 2057 for existing and proposed Pune Metro corridors are presented in the following table:

Table 1 : Travel Demand Forecast for Pune Metro Phase-2A

CORRIDORS	Station	2027	2037	2047	2057
Nigdi to Katraj	Peak Hour	64100	85200	98700	102900
	Daily	668000	888000	1028000	1072000
	PHPDT	18070	22980	27020	28170
Nigdi to Swargate	Peak Hour	55000	70100	80700	84000
	Daily	573000	730000	841000	875000
	PHPDT	16610	21300	24830	25840

The average trip length for various horizon years is presented in table below:

Table 2 : Average Trip length (KM)

Year	Without Extension (Nigdi-Swargate)	With Extension (Nigdi-Katraj)
2027	7.90	8.09
2037	8.11	8.35
2047	8.28	8.63
2057	8.39	8.83

0.4 Train Operation Plan

Train operation plan for proposed corridors is based on the following:

- Running of services for 19 hours of the day (05:00Hrs to 24:00Hrs) with a maximum station dwell time of 40 seconds;
- Make up time of 5-10% with 8-12% coasting;
- Schedule speed has been taken as 33 km/hr.
- Adequate services to ensure comfortable journey for commuters

Based on the projected PHPDT demand, Train operation for Pune Metro Corridor-2A is planned with train carrying capacity calculated @6 persons per square meter of standee area in train.

As PHPDT in sections beyond PCMC-Swargate is very low (PHPDT of 4370), peak headway only 5.4 min in 2027, 5 min in 2037, 2047 and 2057 is considered sufficient in this section. Accordingly, every alternate train is planned to be short looped from PCMC and Swargate, at least during peak hours. This has minimized Rolling Stock and Train Operator requirement.

The headway and capacity provided for different sections of three corridors is given in following table:

Table 3 : Headway and Capacity Provided for Nigdi To Katraj Section

Demand (PHPDT) and Capacity Plan – line 1 Phase 1A (Nigdi- Katraj)								
Year	2027		2037		2047		2057	
Section / Peak Hour characteristics	Nigdi-PCMC & Swargate-Katraj	PCMC-Swargate	Nigdi-PCMC & Swargate -Katraj	PCMC-Swargate	Nigdi-PCMC & Swargate-Katraj	PCMC-Swargate	Nigdi-PCMC & Swargate-Katraj	PCMC-Swargate
Headway (seconds)	327	164	300	150	300	150	300	150
No. of 3- Cars trains/ Hr	11	22	12	10	12	5	12	3
No. of 6- Cars trains/ Hr	0	0	0	2	0	7	0	9
Peak Demand	4370	18070	6770	22980	7680	27020	8010	28170
Total Capacity @6p/sqm of standee area	8404	16808	9168	19956	9168	24006	9168	25626
Total Capacity @8p/sqm of standee area	10725	21450	11700	25458	11700	30603	11700	32661

0.5 System Selection

The Phase 2A is a continuation of existing Phase 1 (PCMC to Swargate) in the southern end. Considering the PHPDT for design year, it is recommended to adopt a medium capacity metro rail system which will provide seamless connectivity. Alternative Analysis for alternate Corridor options and modes has been conducted. It was thus concluded that the medium capacity metro will be suitable to meet the PHPDT of the horizon year. It is proposed that the medium metro runs through Katraj-Swargate – PCMC – Nigdi corridor. In order to ensure the same, the system of Phase2A should be similar and compatible to that of Phase 1 and Phase 1A.

0.6 Technology Selection

0.6.1 Permanent way

0.6.1.1 Choice of Gauge

Standard Gauge (1435mm) is invariably used for metro railways world over due to its inherent advantages. During the last decade, 20 new metros have been constructed in various cities of the world. All these metros have gone in for Standard Gauge even though the national gauge for mainline railways in some of these countries was different from Standard Gauge.

0.6.1.2 Track Structure

Track on Metro Systems is subjected to intensive usage with very little time for day-to-day maintenance. Thus, it is imperative that the track structure selected for Metro Systems should be long lasting and should require minimum or no maintenance and at the same time, ensure highest level of safety, reliability and comfort, with minimum noise and vibrations. Ballastless track with continuous welded head-hardened rails has been proposed as mainline track in underground stretches.

0.6.2 Traction system

Keeping in view the ultimate traffic requirements, standardisation, and other techno-economic considerations, 25 KV OHE/ROCS[3] traction system is considered to be the best trade-off and hence, proposed for adoption on Pune Metro System.

0.6.3 Signalling and Train Control

Metro carries large number of passengers at a very close headway requiring a very high level of safety enforcement and reliability. At the same time, heavy investment in infrastructure and rolling stock necessitates optimization of its capacity to provide the best services to the public. These requirements of the metro are planned to be achieved by adopting 'CATC' (Continuous Automatic Train Control System) based on "CBTC" (Communication based Train Control System) which includes ATP (Automatic Train Protection), ATO (Automatic Train Operation) and ATS (Automatic Train Supervision) sub-systems using radio communication between Track side and Train.

0.6.4 Telecommunication System

The proposed telecom system and transmission media will have following sub-systems:

- Optical Fibre Transmission System
- Telephone Exchange
- Mobile Radio Communication System
- Public Announcement System, Centralized Clock System
- Passenger Information Display System
- Close Circuit Television
- Access control
- Network Monitoring and management
- Supervisory Control and Data Acquisition (SCADA) System
- Wi-Fi system

[3] ROCS is recommended for phase 2A whereas OHE is only used as a reference for calculation purpose.

- Forensic Debriefing Analysis and Cyber Security System

0.6.5 Platform Screen Doors

Platform screen doors are mainly provided at metro stations to ensure safety and comfort of the passengers. In case of Underground stations, PSDs saves considerable amount of energy and improves climate control within the stations (heating, ventilation and air conditioning are more effective when station is physically isolated from the tunnel). In case of Phase 2A, as the complete stretch is underground , thus PSD are proposed at all the stations.

0.6.6 Automatic Fare Collection

It is proposed to provide computer based automatic fare collection system (AFC) with contactless smart token/card type ticketing which is cheaper and offers lower life cycle costs. The proposed AFC system shall be interoperable with existing system.

The System shall be capable for open loop transactions as well to further integrate the mobility solution with the advancements in technology and to allow for seamless transition from dedicated cards to common multi-use stored value fare media that can be used for financial transactions such as making purchases at shops etc. as well as a fare media in the system.

To accommodate the same, the system shall conform to the following standards as a minimum:

1. EMV (Euro Mastercard Visa)
2. PCI-DSS ((Payment card Industry / Data Security Standard)
3. ISO-IEC 14443

0.6.7 Rolling stock

Rolling stock proposed for the Phase 2A corridors will be similar to that of Phase-I. The broad features of rolling stock are presented in table below

Table 4 Broad Features of Rolling Stock

S. No.	Parameter	Rolling Stock
1	Basic Unit	3 Car basic unit 2DMC and 1 TC. Every coach should be fully interchangeable with any other coach of same type.
2	Train Composition	3- Car: DMC+TC+DMC 6- Car: DMC +TC +MC + MC + TC + DMC Capable of GoA4 operation
3	Coach Dimensions	L= 22.6m, W=2.9m, H= 3.9m
4	Coach construction	Light weight Stainless Steel/Aluminium body

S. No.	Parameter	Rolling Stock
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	25kV AC OHE/ROCS system[4]

Train operation plan is formulated such that traffic demand for majority of sections of corridor is met with the passenger loadings @6 passengers/m^2. However, in the sections where planned capacity is less than section load, capacity can be met by carrying standees @ 8 passengers/m^2 or higher which have been deliberately planned for optimum utilization of rolling stock. The total car requirement is following table:

Table 5 : Coach Requirement for Different Horizon Years

Year	2027	2037	2047	2057
Total Requirement*	108	132	150	156

*'Total Car Requirement' includes 90 cars already planned for earlier phases

0.7 Alignment and Civil Engineering

i. Geometric Design Parameters

Table 6 : Design Parameters

SN	CRITERIA	DIMENSION
1	Gauge	1435 mm
2	Maximum Design Speed	90 kmph
3	Maximum Operating Speed	80 kmph
4	Maximum Axle Load	16T
5	Traction System	25 KV AC (OHE/ROCS)[6]

Table 7 : Horizontal Curve Parameters

Description	Underground Section	
Minimum Radius in running track	Limiting = 120m	Preferential = 225m
Absolute minimum Radius	120 m/ 200m in TBM section	
Minimum curve radius at stations	1000 m	
Cant (Ca)	Limiting = 125mm	Preferential = 110mm
Cant deficiency (Cd)	Limiting = 100mm	Preferential = 85mm

[4] ROCS is recommended for phase 2A whereas OHE is only used as a reference for calculation purpose.

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

ii. Gradient Parameters

For running lines, the desirable maximum gradient shall be 3% and where unavoidable shall be 4%. Where gradients of 1% or less are used, it may be unrestricted in length. Gradients above 3.0% shall be kept as short as possible.

Table 8 : Gradient Parameters

Description	Desirable Minimum	Absolute Minimum
Gradient for tunnel	0.5%	0.25%
Gradient at Stations	Not steeper than 0.2%	

iii. Vertical Curve Parameters

Table 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 constant grade between consecutive vertical curve	Desirable Min= 50 m
	Absolute Min. = 25m

0.8 Engineering Survey

Topographical Surveys were conducted based on differential GPS.

0.9 Geotechnical Investigations

Geotechnical investigations have been carried out along the proposed corridor to determine the strata, depth of foundation and safe bearing capacity of foundations required for the above proposed metro corridors. Drilling and sampling in soil and rock was carried out using rotary drilling rig. Borehole in soil was advanced using rotary drilling method.

0.10 Route Alignment

Corridor – 2A: Swargate to Katraj

- Proposed alignment of Phase-2A starts from Swargate and goes up to Katraj near Rajeev Gandhi Zoological Park. Total length of the corridor is 5.464 km which is completely underground.

- This corridor is an extension of existing corridor 1 under Phase 1 i.e. PCMC to Swargate in the south.
- 3 Stations have been proposed in corridor 2A, all of which are underground stations. Summary of the section is given below:

Table 10 : Station chainage

Name of stations	Chainage (in m)	Inter-station distance (in m)	Type
Station 1 (Market Yard, Gultekdi)	17982	1372	Underground
Station 2 (Padamavati)	19568	1586	Underground
Station 3 (Katraj)	21860	2292	Underground

0.11 Station Planning

The stations have been planned based on the following parameters:

a. Station Planning has been done for the peak hour traffic load for each station in the horizon year. The planning norms have been considered for the design year. Accordingly, facilities required at any station for emergency evacuation as per NFPA 130 Guidelines has been adopted. The stations have been planned in accordance with 'Guidelines for Pedestrian Facilities, and 'National Building Code-2016', for Disabled friendly and other Indian best practices/standards.
b. The platform length is 153.4 m.
c. The platform width has been computed considering Peak Minute Peak Direction Boarding; Disruption time of service; Platform congregation during disrupted time of service,0.5sq m/person at Level of Service C.
d. Typical designs have been suggested for various station types and these form basis for planning of all the stations.

Table 11 : summary of type of stations Proposed

Sr. No.	Size (sq. m)	Levels	No. of stations	Construction Type
1	153.4 x 23.73	3	3	Cut and Cover

0.12 Utility Diversion

Table 12 : Utility Responsibility Departments

S. No	ORGANIZATION/DEPARTMENT	UTILITY SERVICE
1.	Pune Municipal Corporation.	Surface water drains, nallahs, Water supply pipelines, Sewerage and drainage conduits, street lights.

S. No	ORGANIZATION/DEPARTMENT	UTILITY SERVICE
2.	Telecommunication Department	Telecommunication cables, junction boxes, telephone posts, O.H. lines, etc.
3.	Traffic Police	Traffic signal posts, junction boxes and cable connections, etc.
4.	Electricity Board	OH & underground electric cables and electric poles
5.	BSNL	Optical Fibre
6.	Maharashtra Natural Gas Limited	Gas Pipe Lines

No. of over ground utilities affected due to metro alignment, as identified during the physical survey are:

Table 13 : List of utilities affected

S.No	Utilities	Location	Units
1	Light Poles	At Station and Entry Exits	31
2	Traffic Signals	At Station	5
3	Sign Boards	At Entry Exits	31
4	Hoarding Boards	At Station and Entry Exits	5
5	Electric Poles	At Station and Entry Exits	23
6	Trees	At Station and Entry Exits	146
TOTAL			**241**

Only visible utilities have been listed out which will be getting affected due to the metro corridor.

0.13 Land Requirement

- Finalization of alignment, location of stations, entry / exits etc. has been done with objective of keeping land requirement to bare minimum.
- Stations sizes for three of the underground stations is 153.4 m long and 23.73 m wide. Since the corridor is underground, land requirement for the project has been estimated for the station locations, which are proposed to be constructed with cut and cover method

and their entry & exits. No land acquisition has been considered for the tunnel section, except for the cross-over location, summary of which is given below.

Table 14 : Total land requirement for Swargate to Katraj corridor

Station	Type of Land	Area (Sqm)
Station 1 (Market Yard, Gultekdi)	Government	4359.52
	Private	1291.45
Station 2 (Padmavati)	Government	2602.45
	Private	3410.06
Station 3 (Katraj)	Government	6388.27
	Private	941.99
Vent Shaft	Private	357.00
Stabling Lines	Government (Defence)	2926.75
RSS	Government	4000.00
	-TOTAL	**26277.48**

0.14 Intermodal Integration

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

- Proper design of circulation area adjoining the station building to ensure rapid/ efficient dispersal of the passengers and avoiding conflicts between pedestrian and vehicular traffic.
- Footpaths in the metro station influence zone are proposed to be upgraded considering direct and easy connectivity, ease of movement and safety.
- Dedicated linkages like subways, skywalks, covered walkways etc. between MRTS, suburban railway and Metro which will reduce the passenger travel time and pedestrian load on the roads

- Circulation area with adequate parking space, designated space for pick-drop zones and feeder modes like Buses, IPTs and NMT.

In addition to improvement of pedestrian and intermodal facilities, Feeder services in the form of buses and public bicycle sharing system have been planned at Phase-2A metro stations for providing last mile connectivity.

Table 15 : Feeder Buses

S. No.	STATION		2027	2037	2047	2057
1	Station 1 (Market Yard, Gultekdi)	R1	1	2	3	4
2	Station 2 (Padamavati)	R1	1	2	3	4
3	Station 3 (Katraj)	R1	1	2	3	5
		R2	1	2	4	5
	TOTAL		**4**	**8**	**13**	**18**

Table 16 : Public Bicycle Requirement

S. No.	STATION	2027	2037	2047	2057
1	Station 1 (Market Yard, Gultekdi)	26	47	52	53
2	Station 2 (Padmavati)	29	53	59	61
3	Station 3 (Katraj)	115	182	203	214
	TOTAL	**170**	**282**	**314**	**328**

0.15 Power Supply System and Power requirement

Traction Power Supply in Metro systems is used for high acceleration and pollution-free services in urban areas. There are three standard and proven systems of electric traction for use in suburban and metro lines, viz:- 750V DC third rail, 1500V DC overhead catenary and 25kV AC overhead catenary system. All these three systems are presently in use in India.

The 25 kV AC Over Head Electrification (OHE) traction system and (ROCS)[5] Rigid overhead catenary system shall be similar to existing power supply system, keeping in view the ultimate traffic requirements, standardization, and other techno-economic considerations as 25 kV AC Over Head Electrification OHE/ROCS traction system has already been used for traction power supply for existing corridor and also for interoperability of the system. 25kV AC traction has the economic advantages of minimal number of traction sub-stations and potential to carry large traffic upto 60,000 PHPDT.

The system requires catenary masts on surface/elevated section for phase 1A (Nigdi to PCMC) and elevated section of Existing line (PCMC to Swargate) and also ROCS in underground Section of Phase 2A (Swargate to Katraj), thereby affecting aesthetics and skyline of the city. Since the proposed alignment of Pune Metro would traverse congested roads and built-up

[5] ROCS is recommended for phase 2A whereas OHE is only used as a reference for calculation purpose.

area of the city, 25kV AC traction system is considered a safe option. Traffic requirements of the Pune Metro (Nigdi to Katraj) have been projected in the range of 28000 PHPDT in year 2057.The alignment of proposed corridors is underground. Keeping in view the techno-economic considerations, 25 KV AC traction system is considered to be the best solution for Power requirements.

The power demand calculation for the extension corridor 2A (Swargate to Katraj) based on the operation plan is projected as below:

Table 17 : Power Demand Estimation (MVA)

Corridor		Year			
		2027	2037	2047	2057
Corridor- 2A Swargate - Katraj No. of stations- (Elevated – 0, Underground – 3, Mid shaft -1)	Traction	1.1 MVA	1.2 MVA	1.2 MVA	1.2 MVA
	Auxiliary	9.9 MVA	9.9 MVA	9.9 MVA	9.9 MVA
	Total	**11.0 MVA**	**11.1 MVA**	**11.1 MVA**	**11.1 MVA**

0.15.1 Sources of Power Supply

The Source of power supply system in Pune city has 220 kV and 132 kV grid substation network on the periphery of the city to cater to various types of power supply demand in vicinity of the proposed corridor.

For corridor – 1A extension PCMC- NIGDI, both existing substations viz PCMC RSS and Depot RSS shall be provided with 2nos. (one as standby) 220/132/25 kV, 21.6 MVA single-phase traction transformers for feeding traction and 2nos. (one as standby) 220/132/33 KV, 20 MVA three phase transformers for feeding auxiliary loads.

For existing corridor PCMC- Swargate, both existing substations viz PCMC RSS and Depot RSS shall be provided with 2nos. (one as standby) 220/132/25 kV, 21.6 MVA single-phase traction transformers for feeding traction and 2nos. (one as standby) 220/132/33 KV, 20 MVA three phase transformers for feeding auxiliary loads.

For corridor – 2A extension Swargate - Katraj, 1 new Receiving Substation shall be provided near Swargate with area approximate 4000 sq. GIS type with 2nos. (one as standby) 220/132/25 kV, 21.6 MVA single-phase traction transformers for feeding traction and 2nos. (one as standby) 220/132/33 KV, 20 MVA three phase transformers for feeding auxiliary loads.

0.15.2 Incremental requirement of RSS

The implementation of Nigdi – PCMC & Swargate-Katraj metro corridor will increase the Power supply Load requirement on Phase 1 corridors as well. It is necessary to duly consider the incremental power supply load requirement while doing the Power load calculations. The incremental load requirement due to the extension of the corridor, viz. Nigdi – PCMC & Swargate-Katraj have been estimated considering the traction power requirement and Auxiliary power requirements for elevated & underground section from NIGDI to KATRAJ. To cater this incremental requirement with reliability of the Power Supply for traction as well as auxiliary load, One RSS is Proposed near Swargate to cater the Power supply load requirements for Phase 1 corridor from Nigdi to Katraj.

0.15.3 Auxiliary Supply Arrangements and Standby Power Supply

For Nigdi to Katraj section, in order to meet the requirement of auxiliary power two dry type cast resin transformers (33/0.415kV) of 500 kVA capacity are proposed to be installed at the elevated stations (one transformer as standby) and two 2.5 MVA transformer for underground stations (one transformer as standby) also, two existing transformer of 2.5 MVA at Depot ASS. Also, Provision of DG set is proposed to provide a standby DG set of 500 KVA capacity at the elevated stations and 800 KVA capacity of DG set at underground station in DG room.

0.15.4 Solar Energy Harnessing System

For solar energy harnessing system, Based on RESCO Model, Maha Metro shall sublet the rooftop to project developer who will be responsible for the solar PV installation. The power shall be purchased by Maha Metro based on the unit rate specified by Power Purchase Agreement (PPA).

0.16 Maintenance Depot

Phase-II augmentation of the Range Hill depot is planned to accommodate 22 numbers of 6-car trains or equivalent number of 3-car and 6-car trains which is enough for planned Phase-2A requirement up to year 2037.
However, for planned requirement in Phase-2A in year 2047 & 2057, i.e. additional 4 number of 6-car trains, additional stabling facility is required.
For Phase -2A in year 2047 & 2057, Four elevated stabling lines are proposed in Nigdi.

0.17 Social and Environmental Impact Assessment

0.17.1 Environmental Impact Assessment

The negative impacts due to location of proposed Phase 2A corridor include: Project Affected People (PAPs), Change of Land use, Loss of trees/forest and Utility/Drainage Problems. The impacts due to construction include: Soil erosion, pollution and health risk at construction site, traffic diversion and risk to existing buildings, excavated soil disposal problems, dust generation, increased water demand, impact due to supply of construction material. Anticipated Impacts due to operation are noise pollution, water supply and sanitation at stations, traffic congestion issues and impact due to depots.

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.

Mitigation measures and Environment management plan for Compensatory Afforestation, Construction Material, Housekeeping, Air Pollution Control, Noise and vibration Control are suggested. The total estimated environmental mitigation measure cost for the proposed project is about **Rs. 3.32 Cr.**

0.17.2 Social Impact Assessment

Total land requirement has been worked out to 2.63 Ha, which comprises 1.94 Ha of land for Main alignment including station locations, 0.29 Ha of defence land for staling lines and its connection to main line and 4000 sqm of land for RSS proposal. Total of 52 structures will be affected; 46 of the structures are privately owned and have commercial activity. 6 of the structures are government owned.

Entitlement matrix, institutional arrangement and schedule for implementation of Resettlement Action Plan (RAP) have been recommended. Compensation for loss of private land and structure forms part of capital cost estimate. RAP has been prepared as per Right to Fair Compensation and Transparency in land acquisition, Rehabilitation and Resettlement Act, 2013 (RTFCTLARR Act), Maharashtra Notification on Resettlement and Rehabilitation, the right to fair compensation and transparency in land acquisition, rehabilitation and resettlement act, 2013 (no. 30 of 2013), and ADB's Safeguard Policy Statement (SPS), 2009 on Involuntary Resettlement. Estimated cost of implementation of R&R Plan is Rs. **27.61 crore.**

The existing BRT will be temporarily closed during construction period, the structure at station location shall be dismantled for the purpose of construction, reassembled and handed over post construction. The total cost for the same has been estimated as **Rs 17.91 Crores** for affected length of ~0.8 km.

So the total cost of R&R is estimated to be **Rs 45.52 Crores.**

0.18 Disaster Management & Security Measures

The main objectives of disaster management measures are as follows:

- Arrange for prompt evacuation of passengers

- Instil a sense of security among passengers
- Protect Metro Rail property
- Expedite restoration of train operation

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. The measures will cover both man-made and natural disasters. The measures will be in consonance with practices suggested by the disaster management authorities.

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, sniffer dogs and related facilities will be part of station security system.

0.19 Detailed Project Cost Estimates

0.19.1 Capital Cost

The detailed cost estimate of the proposed extension line is given below,

CAPITAL COST ESTIMATE (JULY 2021 PRICE LEVEL)

S. No	Description	Total cost (Cr.)
1	Alignment & Formation	
a	Underground Section - Twin Tunnel	1,052.10
b	Viaduct for Stabling Line/Depot	37.63
2	Station Buildings	
a	Station Building - Cut & Cover	570.00
b	E&M tunnel ventilation incl. Lifts & Escalators	169.51
c	Ventilation Shaft between Station 2 & Station 3	50.00
3	Stabling Lines	11.72
4	P-Way for main line and Stabling Line/Depot	47.47
5	Traction and Power Supply	147.28
6	Signaling	54.06
7	Telecommunication	15.26
8	Rolling Stock	162.73
9	Platform Screen Doors (PSD)	10.17
10	Multi Modal Integration	10.17

11	Cost of Security	1.25
12	Environment cost	3.32
13	Utility Shifting	37.05
14	**Total Cost at July '21 price level (Excluding Land, R&R, General Charges, Contingencies, Central & State Taxes)**	**2,379.72**
15	General Charges @ 5%	118.99
16	Contingencies @ 3 % on Sr. No.14 i.e. on basic cost	71.39
17	**Total Cost at July '21 price levels incl. General Charges and Contingencies (Excluding Land, R&R, Central & State Taxes)**	**2,570.10**
18	**Central and State Taxes @ July '21 Price Level**	**376.96**
19	**Total Cost incl. General Charges, Contingencies, Central and state Taxes @ July '21 Price Levels (Excl. Land and R&R)**	**2,947.05**
20	Land	111.30
21	R&R	45.52
22	**Total Cost incl. General Charges, Contingencies, Central and state Taxes @ July '21 Price Levels (Incl. Land and R&R)**	**3103.87**
23	Escalation at 5 % per annum on the above	512.44
24	**Total Completion Cost incl. Land and R&R Costs**	**3,616.31**
25	Interest During Construction (IDC)	30.29
26	**Total Completion cost including IDC**	**3,646.60**
27	PPP component (AFC) incl. escalation & taxes	17.26
28	**Total Completion Cost**	**3,663.86**

Note: July '21 Price Level is considered and the prices are escalated till the completion period to arrive at the completion cost.

0.20 Transit Oriented Development

0.20.1 Premium Levy on Incremental FAR

National Transit Oriented Development (TOD) Policy provides guidelines on development along transit corridors. 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 (500m) of transit station or along the corridor in case the station spacing is about 1km. With application of TOD policy premium shall be collected on incremental proposed FSI. For application of TOD Policy, infrastructure provisions shall be made as well. Thus, at the expense of Rs 191 Cr at FY 19 price levels, Premium Levy over the development period (30 Years) of Rs. 2321.8 crores at FY 19 price level shall be earned. However, the flow of revenue from application of TOD is assumed to take at least 7 years after commencement of the Project. Thus, Share of Premium levy from incremental FAR for the finance of Maha metro shall be 117.8 Cr from the year FY 35.

0.20.2 Sharing of cess on stamp duty

FY 19 – 1% cess collection on stamp duty in PMC stood at 258 Crores. 25% share per year from the same is proposed to be given as revenue support to the extension from Swargate to Katraj over a 30-year period and assumed to be escalated at 2.5%.

Table 18 : Year wise share of cess on stamp duty with Maha Metro

Year	Revenue to Metro from Cess on Stamp Duty (Rs. Cr)
FY 35	95.9
FY 36	98.3
FY 37	100.8
FY 38	103.3
FY 39	105.9
FY 40	108.5
FY 41	111.2
FY 42	114.0
FY 43	116.9
FY 44	119.8
FY 45	122.8
FY 46	125.9
FY 47	129.0
FY 48	132.2
FY 49	135.5
FY 50	138.9
FY 51	142.4
FY 52	146.0
FY 53	149.6
FY 54	153.3
FY 55	157.2
FY 56	161.1
FY 57	165.1
FY 58	169.3
FY 59	173.5
FY 60	177.8
FY 61	182.3
FY 62	186.8
FY 63	191.5

At FY 35 Price levels, the cess and Premium sharing with Maha Metro would translate into an annual revenue grant of INR 213.7 Crores.

0.21 FINANCIAL ANALYSIS

The revenue has been estimated for the fare-box revenue and non-fare-box revenue (i.e.) advertisement and commercial activities. The fare structure is as per the Government Resolution No. PMR-3313/C.R.29/UD-7 dated 11 Sept. 2013A. Non-fare revenue is estimated on account of advertising on stations and trains, kiosk rentals, sharing of cess on Stamp duty, Property development of government land and Premium by application of TOD Policy. The non-fare fox revenue is estimated as follows:

Financial Year	Non fare box revenue (Cr.)
FY 28	6.1
FY 38	236.5
FY 48	301.1
FY 57	812

0.21.1 FIRR Analysis

The FIRR for a project operation period of 30 years is carried out with Non fare Box Revenue including TOD. Non-fare sources of revenue incorporated in financial package for the proposed Metro Projects such as advertisement, rental from kiosks inside stations, sharing of cess on stamp duty, Property development on government land and sharing of Premium from application of TOD policy. Project IRR works out to 14.45%

0.21.2 Sensitivity Analysis

Table 19 : Project FIRR- Sensitivity Analysis

Capital cost sensitivity			
10% increase in capital cost	20% increase in capital cost	10% decrease in capital cost	20% decrease in capital cost
13.46%	12.60%	15.61%	17.01%
O & M Cost			
10% increase in O & M Cost		10% decrease in O & M Cost	
14.25%		14.64%	
Property Development			
With PD		Without PD	
14.45%		12.25%	

0.22 Financial Plan

0.22.1 Multilateral funded loan @ 0.6% per annum

Particulars	Amount (Rs. Cr)	Percentage
Grant by GoI	300.21	10.0%
Grant by PMC	450.32	15.0%
Grant by GoM	450.32	15.0%
Soft Loan from bilateral/multilateral funding agencies	1801.29	60.0%
Project Cost Eligible for Grant	**3002.15**	**100.0%**
SD for State Taxes, Central Taxes & Duties by GoM	440.32	
Contribution for Land, R&R, IDC, etc. by PMC	204.13	
Total	**3646.60**	
PPP Component	17.26	
Total Cost including PPP Component	**3663.86**	

0.23 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. The EIRR in economic terms works out to 19.80 %. Sensitivity analysis of the EIRR with Capital cost increase by 15%, O&M costs increased by 15%, Target beneficiaries reduced by 15%, Delay in accrual of benefit by 1 year has been carried out:

Table 20 : EIRR And Sensitivity Analysis

Details	EIRR (%)	ENPV @14% (Rs Crore)	MIRR (%)	SV	Benefit - Cost Ratio (2021 Price)	Benefit - Cost Ratio (Current Price)
Main Evaluation (Base Case)	19.8036%	10,804	13.56%		1.58	4.44

Details	EIRR (%)	ENPV @14% (Rs Crore)	MIRR (%)	SV	Benefit - Cost Ratio (2021 Price)	Benefit - Cost Ratio (Current Price)
15% Capital Cost Overrun	17.95%	8,103	13.09%	60.0%	1.41	4.13
15% O&M Cost Overrun	19.54%	10,274	13.50%	305.9%	1.54	4.13
15% Decrease in Project Benefits	17.38%	5,953	12.94%	33.4%	1.34	3.78
One Year Delay in Implementation	19.78%	9,388	13.54%		1.58	4.38

0.24 Implementation Plan

Effective institutional arrangements are needed to enable the metro project to be implemented without any loss of time and cost over-run. The Government of Maharashtra has created a Special Purpose Vehicle (SPV) for implementing the Pune Metro Rail Project Phase 1. This SPV named as "NMRCL" was incorporated on 18th February 2015 under the Companies Act and subsequently the name was changed to Maharashtra Metro Rail Corporation on 22nd January 2017. It is a 50:50 jointly owned company of GoI and GoM responsible for implementation of all metro projects in the state of Maharashtra outside Mumbai Metropolitan region including Pune Metro Rail project phase 1 and the current extension from Swargate to Katraj and PCMC to Nigdi.

0.24.1 Implementation Schedule

S. No	Tasks	Anticipated Timelines
1	Approval of DPR by PMC	Septemeber 2021
2	Approval of DPR by GoM	February 2022
3	Final Approval by GoI	May 2022
4	Packaging & Invitation of Bids	August 2022
5	Commencement of Civil Works	November 2022
6	Commencement of Operation	April 2027

1. A PROFILE OF THE CITY

Pune has emerged as a prominent location for manufacturing industries and has now been recognized as the information technology hub and education hub of the country. The city is spread over an area of 243.84 Sq. Km with a population of over 3 million. The rapid growth of the city has transformed from its character as Pensioner's city to Educational – Administrative Centre and now to a bustling economic centre. The city is famous as the Oxford of the East and the cultural capital of Maharashtra. Pune is also one of the most renowned places among tourists coming to Maharashtra. The educational institutions, presence of a number of industries and branches of virtually every array have made Pune a prosperous city.

Pune & Pimpri Chinchwad is the next largest urban conglomerate to Mumbai Metropolitan Region in Maharashtra. These cities are considered to be an educational hub due to the establishment of large number of educational institutes across the city.

Pune & Pimpri Chinchwad have been experiencing tremendous growth in population and employment since the last two decades. The cities have been stretching their limits to the widest extent possible, thus urban sprawl has become evident.

The growth in various industries, particularly automobile, IT and IT enabled services, in and around Pune & Pimpri Chinchwad has added further impetus to the urban sprawl and increase in population and employment.

The district also has an importance as an important military base. The urbanization of this Pune & Pimpri Chinchwad will receive a big impetus in the next 30 years due to the ambitious development plan of the 7000 sq. km Pune Metropolitan Region.

1.1 History

The city of Pune has been a city of major importance in the Indian subcontinent since the 17th century. Confined to the East bank of the Mutha river until the early 19th century, the city started to grow on the west bank as well. The city witnessed fast growth after Independence.

Subsequently, Pune became a major manufacturing as well as a higher education centre.

In addition to its temples, historical attractions in and around Pune include the rock-cut Pataleshwar cave temple, Aga Khan Palace, Shaniwarwada, Lal Mahal, and Sinhagad fort.

Shinde Chhatri, located at Wanowrie, is a memorial dedicated to the Great Maratha Sardar, Mahadaji Shinde (Scindia) who was instrumental in establishing the Maratha supremacy over North India.

1.2 Geography

Pune is located in the State of Maharashtra, approximately 150km South-East of Mumbai as shown in following figure. Pune has a hot semi-arid climate bordering with tropical wet and dry with average temperatures ranging between 19 and 33 °C (66 and 91 °F). Pune experiences three seasons: summer, monsoon, and winter. Typical summer months are from mid-March to June often extending until 15 June, with maximum temperatures sometimes reaching 42 °C (108 °F). The warmest month in Pune is May. The city often receives heavy dusty winds in May (and humidity remains high). Even during the hottest months, the nights are usually cool due to Pune's high altitude.

The monsoon lasts from June to October, with moderate rainfall and temperatures ranging from 22 to 28 °C (72 to 82 °F). Most of the 772 mm of annual rainfall in the city falls between June and September, and July is the wettest month of the year.

The daytime temperature hovers around 26 °C (79 °F) while night temperature is below 9 °C (48 °F) for most of December and January, often dropping to 5 to 6 °C (41 to 43 °F).

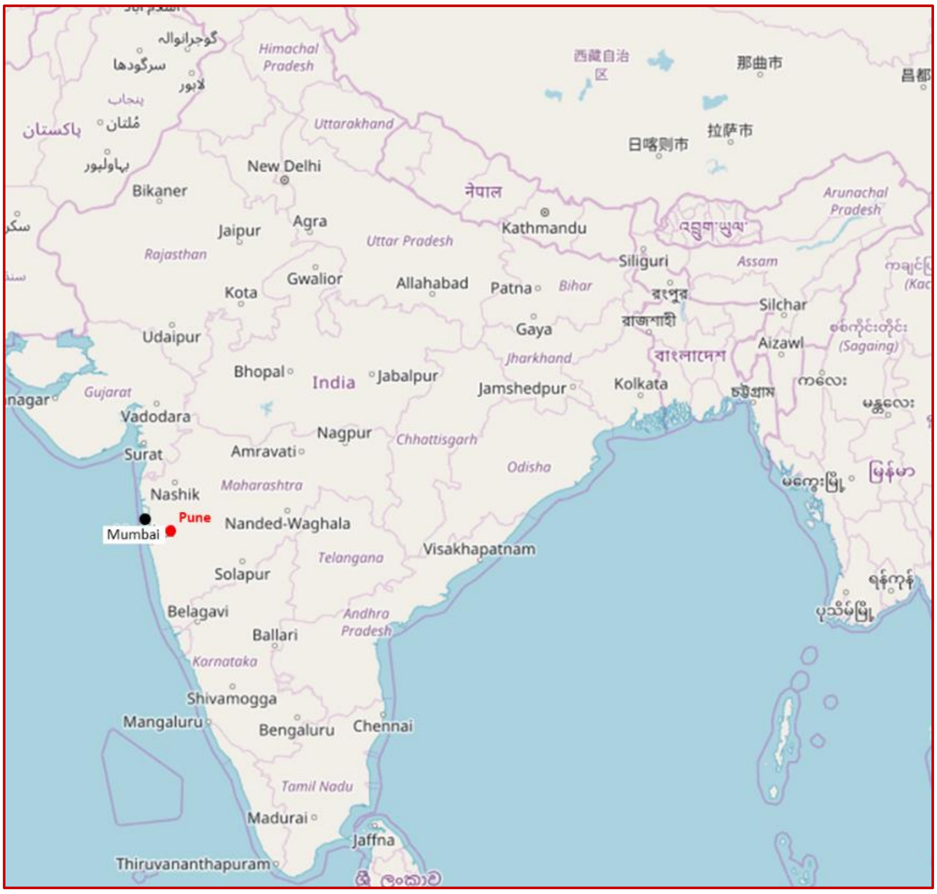


Figure 1. Pune location map
(Source: Open Street Map, 2018)

1.3 Demographic and socio-economic profile

With a population of 31.2 Lakh (2011 census), Pune city is the second most populated city in Maharashtra after Mumbai and the 9th most populated city in India. The total population of the Pune urban agglomeration is 51 Lakh in 2011. The city is considered to be an educational hub due to the establishment of large number of educational institutes across the city.

In the past few years, Pune and surrounding cities including Pimpri-Chinchwad have witnessed major population growth. The population of Pimpri-Chinchwad as per 2001 Census is 1,006,417 persons. The population as per 2011 census is estimated to be in the range of 17.27 lakhs . This growth is partly fuelled by the presence of multiple education institutions as well as industrial developments, notably in the manufacturing and IT sectors (source: PMC, 2008).

1.3.1 Population growth

The population of Pune city as per provisional figures of Census India, 2011 is more than 3 million. There is a growth of more than six times in the city's population in the last 60 years, from 0.48 million in 1951 to 3.11 million in 2011; this is attributed to the advanced economic activities. (Source: City Development Plan, PMC, 2041)

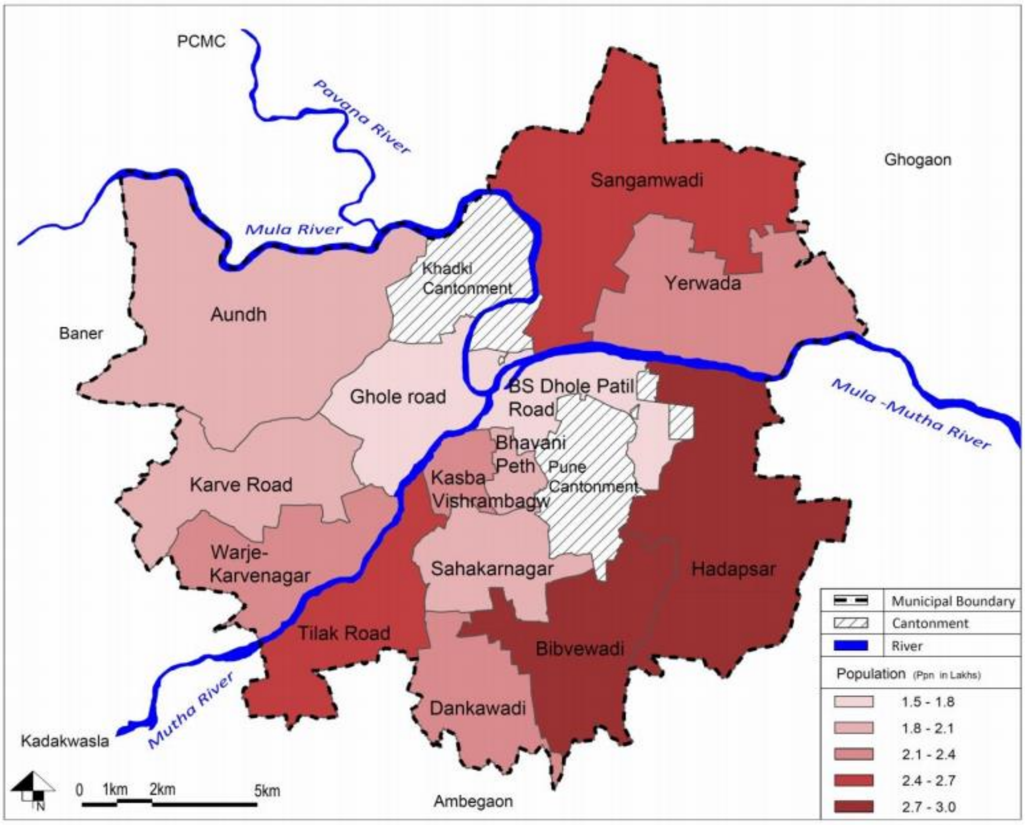


Figure 2. Spatial distribution of Population in PMC

Source: Comprehensive Mobility Plan, PMC, 2018

Table 21 : Population Trend in PMC

CENSUS YEAR	POPULATION	DECADAL CHANGE	GROWTH RATE (%)
1951	488,419		
1961	606,777	118,358	24.23%
1971	856,105	249,328	41.09%
1981	1,203,363	347,258	40.56%
1991	1,691,430	488,067	40.56%
2001	2,538,473	847,043	50.08%
2011	3,115,431	576,958	22.73%

Source: City Development Plan, PMC, 2041

1.3.2 Population Density

The overall liveability of a place is dependent on the population density of that place, in case of Pune as per the provisional figures of Census India, 2011; the population density is 12,777 persons/ Sq. Km (approx. 127 pph). The average population density of Pune city being on the lower side of the permissible limits of the UDPFI guidelines for metropolitan cities. Pimpri-Chinchwad has a population density of 9,353 persons per square kilometre as per the 2011 census, which is comparatively less than that of its neighbouring city, Pune. However, this is mainly due to the large extent of vacant spaces available in the peripheral, undeveloped areas of the city.

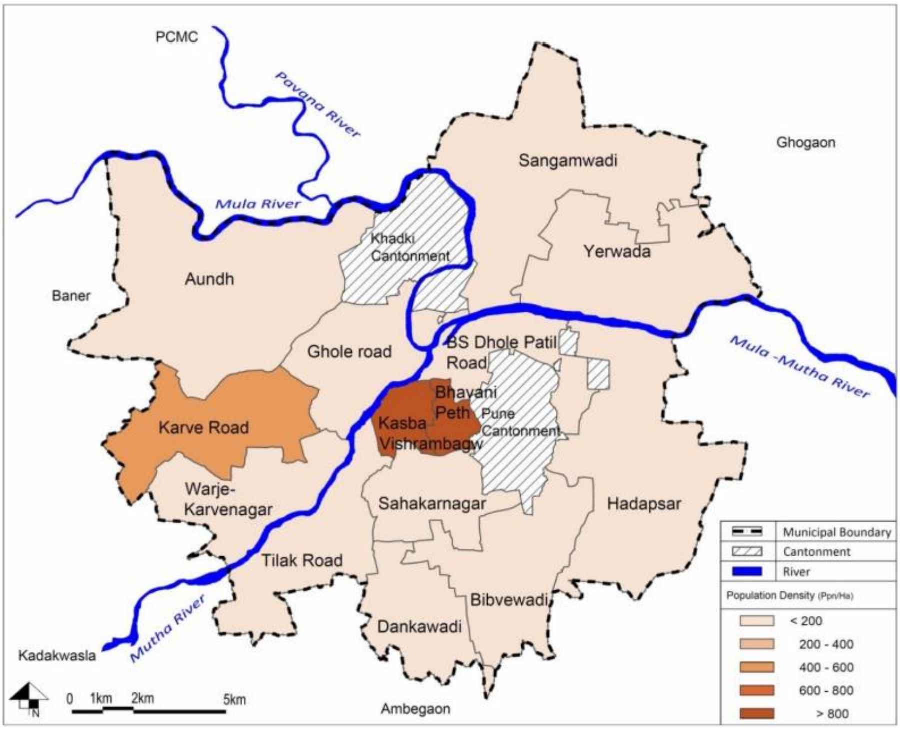


Figure 3. : Spatial distribution of Density in PMC, 2011

Source: Comprehensive Mobility Plan, PMC, 2018

Table 22 : Population Density in PMC Region

YEAR	AREA SQ KM	DENSITY PER SQ KM
1951	125	3,907
1961	125	4,854
1971	139	6,170
1981	146	8242
1991	146	11,585
2001	244	10,410
2011	244	12,777

Source: City Development Plan, PMC, 2041

The population density over the years has increased manifold from 3,907 persons per Sq. Km (39 pph) in 1951 to 12,777 persons per Sq.Km (approx. 127pph) in 2011. From the table below, it is evident that the population density from 1951 to 2011 is gradually increasing except in 2001 which was 10,410 sq.Km. (104 pph); this is mainly due to addition of 23 villages within the PMC area.

The average population densities in the core city wards are higher than the density in the wards on the periphery. Predominantly, the wards forming the locus of the city viz. Kasba Vishram Bagh and Bhavani Peth wards comprising the highest population densities that is 445 and 661 respectively, this overcrowding is the consequence of being the old historic city with specialized and intense trade and commerce activities being taken up; the overcrowding indicated by the densities call for decongestion of these areas.

1.3.3 Migration patterns

Factually, the city of Pune has developed as the counter magnet of Mumbai, the administrative capital of Maharashtra state and business capital of India. Mumbai being overcrowded with high cost of living made Pune, a better place of living in the eyes of people aspiring for better opportunities in all spheres of life, all over the country, which lead to increased migration in the city. Thus, the growth of Pune has been contributed by multiple factors in addition to its natural growth and extension of jurisdiction. It is one of the most preferred destinations for job, education, healthcare treatment, real estate investment and ultimately leading to a better quality of life. Enormous economic opportunities, health and education facilities in the city act as major propellant factors for city's growth. As per the study conducted by Gokhale Institute of Politics and Economics, the in-migrated population of Pune urban agglomeration has increased from 3.1 Lakhs in 1991 to 7.4 Lakhs migrants in 2001 accounting to 13% and 20% of the total population, of which the composition of state migrants is 73% and 65% percent respectively. The migrated population for Pune city has increased from 3.7 Lakhs in 2001 to 6.6 Lakhs migrants in 2011 (the projected in-migration of 2011 as per the Gokhale Demographic Study) accounting to 14% and 21% of the total population.

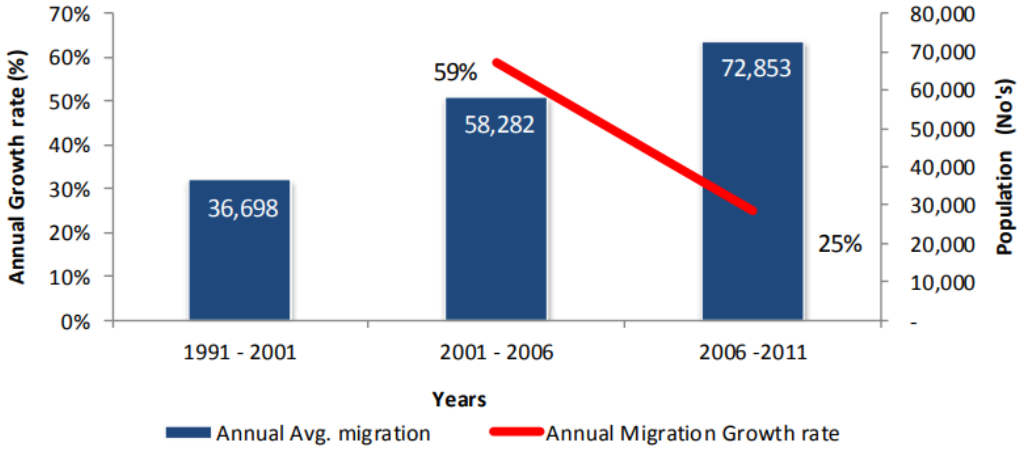


Figure 4. Annual Average Migration and Growth Rate

Source: Gokhale Institute of Politics and Economics

1.3.4 Spatial patterns of growth

From a small area around Kasba Peth, Pune has grown radically; in 1958, small pockets of land in parts of the villages of Katraj, Dhankavadi, Lohagaon, Dapodi, etc. were added increasing the area within jurisdiction of PMC. In 2001, 23 villages were added to Pune city. As a result, PMC area increased to 243.84 Sq.Km. Over the years PMC has grown in the pattern of concentric rings. The driving forces for growth are primarily the development of IT industry in addition to the economic boom in the automobile sector which forms a major portion of the industries in and around Pune. The peripheral growth has resulted into the increased residential areas and area under transportation network and facilities. Pune's population has increased by 5 to 6 times in the last fifty years and the increase has been very rapid from 1981. The ever-increasing pressure of population has led to the growth of the adjoining suburbs and the city has expanded outwards filling in spaces between it and the suburbs. The urban sprawl has taken place in all directions but more significantly in the eastern, southern and south-western directions. Significant changes in land use are evident in the eastern part of the city.

The Central Business District (CBD) of Pune is the high-density zone with major land use under residential and commercial activities. The old city is congested with its narrow roads and lack of open spaces. Majority of the middle- and high-income groups are inhabited on the peripheral areas i.e. on the first belt area. Industrial developments are mostly found in pockets and belts along the radial roads entering the city. The fringe area i.e. the peripheral second belt was recently merged with PMC, which have been developed as an unorganized urban sprawl with residential, industrial and local commercial users. The existing road systems having inadequate widths are connecting all the above components. The railway lines are on the Northern side. The rivers flowing in three directions have a water front of 20 kms. The future growth of PMC will be mainly governed by existing transport corridors, existing and future industrial developments in and around PMC and the expansion of central business district (CBD). Spatial growth of PMC will take place towards employment nodes; in areas which are closer to these nodes and areas which give immediate connectivity to these nodes.

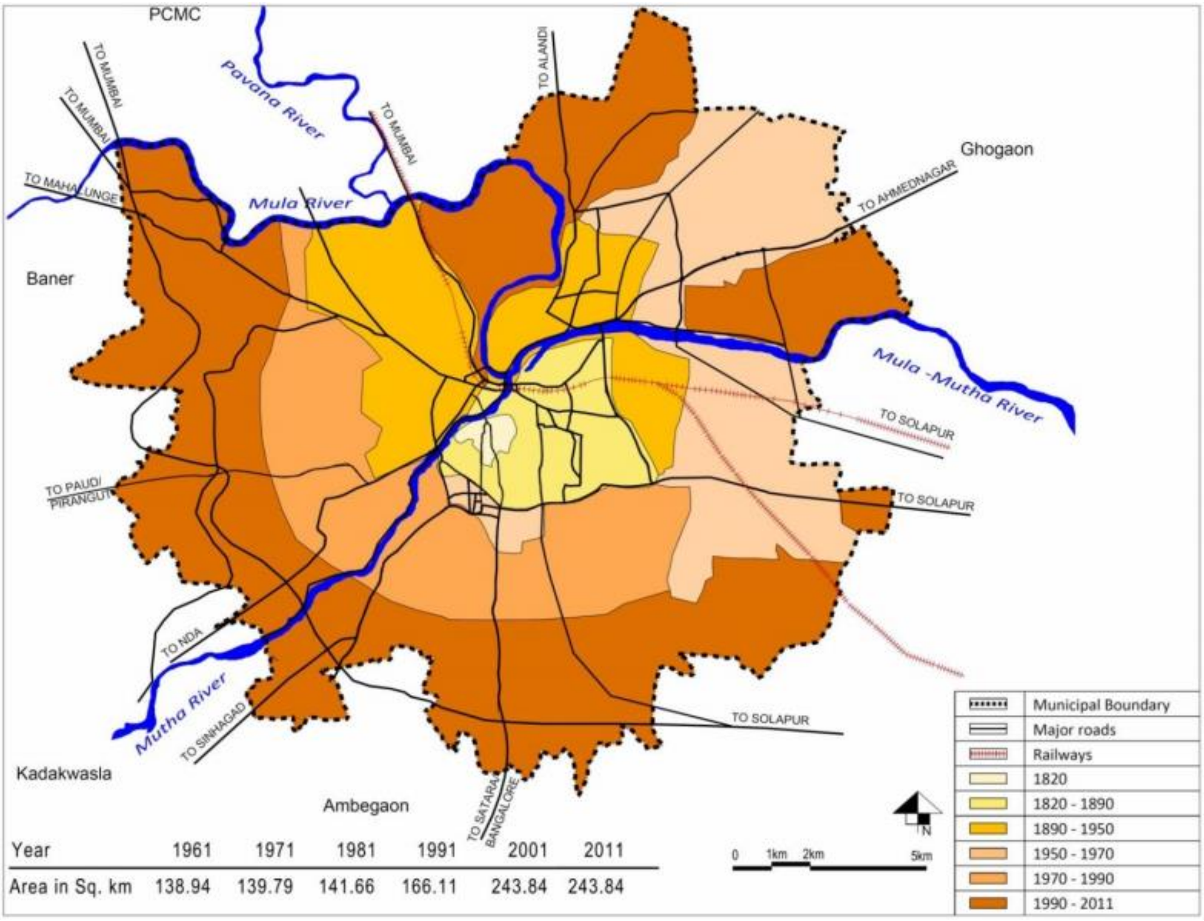


Figure 5. Chronological Development of Pune from 1820 -2011
Source: Town Planning Department, Pune 2011

1.3.5 Population Projections for next 20 years

For the last two decades, the decadal growth rate in population has been in the range of 100%; the previous two decades witnessed population growth in the range of 150%. The very high growth rates of the past decades, accounted for by migration and the addition of new areas, have started to show a downward trend; however, these would still be on the higher side for the next three decades due to the all-round economic development of the Pune region. Current population in year 2011 is 50.5 lakh in Pune Region, out of which Pune and Pimpri Chinchwad combined housed 48.52 lakh persons in year 2011. As of 2011, it is estimated that the total population of the PCMC area is about 17.27 lakhs and 20.8 Lakh in 2017. Accordingly, the population of PCMC is estimated to reach 30.9 Lakh by 2028 and 39.11 lakhs by 2038.

As in the case of Pune city, so in Pimpri-Chinchwad too, the majority of the population (over 80%) is below the age of 50; the city has a very young population with the median age being close to 24 years. Since a large chunk of the current younger generation is expected to start families within the next decade and half, the population will escalate to the projected level. The population of Pimpri-Chinchwad in the last two decades grew at an annual average rate of over 7% against the national average of 2.1% and state average of about 3.3%.

1.4 Urban Land Use Structure / Activity Distribution

1.4.1 Planning study areas and existing plans

Pune has emerged as a prominent location for manufacturing industries and has now been recognized as the information technology hub and education hub of the country. The city is spread over an area of 243.84 Sq. Km with a population of over 3 million. The rapid growth of the city has transformed from its character as Pensioner's city to Educational – Administrative Centre and now to a bustling economic centre. The city is famous as the Oxford of the East and the cultural capital of Maharashtra. Pune is also one of the most renowned places among tourists coming to Maharashtra. The educational institutions, presence of a number of industries and branches of virtually every array have made Pune a prosperous city.

1.4.2 Regional Plans

The Pune Metropolitan Region was established in 1967 for an area of 1340 Sq. Km in Haveli taluka and comprises of Pune city, Pimpri-Chinchwad, three cantonments Pune, Khadki and Dehu cantonments, and close to 100 other census towns and villages. A Regional Planning board was constituted for preparations of a Regional Plan. The first Regional Plan 1970-1991 was sanctioned by the Government and came into force into force in May 1976. A new Regional Plan 1990-2011 was approved by the Government in 1997 and is still valid.

1.4.3 Existing Land use Distribution

The Central Business District (CBD) of Pune is the high-density zone with major land use under residential and commercial activities. The old city is congested with its narrow roads and lack of open spaces. Majority of the middle- and high-income groups are inhabited on the peripheral areas i.e. on the first belt area. Industrial developments are mostly found in pockets and belts along the radial roads entering the city. The fringe area i.e. the peripheral second belt was recently merged with PMC, which have been developed as an unorganized urban sprawl with residential, industrial and local commercial users. The existing road systems having inadequate widths are connecting all the above components. The railway lines are on the Northern side. The rivers flowing in three directions have a water front of 20 kms. The future growth of PMC will be mainly governed by existing transport corridors, existing and future industrial developments in and around PMC and the expansion of central business district (CBD). Spatial growth of PMC will take place towards employment nodes; in areas which are closer to these nodes and areas which give immediate connectivity to these nodes. The development plan 2001 is specially made for the newly added fringe area into Pune Municipal Corporation area. As per 1987 Development plan, the percentage composition of residential is 50.58 Sq. Km i.e. 37% of the total land use and in 2001 DP, the residential land use has increased to 50%. Considering the growing demand of housing, the newly added areas have been utilized for residential use.

As per DP 2001, around 43% of the area is under residential zone, 2% is under commercial zone, 4% under industrial zone and 16% under public/semi-public and recreational use. The area under transport has reduced to only 13% which is low in comparison to other metropolitan cities where it ranges from 16-25%.

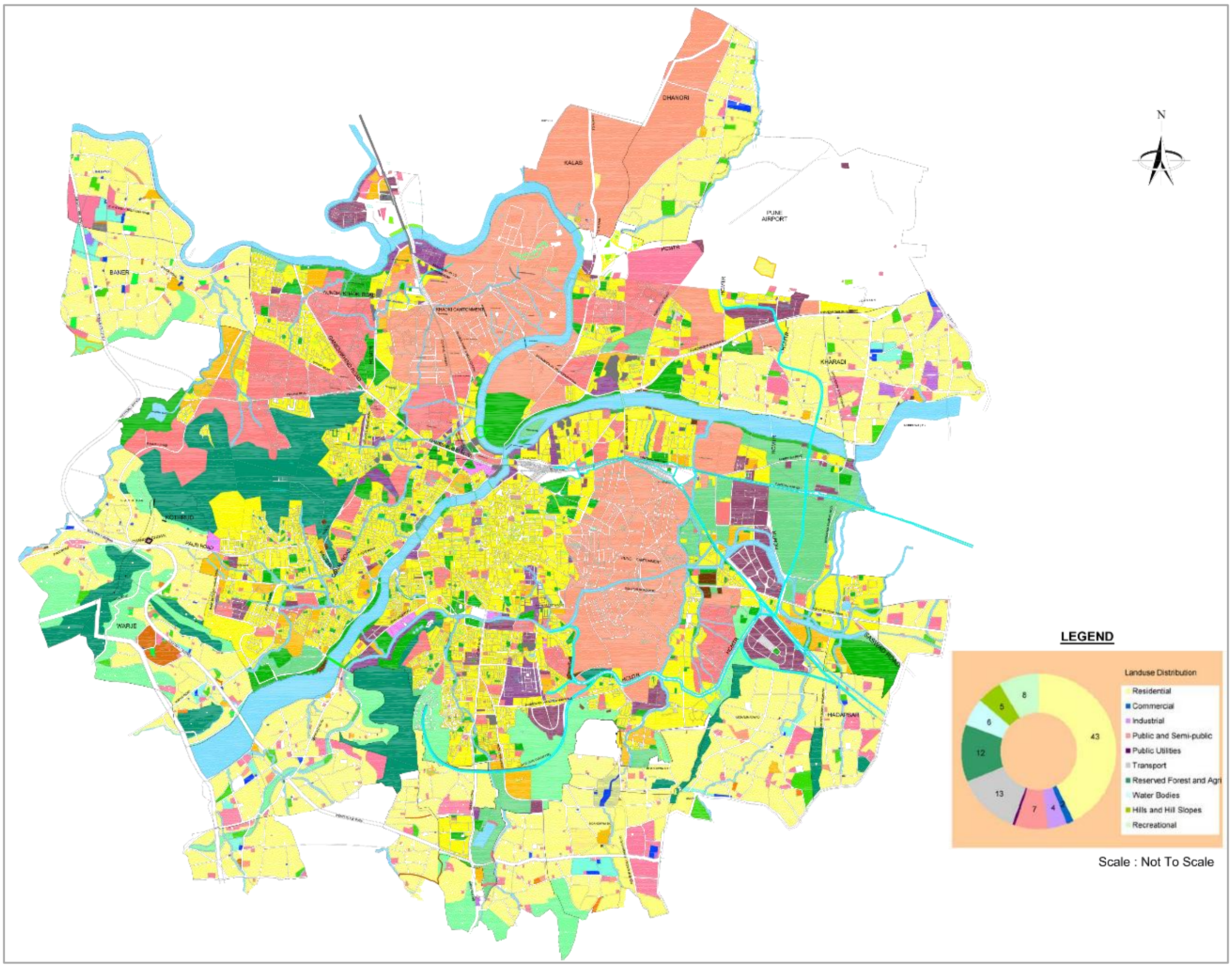


Figure 6. Existing Land Use Map of PMC

Table 23 : Proposed Land Use distribution of PMC as per Development Plan

LAND USE	AREA (KM SQ)	PERCENTAGE
Residential	22.26	55.94%
Commercial	0.19	3.17%
Industrial	1.48	3.81%
Public Semi Public	0.82	3.15%
Transport	2.38	12.95%
Public Utilities	0.39	1.14%
Recreational	0.01	3.03%
Water Bodies	0.95	1.57%
Forest & Agricultural	33.27	15.25%

Source: Comprehensive Mobility Plan, PMC, 2018

1.4.4 Review of zoning regulations

The permissible FAR is 1.5 for purely residential building and 2.00 for building with a mixed residential and commercial user subject to maximum tenement density of 250 T/Ha., provided in a building with mixed residential and commercial user, the commercial user will be permitted only on the ground floor and the residential user and commercial user shall not exceed FAR 1.5 and 0.5 respectively.

1.4.5 Employment distribution by Traffic Zones

Pune has historically been an important economic hub in Maharashtra and continues to be so today, owing to the growing number of industries in the region: the automotive sector being most prominent. The industrial township of Pimpri-Chinchwad, just north of Pune city, houses over 4000 manufacturing units that contributes to the city's economy. Pune is also the headquarters (south command) of the Indian Air Force and a large military training base. IT and education are the other dominant sectors that attract a large population of young professionals to the city. As a result, a new IT park is being developed by the Maharashtra Industrial Development Corporation (MIDC) to accommodate this growth.

1.4.6 Activity locations (Business areas, University, Hospitals, Transport Terminals)

The growth of PMC is being driven by various industry segments. Except Kharadi Knowledge Park, which is located within PMC limits, all other industries are located outside PMC in PMR or close to PMR towards North-West, North and North-East. PCMC houses a majority of the industrial development.

Large proportion of the city's population thrives on wholesale and retail trade and commerce. The city serves as the regional wholesale market for food grains and other commodities. It also serves as the market centre for agricultural produce such as green peas, wheat, rice, pulses, oilseeds, maize, etc., which are cultivated in the rural hinterland. Pune also functions as a distributing centre for agricultural implements, fertilizers, drugs and medicines, iron and steel, cement and minerals, petroleum products and forest products such as timber, and readymade garments and textiles. Currently, Central Business District (CBD) comprises areas of Camp (MG Road, East Road), Swargate, Laxmi Road (Tilak Road, Bajirao Road), Kalyani Nagar, Shivajinagar, Wakad Wadi, Deccan, FC Road, JM Road, and Ahmednagar Road. Main commercial activities observed in these areas are corporate offices/ headquarters for manufacturing and service units, business process outsourcing centres, call centres, banking, insurance, retail trading, shopping malls, entertainment, cinema theatres, heath services, educational institutions, hotels and restaurants etc.

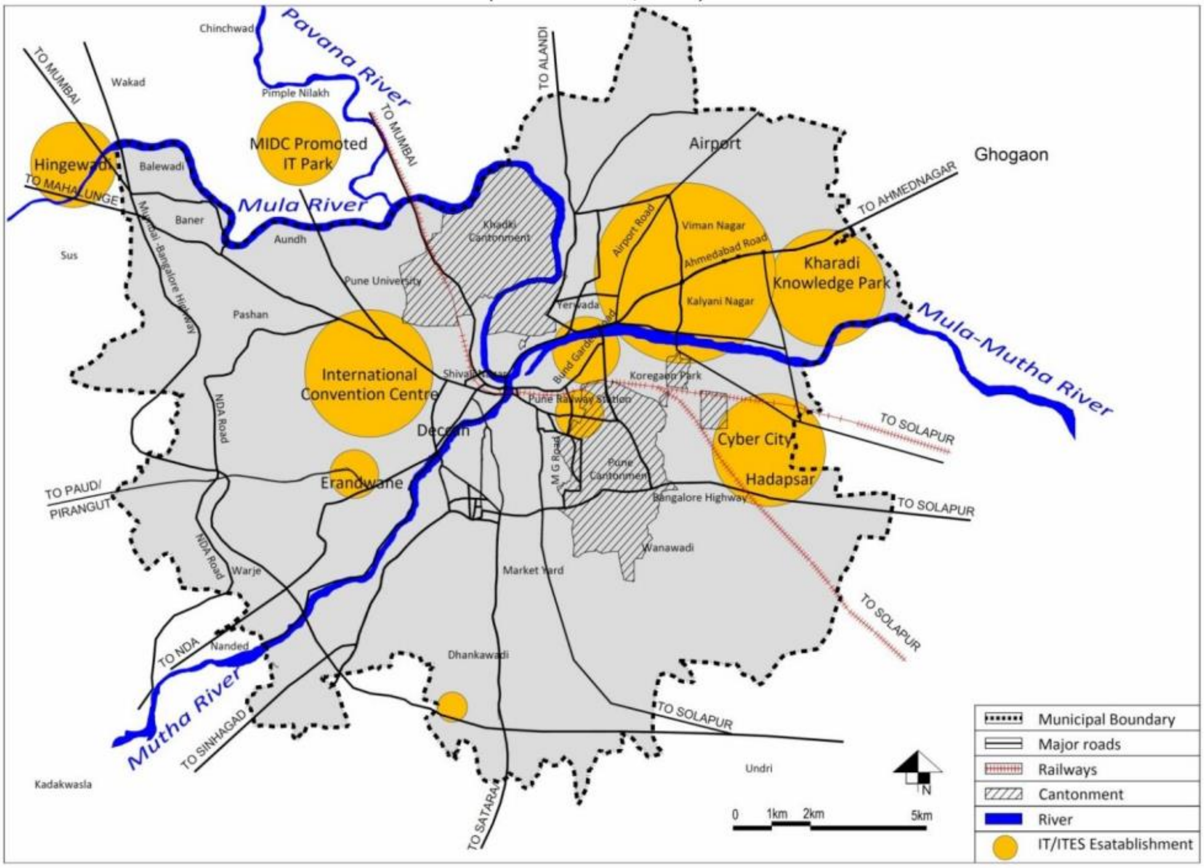


Figure 7. : IT/ITES Establishment in Pune

1.4.7 Road network pattern

Road Network Inventory has been carried out on major radial and circumferential roads in the study area as part of Comprehensive Mobility Plan for Pune Municipal Corporation. The summary of type of road surveyed is shown in the following figure. 35% of roads are two lane roads, 42% are four lanes divided and 12% are four lanes undivided.

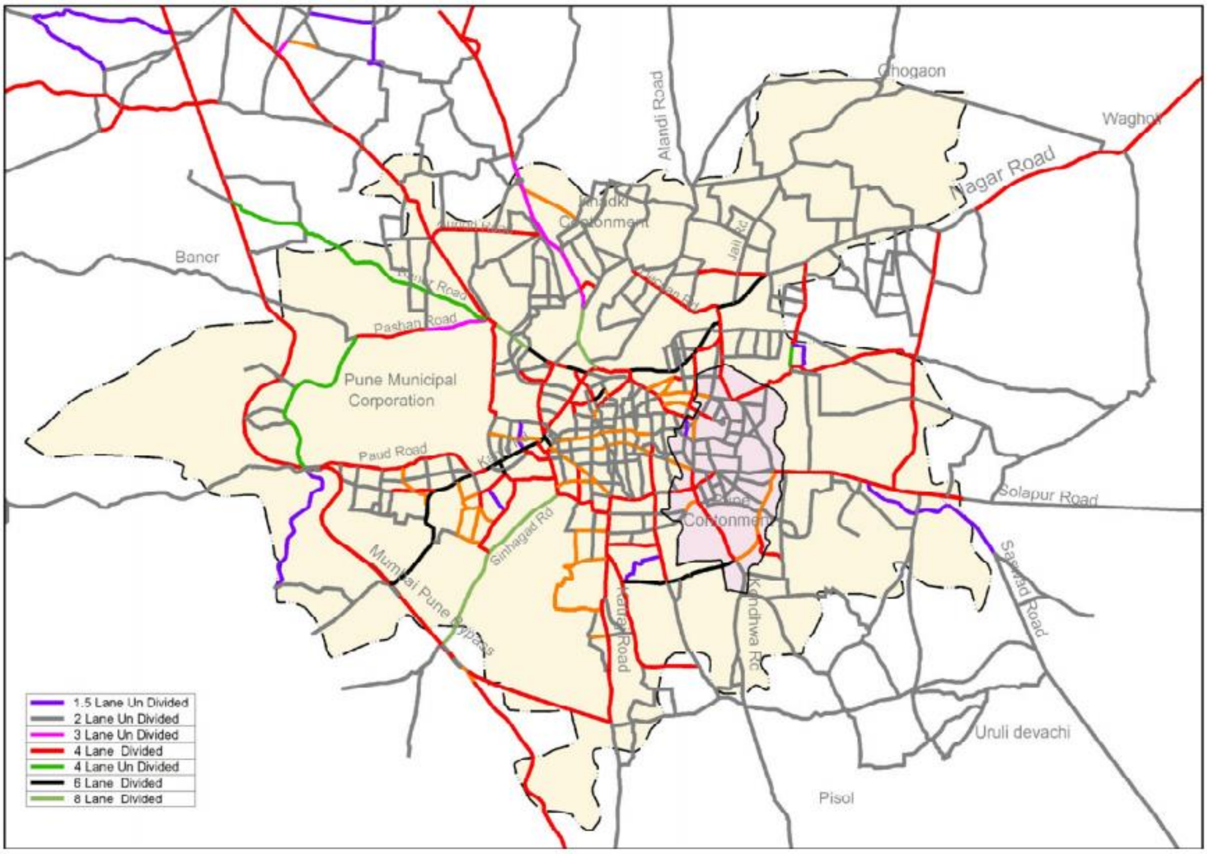


Figure 8. Proposed Road Network in PMC
Source: Comprehensive Mobility Plan, PMC, 2018

1.4.8 Development of Metro Network

With the projected increase in the city's population, strengthening and augmenting the existing transport infrastructure has assumed urgency.

This situation has thus called for the development of an MRT system and in 2016, Phase I of Pune Metro Project was approved by the Central Government of India. It is Maha Metro – Pune Metro that is in charge of the implementation of the Pune Metro Project.

The metro system will connect different parts of the city area with the developed and developing areas. Although the city has relatively low population compared to other metropolitan cities, a planning for a modern transportation system for Pune city shall help it to grow in terms of industrialization and commercialization.

2. EXISTING TRANSPORTATION SYSTEM IN THE CITY

2.1 Introduction

Pune city is an important urban centre in Maharashtra. The city has started experiencing problems in safe and easy movement of people and goods. Traffic and transportation problems in Pune Metropolitan Region have aggravated very fast, firstly due to the population increase through migration and secondly phenomenal rise in vehicle population. The Metropolitan Region is a twin establishment where industrialization at present is concentrated in the Pimpri-Chinchwad Municipal Corporation area, while the Pune City has all the office establishments, state, central, semi-government offices and Commercial Centres with high-density residential habitat. Besides Pune Municipal Corporation Area (PMC), the Pimpri-Chinchwad Municipal Corporation (PCMC), the Pune Metropolitan Area (PMA) also includes Cantonment Boards of Pune and Khirki and some villages. As per 2011 census population of the Pune City is a home to 32 lacs people and 26 lacs vehicles. The city has experienced steep enormous population growth due to inward migration of both skilled and unskilled labour for rising industrial base and service sector. For the last two decades Pune has registered a steep growth in number of public-private vehicles. But the road infrastructure and the utilities have not expanded in commensurate with increase in number of vehicles. Vehicular growth and composition

2.1.1 Vehicular Growth in PMC

The total vehicle population in PMC as on 31st March 2018 was 36.2 lakhs (under the Regional Traffic Office MH-12), and the total number of registered vehicles in PCMC is 15.68 lakhs in which 11.69 lakh two wheelers and 2.54 lakh four wheelers. Thus around 51.88 lakh vehicles are registered in PMC and PCMC. There has been a 700 per cent increase in the number of vehicles in Pune Urban Agglomeration in the last 20 years as per Regional Transport Office (The Indian express, 2017).

The analysis of vehicle registration data from the year 2012 to 2017, Compound Annual Growth Rate (CAGR) was calculated between 2012-13 to 2016-17 for various classes of vehicles. It can be noticed that two-wheelers constitute to 68.70% of the total vehicles, followed by cars with 22.70%. (Source: CMP of PCMC & PMC, 2018). It has been observed that regarding the impact of an increased vehicle population in Pune city very few studies have taken place after year 2000. According to the Srinivas Bonala, 2004 (Author), Pune city is facing problems like increased traffic congestion, reduced driving speed, increased environmental pollution and degradation of the quality of life. The capacity of many intersections has been exhausted. The central city is experiencing capacity gaps, parking problems, low-speed travel, increased congestion, and environmental pollution leading to worsening air quality. The article (India Together, 2004) reports that Pune's municipal transport system, is suffering due to an increased population, inadequate bus fleets and resources, increasing competitive private modes of transport and neglect from political and administrative officers. Pune has been labelled the 5th most polluted city in Asia. 65% of this pollution in Pune is caused by vehicular emissions.

2.2 Road Network Characteristics

Pune district is well connected with the state capital and surrounding headquarters through road linkages. The road network consists of Express Highways. National Highways, State Highways and Major District Roads. The district has total length of 13,642 km of roads.

Pune is connected to other major cities through Highway roads converging towards the centre of the city, 3 of which are going through the areas that are in the study perimeter (see figure below):

- Katraj (NH48 to Kolhapur);
- Pimpri-Chinchwad (NH65/48 to Mumbai);
- Chakan (NH50/60 to Nashik).

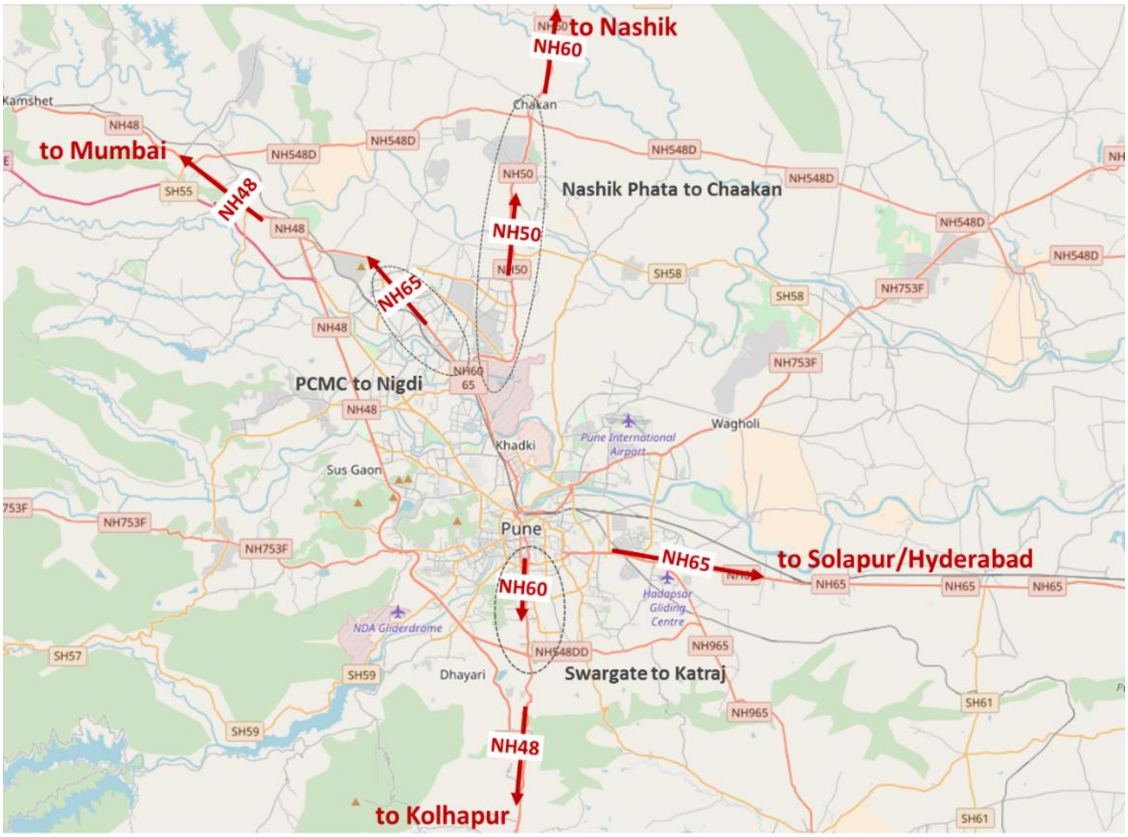


Figure 9. Map of Main Highway Roads from Pune to other Major Cities
(Source: Open Street Map, 2018 & Systra, 2018)

2.3 Major Transport Nodes

2.3.1 Road Network

The Pune is located to the South East of Mumbai at a distance of 150 km. The Mumbai-Bangalore National Highway (NH-48) passes through the city and runs towards southern direction. Pune is well connected with all the major cities of India by network of National and State Highways. Some of the major highways passing through the study area are as follows:

- Mumbai - Bangalore National Highway (NH 48)
- Pune - Hyderabad National Highway (NH 65)
- Pune Nashik National Highway (NH 60)
- Mumbai Pune Expressway Major State Highways include
- Pune- Ahmednagar- Aurangabad State Highway
- Pune- Alandi State Highway
- Pune- Saswad- Pandharpur State Highway
- Pune- Paud Road State Highway
- Talegaon- Chakan State Highway the Mumbai-Pune Expressway is India's first six-lane expressway and was built in 2002. The expressway has reduced the travel time between Pune and Mumbai to almost two hours.

2.3.2 Rail Network

The district of Pune has a total rail network of 311 km. Pune is one of the two main stations of the district (the other being Daund). Following are the three main railway routes pass through the district:

- Mumbai-Pune-Solapur;
- Pune-Miraj;
- Daund-Baramti.

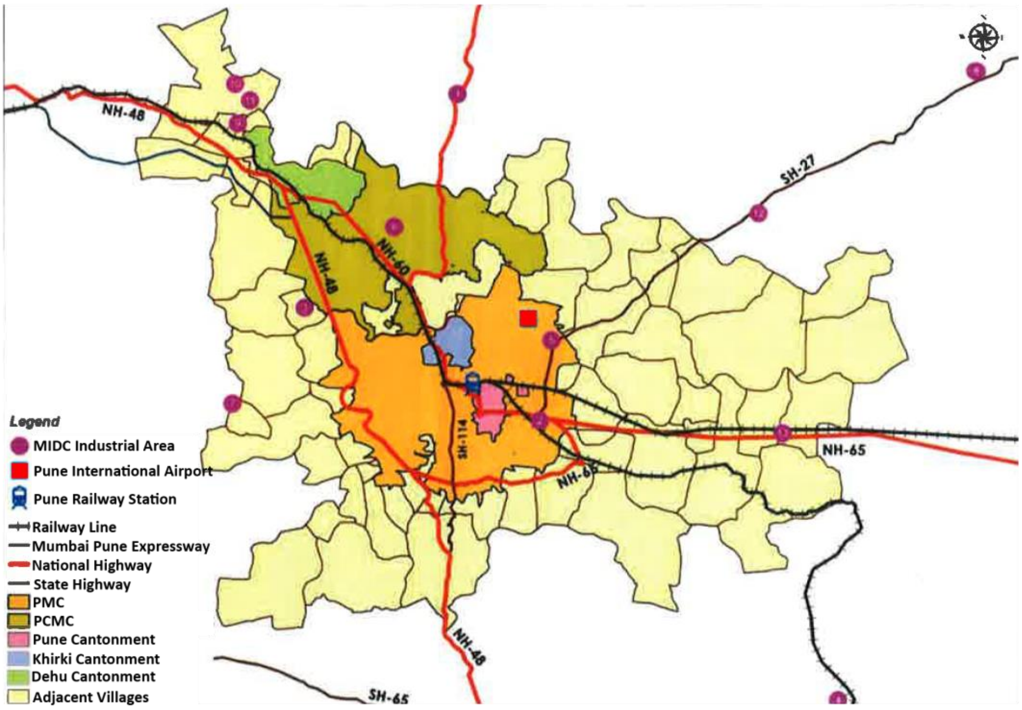


Figure 10. Map of Major Transportation Nodes in and around Pune City

2.3.3 Bus

2.3.3.1 Intercity bus service

MSRTC is a state-run bus service of Maharashtra. it operates buses from Pune to all major parts of the state from four bus terminals: Swargate, Shivaji Nagar, Pune Railway Station and Vallabh Nagar. Buses to Mumbai, Solapur, Nasik, Shiridi etc will be plying at regular intervals from Pune. Wide range of services is operated by MSRTC which includes Ordinary, Asiad, Hirkani, Ashwamed, Shivneri and Shivshahi.

Apart from MSRTC, state transport corporations of neighbouring states such as Gujarat, Karnataka and Telangana also operate bus services to Pune.

2.3.3.2 City Bus Service

PMPML is responsible for operating bus service in the city and its suburbs. The fleet size of PMPML is about 1,500. The average life of fleet is 8 years. Average number of buses on road per day is 1,382 operating on 371 routes. On an average 17,000 trips per day and carrying around 10.65 lakhs trips passengers per day with average occupancy of 770 passengers per bus. PMPML operates various services like Regular Service, Rainbow Buses, Night Buses, Pune Darshan, Ladies Special and Airport Buses. At present PMPML have 13 bus depots and 2392 bus stops which clearly indicates need for replacing old fleet with new one. The 13 bus depots are at Swargate, Shivaji Nagar, Kothrud, Katraj, I-Iadpasar, Market Yard, Upper Depot, Pune Railway Station, Nigdi, Pimpri, Bhosari, Wagholi, Bhekrai Nagar. Apart from these the other major bus stands are Deccan Gymkhana, PMT Bus Stand, Mahatma Gandhi Bus Stand at Pulgate, Bhakti Shakti Bus Stand in Nigdi and Chinchwad Bus Stand.

2.3.4 Airport

Pune International Airport is located at Lohegaon at around 10 km from the city. It is operated by the Airports Authority of India (AAI). AAI shares its runways with the Indian Air Force base. In addition to domestic flights to all major Indian cities, the airport serves international direct flights to Dubai and Frankfurt. In 2017-18, the airport has handled about 8.16 million passengers and 41,566 tonnes of cargo. The current Airport is saturated, and the new green field airport is proposed at Purandhar on southern side of Pune city near Saswad town.

2.3.5 Metro

2.3.5.1 Pune Metro Project – Phase I

The Phase I of Pune Metro project comprises two lines. The two lines with 30 stations are presented on the following figure

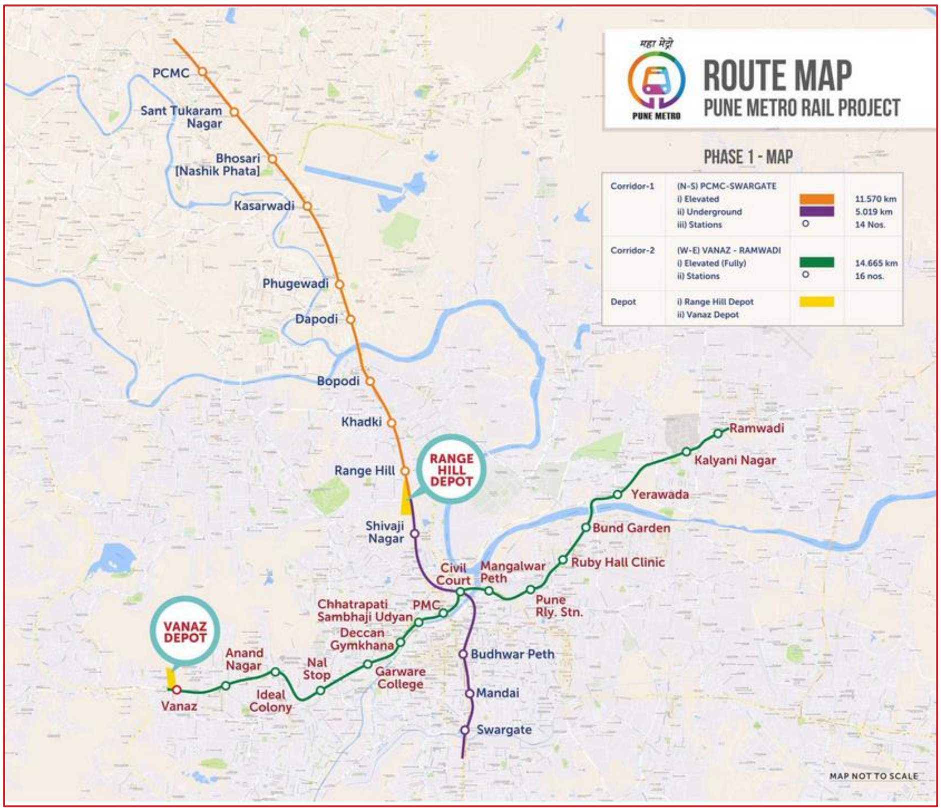


Figure 11. Map of phase 1 Pune Metro Project
(Source: Maha Metro – Pune Metro, 2018)

- **Line 1** running from North to South from PCMC to Swargate. It is 17.8 km long and comprises 14 stations including 5 underground and 9 elevated stations;
- **Line 2** running from West to East from Vanaz to Ramwadi. It is 15.7 km long and comprises 16 elevated stations.

As mentioned above, Phase I of the Metro Project was approved in 2016 and construction is currently taking place on the two lines.
In addition, Line 3 is also planned under PPP model, being implemented by PMRDA, which will be running between Shivajinagar and Hinjewadi. Line 3 metro is 23.33 km long and comprises of 23 stations.

2.3.5.2 Pune Metro Project – Phase II

Maha Metro – Pune Metro is planning to further develop this metro network as an extension of Phase 1 to cater to the fast development of the city.

After experiencing the rapid growth, particularly in the out-growth areas of PMC & PCMC and Chakan area, the Government of Maharashtra/ Maha Metro – Pune Metro is planning to further develop the metro network as an extension of Phase I.

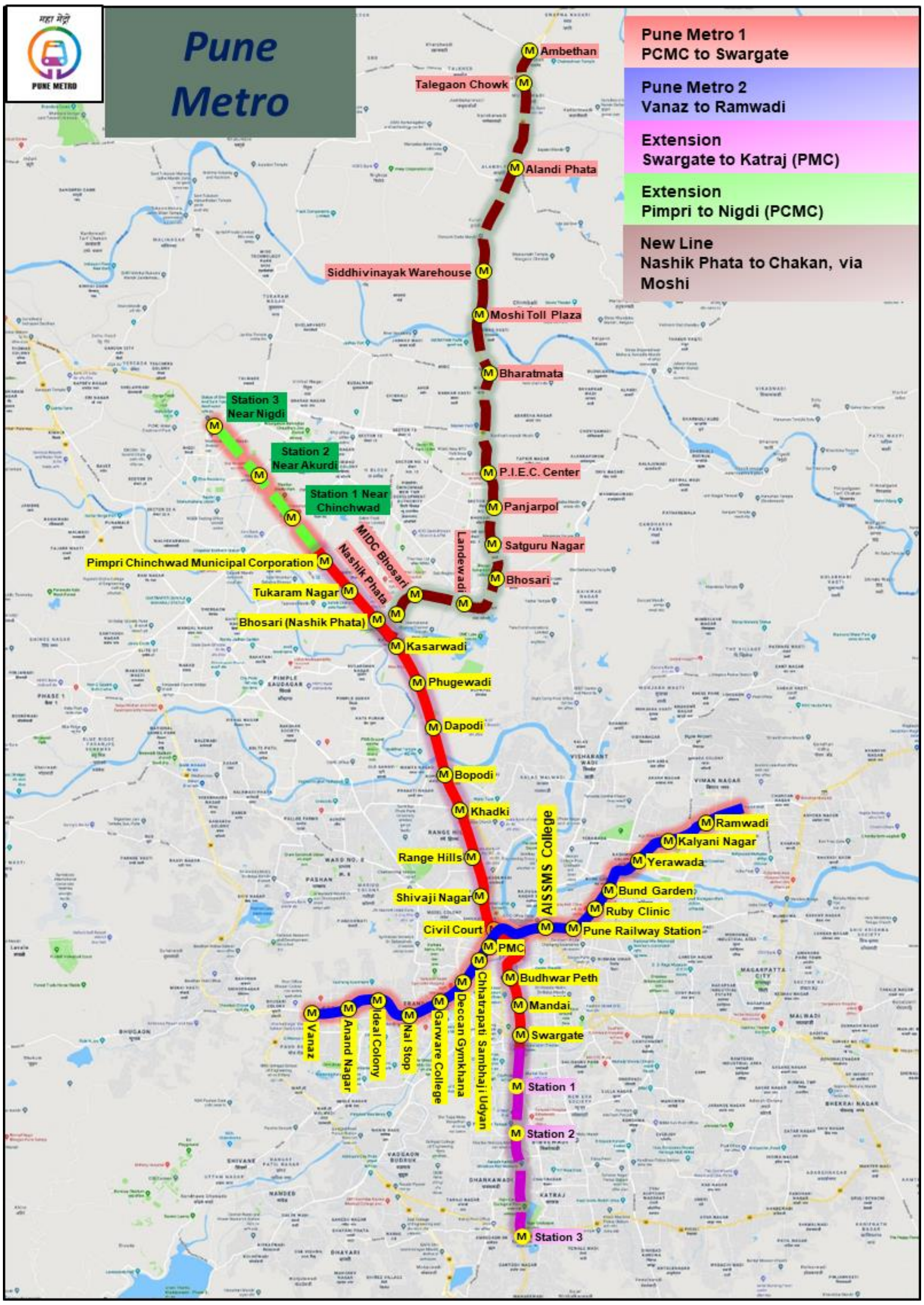


Figure 12. Pune Metro Project Corridors

Extension of Phase 1 i.e. From PCMC to Nigdi (corridor 1A), and Swargate to Katraj (Corridor 2A) have received the in principal approval of Government of Maharashtra in October 2013. This extension corridors, as part of Pune Metro Phase II, include:

This development includes:

- **Corridor 1A**, which is an extension of line 1 from PCMC to Nigdi in the North (4.413 km);
- **Corridor 2A**, which is an extension of line 1 from Swargate to Katraj in the South (approximately 5.464 km);
- **Corridor 2B**, which is a new line running from Nashik Phata on line 1 to Chakan in the north east of the city (23.18 km, including connection to Depot from Main line). It will have interchange station with existing Bhosari Station.

2.4 Traffic Management Including Parking Management

Mobility Management (also called Transportation Demand Management or TDM) Is a general term for strategies that result in more efficient use of transportation resources, as opposed to increasing transportation system supply by expanding roads, parking facilities and facilities for private vehicles. Mobility Management emphasizes the movement of people and goods, not just motor vehicles, and therefore gives priority to modes (public transport, NMT and ridesharing) which optimizes available road space and causes least pollution under congested conditions. Mobility Management is particularly relevant for Indian cites, because of low costs and multiple benefits. The benefits include congestion reduction, savings on road and parking facility development, improved consumer choice, road safety, better environmental quality, community liveability, efficient land-use and equity. Mobility Management can provide significant savings to commuters and society by reducing and deferring road-way capacity expansion costs. These measures can be implemented quickly, and target a particular location, time period or user group. More efficient management gives priority to modes that require less space per passenger-kilometre, and to particularly high-value trips such as emergency vehicles and walking etc., In general, Mobility Management should reflect the following priorities: Emergency vehicles/trips, Walking, Cycling, Public Transit, Service/Fright Vehicles, Taxi, Single Occupant Cars, Automobile Parking. Traffic police have a vital role to play in the success of traffic management. This may require special efforts to establish modern traffic enforcement techniques, adequately train and compensation for officers to maintain the professional force and maintain good communication with general public. Summary of Parking Management strategies is given in the Table 33.

Table 24 : Summary of Parking Management strategies

Method	Advantages	Disadvantages
Pricing and Regulatory Strategies		
Regulate curb-side parking (loading zones, 1-hour limits, etc.) for priority	Low implementation costs	Enforcement requirements
	Flexible- can be quickly changed or apply to specific times	Generates no revenue
		Does little to reduce overall vehicle travel demand

Method	Advantages	Disadvantages
		May shift traffic to other locations
Imposing parking prices	Generates revenue	Enforcement requirements
	Reduces travel demand	Risk of fraud
	Allows higher priority, uses more convenient spaces	May shift traffic to other locations
	Moderate implementation cost	
Require vehicle owners to have an off-street parking space	Reduces on-street parking congestion	Difficult to enforce (some residents may register their vehicles elsewhere)
	May reduce vehicle ownership	
	Low implementation costs	
Tax parking	Generates revenue	May shift traffic to other locations
	May reduce vehicle travel demand	Risk of fraud
More efficient use of parking facilities		
Share parking facilities	Cost effective	Reduces parking convenience
	Can reduce parking requirements	Requires new administrative arrangements
	Flexible	Depends upon circumstances
More accurate parking supply	Cost effective	May create future parking/ congestion problems
	Can reduce parking requirements	
Reduce parking requirements for mobility management programs	Cost saving	Limited guidance avaiable
	Can reduce parking requirements	Requires ongoing management
	Create incentives for employee trip reduction programs	
Transportation management association	Can reduce parking requirements	Requires new administrative arrangements
	Can provide many services to business, employees and customers	
Control complementary Parking Passes	Reduce vehicle travel demand	Requires review and enforcement
	Can increase revenue	
Cash out free parking	Can reduce vehicle travel demand and parking needs	Requires new administrative arrangements
	Gives employers a way to reduce parking demand	Risk of fraud
Unbundle parking	Reduce vehicle travel demand	Requires new administrative arrangements

Method	Advantages	Disadvantages
	Can reduce parking requirements	Risk of Fraud
	Increases customer choices	
Other strategies		
Location efficient development	Supports land use objectives	Slow to achieve benefits
	Reduce vehicle travel demand	
	Can reduce parking requirements	
	Increases customer choices	
Response to spill over problems	Avoid problems	Requires new administrative arrangements
	Is equitable	
Over flow parking plans	Reduce vehicle travel demand	Requires new administrative arrangements
	Can reduce parking problems	
	Is equitable	
Parking maximums	Saves money	May lead to future parking problems
	Supports land use objectives	
	Reduce vehicle travel demand	
	Can reduce parking problems	
In Lieu fees	Saves money	Requires new administrative arrangements
	Results in more efficient use of parking facilities	May lead to future parking problems
	Reduce vehicle travel demand	
Bicycle parking	Saves money (compared with automobile parking)	Only effective where people wants to bicycle
	Support bicycle travel	May lead to future parking problems
	Is equitable	
Improve parking facility design	Addresses many problems	May increase cost
		Require new design guidelines

2.5 Traffic Characteristics

2.5.1 Traffic Volume and Composition

About 10.6 Lakh PCU has been observed at various cordon points in Pune and Pimpri-Chinchwad City as Per CMP, 2018. Total of 10.6 Lakh vehicles and 10.18 Lakh PCU has been observed. Satara Road is having highest number of vehicles followed by Mumbai Pune Expressway at Talegoan Toll Plaza. On Khed Shivapur Toll Plaza and Pune-Mumbai Expressway, a greater number of goods vehicles are observed as high as compared to other locations. Traffic volume on Velhe Bhudruk village Road, Velhe Bhagud MIDC (Mulshi Road) and Nirvi-

Nhavare Road is less. Number of vehicles at Kusgaon Toll Plaza is less compared to Talegoan Toll Plaza, as the Kusgaon Toll Plaza is an entry/exit toll plaza to Lonavala.

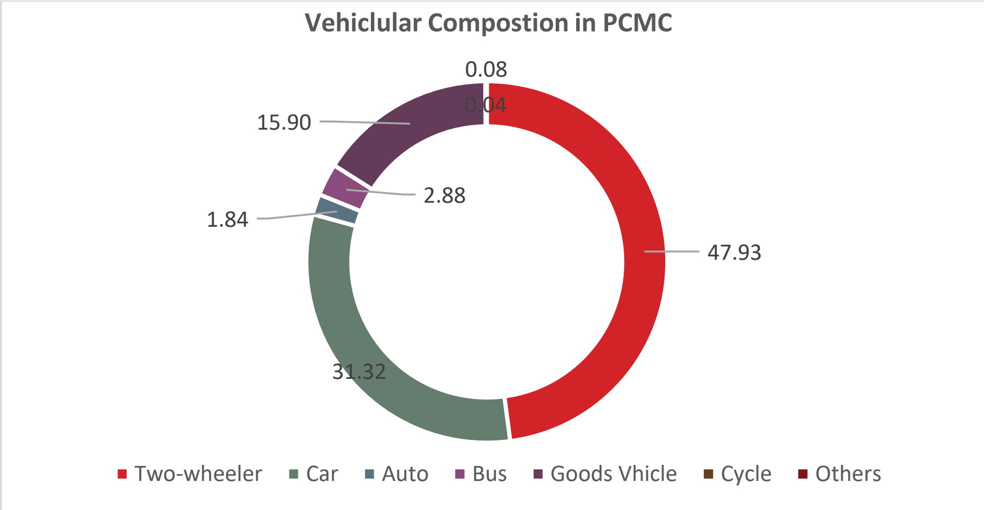


Figure 13. Vehicular Composition in PMC, 2018
(Source: CMP of PCMC & PMC, 2018)

More dominant mode of transport used in PMC is two-Wheeler, followed by car. Cycle is least preferred mode which shares just 4% of traffic composition. The share of two wheelers is more on village roads as they constitute the local trips. The share of goods vehicles is considerably high on National Highways like Nasik Road, Solapur Road, Mumbai Highway and Satara Road as compared to other roads. The share of two wheelers is almost zero on Mumbai Pune Expressway as the movement of two wheelers is restricted on the expressway. Share of buses is also minimal on roads like Velhe Budruk Road, Nirvi- Nhavare Road, Saswad Supa Road and Uruli Kanchan road as these roads are not connecting any major settlements.

2.5.2 Speed and delay Survey

Journey speed is an important parameter to measure traffic flow and Level of Service of traffic. Measurement of speed is frequently required in transport planning particularly to evaluate the road network system, to provide vital inputs to transport demand modelling process and assist in economic analysis of improvement plans.

The average journey speed varies from 10 kmph to 60 kmph in Pimpri Chinchwad city. Maximum journey speed of 60 kmph is observed on bypass road. This is due to four lane divided carriageway in good condition. Some roads like Laxmi Road, NC Kelkar Road, Shivaji Road, Bajirao Road, Jawaharlal Nehru Road etc the speeds are very less as these roads are in CBD area where the speed of vehicles is being affected by various factors like pedestrian flow, narrow roads, heavy vehicular flow and roadside friction such as on-street parking, encroachments etc.

2.5.3 Pedestrian and NMV movement

As per CMP, 2018, Maximum number of pedestrians in peak hour are observed at Belbaug chowk which is around 13,000, this is because of Dagdusheth Halwai Ganapati Temple and commercial areas on Shivaji Road. On mid-block locations, maximum number of pedestrians are observed on Lal Bahadur Sastri Road near Rambaug colony road.

Less than 15% of road network is covered with NMV facilities.

2.6 Traffic safety

Various traffic safety measures are proposed in CMP pertaining to Road marking, signage and street lighting. Proper signs will be installed at appropriate locations as per guidelines provided in IRC publications 67-2001 'Code of practice for Road signs. The following short-term alternatives may be considered for implementation:

- Speed breakers and humps be marked and signed adequately for night time visibility,
- All traffic signages be made retro reflective,
- Install minimum pavement markings such as lane lines, median lines, stop bar, fog line, etc.
- Ensure that adequate street lighting is provided on all collectors, sub-arterials, and arterial roads.

Improvement in street lights are also proposed. Along with this, strategies for junction improvement and traffic calming measures are also considered.

2.7 Intermediate Public Transit (IPT) System

Auto rickshaws are the main IPT modes in Pune. The various modes of IPT in Pune are: Auto-rickshaw, Share Auto and Taxi services which include application-based taxi aggregators like Ola and Uber. There are no specific route restrictions for these autos. Auto rickshaws running on the streets of Pune provide better connectivity to the city core which has a narrow road network. Many people prefer them over local bus service due to shorter wait time and point to point service. A total of 50,892 auto rickshaws, 46,511 taxies and 7759 other passenger vehicular permits are availed in Pune and Pimpri-Chinchwad.

2.8 Public Transportation System

Bus and Railway are the types of public transport available in the city. Intercity as well as city bus service is available. BRTS is also in Place. Bus is the most common public transport system used in the city. With time, usage of city bus service has been declining due to change in personal choices as shown in PMPML passenger data (Table 25).

BRTS in Pune is named as Rainbow BRTS. BRTS serves both Pune and PCMC. At present 4 corridors of 38km is operational. Rainbow BRTS caters to 51 routes with 319 buses plying along 4 corridors.

BRTS route from Dapodi-Nigdi on Pune-Mumbai highway will be operational soon. The ridership is listed in Table 25

Table 25 : Yearly PMPL Passenger data (2013-2017)

YEAR	TOTAL PASSENGERS	DAILY PASSENGERS
2013-14	424894432	1164094
2014-15	444357132	1217417
2015-16	411503942	1124328
2016-17	393916615	1079224

Source: CMP, PMC, 2018

Another form of Public transportation is sub urban railways. Pune Suburban Railway is operated by Central Railway between Pune to Lonavala, runs on double line electrified broad-gauge section of 63.84 km. The suburban trains are operated from Pune to Lonavala regularly to cater the suburban traffic. In a day 18 trains are being operated from Pune to Lonavala and 5 trains between Pune and Talegaon. The minimum headway of the trains is 30 minutes and generally frequency is observed to be low, which makes the system heavily crowded in peak hours. A large number of students, employees, industrial workers travel by the local trains and the poor frequency of trains leads to increased rush of passengers through the day. Mumbai Rail Vikas Corporation is planning for 3rd and 4m line between Pune and Lonavala, exclusively for suburban rail operations. Stations along Pune-Lonavala railway line are Shivajinagar Station, Khadki Station, Pimpri Station, Chinchwad Station, Akurdi Station, Dehu Road Station, Talegaon Station and Lonavala Station. It covers Lonavala to Daund and Pune to Miraj.

Metro: Metro has been approved for the Pune In December 2016. Pune Metro project has been undertaken by MAHA Metro, a SPV (Special Purpose Vehicle) of Government of India and Government of Maharashtra. Surveying and design work of Pune Metro has begun in June 2017. It will be a combination of elevated and underground sections, with initial routes being planned between PCMC - Swargate and Vanaz - Ramwadi. The estimated cost of the project is about Rs.11,522 crore. The project is expected to be completed by 2021.

2.9 Past proposals from CMP/CTTS/Transport Master Plan

2.9.1 Mass Transit System

Under CMP, 2018, the public transport network and system has been selected, considering the evaluation of public transport networks. Metro, Light Metro and BRT systems have been recommended for various corridors. The recommended Public transport network in 2028 is presented in

Table 26.

Table 26 : Recommended Public Transport Network and system, 2038 (CMP 2018)

		Length in Km (2028)	PHPDT (2028)	Length in Km (2038)	PHPDT (2038)
Metro Corridor					
1	Nigdi – Katraj	33.63	15500	33.63	19000
2	Chandani Chowk – Wagholi	25.99	13000	25.99	18000
3	Hingewadi - Hadapsar	30.35	13500	30.35	22000
4	Sinhagad Road	9.08	9500	9.08	16500
5	Hinjewadi - Chakan	30.08	14000	30.08	24000
6	Warje to Swargate			8.87	8000
7	Wagholi-chikali-Hinjewadi			35.23	95000
	Total	129.1		173.2	
BRTS Corridor					
1	Yerwada – Airport	5.05	2000	5.05	2500
2	Kalewadi phata – Chikali	12.03	2500	12.03	3400
3	HCMTR PMC	38.45	2200	38.45	2900
4	HCMTR PCMC	31.40	2000	31.40	2700
5	Chinchwad-Talewade	12.00	2800	12.00	3500
6	Total	98.93		98.93	

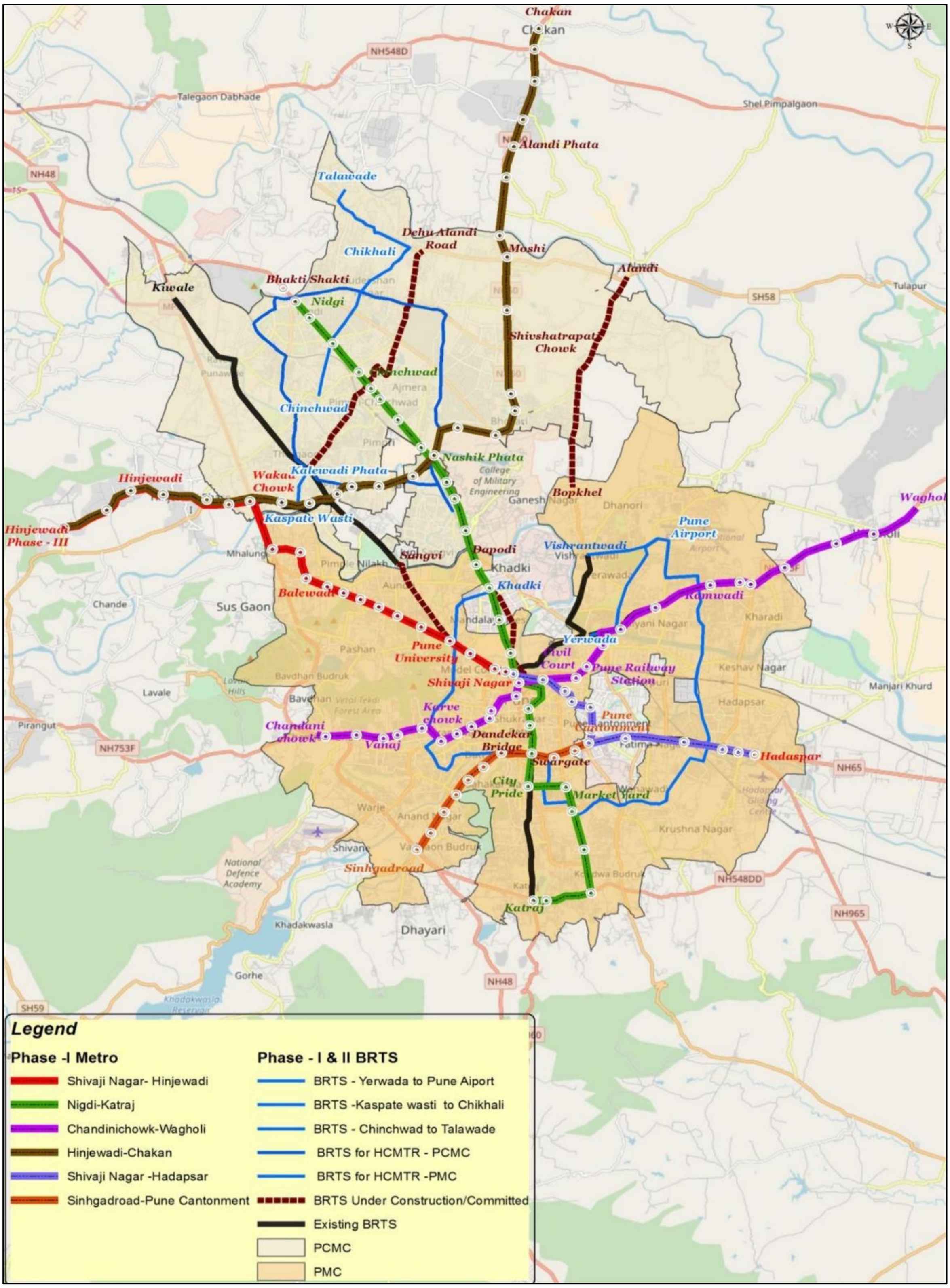


Figure 14. Recommended Mass Transit Corridors in 2028 (CMP, 2018)

2.9.2 NMT Improvement Plan

In view of the importance of NMT infrastructure, PMC has initiated several projects besides establishing the NMT Cell. The projects initiated by PMC are listed below:

• Bicycle Master Plan for Pune prepared in 2017. It is under implementation.

• Public Bicycle Sharing scheme (PBS) is prepared and is under implementation

• Pune Street redesign as per Urban Street Design Guidelines

• SMART City Street Development (for ABD Area)

• Pedestrian Policy A Non-Motorized Transport (NMT) Cell was set up in 2008 by PMC to look at the issues related to pedestrians and cyclists, and provision of footpath and bicycle track infrastructures.

The objective is to plan and maintain consistent, high quality pedestrian infrastructure with equitable allocation of road space. The Cell has planned to develop 75km footpath along BRT and complementary 15 km bicycle tracks on following roads:

- Sancheti-Aundh road
- Wakdewadi-Harris Bridge
- Alandi road
- Nagar road
- Nehru-Market yard road
- Upper Indiranagar road
- Satara road
- Sinhgad road
- Karve road
- Paud road

The Bicycle Plan for Pune has recommended formulation and implementation of following:

- City-wide Bicycle Network
- Bicycle Design Guidelines
- Public Bicycle System
- Bicycle Parking
- Integration with Transit
- Regulation and Enforcement

It envisaged a construction of 375 km of footpath at a cost of Rs.375 crore and Bicycle tracks for 75 km at a cost of 150 crore during 2016-2020.

2.10 Issues and Prospects

- Inefficient Road Network: Since 1960, Pune traffic has increased by more 105 times, whereas the road network has grown by merely by 6 times. Hence due to huge traffic load, the road network is insufficient and hence is causing traffic jams and fatal accidents. As per the data, the existing road network is 7% while the requirement is more than the double i.e. 15% .Hence there is a gap of 8% between them and due to this gap, there are many huge traffic jams in different parts of the city and these traffic jams are time consuming and hence the commuters are in hurry to reach their destinations. For saving their journey time, some of them increase their speeds and meet with accidents which may cost to their properties and sometimes to their life. The road infrastructure has not expanded in tandem with the increase in the number of vehicles in the city. In the last four decades, the population of the city has increased four times whereas the vehicle population has increased 87 times and the road length has increased by only five times. With the projections indicating that PMC would have a population of about 45 lakhs by 2021 and 57 lakhs by 2031, the road and transportation infrastructure has to not only meet the existing demand but also cater to the demand that will be generated by the increasing population. There are more than 12.5 lakh registered vehicles in Pune as on date. The total number of registered vehicles has grown at a compound annual growth rate (CAGR) of 8 percent. The total length of roads in the city is 1800 km. including about 50 km. of National Highways and State Highways (Source: Pune traffic problems & control measures, Journal of information, knowledge and research in civil engineering, 2017)

- Inter-City Bus Transport: There are three major inter- city bus terminals in the city located at Swargate, Shivajinagar and Pune Station. These terminals cater to the inter-city traffic with origin and destination other than Pune. Parking organized on-street parking facilities are provided in selected locations in the city. It may be multi- storey dedicated for parking vehicles. (Source: Pune traffic problems & control measures, Journal of information, knowledge and research in civil engineering, 2017)
- Poor Traffic Management: Traffic police are deployed at major traffic signals and mainly they are busy in issuing challans to the offenders. They mismanagement the condition is very pathetic. (Source: Pune traffic problems & control measures, Journal of information, knowledge and research in civil engineering, 2017)
- Violations of Traffic Rules & Regulations: Commuters are not following the traffic rules. The main reason is breaking roadsides, narrow the roads and vehicles are not able to move smoothly. Many are parked at zebra crossings and hence the pedestrians are forced to cross the roads without using zebra crossing and sometimes meet with accidents. (Source: Pune traffic problems & control measures, Journal of information, knowledge and research in civil engineering, 2017)
- Bad Constructions & Improper Management: There are no any quality constructions. The contactors are making money by doing bad constructions which causes jams and accidents. There is no any road maintenance and master plan to the concern authority. Inefficient Public Transport: The public transport numbers and frequency are limited, and the passenger number is unlimited. Hence there is a huge gap in required public

transport and existing public transport. (Source: Pune traffic problems & control measures, Journal of information, knowledge and research in civil engineering, 2017)

- Absence of Infrastructural Requirements: Flyovers, ROB and Subways are limited in number in Pune city and due to which many parts are facing huge traffic jams problems (Source: Pune traffic problems & control measures, Journal of information, knowledge and research in civil engineering, 2017).
- Area under circulation below the normative standard (10-12percent) (Source : CDP, PMC, 2041)
- Radial and rectilinear pattern leads congestion in core areas
- Encroachment along the road side creating the problem of traffic congestion
- High volume capacity ratio in all Major roads. Road network is not up to the mark in newly added areas.
- Lack of pedestrian facilities.
- High rate of accidents.
- Lack of traffic sense among the citizens.
- Non-availability and poor condition of footpath.
- Poor and inefficient public transport system.

3. TRAVEL CHARACTERISTIC AND DEMAND ESTIMATE

3.1 Preamble

Pune & Pimpri Chinchwad is the next largest urban conglomerate to Mumbai Metropolitan Region in Maharashtra. The urbanization of this region will receive a big impetus in the next 30 years due to the ambitious development plan of the 7000 sq. km Pune Metropolitan Region. These cities are considered to be educational hub due to the establishment of large number of educational institutes across the city. Pune & Pimpri Chinchwad have been experiencing tremendous growth in population and employment since the last two decades. The cities have been stretching its limits to the widest extent possible and urban sprawl has become evident. The growth in various industries, particularly automobile, IT and IT enabled services, in and around Pune & Pimpri Chinchwad has added further impetus to the urban sprawl and increase in population and employment.

The public transport system in Pune & Pimpri Chinchwad consists mainly of buses, and a few services of Bus Rapid Transit (BRT) System and suburban rail at present. The public transport share has been completely toppled by the tremendous growth in private vehicle transport. The vicious cycle of increase in private vehicle ownership (mostly two-wheelers and cars) has become unstoppable due to the increased transport demand and lack of convenient public transport options. In a nutshell, in the absence of augmentation of mass transit services, Pune may head towards unsustainable urban transport scenario. In order to augment public transport system to cater to the rapid increase in demand for transportation services and make urban transportation in Pune & Pimpri Chinchwad sustainable, the implementation of metro rail was envisaged, and Metro master plan was prepared by Delhi Metro Rail Corporation (DMRC) in 2008.

The Pune metro project comprised two lines initially, which are being constructed;

Line 1: running from North to South from PCMC to Swargate. It is 17.8 km long and comprises 14 stations including 5 underground and 9 elevated stations.

Line 2: running from West to East from Vanaz to Ramwadi. It is 15.7 km long and comprises 16 elevated stations.

Phase I of the Metro Project was approved by the Government in the year 2016 and the construction is currently in process on the above two lines. In addition, Line 3 is also planned under PPP model, which will be running between Shivajinagar and Hinjewadi, which is being implemented by PMRDA. Line 3 metro is 23.33 km long and comprises of 23 stations. After experiencing the rapid growth, particularly in the out-growth areas of PMC & PCMC and Chakan area, the Government of Maharashtra/ Maha Metro – Pune Metro is planning to further develop this metro network as an extension of Phase I. The extension corridors, as part of Pune Metro Phase II, include:

Corridor 2A, which is an extension of line 1 from Swargate to Katraj in South (5.464 km);

Corridor 1A, which is an extension from PCMC to Nigdi in the North (approximately 4.413 km);

Corridor 2B, which is a new line running from Nashik Phata on line 1 to Chakan in north east of the city (approximately 23.18 km including connection to depot from main line).

Pune Metro Project extension Corridor IA and Corridor 2A had received the *in-principle* approval of Government of Maharashtra in October 2013.

The transport demand model recently calibrated in the year 2017, is used as a base for the modelling process. The travel demand model uses the present and future land use patterns to estimate the origins and destinations of trips. It then assigns these trips to different travel routes and travel modes, including metro, based on the type and quality of the transportation network.

3.2 Objective and Scope of Traffic Study

The main objective of the traffic study is to estimate the passenger ridership on the proposed metro extension corridors; Nashik Phata - Chakan, PCMC - Nigdi and Swargate - Katraj Corridors; The scope of the traffic study includes;

- Updation of recently validated transport demand model using **CUBE Voyager** Software
- Collection and review of secondary data
- Collection of primary data including carrying out Classified Traffic Volume Counts and occupancy along the proposed metro corridors.
- Patronage forecast on entire metro corridors including the proposed PCMC – Nigdi & Swargate-Katraj extension. The forecast includes station wise boarding/ alighting, link loads, PHPDT, etc., for identified land use, transport and fare scenarios.

Following figure presents all the survey locations conducted as part of the study.

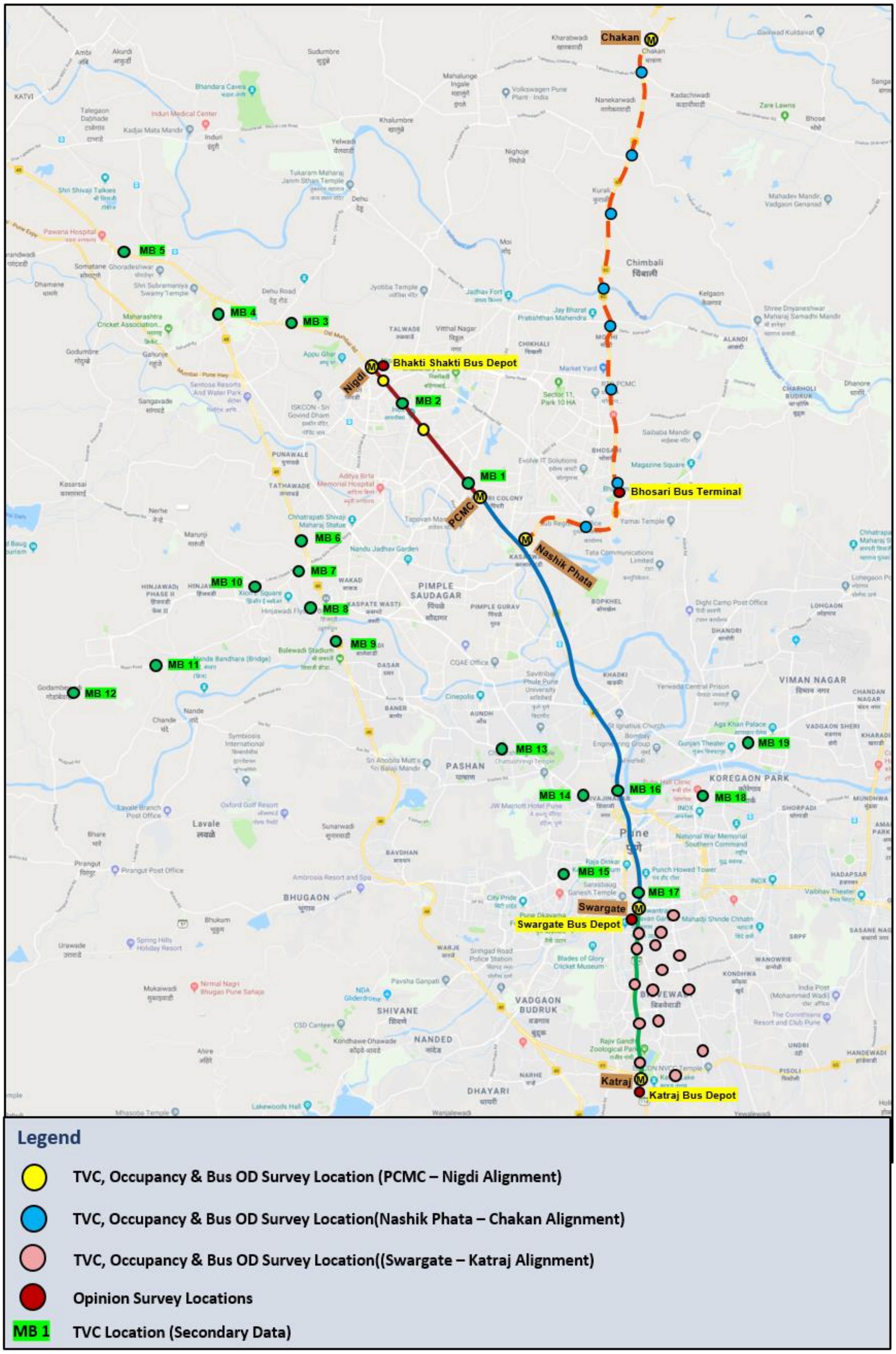


Figure 15. Traffic Survey Locations

3.3 Secondary Data

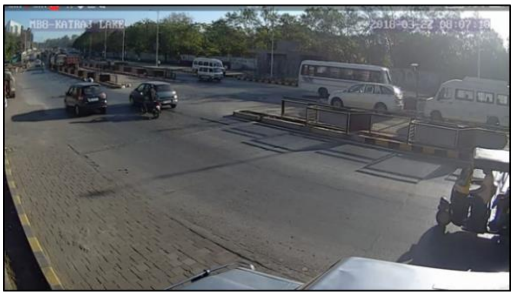
Past traffic data and transportation surveys conducted during earlier studies as well as other related secondary data were collected, and relevant data is compiled. This data is used in the updation of the transport demand model and validation.

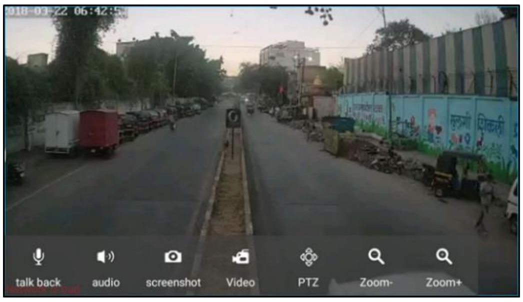
3.4 Primary Traffic Surveys

As part of the present study, the following surveys were conducted. The analysis of these surveys is presented in the below sections.

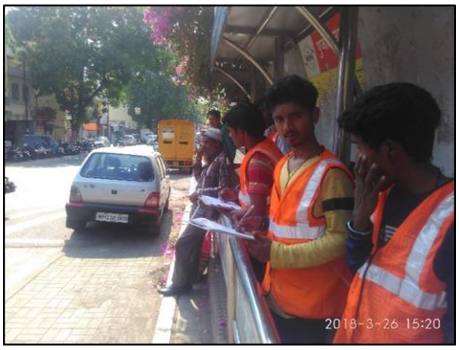
- Classified Traffic Volume Count;
- Bus Origin Destination (OD) Survey;
- Occupancy Survey;
- Opinion Survey

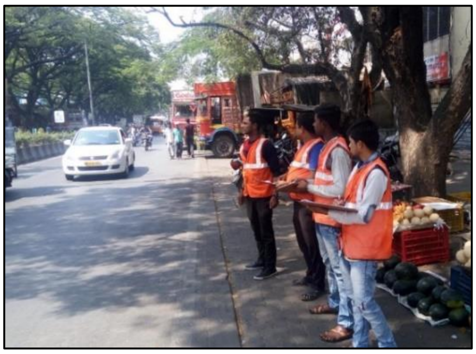
The metro patronage forecast is carried out using the transport demand model, which is calibrated and validated in the year 2017. Considering the data already available from recent past studies, survey locations for Classified Traffic Volume Count (TVC) were identified. Survey locations for Classified Traffic Volume Count and Other Surveys were included in the Weekly Progress Report 03 and 04, submitted to Client. The survey locations are identified along all the proposed metro corridors to know the existing traffic volume and traffic composition. In total, there are 25 TVC locations identified and traffic volume count surveys were conducted by video graphic technique at all the locations. The traffic data was extracted manually by playing video on computer in slow motion for better accuracy.





Bus Occupancy and other passenger modes occupancy surveys were conducted to assess average number of passengers travelling by each mode. This is done by manual observation technique. The mode wise number of occupants were recorded at all TVC locations. These surveys were conducted simultaneously with traffic volume count surveys and provide the existing mode-wise passenger demand (person trips). Bus OD surveys were conducted at all the locations along with traffic volume counts.






3.4.1 Classified Traffic Volume Count Survey

3.4.1.1 Swargate - Katraj Section

The traffic survey locations along the Swargate – Katraj Section are presented in Figure 15 and Figure 16. The analysis of the traffic surveys is carried out and the peak hour traffic, both during morning and evening, at each of the survey locations is presented in Table 27.

Table 27 : Traffic Survey Locations: Swargate-Katraj Section

Sr No.	Road Name	Landmark
1	MB 1: Pune Satara Road	S T Colony Bus Stand
2	MB 2: Kushaba Zanjale Road	Mukund Nagar Bus Stop
3	MB 3: Jawahar Lal Nehru Road	Canol Jhopadpatti Bus Stop
4	MB 4 : Jawahar Lal Nehru Road	Market Yard Road Bus Stop
5	MB 5 : Bibwewadi Kondhwa Road	Kumar Park Bus Stop
6	MB 6 : Swami Vivekanand Marg	Bibwewadi Bus Stop
7	MB 7 : Swami Vivekanand Marg	Chintamani Nagar Bus Stop
8	MB 8 : Pune Satara Road	Katraj Lake
9	MB 9 : Pune Satara Road	Balajinagar Bus Stop
10	MB 10 : Pune Satara Road	Padmavati Bus Stop
11	MB 11 : Pune Satara Road	Hotel Utsav

Sr No.	Road Name	Landmark
12	MB 12 : Market Yard Road	Shivaji Putala Bus Stop
13	MB 13 : Indrayani Road	Gangadham Bus Stop
14	MB 14 : VIT Hostel Road	Ladies Hostel Upper Bus Stop
15	MB 15 : Katraj Kondhwa Road	Sundarban Bus Stop

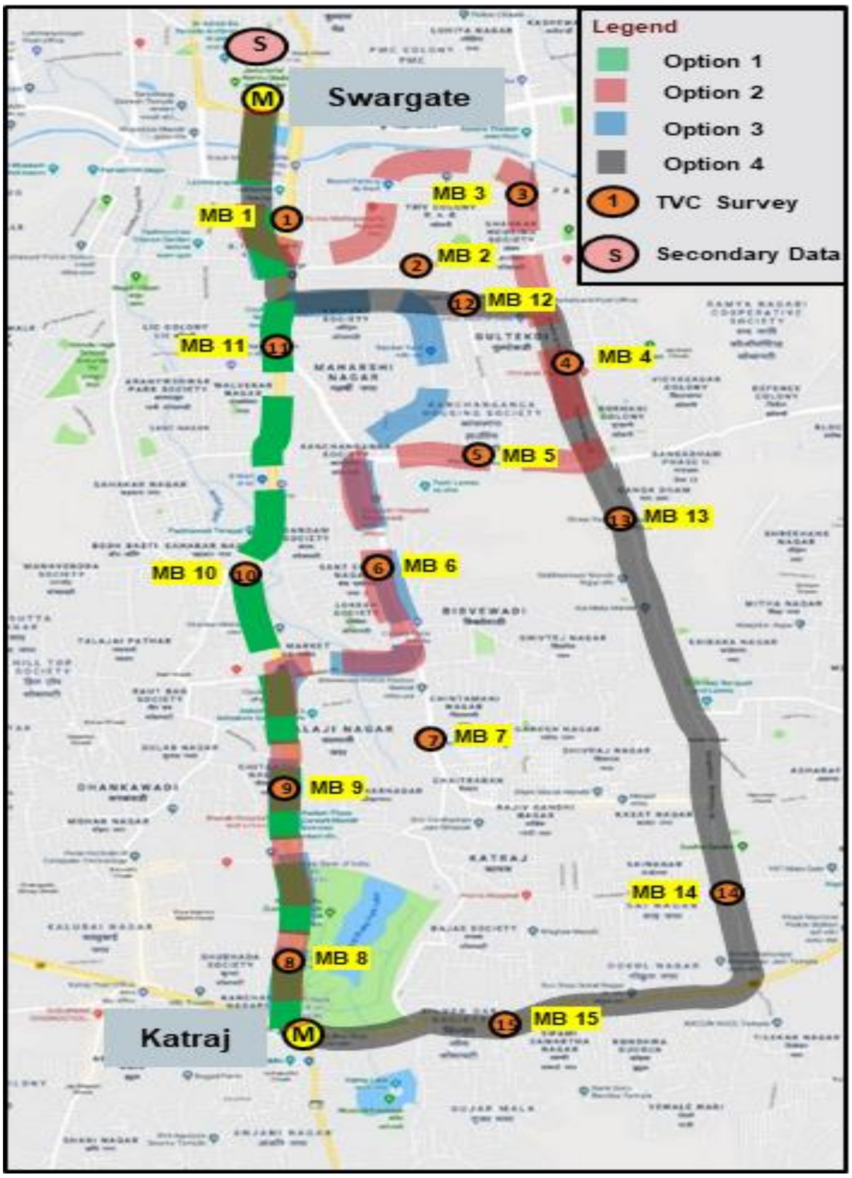


Figure 16. Traffic Survey Locations: Swargate-Katraj

3.4.1.1.1 Option 1 Pune Satara Road

This is fully underground section of about 5.464 Km in length, between Swargate and Katraj Bus Depot. It runs along Pune-Satara Road. This alignment attracts the highest traffic among other corridor options as the section is along a major highway which leads to Bengaluru.

3.4.1.1.2 Option 2 KK Market

Option continues from Swargate Station of N-S corridor, runs along Pune-Satara Road to cross Laxmi Narayan Chowk to take a left turn with a curve trajectory to join Jawaharlal Nehru Road, straight towards Aai Mata Chowk, takes right on Bibwewadi Road, travels about 1 km to take a left on Swami Vivekananda Road to move a little over 1km, takes a right towards K.K. Market Road and takes left to join Pune-Satara Road to terminate at Katraj Chowk.

3.4.1.1.3 Option 3: Market Yard

This passes from Swargate via Market Yard and similar to option 2.

3.4.1.1.4 Option 4 Kondhwa Road

The alignment continues from Swargate Station of N-S corridor, runs alongside Pune-Satara Road for about 1km, takes left from City Pride Chowk to travel a distance of 1.5 Km, turns right on Jawaharlal Nehru Road till Aai Mata Chowk, follows the path of Shatrunjay Road till the end to take a right to join Katraj - Kondhwa Road and to terminate at Katraj Chowk. presents Swargate – Katraj alignment via Kondhwa Road.

Table 28 : Traffic Volume Count: Swargate-Katraj section

Existing Traffic Volume Count: Swargate - Katraj Section		
MB 1 (Pune Satara Road)	**Time**	**Total**
Morning Peak (Vehicles)	10:00 AM to 11:00 AM	11864
Morning Peak (PCUs)	10:00 AM to 11:00 AM	8403
Evening Peak (Vehicles)	07:00 PM to 08:00 PM	13990
Evening Peak (PCUs)	07:00 PM to 08:00 PM	8822
MB 2 (Kushaba Zanjale Road)	**Time**	**Total**
Morning Peak (Vehicles)	10:00 AM to 11:00 AM	2563
Morning Peak (PCUs)	10:00 AM to 11:00 AM	1703
Evening Peak (Vehicles)	06:00 PM to 07:00 PM	2603
Evening Peak (PCUs)	06:00 PM to 07:00 PM	1668
MB 3 (Jawaharlal Nehru Road)	**Time**	**Total**
Morning Peak (Vehicles)	10:00 AM to 11:00 AM	7340
Morning Peak (PCUs)	10:00 AM to 11:00 AM	4928
Evening Peak (Vehicles)	06:00 PM to 07:00 PM	6308
Evening Peak (PCUs)	06:00 PM to 07:00 PM	4158
MB 4 (Jawaharlal Nehru Road)	**Time**	**Total**
Morning Peak (Vehicles)	10:00 AM to 11:00 AM	7343
Morning Peak (PCUs)	10:00 AM to 11:00 AM	4759
Evening Peak (Vehicles)	06:00 PM to 07:00 PM	6798
Evening Peak (PCUs)	06:00 PM to 07:00 PM	4534
MB 5 (Sitaram Thakre Road)	**Time**	**Total**

Existing Traffic Volume Count: Swargate - Katraj Section		
Morning Peak (Vehicles)	10:00 AM to 11:00 AM	7330
Morning Peak (PCUs)	10:00 AM to 11:00 AM	4744
Evening Peak (Vehicles)	06:00 PM to 07:00 PM	6958
Evening Peak (PCUs)	06:00 PM to 07:00 PM	4525
MB 6 (Swami Vivekananda Road)	**Time**	**Total**
Morning Peak (Vehicles)	09:00 AM to 10:00 AM	6680
Morning Peak (PCUs)	09:00 AM to 10:00 AM	4271
Evening Peak (Vehicles)	07:00 PM to 08:00 PM	9199
Evening Peak (PCUs)	07:00 PM to 08:00 PM	5683
MB 7 (Swami Vivekananda Road)	**Time**	**Total**
Morning Peak (Vehicles)	10:00 AM to 11:00 AM	8886
Morning Peak (PCUs)	10:00 AM to 11:00 AM	5375
Evening Peak (Vehicles)	07:00 PM to 08:00 PM	8466
Evening Peak (PCUs)	07:00 PM to 08:00 PM	5079
MB 8 (Pune Satara Road)	**Time**	**Total**
Morning Peak (Vehicles)	09:00 AM to 10:00 AM	7148
Morning Peak (PCUs)	09:00 AM to 10:00 AM	5464
Evening Peak (Vehicles)	07:00 PM to 08:00 PM	7403
Evening Peak (PCUs)	07:00 PM to 08:00 PM	5403
MB 9 (Pune Satara Road)	**Time**	**Total**
Morning Peak (Vehicles)	10:00 AM to 11:00 AM	12563
Morning Peak (PCUs)	10:00 AM to 11:00 AM	8550
Evening Peak (Vehicles)	06:00 PM to 07:00 PM	10370
Evening Peak (PCUs)	06:00 PM to 07:00 PM	7440
MB 10 (Pune Satara Road)	**Time**	**Total**
Morning Peak (Vehicles)	10:00 AM to 11:00 AM	7675
Morning Peak (PCUs)	10:00 AM to 11:00 AM	5588
Evening Peak (Vehicles)	02:00 PM to 03:00 PM	5623
Evening Peak (PCUs)	02:00 PM to 03:00 PM	4398
MB 11 (Pune Satara Road)	**Time**	**Total**
Morning Peak (Vehicles)	11:00 AM to 12:00 PM	13551
Morning Peak (PCUs)	11:00 AM to 12:00 PM	9300
Evening Peak (Vehicles)	06:00 PM to 07:00 PM	11932
Evening Peak (PCUs)	06:00 PM to 07:00 PM	8286
MB 12 (Market Yard Road)	**Time**	**Total**
Morning Peak (Vehicles)	12:00 PM to 01:00 PM	5734
Morning Peak (PCUs)	12:00 PM to 01:00 PM	4039
Evening Peak (Vehicles)	02:00 PM to 03:00 PM	4658
Evening Peak (PCUs)	02:00 PM to 03:00 PM	3364
MB 13 (Indrayani Road)	**Time**	**Total**
Morning Peak (Vehicles)	10:00 AM to 11:00 AM	5325

Existing Traffic Volume Count: Swargate - Katraj Section		
Morning Peak (PCUs)	10:00 AM to 11:00 AM	3586
Evening Peak (Vehicles)	06:00 PM to 07:00 PM	5248
Evening Peak (PCUs)	06:00 PM to 07:00 PM	3345
MB 14 (VIT Hostel Road)	**Time**	**Total**
Morning Peak (Vehicles)	9:00 AM to 10:00 AM	2784
Morning Peak (PCUs)	9:00 AM to 10:00 AM	1860
Evening Peak (Vehicles)	07:00 PM to 08:00 PM	2696
Evening Peak (PCUs)	07:00 PM to 08:00 PM	1838
MB 15 (Katraj Kondhwa Road)	**Time**	**Total**
Morning Peak (Vehicles)	09:00 AM to 10:00 AM	6859
Morning Peak (PCUs)	09:00 AM to 10:00 AM	5161
Evening Peak (Vehicles)	06:00 PM to 07:00 PM	6553
Evening Peak (PCUs)	06:00 PM to 07:00 PM	5149

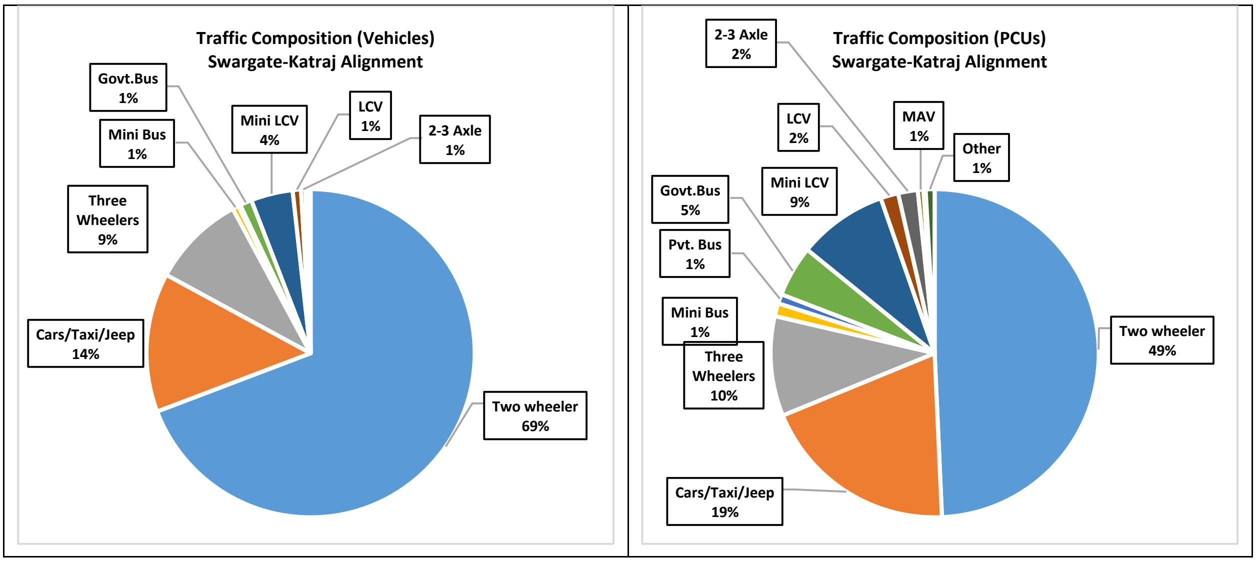


Figure 17. Traffic Composition: Swargate-Katraj Section

3.4.2 Passenger Vehicle Occupancy Surveys

Passenger vehicle occupancy surveys were conducted, along with classified traffic volume counts, to assess average number of passengers travelling by each mode. This survey was done by manual observation technique. The mode wise number of occupants were recorded at the selected survey locations. These surveys provide the existing mode-wise passenger demand (person trips) at the survey locations.

Table 29 : Passenger Vehicle Occupancy

Corridor	Two Wheelers	Cars	Three Wheelers*	Bus*
Swargate-Katraj	1.32	2.31	2.67	35.70

** excluding driver*

3.4.3 Opinion Surveys

Opinion survey was conducted to understand the passengers' experience concerning current mode of transport and opinion about willingness to pay for Metro. Four locations (Bus depots) were identified along the proposed metro alignment for opinion survey. The surveys were conducted for 12 hours at each location. Questionnaire for the opinion survey was prepared and the data was collected from the bus passengers. Outcome from the opinion survey is presented in Following Figures.

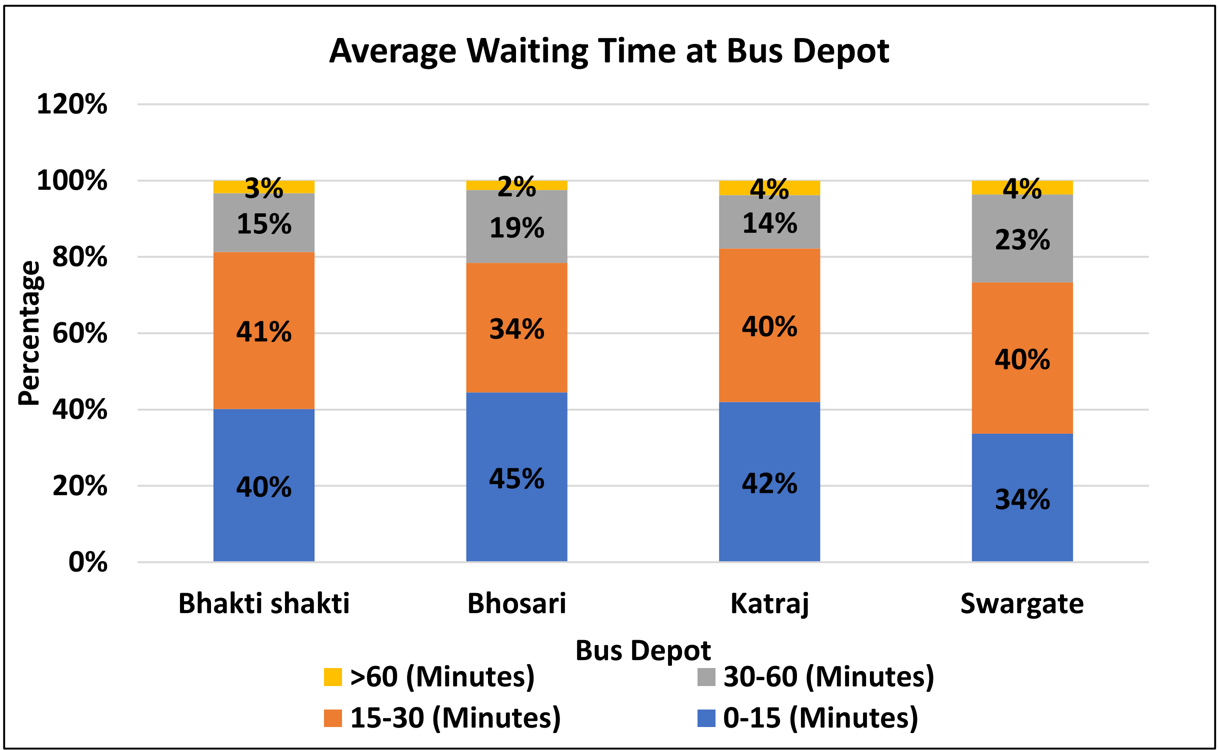


Figure 18. Average Waiting Time at Bus Depot

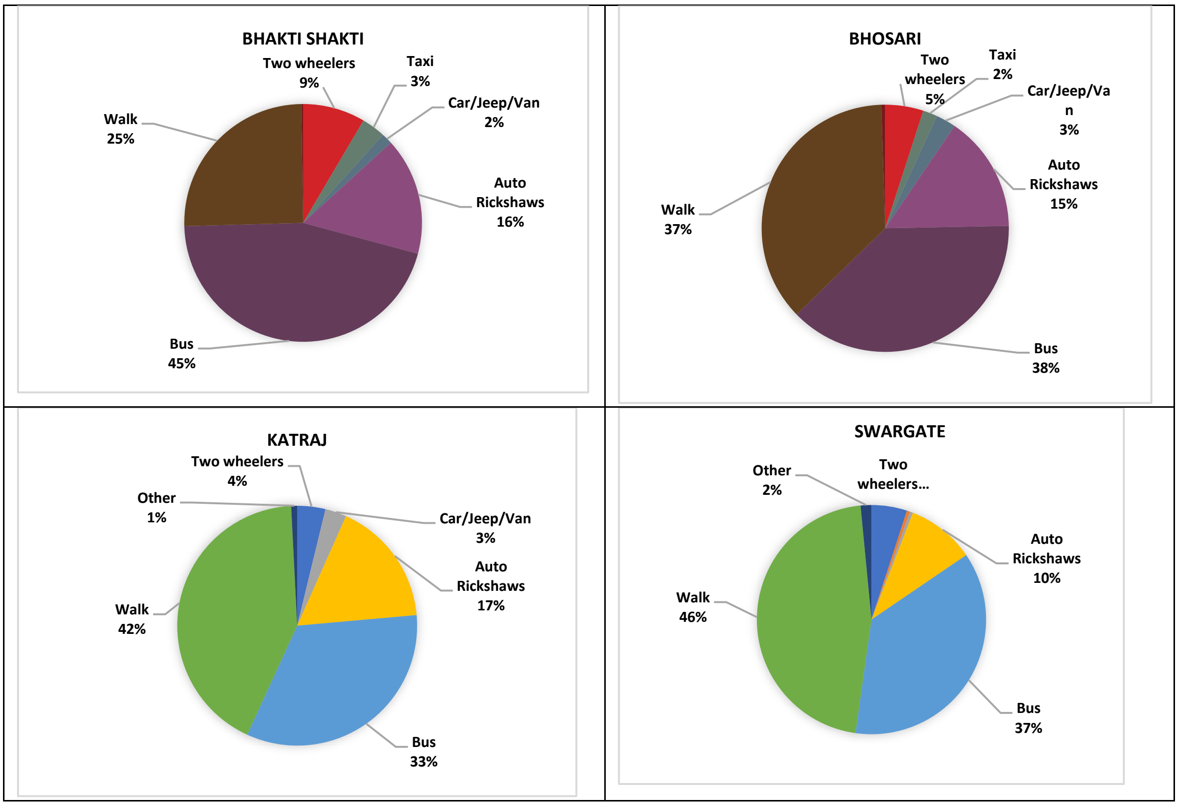


Figure 1 : Access Mode Split

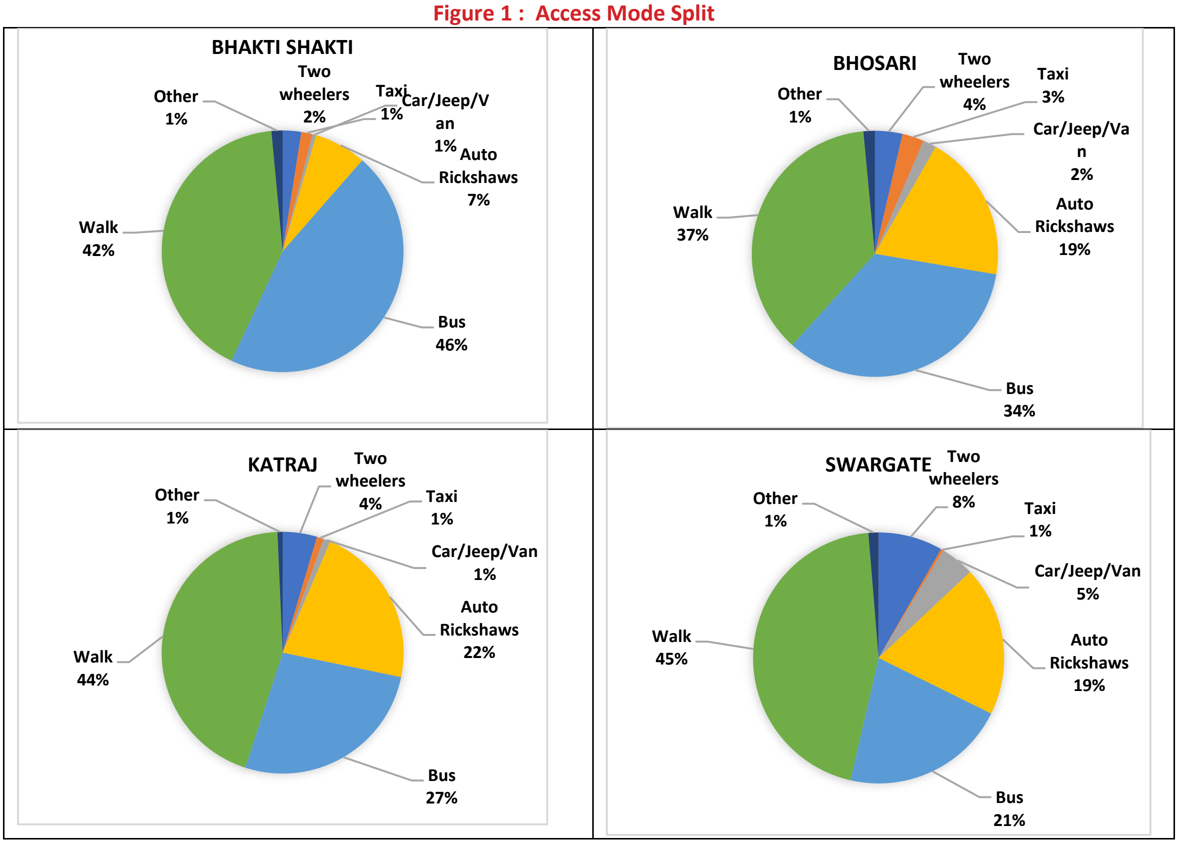


Figure 19. Dispersal Mode Split

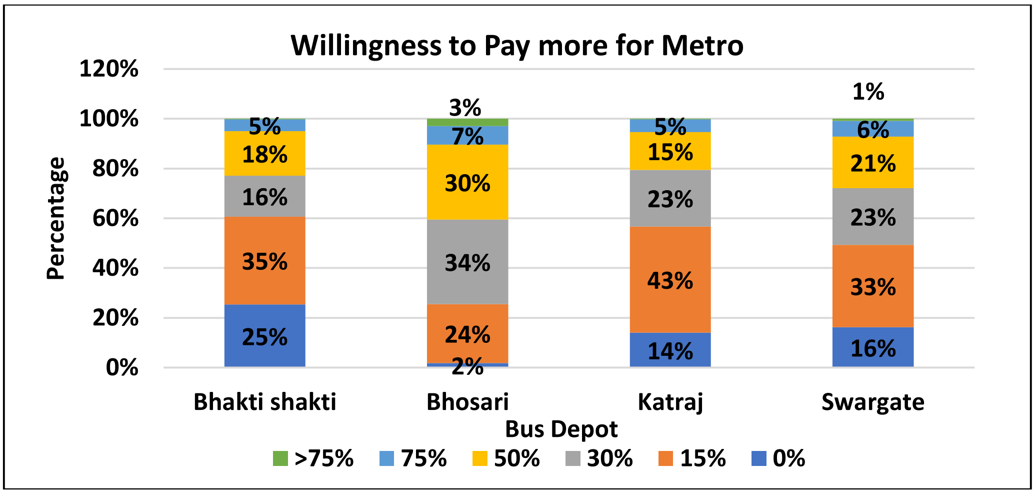


Figure 20. Willingness to Pay more for Metro

3.5 Peak Hour Passenger Trips

Using the peak hour trips and the average occupancy, the existing direction-wise peak hour passenger trips on Swargate-Katraj extension corridor are estimated and presented in following figure

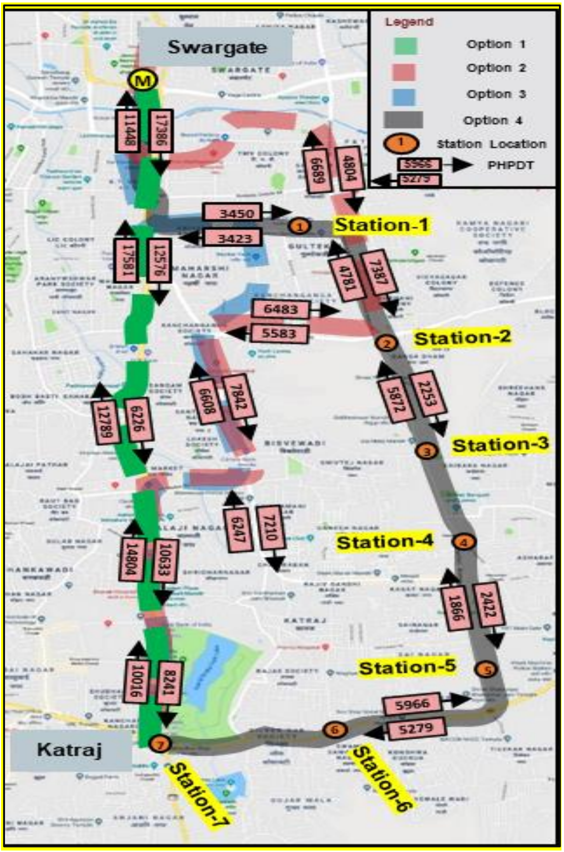


Figure 21. Existing Peak Hour Passenger Trips on Swargate-Katraj Section

3.6 Review of CMP - Traffic Surveys & Analysis

3.6.1 Traffic Surveys at Cordon Location

Table 30 presents peak hour traffic and its share in the daily traffic at cordon locations. Percentage of traffic in peak hour ranges between 5.6% and 9.9% with an average of 7.0%.

Table 30 : Daily Traffic at Cordon Lines

No.	Road/ Location ID	Total		Share
		Vehicles	PCUs	%
1	Moshi Toll Plaza, Nasik Road (L1)	85,455	88,270	8.10%
2	Near Sambhaji Chowk, Alandi Road, Alandi (L2)	63,846	58,152	6.00%
3	Nagar Road (L3)	1,38,570	1,33,484	13.10%
4	Kawadipeth Toll Plaza, Solapur Road (L4)	75,077	79,623	7.10%
5	Saswad Road (L5)	38,514	39,926	3.60%
6	Saswad-Bopdev Road (L6)	38,981	36,008	3.70%
7	Sinhgad Road (L7)	68,432	63,629	6.50%
8	NDA Academy Road (L8)	84,107	72,307	8.00%
9	Near Bhugaon, Mulshi Road (L9)	47,080	42,854	4.50%
10	Shivaji Chowk, Hinjewadi (L10)	1,15,248	1,04,056	10.90%
11	Dehu Road Toll Plaza, Mumbai- Pune Highway (L11)	61,535	65,080	5.80%
12	Talwade, Dehu Alandi Road (L12)	92,980	92,133	8.80%
13	Katraj - Satara Road (L13)	51,933	50,864	4.90%
14	Sus Road (L14)	33,449	30,563	3.20%
15	Nande-Balewadi Road (Mahalunge) (L15)	19,425	16,789	1.80%
16	Manjari Village, Manjari Road (L16)	21,115	19,814	2.00%
17	Lohegaon-Nirgudi Road (L17)	1,751	1,668	0.20%
18	Lohegaon-Wagholi Road (L18)	18,217	17,420	1.70%
Total		**10,55,715**	**10,12,640**	**100%**

Source: CMP for PMC and PCMC, 2018

3.6.2 Traffic Surveys at Screen Lines (16 Hr.)

Screen-lines in the study area are classified into North-South and East-West screen-lines. In the study area, Railway line and Mutha river are considered as North-South screen-lines and Mula and Mula Mutha rivers as the East-West screen-lines in the study area. Classified traffic volume counts are conducted at 59 screen-line locations. Table 31 presents the 16-hour traffic (06:00 a.m. to 10:00 p.m.). Based on analysis, total of about 26.48 lakh vehicles (24.60 lakhs PCU) cross the North- South screen-line locations and 14.36 lakh vehicles (13.28 lakh PCU) cross the East-West every day.

Table 31 : Daily Traffic at Screen Lines (16 Hr.)

No	Road/ Location ID	Vehicles	PCUs	Share %
North-South				
1	Talegaon Industrial Area (SL 1)	16177	22303	0.61%
2	Talegaon Chakan Road (SL2)	63,673	59,599	2.40%

No	Road/ Location ID	Vehicles	PCUs	Share %
3	Begdaewadi (SL3)	4,653	4,079	0.18%
4	Dehu (SL4)	50,694	47,695	1.91%
5	Bhau Patil Road (SL5)	28,126	26,883	1.06%
6	Yashwanthrao Chavan Path (SL6)	3,770	3,057	0.14%
7	Khadki Police Chowk (SL7)	58,136	52,281	2.20%
8	Dhanori Alandi Road (SL8)	28,680	25,627	1.08%
9	KB Joshi Path (SL9)	76,304	65,370	2.88%
10	HK Firodia Bridge (SL10)	1,84,933	1,77,961	6.98%
11	Juna Bazar (SL11)	99,433	93,446	3.75%
12	Connaught Road (ROB) (SL12)	42,958	46,444	1.62%
13	Bund Garden Road (SL13)	79,958	79,766	3.02%
14	Koregaon Park Road (SL14)	1,13,462	1,02,882	4.28%
15	BT Kawade Road (ROB) (SL15)	45,658	40,263	1.72%
16	Solapur Road (ROB) Kirloskar (SL16)	31,771	34,798	1.20%
17	Hadapsar Road (SL17)	76,793	74,356	2.90%
18	Western Bypass (After Warje) (SL18)	1,59,621	1,52,646	6.03%
19	Mhatre Bridge (SL19)	1,08,941	95,811	4.11%
20	SM Joshi Bridge (SL20)	62,138	55,271	2.35%
21	Shivaram Mhatre Road (Chavan Bridge) (SL21)	44,752	33,412	1.69%
22	Sambhaji Bridge (SL22)	44,615	61,991	1.68%
23	Kakasaheb Gadgil Bridge(Z Bridge) (SL23)	18,942	14,082	0.72%
24	Baba Bhide Bridge (SL24)	98,093	76,462	3.70%
25	Maha Rishi Shinde Bridge (SL25)	71,123	64,247	2.69%
26	PMC Bhavan Bridge (SL26)	59,044	51,895	2.23%
27	Shivaji Bridge-Nava Pool (SL27)	83,941	81,622	3.17%
28	Dengale Bridge Road (SL28)	75,078	75,422	2.84%
29	Sangam Bridge 1 (SL29)	1,16,910	1,12,685	4.41%
30	Sangam Bridge 2 (SL30)	53,254	49,825	2.01%
31	Ravat Nigdi Raod (SL31)	63,741	56,053	2.41%
32	Akurdi Chikhali Road (SL32)	63,430	55,237	2.40%
33	Chinchwad Akurdi Link Road (SL33)	61,780	53,593	2.33%
34	Kaspate Wasti Road (SL34)	89,995	82,630	3.40%
35	Karachi Chowk (SL35)	1,02,480	97,995	3.87%
36	Jawaharlal Nehru Road (SL36)	29,086	23,188	1.10%
37	Power House Road (SL37)	17,564	14,671	0.66%
38	Pimple Gurav Road (SL38)	26,495	21,693	1.00%
39	Nashik Phata (SL39)	68,389	62,962	2.58%
40	From Jai Maharashtra Chowk (SL40)	17,385	14,677	0.66%
41	Dapodi Bridge (SL41)	50,160	45,341	1.89%
42	Sangam Cross Road (SL42)	7,861	6,410	0.30%
43	Ghorpadi Road (SL43)	48,023	43,673	1.81%

No	Road/ Location ID	Vehicles	PCUs	Share %
	Total	**26,48,020**	**24,60,302**	**100%**
	East-West			
44	Manjari Village (SL44)	21,115	19,814	1.47%
45	Theur Kesanand Road (SL45)	11,085	13,358	0.77%
46	Uruli Ashtapur Road (SL46)	3,001	2,558	0.21%
47	Western Bypass Road (SL47)	1,86,776	1,85,778	13.00%
48	Mahatma Jyotiba Phule Bridge (SL48)	44,051	37,466	3.07%
49	Mahadji Shinde Road (Aundh) (SL49)	55,618	47,847	3.87%
50	Rajiv Gandhi Bridge (Aundh Ravet Road) (SL50)	1,13,662	1,03,874	7.91%
51	Jai Ganesh Chowk (SL51)	71,265	60,450	4.96%
52	Old Sangavi Nera Petrol Pump (SL52)	66,130	62,912	4.60%
53	Harris Bridge (Old Mumbai Highway) (SL53)	1,69,809	1,58,236	11.82%
54	Yerwada Bridge (SL54)	1,33,603	1,25,251	9.30%
55	Yerwada Bridge (SL55)	1,37,401	1,29,007	9.57%
56	HH Aga Khan Bridge (SL56)	1,06,985	97,644	7.45%
57	Mundhwa Bridge (SL57)	1,00,833	95,874	7.02%
58	Alandi Road (Near Tata Communication Centre) (SL58)	80,863	74,103	5.63%
59	Rajaram Bridge (SL59)	1,34,044	1,13,831	9.33%
	Total	**14,36,241**	**13,28,001**	**100%**

Source: CMP for PMC and PCMC, 2018

3.6.3 Analysis of Mid-Block Volume Count

Classified traffic volume counts are conducted at 15 mid-block locations. The location-wise traffic details are presented in Table 32.

Table 32 : Traffic on Mod-Blocks (16 Hr.)

No	Road/ Location ID	Vehicles	PCUs
1	Pashan Road	71,083	63,053
2	Jaganath Shankarsheth Road	1,35,707	1,24,679
3	Spine Road	51,295	47,836
4	Lal Bahadur Shastri Road	86,623	81,195
5	Senapati Bapat Road	90,081	80,850
6	Balagangadhar Tilak Road	74,449	69,767
7	RB Kumthekar Road	23,973	24,532
8	Nashik Road	86,048	76,311
9	Dehu Alandi-Akurdi Chikhali Road	59,216	55,844
10	PCMC Link Road	5,807	4,648
11	Morwadi Road	31,678	28,968
12	Timber Market Road	1,06,169	1,08,056
13	Baner Road	79,353	71,035
14	Kondhwa Road	1,30,501	1,27,483

No	Road/ Location ID	Vehicles	PCUs
15	Aundh Ravet Road	53,042	47,024
	Total	**7,12,648**	**6,51,063**

3.7 Socio-economic Characteristics

The total population of Pune Municipal Corporation (PMC) and Pimpri Chinchwad Municipal Corporation (PCMC) as per Census 2011 was 31.24 lakhs and 17.27 lakhs respectively. Table 33 and Table 34 present the past trends of the study area population. The data reveals that the annual growth rate in population of PCMC is highest in the study area.

Table 33 : Past Trends of Population Growth

Year	PMC	PCMC	PC	KC	DC	Total
1961	606777	39654	65838	58496	-	770765
1971	856105	98572	77774	65497	24709	1122657
1981	1203363	251769	85986	80835	33267	1655220
1991	1566651	520639	82139	78323	40555	2288307
2001	2538473	1015598	79965	77473	46921	3758430
2011	3124458	1727692	71781	78684	48961	5051576

Source: Census of India, PC: Pune Cantonment; KC : Khadki Cantonment; DC: Dehu Cantonment

Table 34 : Compound Annual Growth Rate (CAGR) of Population

Year	PMC	PCMC	PC	KC	DC
1961-1971	3.50%	9.53%	1.68%	1.14%	-
1971-1981	3.46%	9.83%	1.01%	2.13%	3.02%
1981-1991	2.67%	7.54%	-0.46%	-0.32%	2.00%
1991-2001	4.94%	6.91%	-0.27%	-0.11%	1.47%
2001-2011	2.10%	5.46%	-1.07%	0.16%	0.43%

PC: Pune Cantonment; KC : Khadki Cantonment; DC: Dehu Cantonment

3.7.1 Age wise Population Distribution

Table 35 and Table 36 : Literacy Rate in PMC and PCMC present the distribution of population by age, as per Census 2011. From the data, it can be observed that, the population in the age group of 20-44 years has the highest contribution in the total population; 45.12% in PMC and 49.94% in PCMC.

Table 35 : Age wise Population Distribution in PMC and PCMC

Age Group (years)	PMC	PCMC
0-4	239964	160615
5-9	235616	142356
10-14	242254	131745
15-19	255256	139284
20-24	323148	225375

Age Group (years)	PMC	PCMC
25-29	338321	227782
30-34	289767	173620
35-39	250558	134418
40-44	207887	101588
45-49	172972	79126
50-54	144551	63056
55-59	118278	48412
60-64	103604	39379
65-69	69702	25192
70-74	49590	15321
75-79	29557	7614
80+	32766	9159
Age not stated	20667	3650
Total	**3124458**	**1727692**

Source: Census of India, 2011

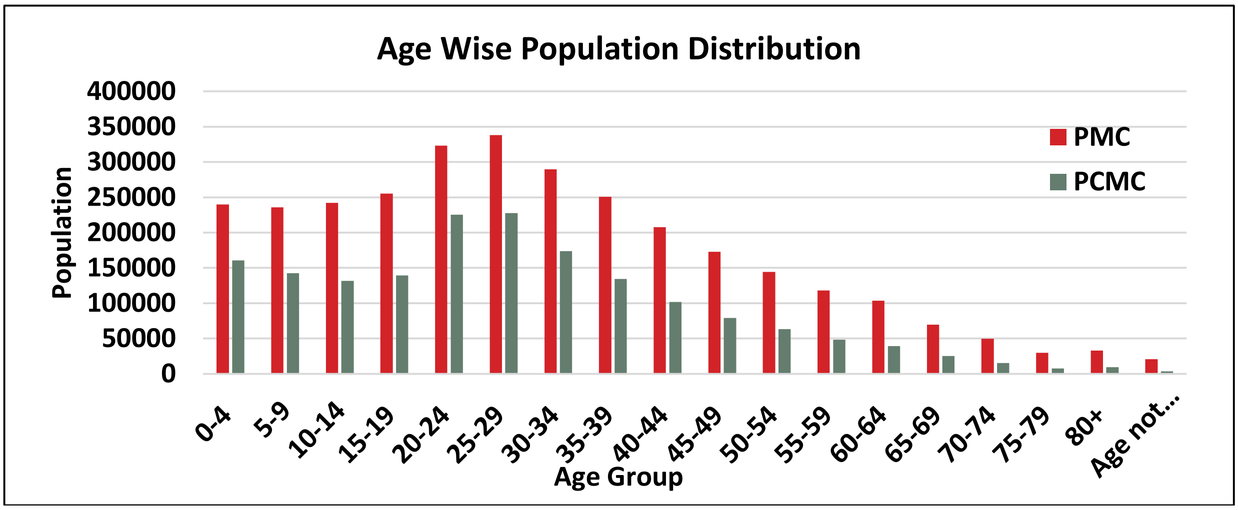


Figure 22. Age Wise Population Distribution in PMC and PCMC

3.7.2 Literacy Rate

Literacy rate reflects the person's participation in social and economic development which contribute to the human development and poverty reduction. As per the Census 2011, Pune city has highest literacy rate (89.56%) in Pune district. The percentage of male and female literates of Pune city is 92.31% and 86.67% respectively. The literacy rate of Pimpri-Chinchwad is 89.22% and the percentage of male and female literacy of the city is 92.41% and 85.37% respectively. Table 36 presents the literacy rate in PMC and PCMC.

Table 36 : Literacy Rate in PMC and PCMC

Description	PMC	PCMC

	Literates	Percentage	Literates	Percentage
Total Literates	2,496,324	89.56%	1,343,658	89.22%
Male Literates	1,317,345	92.31%	761,715	92.41%
Female Literates	1,178,979	86.67%	581,943	85.37%
Children (0-6 Years)	337,062	-	221,746	-

Source: Census of India, 2011

3.7.3 Work and Education Profile

In order to understand the existing traffic and transportation scenario in the study area, Household Interview Survey conducted by L&T Infra Engineering as part of Comprehensive Mobility Plan for Pune Municipal Corporation and Pimpri - Chinchwad Municipal Corporation in Pune Metropolitan Region, has been considered. Around 1% of the households were interviewed to capture the travel characteristic of residents. In total 18830 household samples were collected from different zones by L&T Infra Engineering.

Table 37 presents the distribution of population, by education level and Table 38 presents the distribution by employment in PMC and PCMC.

Table 37 : Distribution of Population by Education Level

Education Level	PMC	PCMC
Illiterate	6.30%	6.00%
Primary School (5th)	16.40%	19.60%
Secondary School (10th)	27.40%	29.00%
Higher Secondary (12th)	20.60%	19.30%
Technical Diploma	2.30%	4.30%
Graduation	21.40%	18.40%
Post- Graduation	5.50%	3.40%
Doctorate (Ph.D.)	0.30%	0.20%
Total	**100%**	**100%**

Source: CMP for PMC and PCMC, 2018

Table 38 : Distribution of Population by Employment

Employment Sector	PMC	PCMC
Argo-based/Farming	1.50%	1.00%
Construction/ Mining	8.40%	10.70%
Manufacturing (Household)	2.60%	0.90%
Manufacturing (Others)	2.60%	2.30%
Service Sector (Govt)	5.50%	5.60%
Service Sector (Private)	36.20%	58.20%
Retail/ Whole Sale Trade	10.00%	6.30%
Transport/Communication/Utilities	7.90%	3.20%
Finance/Insurance/Real Estate	2.30%	1.20%

Employment Sector	PMC	PCMC
Educational	4.70%	1.90%
Informal Employment	14.00%	7.70%
Tourism	0.40%	0.70%
Information Technology / Information Technology Enabled Service	4.00%	0.30%
Total	**100.00%**	**100.00%**

Source: CMP for PMC and PCMC, 2018

3.7.4 Average Household Size

The average household size in PMC and PCMC are 3.95 and 3.2 respectively. The distribution of household by size is presented in following table**.**

Table 39 : Distribution of Household by Size

Household Size	PMC	PCMC
1	2.9%	1.14%
2	14.93%	10.83%
3	23.37%	26.44%
4	33.19%	37.84%
5	15.81%	16.26%
6	6.67%	5.77%
7	1.91%	1.1%
8	0.91%	0.51%
9	0.17%	0.08%
10	0.11%	0.03%
>10	0.02%	0%

(Source: CMP, 2018)

About 20% of households are having 3 members in PMC and PCMC area. The distribution for households having 4 members is around 33% in PMC and 38% in PCMC area.

3.7.5 Income Distribution

From the Household Interview Survey data, it is observed that the monthly income range between Rs 10000 - Rs 30,000 has highest percentage both in PMC and PCMC. This clearly indicates the domination of middle-class family in the region. The average household income in PMC and PCMC area is observed to be Rs. 26,954 and Rs. 23,610 respectively. Following table presents the distribution of Household by monthly income.

Table 40 : Distribution of Households Monthly Income

Income Range (Rs.)	PMC	PCMC
Less than 2,000	2.50%	0.80%
2,000 - 5,000	5.50%	1.00%

5,001 - 7,500	4.70%	2.20%
7,501-10,000	9.70%	10.40%
10,001-15,000	21.20%	27.90%
15,001-20,000	24.20%	27.90%
20,001-30,000	18.10%	17.10%
30,001-40,000	9.00%	9.60%
40,001-50,000	3.70%	2.50%
50,000 - 1 lakh	1.20%	0.50%
Greater than 1 lakh	0.20%	0.10%
Total	**100%**	**100%**

Source: CMP for PMC and PCMC, 2018

3.7.6 Vehicle Ownership

Vehicle ownership has a relation with household income. Since the middle-class family percentage is more in PMC and PCMC, the ownership of two-wheelers is very high. Moreover, it was also observed from the traffic data that the two-wheeler share is highest in mode split (around 60%-70%). Table 41 shows the distribution of vehicle ownership.

Table 41 : Distribution of Vehicle Ownership

Mode	PMC	PCMC
Cycle	2.80%	2.30%
Two-Wheeler	57.70%	61.50%
Car	0.90%	1.00%
Two-Wheeler & Cycle	6.60%	3.70%
Car & Two-Wheeler	12.50%	12.80%
Car, Two-Wheeler & Cycle	2.40%	1.80%
Others	4.20%	3.40%
No Vehicle	12.90%	13.50%
Total	**100.00%**	**100.00%**

Source: CMP for PMC and PCMC, 2018

3.8 Travel Characteristics

3.8.1 Trip Rate

As per the Comprehensive Mobility Plan for Pune Municipal Corporation and Pimpri - Chinchwad Municipal Corporation, the overall Per Capita Trip Rate (PCTR) observed in PMC and PCMC area was 1.33 and 1.17 respectively, while the vehicular PCTR (excluding walk) in PMC and PCMC area was 0.88 and 0.76.

3.8.2 Trip Purpose

The CMP Household Interview Survey data revealed that, most of the trips generated from PMC and PCMC are either work trips or educational trips. The distribution of trip purpose is presented in following table.

Table 42 : Distribution of Trip Purpose

No.	Purpose	PMC	PCMC
1	Work	50.05%	54.18%
2	Business	5.18%	1.67%
3	Education	37.67%	41.55%
4	Shopping	3.62%	0.31%
5	Social/Religious/Recreation	0.57%	0.02%
6	Health/Hospital	0.34%	0.04%
7	Tourism	0.23%	0.01%
8	Other purpose	2.35%	2.23%
Total		**100%**	**100%**

Source: CMP for PMC and PCMC, 2018

3.8.3 Mode of Travel

The mode–wise distribution of trips in PMC and PCMC area is shown in Table 43. Trips by walk (i.e. Non-motorized) are considerably high in PMC and PCMC compared to other modes of transport. Share of two wheelers in the total trips is around 35% both in PMC and PCMC.

Table 43 : Mode wise Distribution of Trips

Mode of Travel	Total Trips		Motorized Trips	
	PMC	PCMC	PMC	PCMC
Walk	26.00%	23.10%	-	-
Cycle	3.50%	0.90%	-	-
Two-Wheeler	35.00%	35.00%	49.66%	46.06%
Car	12.50%	13.90%	17.73%	18.33%
IPT	8.50%	7.10%	12.06%	9.31%
Bus	11.00%	13.90%	15.61%	18.29%
Train	0.30%	0.60%	0.40%	0.79%
Company/ School Van	3.20%	5.50%	4.54%	7.22%
Total	**100%**	**100%**	**100%**	**100%**

Source: CMP for PMC and PCMC, 2018

3.8.4 Trip Length

Table 43 presents the mode wise average trip length in PMC and PCMC. Trip length of PMPML bus is 7.57 km in PMC and 8.14 km in PCMC. The trip length of Two-wheeler, Auto and Shared

Auto varies between 6 km to 7 km. The average trip length for motorized trips is observed to be 7.13 km in PMC and 7.02 km in PCMC area.

Table 44 : Mode wise Trip Length (Km)

Mode	PMC	PCMC
Walk	1.11	0.51
Cycle	2.37	2.64
Two-Wheeler	7.13	7.18
Auto	6.7	6.5
Shared Auto	7.2	6.9
Car/ Jeep/ Van	12.87	6.17
Tempo/ others	7.83	5.56
PMPML Bus	7.57	8.14
Private Bus	9.62	6.65
State Bus	29.84	21.65
Govt/ Office Car	10.33	4
Taxi/ Ola/ Uber	11.85	7.64
Company/ School Bus	8.14	7.94
Company/ School Van	5.37	5.62
Local Train/ Train	40.85	14.7

Source: CMP for PMC and PCMC, 2018

3.8.5 Monthly Expenditure on Travel

As per the CMP, the average household expenditure on travel is Rs. 1373 and Rs. 1014 per month for PMC and PCMC, respectively. Average travel expenditure ranges about 5.1% and 4.3% of total household income for PMC and PCMC respectively.

3.9 Travel Demand Analysis

3.9.1 Transport Demand Modelling Approach

Travel Demand models can be used for testing different scenarios without implementing the projects. For example, one can see the impact of adding a mass transport like a metro system. Similarly, impact on transportation network due to changes in the land use patterns can be analysed.

The objective of the transport demand assessment is to provide realistic ridership on the proposed metro corridors. The transport demand model, which is recently validated in the year 2017, is used as a base for the modelling process. The original transport demand model was developed as part of DPR for Pune Metro Rail Project (2008) and later this model has been updated and validated through the following studies;

- Evaluation of Development Plans (2011)

- Feasibility of LRT/Metro within Hinjewadi (2012)
- Pune BRTS (2014)
- Pune HCMTR (2016)
- Proposed 3rd and 4th Suburban rail lines between Pune and Lonavala (2017)

The broad framework for the transport demand modelling adopted for the present study is given in following figure.

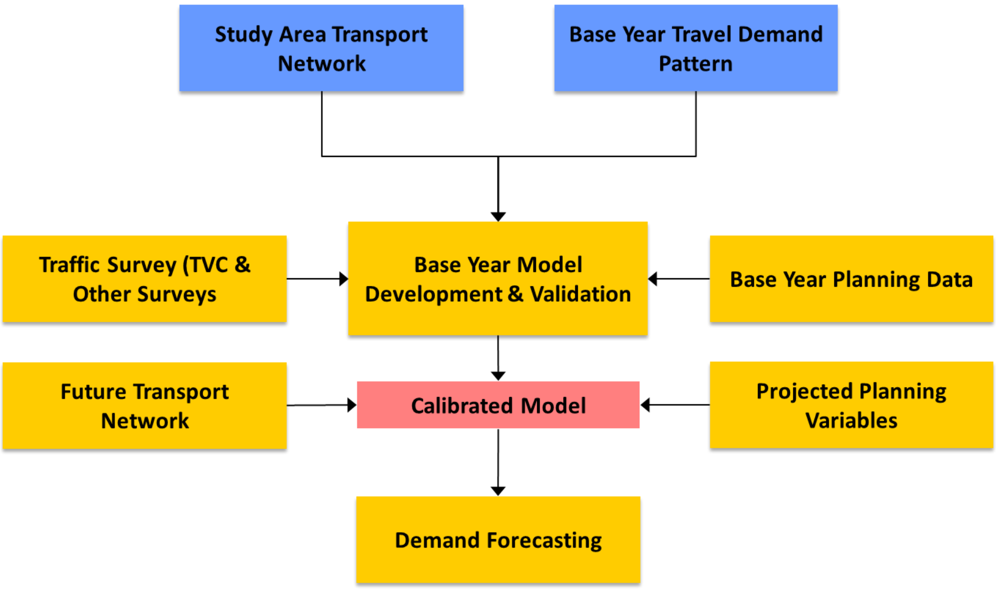


Figure 23. Broad Framework for Transport Demand Modelling

3.9.1.1 Planning Period

Since this study is being initiated in 2018, the year 2018 is taken as the base year. Demand forecasting on the network and on any proposed transport infrastructure project/ mass transit system is required over a 30 years period. In order to analyse the travel demand in the study area and in particular the travel demand on the proposed MRT system, it is proposed to have four horizon years, viz. 2027, 2037, 2047, and 2057 and the model forecasts are made for these four horizon years.

3.9.1.2 Modelling Software

Several software programs are available for developing travel demand models. For the present study, CUBE Voyager (a state-of-the-art Travel Demand Modelling software) for the transport demand model.

CUBE Voyager is user-friendly software for modelling a wide variety of planning policies and improvements at the urban, regional and long-distance level. The software provides interactive data input and analysis, GIS functionality via ArcGIS, model building and scenario development. Its Application Manager uses a flow-chart system for designing, coding, documenting and running the model. The structure allows the professional planner to add functions as required without the need to learn a new interface and without the need to create multiple databases. Figure below illustrates the model structure in CUBE.

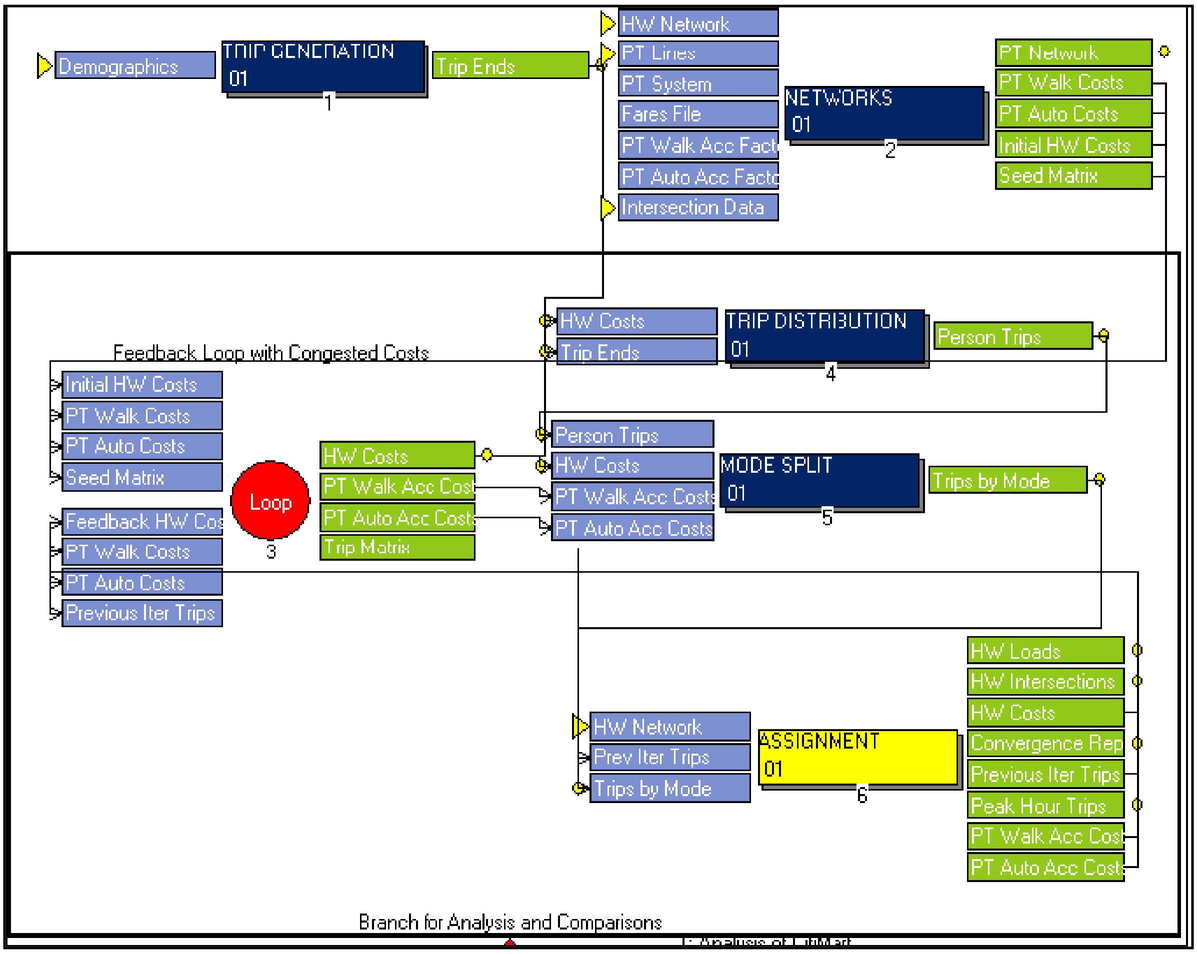


Figure 24. Model structure as defined in CUBE

3.9.1.3 Study Area

The study area, for the transport demand modelling, comprises of Pune Municipal Corporation (PMC) area, Pimpri-Chinchwad Municipal Corporation (PMC) area, Chakan area and three cantonments, viz. Pune, Khadki and Dehu Road. The study area is shown in the following figure Delineation of Traffic Analysis Zones

The zoning system considered for the previous metro study by DMRC (2008) included of 91 internal zones and 13 external zones. This zoning system is further disaggregated considering the study requirement. In the updated Traffic Zoning, PMC area consists of 144 zones, PCMC 121 zones and Chakan area 12 zones. The cantonment areas are considered as separate zones. In total, there are 280 internal zones and 13 external zones. The zonal map of the study area is shown in following figure

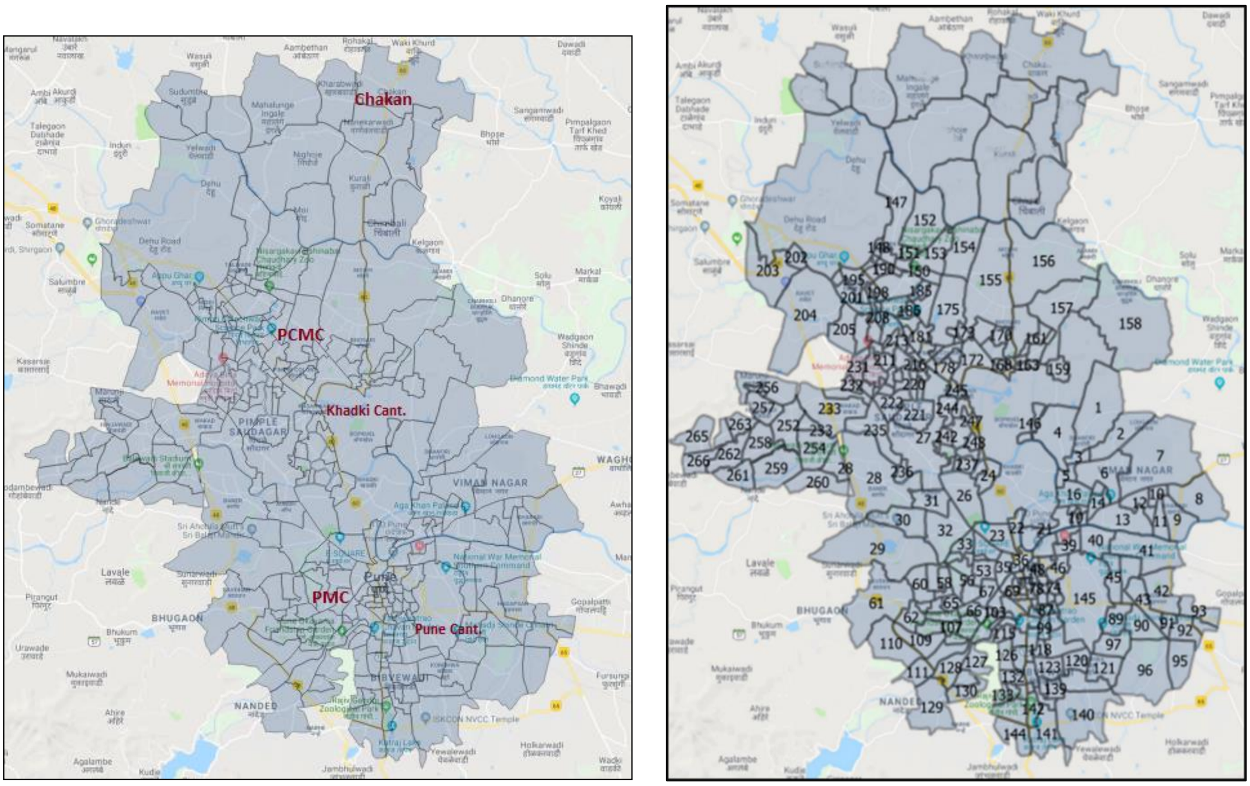


Figure 25. Study area (Left) and Zonal Map of Study area (Right)

3.9.1.4 *Population and Employment*

The population and employment forecast for the study area, for the horizon years, is done considering the past trend in growth in population and employment, development plan, population density, availability of developable land, etc. The data from the latest CMP carried out by PMRDA is also considered. The projected population of study area for various horizon years is presented in Table 45.

The employment data for the study area is compiled from various authentic sources. The employment forecast made as part of the recent CMP prepared by PMRDA is also taken into account.

Table 45 : Study Area Population Forecast

Study Area	2018	2021	2031	2041	2048
PMC	37,00,000	40,00,000	48,00,000	55,00,000	58,00,000
PCMC	22,00,000	24,00,000	32,00,000	40,00,000	48,00,000
Total	**5900000**	**6400000**	**8000000**	**9500000**	**10600000**

3.9.1.5 *Transport Network*

The transport network consists of highway and public transport network. The length of road network considered is about 5,300 km comprising of 35,720 links and 15,039 nodes. The different link types and their typical characteristics are shown in Table 46. The public transport network consists of:

- PMPML (Pune Mahanagar Parivahan Mahamandal Limited) Bus routes
- Intermediate Public Transport-IPT (Auto) routes
- Suburban rail routes
- BRTS (Bus Rapid Transit System) routes
- Shared liner routes
- Out-station bus routes
- Proposed metro routes

The highway network and public transport route network considered for the study are shown in Table 46 : Highway Links and Characteristics.

Table 46 : Highway Links and Characteristics

Link Type	No. of Lanes	Divided/ Undivided	Type of Flow	Capacity Per Direction (PCU/hr)	Free Flow Speed (km/h)
1	One Lane	Undivided	One-way	1650	30
2	Two Lane	Undivided	One-way	3200	40
3	Three Lane	Undivided	One-way	4350	40
4	Four Lane	Undivided	One-way	5300	50
6	Four Lane	Divided	One-way	5500	50
7	Six Lane	Divided	One-way	7000	60
10	One Lane	Undivided	Two-way	600	25
11	Two Lane	Undivided	Two-way	1100	35
12	Three Lane	Undivided	Two-way	1500	35
13	Four Lane	Undivided	Two-way	2150	40
14	Six Lane	Undivided	Two-way	3600	50
16	Two Lane	Divided	Two-way	1500	40
17	Four Lane	Divided	Two-way	2600	50
18	Six Lane	Divided	Two-way	3800	60
19	Eight Lane	Divided	Two-way	4800	60
31	Four Lane (Express way)	Divided	Two-way	3000	80
41	Two Lane (Flyover)	Undivided	One-way	3840	50
42	Four Lane (Flyover)	Undivided	One-way	6360	60
43	Two Lane (Flyover)	Undivided	Two-way	1320	45
44	Six Lane (Flyover)	Undivided	Two-way	4320	60
45	Four Lane (Flyover)	Divided	Two-way	3120	60
46	Six Lane (Flyover)	Divided	Two-way	4560	70
21	Highway Node to Transit Stop				

Link Type	No. of Lanes	Divided/ Undivided	Type of Flow	Capacity Per Direction (PCU/hr)	Free Flow Speed (km/h)
22	Road Node to Zone Centroid Connection				
25	Suburban Rail Links				
26	BRT Links				
27	Metro Links				

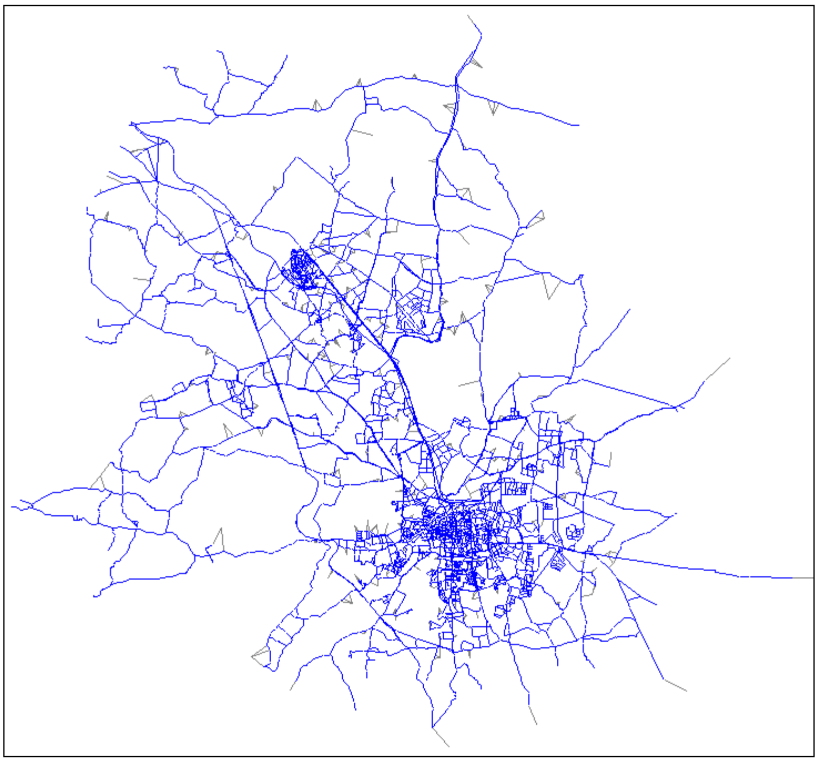


Figure 26. Road Network of the Study Area

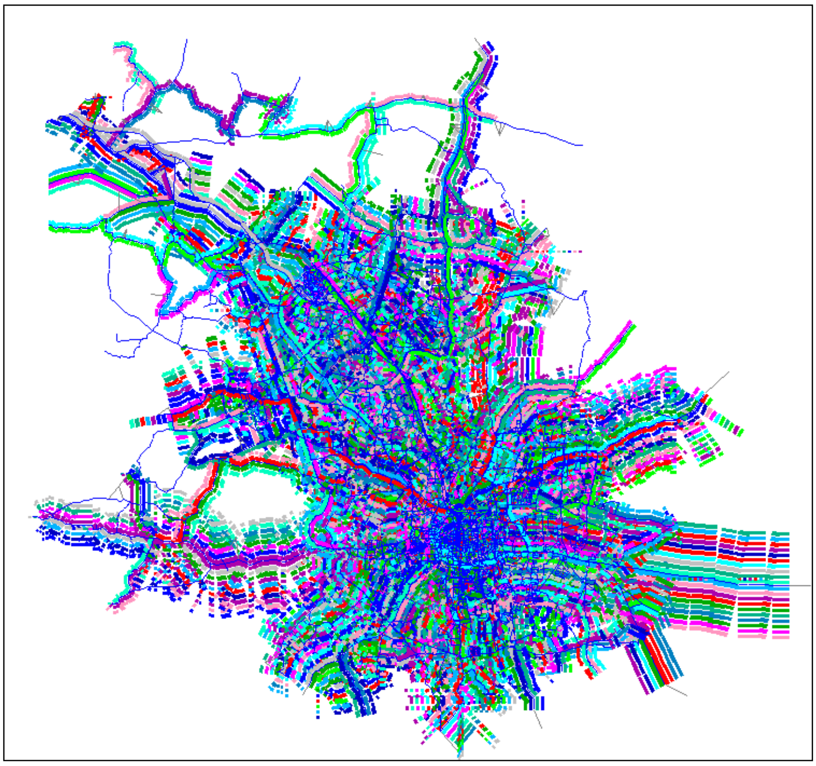


Figure 27. Public Transport Route Network of the Study Area

3.9.1.6 Transport Network Scenarios

The year 2018 is considered as the base year for the travel demand model. The base year transport network considered all the existing routes of Bus, IPT, Shared liner, existing suburban rail routes and currently operational BRT routes. The proposed metro corridors are shown in following Figure.

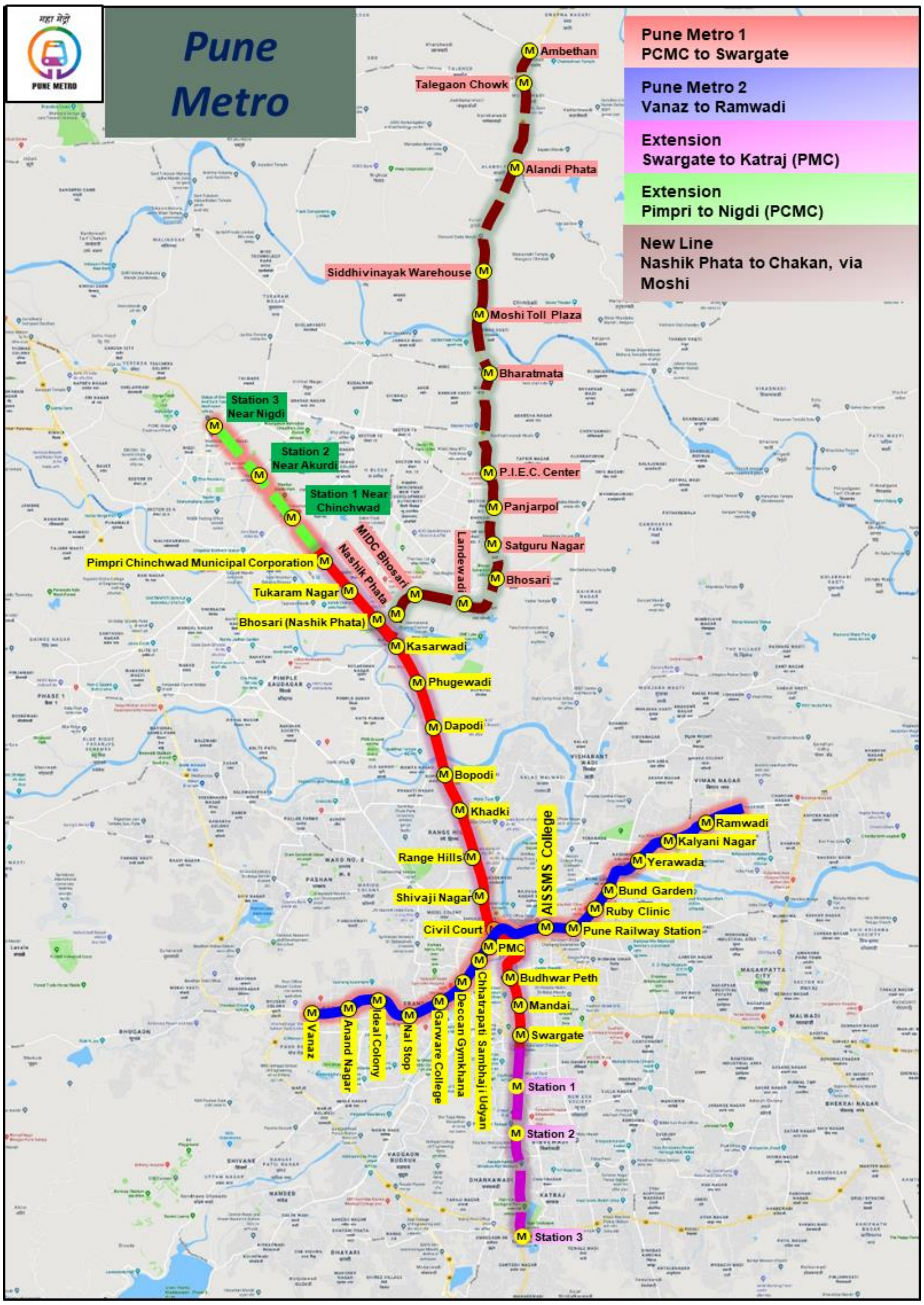


Figure 28. Proposed Metro Corridors

For the horizon years following scenarios are considered:

1. **Scenario 2A** considers all the existing public transport services listed in base case scenario (refer Table 47). Apart from the three under construction metro lines and various mass transit corridors proposed in the latest CMP, the proposed Swargate – Katraj and PCMC – Nigdi extension corridors are considered.

2. **Without Project Scenario** is same as Scenario 2A, exclusion of Swargate-Katraj corridor.

The network scenarios described above are briefly given in following table

Table 47 : Different Transport Network Scenarios

Scenario	Year	Transport Network Systems
Base Case	2018	• Bus, IPT, Shared liner, Out-station bus routes • Existing suburban rail routes • Currently operational BRT routes
With Project	2027,2037, 2047 and 2057	• Bus, IPT, Shared liner, Out-station bus routes • Existing and proposed suburban rail route • Currently operational and proposed BRT routes • Metro Lines Under Construction and proposed mass transit corridors as per CMP • Proposed Extension Corridors, viz. PCMC-Nigdi & Swargate-Katraj
Without Project	2027,2037, 2047 and 2057	• Bus, IPT, Shared liner, Out-station bus routes • Existing and Proposed Suburban rail route • Currently operational and proposed BRT routes • Metro Lines Under Construction and proposed mass transit corridors as per CMP • Proposed extension corridor Swargate-Katraj is excluded.

3.9.1.7 Four Stage Transport Demand Model

The traditional four stage transportation planning model has been employed to estimate the metro ridership. For this purpose, the study area is divided into traffic analysis zones (TAZ). Study Area is divided into 280 internal TAZs as explained in the earlier sections. The model is implemented in state-of-the-art transportation planning software - CUBE Voyager. The four stages of this transportation planning model are explained here:

1. Trip Generation: Residences produce trips for work, education, business, shopping, social and recreation purposes. Activity centres such as Industries, commercial centres, offices, educational institutions, banks, shopping centres, recreational areas, etc. attract these trips. Thus, trip productions are computed based on the resident population in zones and trip attractions are computed based on employment in zones. These trip production and attraction equations are calibrated as a first step. Separate equations are developed for the three income groups, viz., High (Car owning group), Middle (Two-wheeler owning group) and Low (No vehicle owning group) as shown in following table

Table 48 : Trip Generation Models

Income group	Trip Generation

	Trip Productions	Trip Attractions
Car owning group	0.72 * POP	1.45*EMP + 0.12*STEN
Two-Wheeler owning group		1.28*EMP + 0.1*STEN
No vehicle owning group		1.18*EMP

Where, POP: Population, EMP: Employment, STEN: Student Enrolment

2. Trip Distribution: The zonal trips produced/attracted are distributed to their destination/origin zones in this step to get the origin – destination matrix (zone to zone travel) after this step. The trip exchanges between zones will depend on the magnitude of their activity (population for a production zone and employment for attraction zone) and the friction due to geographical separation (represented in terms of generalized cost of travel) between them. A mathematical model is calibrated to synthesize this trip distribution process based on zonal productions, attractions and the generalized cost of travel between them. These models are calibrated separately for the three income groups. A Gravity Trip Distribution model of the following form is developed.

$$T_{ij} = A_i O_i B_j D_j F_{ij}$$

Where,

$$A_i = \frac{1}{\sum_j B_j D_j F_{ij}} \qquad B_j = \frac{1}{\sum_i A_i O_i F_{ij}} \qquad F_{ij} = \left(C_{ij}\right)^{\alpha} \exp\left(\beta C_{ij}\right)$$

the deterrence function

$C_{ij} =$ Generalized cost from zone *i* to zone *j*

$T_{ij} =$ Trips between zones *i* and *j*

α = Calibration parameter – power function

β = Calibration parameter – exponential function

The gravity model parameters are shown in following table

Table 49 : Gravity Model Parameters

Income group	α	β
Car owning group	-2.09557	-0.0001819
Two-Wheeler owning group	-1.07986	-0.0236587
No vehicle owning group	-0.897392	-0.0255572

3. Modal Split: After the trip distribution stage, the trips between any pair of TAZs is known. These trips between zones are to be split as per the mode used. The behaviour of people in choosing a transport mode is modelled based on the characteristics of the mode (travel time, travel cost, waiting time, transfers, comfort, convenience, etc.), characteristics of travellers (income, employment status, etc) and journey characteristics (trip purpose, time of day of travel, etc.). A mode choice model is calibrated based on these attributes to split the trips between origin and destination into private vehicle (two-wheeler and car) and public transport trips. A multinomial logit model of the following form is developed.

$$P_j = \frac{e^{V_j}}{\sum_l e^{V_l}}$$

Where,

P_j = probability of choosing mode *j*

V_j = deterministic component of utility for mode *j*

j and *l* are indices for modes

Table 50 : Modal Split Model Parameters

Income group	Utility Equations
Car Owning Group	a) U_{car} = -0.2754*TT-0.04918*TC+0.2327 b) U_{2W} = -0.2754*TT-0.04918*TC-1.2181 c) U_{PT} = -0.2754*TT-0.04918*TC-0.1102*AT
Two-Wheeler owning group	a) U_{2W} = -0.2255*TT-0.1574*TC-3.111 b) U_{PT} = -0.2255*TT-0.1574*TC-0.0770*WT-0.1214*AT

**TT = Travel Time, TC = Travel Cost, AT = Access Time, WT = Waiting Time*

3. Trip Assignment: In this step the mode wise trips between TAZs are assigned to the transport network. Trips by private vehicle (two-wheeler and car) are assigned to road network and trips by public transport (bus, BRT, metro, auto rickshaw and taxi) are assigned to public transport network. Public transport modes like BRT and Metro have exclusive right of way and bus, auto rickshaw and taxi share the road space with private modes. The road network is represented in the form of links and nodes with each link (a road segment) characterized by its width (number of lanes), type (divided or undivided), capacity, volume-speed relation (for computing travel time at different volumes), etc. The public transport network is represented by routes (sequence of road links/exclusive links) with their characteristics such as frequency, seating capacity, crush capacity, fare, speed, etc. Highway assignment is carried out based on user equilibrium (user choses paths based on perceived generalized cost of travel) and public transport assignment is carried out based on path based stochastic user equilibrium (user choses a route again based on generalized cost, as users may not have full information stochastic aspect comes into picture). These models are calibrated for the base year (2018 for the present study). At the end of the assignment, the mode wise traffic volumes on road links, and boarding/alighting and link loads on public transport routes will be obtained. As this traffic assignment is done for peak hour, all these outputs are for typical peak hour.

Generalized Cost parameters

The generalized cost (GC) between an origin and destination is computed as:

GC = (value of waiting time × waiting time) + (value of in-vehicle travel time × in-vehicle travel time) + (fare paid) + (value of one transfer × number of transfers) + (value of one unit of discomfort × number of units of discomfort)

The parameters of PT assignment and Highway assignments used in the model are shown in following table.

Table 51 : Modal Split Model Parameters

VOT (Rs/Hr)	PT Assignment	Highway Assignment	
		Two-wheeler	Car
	32	34	107

3.9.1.8 Validation of the Four Stage Travel Demand Model

The transportation planning model has been updated and revalidated particularly on the road corridors where the metro extension is proposed. For the current study traffic volume counts at all the entry points and on a few important links of catchment are collected. All the models are recalibrated and validated to reproduce the observed travel pattern (mode wise). The assigned total road-based flows during peak hour (in PCUs) and public transport passengers in peak hour in peak direction are compared with the flows observed across the screen lines. The assigned traffic flow in terms of passenger car equivalencies across all screen lines was found to match reasonably close with the observed flows.

3.9.1.9 Model Application for Forecasting

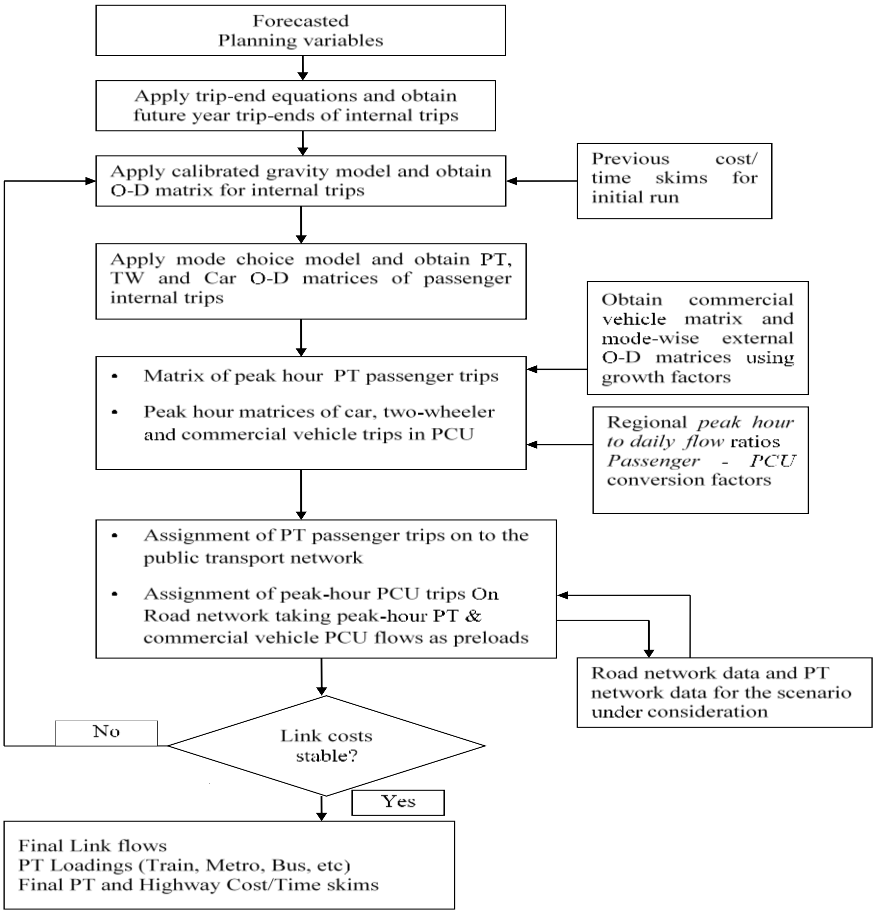


Figure 29. Application of Four Stage Travel Demand Model

Models are applied on future land use (zonal population and employment) and transport scenarios (transport network with proposed road links and public transport routes with all their characteristics) for getting the corresponding mode wise traffic flows on road links and ridership on public transport modes on all their routes.

Thus, it can be seen from above methodology that the model works at system level and takes care of competitive and complementary nature of all private and public transport modes. Essentially the traveller will choose that mode or route for which the perceived generalized cost is the lowest. As the perceived values of travel time gain, reduction in waiting time, number of transfers and discomfort are different for different income groups, the models are stratified accordingly to account for this variation.

3.10 Modal Share of Swargate-Katraj Metro Line

Daily Passenger Trips (in Lakhs)	Modal Share Without Swargate-Katraj Metro				Modal Share With Swargate-Katraj Metro			
	2027	**2037**	**2047**	**2057**	**2027**	**2037**	**2047**	**2057**
Car	13.77	19.24	25.65	32.61	13.72	19.18	25.57	32.52
2-wheeler	37.23	52.01	69.35	88.16	37.11	51.85	69.14	87.93
Intermediate Public Transport	6.88	10.25	14.02	18.41	6.57	9.72	13.43	17.87
Public Transport	16.85	19.87	23.37	27.46	16.36	19.05	22.38	26.33
Swargate - Katraj Metro	0.00	0.00	0.00	0.00	0.95	1.58	1.87	1.97
Total Trips (In Lakhs)	**74.72**	**101.37**	**132.39**	**166.63**	**74.72**	**101.37**	**132.39**	**166.63**

3.11 Future Travel Demand Scenarios

As discussed in earlier sections, two scenarios are developed (*With* and *Without* project) for Metro patronage forecast. Scenario 2A includes the metro corridor between Nigdi and Katraj. Without Project Scenario do not include the proposed metro extension, viz. PCMC-Nigdi & Swargate-Katraj. The Nigdi – Katraj metro corridor passes through 20 stations. The proposed alignment of the metro corridor with all the stations is shown in Table 52 : Adopted Fare.

<u>Metro System Characteristics</u>

The characteristics of the metro system considered for the travel demand modelling are given below: The adopted fare structure is shown.

- Headway
    - Nigdi – Katraj: 2027, 2037, 2047 and 2057 – 3 minutes

- Seating Capacity – 360
- Crush Capacity – 1574 passengers

Table 52 : Adopted Fare

Distance (Km)	Fare (Rs.) @ 2018-19 prices
0-2	13
2-4	17
4-6	20
6-9	25
9-12	27
12-15	30
15-18	32
18-21	35
21-24	37
24-27	38
27-30	42
>30	45

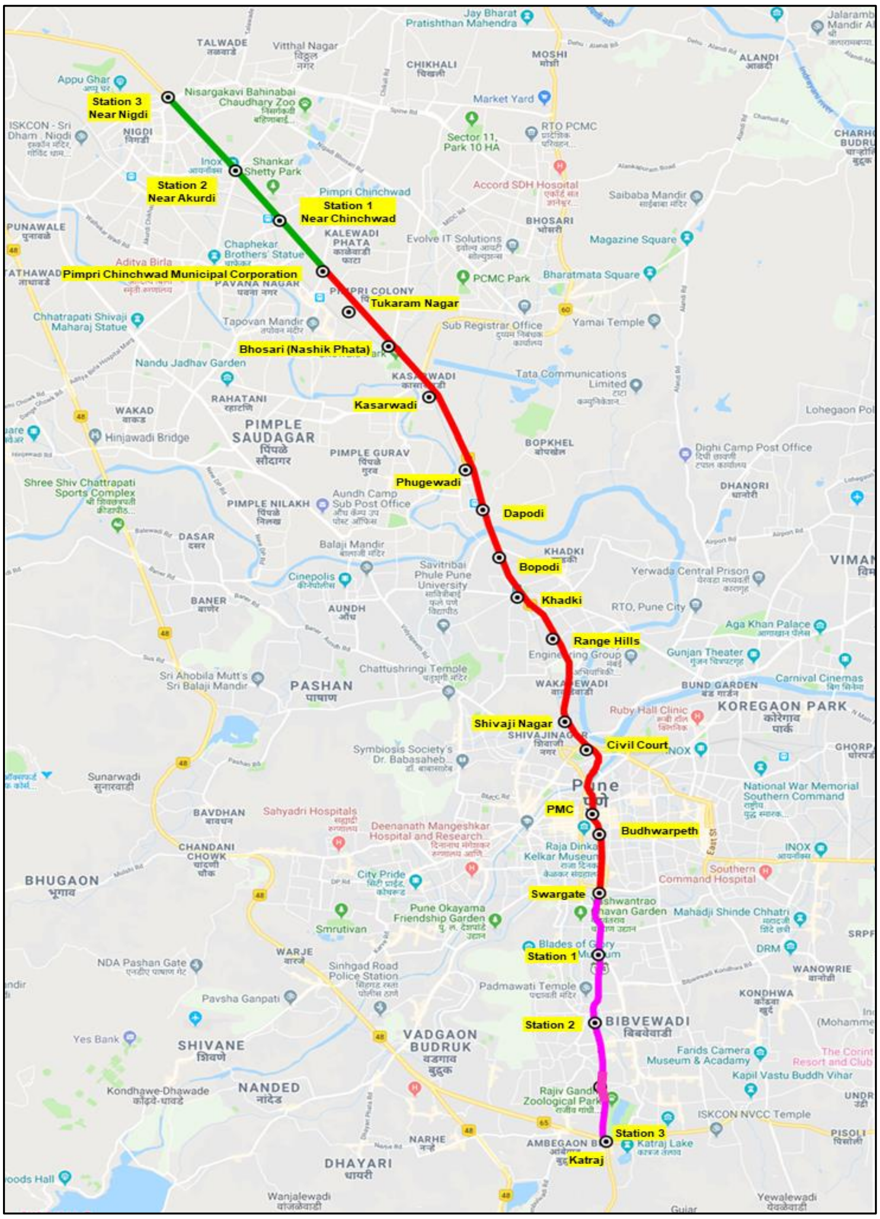


Figure 30. Proposed Alignment: Nigdi - Katraj Metro Corridor

3.11.1 Ridership Assessment for Horizon Year

The estimated peak hour station loads (two-way boarding & alighting) at each of the metro stations on Nigdi – Katraj Corridor for the horizon years 2027, 2037, 2047 and 2057 for the Scenario 2A are presented in Table 53**.** The section loads between two adjacent stations for the horizon years are presented in Table 54.

Table 53 : Peak Hour Station Loads on Nigdi - Katraj Corridor (Scenario 2A)

SI NO	Station	Boarding				Alighting			
		2027	2037	2047	2057	2027	2037	2047	2057
1	Nigdi	1020	1360	1570	1640	1090	1830	2210	2300
2	Akurdi	1310	1530	1760	1830	1450	2130	2530	2640
3	Chinchwad	1140	1630	1890	1980	1390	2110	2580	2690
4	PCMC	4970	6230	7030	7330	3390	4770	5460	5690
5	Tukaram Nagar	2670	3610	4090	4260	2630	3900	4560	4750
6	Bhosari	3750	4840	5460	5690	3680	4970	5660	5910
7	Kasarwadi	2390	3260	3660	3820	2330	3350	3760	3920
8	Fugewadi	2100	2860	3200	3340	1820	2650	3080	3220
9	Dapodi	4480	5310	5920	6170	4000	5030	5910	6160
10	Bopodi	4420	5370	6100	6370	4380	5510	6360	6640
11	Khadki Station	2140	2780	3090	3220	2370	2980	3420	3560
12	Range Hill	2610	3310	3740	3900	3080	3880	4460	4650
13	Shivaji Nagar	5180	6600	7630	7950	5350	6550	7750	8080
14	Civil Court	7990	10240	11690	12190	8730	11120	12560	13100
15	Budhwar Peth	3570	4550	5400	5630	2860	3660	4330	4510
16	Mandai	2670	3430	4180	4350	2520	3260	3940	4110
17	Swargate	6100	8830	11830	12330	7180	8830	10340	10780
18	Station 1	880	1580	1740	1750	880	1480	1690	1720
19	Station 2	950	1780	1950	2020	1000	1610	1630	1690
20	Station 3	3820	6060	6760	7130	3970	5570	6470	6790
Total		64150	85150	98700	102900	64100	85200	98700	102900

Table 54 : Peak Hour Section Loads - Nigdi-Katraj Corridor

From	To	Forward				Reverse			
		2027	2037	2047	2057	2027	2037	2047	2057
Nigdi	Akurdi	1020	1360	1570	1640	1090	1830	2210	2300
Akurdi	Chinchwad	2310	2880	3300	3440	2520	3940	4700	4900
Chinchwad	PCMC	3280	3950	4470	4660	3750	5490	6560	6840
PCMC	Tukaram Nagar	7720	9340	10470	10920	6600	9430	10990	11460
Tukaram Nagar	Bhosari	9860	12000	13410	13980	8700	12370	14400	15010
Bhosari	Kasarwadi	12470	15300	17130	17860	11250	15800	18330	19110
Kasarwadi	Fugewadi	13800	17070	19060	19880	12520	17660	20360	21230
Fugewadi	Dapodi	15320	18950	21060	21960	13770	19320	22240	23190
Dapodi	Bopodi	17060	20910	23210	24200	15020	21020	24380	25420
Bopodi	Khadki Station	18030	22150	24700	25760	15960	22390	26120	27240
Khadki Station	Range Hill	18070	22320	24880	25940	16230	22760	26630	27770
Range Hill	Shivaji Nagar	17740	21970	24550	25600	16380	22980	27020	28170
Shivaji Nagar	Civil Court	15910	19940	22240	23190	14730	20890	24840	25900
Civil Court	Budhwar Peth	14150	17950	20010	20870	13710	19780	23480	24480
Budhwar Peth	Mandai	12450	15840	17870	18630	11290	16770	20260	21130
Mandai	Swargate	10110	12960	14760	15390	8820	13720	16920	17640
Swargate	Station 1	4370	6020	7010	7310	4160	6790	7680	8010
Station 1	Station 2	4350	5940	6810	7210	4140	6600	7430	7890
Station 2	Station 3	3970	5570	6470	6790	3820	6060	6760	7130
Maximum Section Load (PHPDT)		18070	22320	24880	25940	16380	22980	27020	28170

The summary of patronage forecast along with peak hour peak direction traffic (PHPDT) are presented in Table 55.

Table 55 : Summary of Patronage Forecast

	Daily Ridership			
Nigdi -Katraj Corridor	**2027**	**2037**	**2047**	**2057**
	668,000	888,000	1,028,000	1,072,000
	PHPDT			
	2027	**2037**	**2047**	**2057**
	18,070	22,980	27,020	28,170

3.11.2 Incremental Ridership

The implementation of Nigdi – PCMC and Swargate-Katraj metro corridor will increase the patronage on Phase 1 corridors as well. It is necessary to duly consider the incremental patronage while doing the train operation plan, rake requirement and O&M. The incremental daily patronage due to the extension of the corridor, viz. Swargate-Katraj has been estimated considering the difference in the patronage with Swargate-Katraj Metro Corridors in comparison to *Without the extension corridor* and the same is presented in Table 56. The incremental daily patronage due to Swargate-Katraj & PCMC-Nigdi corridor has been estimated considering the difference between Nigdi-Katraj Corridor (Phase 2A) and without these extension corridors is presented in Table 57.

Table 56 : Incremental Daily Patronage due to Swargate-Katraj Corridor

	Daily Ridership			
Swargate-Katraj Corridor	**2027**	**2037**	**2047**	**2057**
	95,000	158,000	187,000	197,000

Table 57 : Incremental Daily Patronage due to Nigdi-PCMC & Swargate-Katraj Corridor

	Daily Ridership			
Nigdi - PCMC & Swargate-Katraj Corridor	**2027**	**2037**	**2047**	**2057**
	128,000	211,000	255,000	269,000

4. SYSTEM AND TECHNOLOGY SELECTION

4.1 Technology

There are several Mass Transit Systems and Technological options available for public transport worldwide. Various options available today are described in following sections.

4.1.1 Comparison of public transport systems

Each type of mode is associated with a specific capacity range, expressed in PPHPD. The figure hereafter shows the relation between mode and capacity (as an indication, it also shows the relation between mode, capacity, commercial speed and investment costs).

For instance, it can be inferred from the figure hereafter, that heavy metros are recommended on a corridor when its busiest section has >20,000 PPHPD. On the other hand, for corridors with PPHPD of 3,000, one may recommend either bus, Bus with a High Level of Service (BHLS), Streetcar or Urban Tram.

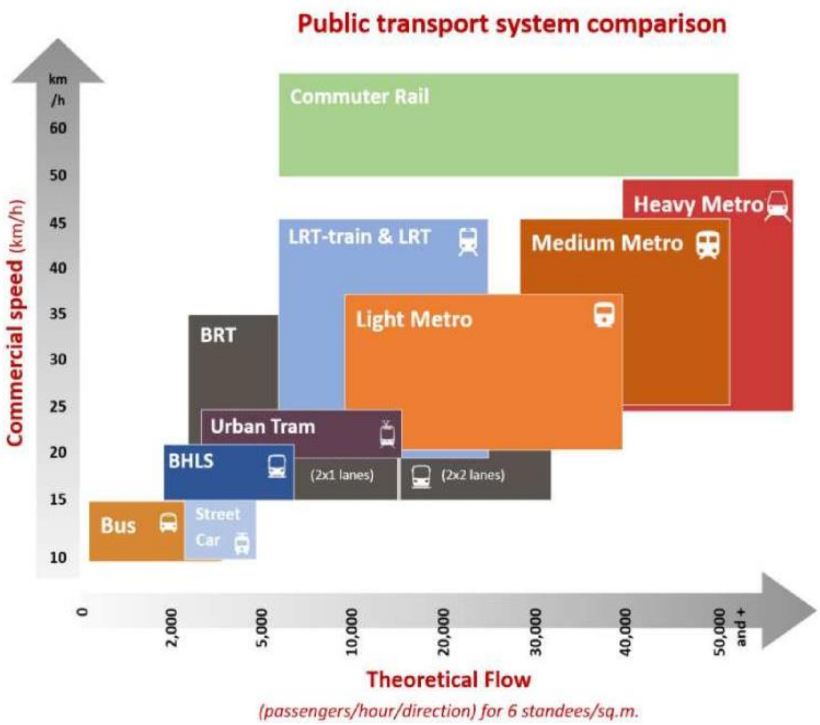


Figure 31. Public transport system comparison graph (6 standees/sq.m.)

(Source: Systra, 2018)

The sections hereafter provide information regarding the characteristics of each mode of transport. The figures presented are indicative, the values may change a lot depending on the options taken in the MRT project.

Note: the distinction between modes is theoretical.

4.1.2 BRT systems

BRT systems can have one-lane in each direction or two-lanes in each direction. The first configuration offers capacities of up to 15,000 PHPDT for 6 standees/sq.m., 20,000 for 8 standees/sq.m. Systems with two lanes in each direction, such as the Transmilenio in Bogota (Colombia), can approximately double the capacity to 33,000 PHPDT (6 standees/sq.m.).

BRT is typically provided at grade, but there are examples of both elevated and underground BRT systems. Providing high capacity by BRT is, however, reliant on operating articulated (or even bi-articulated) vehicles.

BRT systems are distinct from other bus-based transport systems. The ITDP (Institute for Transportation & Development Policy) has established a BRT scoring system with multiple scoring items, which helps to identify the characteristics of BRT systems and their level of service. These items include notably the BRT basics which includes 5 elements, among which are the right-of-way and alignment.

According to the ITDP scoring system, in order to be considered as a BRT, a system must:

- be at least 3km long with dedicated bus lanes;
- score 4 or more points in the dedicated right-of-way element;
- score 4 or more points in the busway alignment element;
- score 20 or more points across all five BRT Basics element.

Examples of BRT corridor

Figure 32. Bogota Transmilenion

Figure 33. Transjakarta in Jakarta, Indonesia

(source : Wikipedia[6])

4.1.3 Streetcar

The streetcar system could be defined as a similar mode to the urban tram system but mixed with traffic. Indeed, the system runs at grade with no significant degree of segregation.

This mode is not the most adapted solution for Pune due to the traffic condition. Moreover, the commercial speed of this system is low and thus may not be suitable for the corridors. However, it has been included in this report in order to give a complete picture of the offer/possibilities.

Example of street car systems:


Figure 34. **Toronto streetcar**

4.1.4 Urban Tram

Urban Tram systems typically offer capacity for 3,500 to 14,500 PPHPD (6 standees/sq.m.). They are able of operating in pedestrianized areas as well as along roads (mostly segregated).

Examples of Urban Trams


Figure 35. Grenoble tram, France **Barcelona Tram, Spain**
(Source: SYSTRA, 2005) (Source: SYSTRA, 2005)

[6] By Maxime Lafage - Own work, CC BY-SA 3.0, https://commons.wikimedia.org/w/index.php?curid=18631356

4.1.5 LRT systems

LRT systems typically offer capacity for 6,000 to 25,000 PPHPD (6 standees/sq.m.). They have a dedicated right of way but are usually only partially segregated.

Examples of LRT systems:

Figure 36. Manchester Metro Link

Figure 37. Stuttgart Stadt Bahn, Germany (Source: SYSTRA,2016)

4.1.6 LRT-Train system

LRT-Train systems are systems that are designed to serve dense urban areas where distance between station is low on the one hand, and less dense areas on the other hand. They allow for speeds on less dense sections of the line that are higher than standard LRT systems, so that the offered commercial speed is higher.

Figure 38. Line T4 in Paris (Source : Wikipedia[1])

4.1.7 Light metro

Light metro systems have a typical capacity of 10,000 to 40,000 PHPDT. They run on a segregated alignment which can be elevated, or underground.

Examples of light metros:

Figure 39. Stuttgart Stadtbahn, Germany Source: SYSTRA, 2016)

Figure 40. Manchester Metro-Link Source: David Dixon[2]

4.1.8 Medium metro

A medium metro is a system half-way between light and heavy metro. Its capacity lies between 30,000 PPHPD, and 50,000 PPHPD (6 standees/sq.m.).

Examples of medium metro systems[7]

Figure 41. Nippori-Toneri Liner, Tokyo, Japan [3]

Figure 42. Lyon Metro, France (Source Wikipedia[2])

4.1.9 Heavy Metro

A heavy metro is a system that can move more than 40,000 PPHPD (6 standees/sq.m.) and that runs fully segregated (either elevated or underground). Theoretically some very high capacity system could reach an operating capacity of 100,000 PPHPD (6 standees/sq.m.). The PPHPD on Pune Metro Line-1 extension (Nigdi-Katraj) is projected to be 8010 in year 2057. Hence, choosing this mode will increase the cost of the system without taking advantage of the high capacity offered by this mode. It is not the most adapted solution for the present system. However, this mode is included in this report in order to give a complete picture of the metro offer/possibilities.

Examples of heavy metro systems

Figure 43. : Shanghai Metro, China (Source: Wikipedia [4])

Figure 44. Paris Metro Line14

4.1.10 Commuter rail

Commuter rail is a system that operates between the city centre and its suburb. Unlike others, this system has a high distance between its stations and operates following a schedule.

Examples of commuter rail systems:

Figure 45. Paris RER, France(Source: SYSTRA, 2011) & : Frankfurt S-Bahn, Germany (Source: Wikipedia)

4.1.11 Alternative Options for Lower Ridership Volumes

4.1.11.1 Personal Rapid Transit/ Cable Car

Based on worldwide experience, Light Metro and LRT are feasible solutions for mass transit at volumes of around 5000 PHPDT or more.

Alternatives to Light Metro or LRT could be considered for the extension, for example monorail or various forms of Personal Rapid Transit (PRT).

- **A PPHPD too high for the people mover option**

Typically, PRT vehicles are small in order to provide a personalised service, usually carrying between two and six passengers. As vehicles are small, infrastructure can be lighter in design.

Although larger vehicles have not so far been used for the limited examples of PRT in current operation, it might be possible to offer larger vehicles, but this would increase the size and cost of infrastructure and reduce the benefits of offering a personalised service.

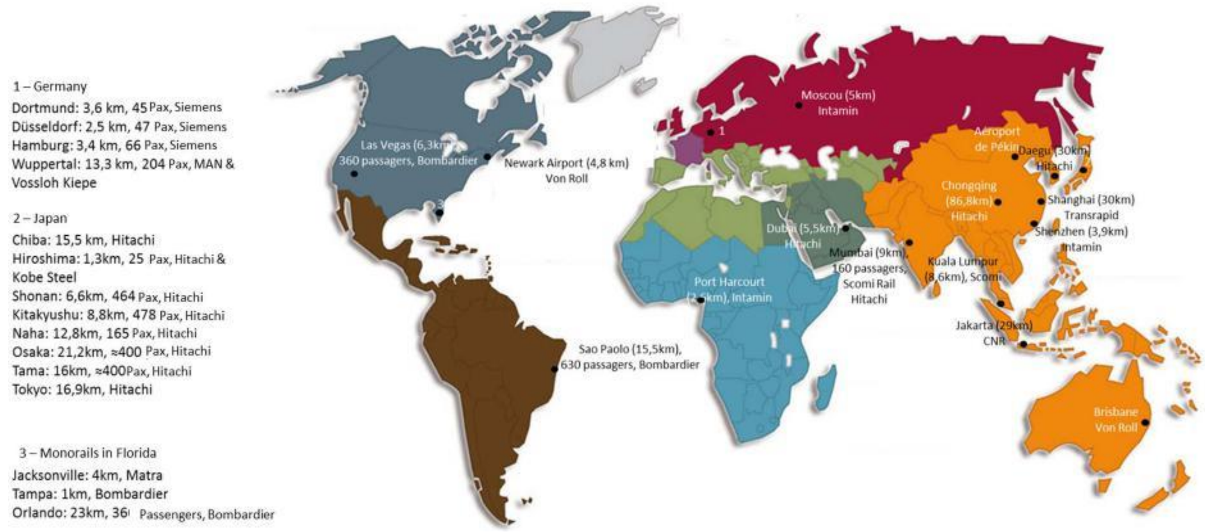
If we assume vehicles carrying as many as 20 passengers (much larger than any application so far in the world), then 400 departures would be required in the peak hour in 2057, which does not appear feasible.

4.1.11.2 Monorail

- **Monorail, a transport mode that has higher capacity than PRT but has been mainly developed for other than mass transit so far**

Monorail can accommodate larger volumes of riders than PRT, similar to Light Metro and LRT, and at similar commercial speeds.

Most Monorail systems in the world have been short-distance lines, often aimed at tourists, but there are growing applications to mass transit systems (e.g. the Mumbai Monorail can accommodate over 550 passengers per train).



- **Monorail, a system that has cheaper infrastructure than conventional rail-based project**

To be suitable for extension line, up to 11860 PHPDT would need to be accommodated by 2057 or beyond- even assuming trains of similar capacity to Mumbai monorail, this could require at least 15 departures per hour by 2047. Construction requires similar infrastructure to elevated Light Metro and LRT, although structures typically require less material compared to an equivalent Light Metro or LRT, without-turn infrastructure costs per km approximately 25% lower.

- **Monorail, a system that lacks flexibility compared to more conventional modes**

One major challenge is that monorail systems are less flexible than conventional Metro and LRT systems, for example switching between tracks requires additional infrastructure than with steel rails, and ride quality is lower than on steel rails. Evacuation can be more difficult/dangerous than even elevated conventional rail systems, unless adequate additional escape routes are built into the infrastructure.

- **Lack of diversity in monorail systems suppliers implying potential higher costs and risks**

Monorail vehicles are available from only a few suppliers, have less of a successful record of operation, and are more specialist than Light Metro or LRT vehicles. Consequently, monorail vehicles are likely to be more expensive than equivalent Light Metro or LRT vehicles, and the whole operating system would be provided by the vehicle supplier as it is bespoke which would increase risk and potential cost.

Different monorail systems are not compatible with each other so that for example, a Hitachi monorail system will not run with rolling stock from another supplier. If the chosen supplier decided to end its monorail business line, then the system itself would be threatened (no possibility to renew rolling stock notably).

Timelines for completing systems of similar length to that proposed for extension appear to be similar for monorail and conventional rail-based systems (e.g. Mumbai Monorail five years to opening of first section; five years for São Paulo monorail line 15).

4.2 Mode Selection

Pune is a growing city with high potential of economic activity and population growth. Commuting for day to day business and personal reasons results in to high passenger traffic and congestion on roads. Therefore, Phase-I of Pune Metro is already approved by Government and is currently under construction phase. Following this development, there is a demand for extension of Phase-I corridor from Swargate to Katraj.

The objective of Mass Transportation systems should be to provide high mobility, freedom and comfort at optimum cost, keeping safety and security of passengers on high priority. Mode change over a trip should be minimized to avoid passenger discomfort. The system and technological option should be selected keeping long term demand in view.

Phase-I of Pune Metro is designed and implemented as a medium metro. Based on worldwide experience, a medium metro is a system half-way between light and heavy metro. Its capacity is around 30,000 PPHPD (6 standees/sq.m.) or more.
While projections of demand for the Swargate to Katraj extension show maximum PHPDT to be around 8010 in 2057 in section Swargate station to Station 1 (Near Market Yard, Gultekdi) and beyond, PHPDT for corridor-1 with extension in Nigdi-Swargate section, is projected around 18070 in 2037 and 28170 in 2057. PHPDT criteria indicates that Light Metro, LRT, BRT, Street-car, Urban Tram, monorail are feasible solutions for mass transit at volumes of around 10,000 to 15,000 PHPDT or more should satisfy projected traffic demand reasonably.

Feasible alternatives (e.g. Monorail) offer limited advantages and are unlikely to be delivered any faster than Light Metro or LRT. Ensuring compatibility across the whole network should offer economies of scale (both in capital expenditure – such as sharing depots – and in operating expenditure – sharing maintenance, staff, rolling stock, etc).

Considering the above factors and systems options, it is concluded that an extension of Phase-1A corriodor-1 (Nigdi-Swargate) from swargate to Katraj provides a suitable Mass Rapid Transit System (MRTS) option to public in the area of extension and beyond. It will connect public in and around the area of Swargate to Katraj to the core area of city and can act as catalyst for further growth in this area.

4.3 System Specification to be adopted for corridor

Phase-I of Pune Metro including Line-1 is already under construction phase after due deliberation for system selection. Its extension from Swargate to Katraj is small stretch which should be planned with system specification similar to Phase-I to ensure uniformity and compatibility. However, improvement in design may be incorporated during implementation phase based on learnings from Phase-I implementation.

The Metro system proposed for Pune Metro is recommended with system specifications described in following sub-sections. Refer relevant sub-system chapters for detailed specification.

4.3.1 Permanent Way

Choice of Gauge : Standard Gauge (1435mm) is generally adopted for metro railways world-over. During the last decade, most of the new metros, constructed in various cities of the world have gone for Standard Gauge even though the national gauge for main-lines in some of the cases was different from Standard Gauge.

Track Structure : Track on Metro Systems is subjected to intensive usage with very little time for day-to-day maintenance. Thus, it is imperative that the track structure selected for Metro systems should be long lasting and requires minimum maintenance and at the same time, ensure highest level of safety, reliability and comfort, with minimum noise and vibrations. The track structure has been proposed keeping the above philosophy.

The proposed Track specification are further detailed in Chapter 5

4.3.2 Rolling Stock

Rolling Stock proposed for the corridor 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 important criteria for selection of rolling stock are as under:

- Proven equipment with high reliability
- Passenger safety feature
- Energy efficiency
- Light weight equipment and coach body
- Optimized scheduled speed
- Aesthetically pleasing Interior and Exterior
- Low Life cycle cost
- Flexibility to meet increase in traffic demand

The controlling criteria are reliability, low energy consumption, lightweight and high efficiency leading to lower annualized cost of service.

The proposed Rolling Stock specification are further detailed in Chapter 11.

4.3.3 Traction System

Traditionally, electric traction is used in Metro systems for requirement of high acceleration and pollution-free services in urban areas. There are three standard and proven systems of electric traction for use in suburban and metro lines, viz:- 750V DC third rail, 1500V DC overhead catenary and 25kV AC overhead catenary system. All these three systems are presently in use in India (750 V DC third rail in Kolkata & Bangalore Metro, 1500V DC catenary in Mumbai suburban of Central & Western Railways and 25 kV AC catenary in Delhi, Jaipur, Chennai, Hyderabad Metro & Indian Railways). 1500 V DC system of Central and Western Railways in Mumbai suburban is currently being converted to 25 kV AC to meet increase traffic demand.

The 25kV AC overhead catenary system is being provided on the phase-I corridor of Pune Metro. Thus, to ensure consistency with the existing system, 25kV AC overhead catenary system is proposed for the extension.

The proposed Traction system specification are further detailed in Chapter 12.

4.3.4 Signalling System

Signalling & Train Control system for Pune Metro Phase-I is proposed for design headway of 90 seconds so as to meet sustained train operation at up to 2 minutes interval during peak hours. The proposed system shall be compatible with the existing Phase-I system for seamless operation & maintenance. Therefore, these requirements of the metro are planned to be achieved by adopting a State of art Communication based Train Control System. This will enable running of optimum train services meeting traffic requirements in the most efficient and cost-effective way. The Signalling & Train Control system will ensure: High level of safety with trains running at close headway ensuring continuous safe train separation.

- Eliminate accidents due to driver passing Signal at Danger by continuous speed monitoring and automatic application of brake in case of disregard of signal / warning by the driver.
- Provide safety and enforces speed limit on section having permanent and temporary speed restrictions.
- Improve capacity with safer and smoother operations. Driver will have continuous display of Target Speed / Distance to Go status in his cab enabling him to optimize the speed potential of the track section.
- Moving block feature shall provide enhancement of headway.
- Increase productivity of rolling stock by increasing line capacity and train speeds and enabling train to arrive at its destination sooner. Hence more trips will be possible with the same number of rolling stocks.

- Improve maintenance of Signalling and Telecommunication equipments by monitoring system status of trackside and train born equipments and enabling preventive maintenance.

The proposed Signalling system specification are further detailed in Chapter 6.

4.3.5 Telecommunication

The telecommunication system acts as the communication backbone for Signalling and other systems and provides telecommunication services to meet operational and administrative requirements of metro network. The proposed system shall be compatible with the existing Pune Metro Phase-I system for seamless operation & maintenance.

The proposed telecom system and transmission media will have following systems:

- Optical Fibre Cable
- Telephone Exchange
- Mobile Radio Communication
- Public Address System
- Centralized Clock System
- Passenger Information System
- Close Circuit Television
- Central Voice Recording System (CVRS)
- Access Control
- Network Monitoring and Management and
- Forensic Debriefing Analysis and Cyber Security System

The proposed Telecommunication system specification are further detailed in Chapter 9.

4.3.6 Fare Collection System

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.

Keeping in view Metro Railways Automatic Fare Collection System and the fact that Contactless card/ token technology proves to be cheaper than magnetic technology in life cycle cost due to reduced maintenance as it has less wear and tear and is less prone to dusty environment, computer based automatic fare collection system with contactless smart token/card type ticketing is obvious choice.

The proposed system shall be compatible with the existing Pune Metro Phase-I system for seamless operation & maintenance.

The System shall be capable for open loop transactions as well to further integrate the mobility solution with the advancements in technology and to allow for seamless transition from dedicated cards to common multi-use stored value fare media that can be used for financial transactions such as making purchases at shops etc. as well as a fare media in the system.

To accommodate the same the system shall conform to the following standards as a minimum:

1 EMV (Euro Mastercard Visa)

2 PCI-DSS (Payment card Industry / Data Security Standard)

3 ISO-IEC 14443

The system shall be of open architecture to allow for the integration of multiple fare products and shall be capable of interfacing with cards from different vendors. Additionally, the system shall not be proprietary as far as possible to allow multiple types of fare media from multiple sources to be integrated into the system.

The proposed system shall offer high fare revenue protection and minimize fare revenue evasion and fare related fraudulent activities. The system shall be capable of detecting any irregularity and allow the authority to take action to correct the same.

The proposed AFC system specification are further detailed in Chapter 10.

5. CIVIL ENGINEERING AND ALIGNMENT DETAILS

5.1 Alignment Description

5.1.1 Site appreciation and reconnaissance survey

With a view of examining the alignment proposals on ground, joint inspection visits were organised from March to May 2018. After that the detailed investigation as per TOR are being carried out as a routine manner.

Teams of experts from Signalling, Traffic, Alignment, Geo-tech, Structure, Hydrology, R & R and Environment disciplines were deployed.

With an aim of assessment and appreciation of the existing condition/characteristics of the project stretch in terms of traffic, geometry, pavement, structures, social and environmental concerns and safety issues, the key professionals of the consultants carried out the reconnaissance survey during the above said period.

This team was equipped with handheld GPS units loaded with the alignment proposals, KM-marks and other salient points so as to navigate to the correct positions on ground, measure distances between salient points and to record new points of interest. Important locations traced on ground with help of GPS were correlated with that on alignment plans. All points of interest were observed in depth and discussed with experts of various disciplines in detail at site.

During reconnaissance, all the important technical site information was collected. The secondary data for some stretches were collected during the period. Photographs of important features of whole project corridor are captured. Necessary modifications/detours requested by the site conditions were also recorded for implementations in the alignment design.

Detailed Road Inventory, condition survey and investigation has been conducted. Route alignment option studies

5.1.1.1 General overview of corridor

The following three lines in this Pune MRTS projects are under purview of the DPR Study:

Name of line	Origin-Destination	Route km	No. of stations
Phase 1A	PCMC to Nigdi	4.413	3
Phase 2A	Swargate to Katraj	5.464	3
Phase 2B	Nashik Phata to Chakan	23.18	13

Proposed Corridors comprise of 16 elevated and 3 Underground stations.

Out of the three designated corridors, two are extensions of under construction PCMC to Swargate (North South) line 1 of Pune Metro Phase 1. The line 1 of Pune metro rail project which passes across the middle of Pune city and runs in North-South direction, originating from Pimpri Chinchwad (PCMC) in North and terminating at Swargate in South:

- The Corridor 1A is extension of the same line on Northwards, from PCMC to Nigdi (Near Bhakti Shakti Chowk);
- Corridor 2A i.e. extension corridor starts from Swargate, moves southward to reach Katraj;
- Corridor 2B is a new line, which is along Nashik Highway, connecting the under-construction Nashik Phata to the fast developing Chakan towards North-Eastern side.

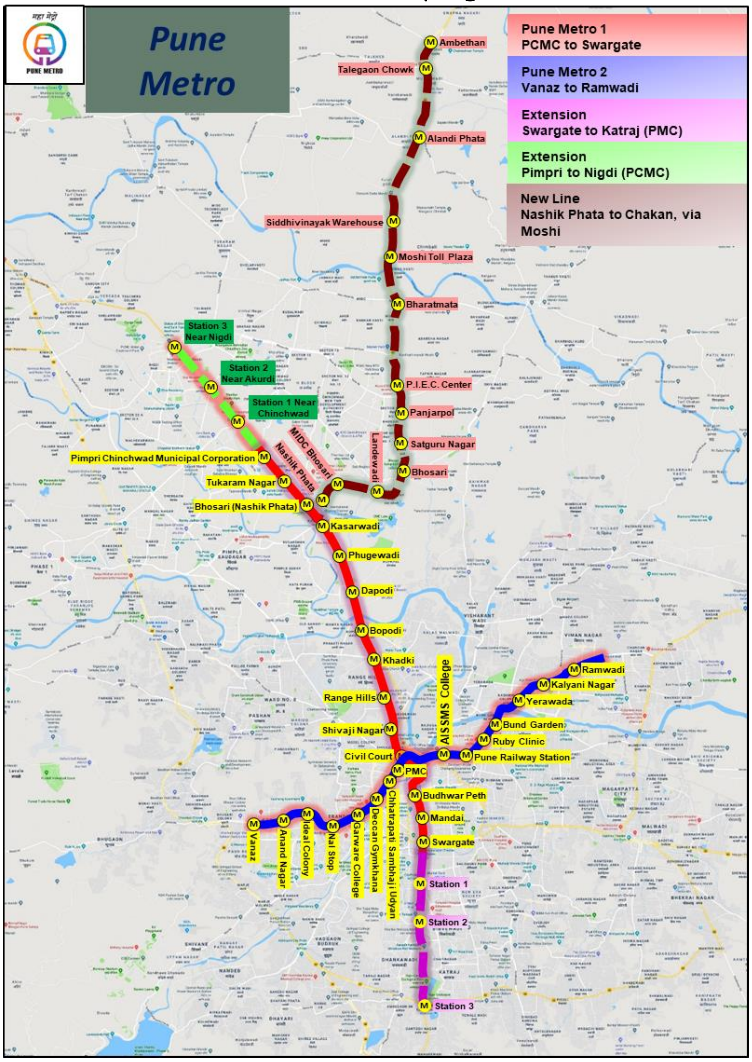


Figure 46. Pune Metro Phase II with stations locations

(Source: Google Maps and Systra, 2018)

This report deals with corridor 2A only and the next section presents the alignment options considered on this corridor.

5.1.1.1.1 Line 1 extension-Corridor 2A : Swargate to Katraj

Extension of line 1 towards Katraj starts from Southern end of the under-construction line 1 of Phase 1 and follows the corridor along Pune Satara in general.

The most part of the corridor runs under the Pune - Satara corridor and at one locations alignment runs along the left side of the road (when travelling from Swargate towards Katraj). Such deviation in alignment is chosen because there is a road flyover along the highway.

The terminal station i.e. Katraj is proposed near at Katraj – Dehu Road , which is on the opposite side of Rajiv Gandhi National Park in Katraj.

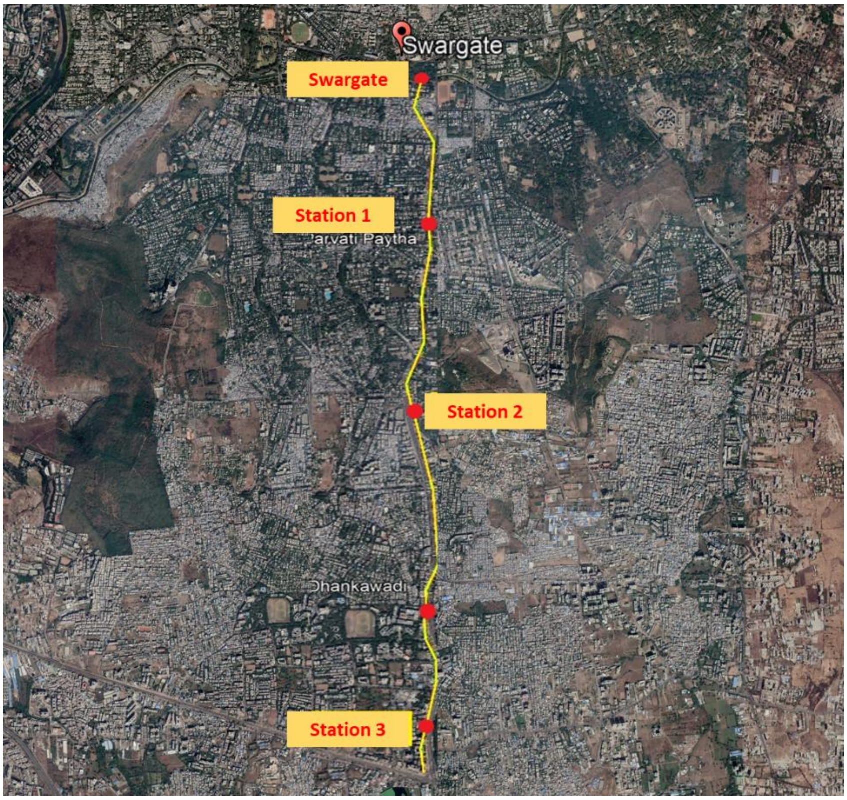


Figure 47. Corridor 2A – Swargate to Katraj Analysis of corridor options
(Source: Google Earth and Systra, 2019)

The end of chainage of line 1, Phase 1 (PCMC- Swargate) is 16815.290 and the end of chainage of corridor 2A (Swargate to Katraj) is 22282.933 for north bound track and 16821.530 and 22282.848 as start and end chainage for south bound track. Thus, total length of corridor is 5.464 km, which is fully underground. Station – Near Padmavati has been proposed on the south side of road, whereas Station – Near Market Yard and Katraj Station has been proposed on the median of the road (when travelling from Swargate to Katraj). This is due non-availability of land at the respective locations. Scissor Crossover has been planned just before the terminal station i.e. Katraj Station, at chainage 21625.754 to 21765.705 and 21630.697 to 21770.632 on North Bound track and South Bound track respectively. Permanent Speed restriction of 25kmph, 15kmph and 5kmph may be required to be imposed progressively for safe degraded operation. Length of alignment post terminal station is 349.459m for North bound track and 364.625m for South bound track.

5.2 Design Norms

5.2.1 Alignment definition

This chapter deals with geometrical standards adopted for horizontal and vertical alignments, route description, etc. The proposed corridors under Pune MRTS network will consist of Standard Gauge (SG) lines.

The geometrical design norms are based on international practices adopted for similar systems with standard gauge on the assumption that the maximum permissible speed on the section is limited to 80 kmph. Planning for any higher speed is not desirable as the shorter inter station distance will not lead to significant difference in running time.

The underground tracks will be carried on two parallel tunnels, generally spaced at constant centre to centre distance of 15.35m. The horizontal alignment and vertical alignment are dictated to a large extent by the geometry of the road and ground levels followed by the alignment.

5.2.2 Rolling stock assumptions for alignment study

The conditions of implementation of the MRT system, partly at-grade & partly elevated without impacting the space given to road vehicle circulations command the choice of a rail based MRT system rather than a BRT. Therefore, assumptions of MRT rolling stock had been used for the alignment studies and are detailed in Chapter 11 Rolling stock.

5.2.3 Geometric design parameters

The design parameters related to the metro system described herewith have been worked out based on a detailed evaluation, experience and internationally accepted practices. Various alternatives were considered for most of these parameters, but the best-suited ones have been adopted for the system as a whole.

5.2.4 Horizontal alignment

As far as possible, the alignment follows the existing roads. This leads to introduction of horizontal curves. The criteria for designing horizontal curves are detailed next.

5.2.5 Transition Curves

It is necessary to provide transition curves at both ends of the circular curves for smooth riding on the curves and to counter act centrifugal force. Due to change in gradients at various locations in the corridor, it is necessary to provide frequent vertical curves along the alignment. It is desirable that the vertical curves and transition curves of horizontal curves do not overlap. These constraints may lead to reduced lengths of transition curves at certain locations. The transition curves have certain minimum parameters.

- Length of Transitions of Horizontal curves (m)
  - Minimum: 0.44 times actual cant or cant deficiency (in mm) whichever is higher;
  - Desirable: 0.72 times actual cant or cant deficiency, (in mm), whichever is higher.
- Overlap between transition curves and vertical curves not allowed;
- Minimum straight between two transition curves: either 25m or nil;
- Minimum curve length between two transition curves: 25 m.

Assumptions

Track gauge (between interior rails)	1435mm
Spacing of rail lines (between axes of rails)	1507mm
Maximum design speed*	90 km/h
Maximum operating speed*	80 km/h

Note*: *This maximum design speed is applicable for the straight and the flatter curved alignment, which covers most of the alignment. However, in curves sharper than 1000m radius, suitable speed restriction shall be applicable, which may be optimized for higher speed based on final survey details available.*

For any consecutive circular curves with opposite direction of curvature, the length of straight track between the ends of the curves or of the transitions where these are required shall be not less than 25m. When it is not possible to provide a straight portion of 25m, no straight portion shall be provided, and the transitions extended accordingly. The rate of change of cant and versine over both transitions shall be kept the same in such cases.

Transition curves will not normally be required between different radii of a compound curve where the change of radius of curvature does not exceed 15% of the smaller radius and provided that the cant deficiency and/or cant excess criteria are not exceeded for either curve.

Where a compound curve is employed with a change of radius greater than 15% of the smaller radius, or where the cant deficiency or cant excess criteria necessitates a change in cant between the circular curves, a suitable transition curve shall be interposed between the two parts of the curve. The length of such a transition shall be equal to the difference between the required transition lengths at each end of the curve.

When the actual shift of any calculated transition curve would be less than 10mm the actual transition curve may be omitted. In this case, the required change of cant shall take place over the calculated length of the transition, or 25 m whichever is the greater, and in the same location as if the transition had been provided.

In general, for all running and depot lines transition curves shall be provided wherever possible between a circular curve and adjoining straight, between the different radii of a compound curve and at the adjoining ends of circular curves forming reverse curves. Transition curves are not required in sidings.

Applied cant shall be specified to the nearest millimetre for concrete track and to the nearest 5 mm for ballasted track.

Track at terminus stations shall continue past the end of the platforms by 25 metres where stabling or refuge tracks are not required. Minimum radius in station must not be less than 1000m.

Whenever possible the track shall be straight throughout the length of the stations. The presence of external restrains may necessitate limited encroachment of transition curves at station ends but this shall be avoided whenever possible. Where encroachment is unavoidable this shall be limited such that the vehicle throw does not affect the platform nosing clearance.

5.2.6 Design value

Table 58: Design Values Summary

Parameters	theoretical formulae	requirements to comply with	
		limiting	project's preferential
Theoretical equilibrium cant	11.8V2/R	225 mm	195mm
Cant		125 mm	110mm
Cant deficiency		100 mm	85mm
Cant Gradient (geometrical variation of the cant)		≤ 1 in 500	≤ 1 in 750
Rate of change of cant		55 mm / s	35 mm / s
Rate of change of cant deficiency		55 mm / s	35 mm / s

Parameters	theoretical formulae	requirements to comply with	
		limiting	project's preferential
Minimum radius in Running Track		120 m	225 m
Minimum radius in Depot		100 m	190 m
Length of pure circular arc between transitions		25 m	50 m
Length of Transition or Tangent Length		15 m	25 m
Minimum length of straight between reverse direction curves		25m or 0m	25m

5.2.7 Vertical Alignment

Vertical curves shall wherever possible be positioned such that coincidence with horizontal transitions is avoided. Where such coincidence is unavoidable, the largest practicable vertical curve radius shall be employed.

Vertical curves shall, for each location, be selected on the basis of the largest practicable vertical curve radius subject to the following limit:

- Minimum desirable radius 2500 m
- Absolute Minimum Radius 1500 m

The length of constant grade between consecutive vertical curves shall be as follows:

- Desirable minimum 50 m
- Absolute minimum 25 m

At point and crossing work, vertical curves shall not coincide with any part of the overall length of switches or of cast crossings. At other point and crossing work vertical curves shall be avoided whenever possible. Where they cannot be avoided the vertical curve radius shall be 3000 m or more.

At station ends, the tangent point of the vertical curve shall be permitted to encroach within the length of the platform to a limited extent. This length of encroachment shall be such that the vertical offset of the curve from the station gradient at the platform end shall not exceed 15mm.

5.2.8 Gradient

For running lines, the desirable maximum gradient shall be 3% and where unavoidable shall be 4%. Where gradients of 1% or less are used they may be unrestricted in length. Gradients above 3.0% shall be kept as short as possible.

At stations, the track shall be level or of constant gradient not steeper than 0.2% throughout the platform length except for the limited lengths of vertical curves as specified in relevant clause under Vertical Alignment.

A drainage gradient shall be provided for all tunnel, other than at stations, as follows :

- Desirable minimum 0.5%
- Absolute minimum 0.25%

Sidings shall be level or shall fall away from the main line switch at a gradient not exceeding 0.25%. Train berths shall be level or shall fall towards the buffer stops at a gradient not exceeding 0.25%.

5.2.9 Levels

All levels shall be quoted in metres correct to three decimal places and shall be above mean sea level (MSL).

Rail level on canted track will refer to the level of the running edge of the lower rail.

5.2.10 Points and crossings

Whenever possible, points and crossing work shall not coincide with vertically or horizontally curved track.

Where it is not possible to avoid coincidence with vertical curves the switches and stock rails shall not be laid on vertical curves.

Points and crossing work shall not coincide with horizontal transitions.

No part of the switches switch operating gear or crossing nose shall be over a structural movement joint.

In case of unavoidable circumstances, if the coincidence with horizontal curve cannot be avoided, the same may be laid in curve having radius greater than 1000m with cant applied made zero.

Generally, 1 in 9 turnouts with 300m Radius (1 in 9 R300) is to be adopted in Main Line and 1 in 7 turnouts with 190m Radius (1 in 7 R190) is to be adopted in depot tracks.

5.2.10.1 Scissors crossovers

Scissors crossovers shall be based on a transitioned crossover with vertical rails.

The switch points and turnout radius shall be standard UIC or approved equivalent, designed to accommodate a minimum operational speed of 40 km/hr.

5.2.10.2 Turnouts

Turnouts shall be based on a transitioned turnout with vertical rails.

- The speed through the turnout shall be 50 km/hr.
- Operational speed in the depot shall be 25 km/hr.

5.2.11 Stations locations

Stations have been located so as to serve major passenger destinations and to enable convenient integration with other modes of transport. However, effort has also been made to propose station locations such that the locations where maximum commuter travel. Further detail on stations locations is provided in the Station Planning chapter - 6 of this report.

5.2.12 Track structure

Track on MRT systems is subjected to intensive usage with very little time for day-to-day maintenance. Thus, it is imperative that the track structure selected for MRT systems should be long lasting and should require minimum maintenance and at the same time, ensure highest level of safety, reliability and comfort, with minimum noise and vibrations. The track structure has been proposed keeping the above philosophy in view.

Two types of track structures are proposed for the corridors under Pune MRT network. The normal ballasted track in depot (except inside the workshops, inspection lines and washing plant lines). The ballastless track is recommended on viaducts as the regular cleaning and replacement of ballast at such locations will not be possible. For the depots, ballasted track is recommended as ballastless track on formation is not suitable due to settlement of formations. Ballastless track in depot is required inside the workshop, on inspection lines and washing plant lines.

From considerations of maintainability, riding comfort and also to contain vibrations and noise levels, the complete track is proposed to be joint-less and for this purpose even the turnouts will have to be incorporated in LWR (Long Welded Rail)/CWR (Continuous Welded Rail).

The track will be laid with 1 in 20 canted rails and the wheel profile of Rolling Stock should be compatible with the rail cant and rail profile.

5.2.13 Rail section

Keeping in view the proposed axle load and the practices followed abroad, it is proposed to adopt UIC-60 (60 kg. /m) rail section. Since on main lines, sharp curves and steep gradients would be present, the grade of rail on main lines should be 1080 Head Hardened. For the depot lines, the rails of grade 880 are recommended.

5.2.14 Ballastless track on main lines

Inside the tunnel, it is proposed to adopt slab type ballastless track structure.

5.2.15 Ballasted track in depot

The ballasted track in depot may be of the following types:

- Supported on steel pedestal for inspection lines;
- Embedded rail type inside the workshop;
- Plinth type for washing line;
- Track is to be laid on PSC sleepers with sleeper spacing of 65 cm;
- All the rails are to be converted into rail panels by doing flash butt/alumino thermic welding.

5.2.16 Buffer stops

On main lines and depot lines, friction buffer stops with mechanical impact absorption (non-hydraulic type) will be provided.

In underground portion, the spans on which friction buffer stops are to be installed will be designed for an additional longitudinal force, which is likely to be transmitted in case of Rolling Stock hits, the friction Buffer Stops.

5.2.17 Rail Structure Interaction

For continuing LWR (Long Welded Rail)/CWR (Continuous Welded Rail) on viaducts, the elevated structures will be adequately designed for the additional longitudinal forces likely to be transmitted as a result of Rail-Structure interaction. Rail structure interaction study will determine the need and locations of Rail Expansion Joints (REJ) required to be provided.

5.3 Geometric Design of Corridor including plan/profile

Enclosed

5.4 Conclusion

The alignment options discussed and finalized in the Technical Expert Committee Meeting dt. 20th June, 2019 with the following amendments/conclusions :

1. The alignment is designed under the road median throughout the length to minimise the effect on the inhabited area, except at the locations where existing flyover is present at the road center. At this location, the alignment is taken beside the flyover with one tunnel under building and the other one under service road to avoid any risk of demolishing part of flyover in case of infringment of TBM with the pier foundation of the flyover during tunnelling works, which may have to be dealt with demolition of the Flyover.
   The alignment is planned such that any eventual defect in TBM does not hamper the traffic movement on the flyover and can be rectified in-situ.
2. The alignment shifts at the road median just after the end of flyover and follows the road median throughout the length.
3. As suggested, all the stations are proposed under the road median, except station 2 Padamavati.
4. Station 3 Near Bharti Vidyapith has been eliminated from the alignment finalization , in order to bring down the vertical gradient to below 3% between the 2 adjacent stations (Padmavati and Near Katraj) and Project cost.
5. In doing so, the interstation distance between station 2 and 3 worked out to be 2.29km , which brings out the requirement of a ventilation shaft between these stations, as per the NFPA codal provisions.

5.5 Geotechnical Investigations

5.5.1 General geology & characteristics

5.5.1.1 Location

The rail corridor which has been identified as potential MRT corridor runs through the Pune Metropolitan city & Pune Municipal Area (PMC).

The proposed corridors 2A, covers the distance of 5.464 km of main alignment which run along the road. The proposed section from Swargate to Katraj is completely underground.

Geotechnical investigations have been carried out along the proposed corridor including to determine the strata, depth of foundation and safe bearing capacity of foundations required for the above proposed metro corridors.

5.5.1.2 Physiography & Climate

Pune District is in the western part of Maharashtra. It is bounded by Thane District to the northwest, Raigad District to the west, Satara District to the south, Solapur District to the southeast, and Ahmednagar District to the north and northeast.

Pune district lies in the Western Ghats or Sahyadri mountain range and it extends on to the Deccan Plateau on the east. Pune stands on the leeward side of the Western Ghats. Pune is at an altitude of 559m (1863 ft.).

Pune city has assessed in seismic Zone 3. The temperature ranges from 5°C to 40°C. The city gets an average yearly rainfall of 772mm.

5.5.1.3 Geotechnical Characteristics

A total of 9 boreholes were drilled for the corridor Phase 2A from Swargate to Katraj section. Boreholes were drilled from depth 12.0m to 30.0m below ground level. The details of boreholes along the section is given below,

Table 59 : Details of boreholes along the section

Borehole No.	Borehole Location	Water Table below ground level (m)
BH-1	Corner of Swargate Stand	Nil
BH-2	Parvati Industrial Estate	6.5
BH-3	Near Walwekar Lawns	17.0
BH-4	Near Nimantran Hotels	4.0
BH-5	Near Anil Optic Bibwewadi Road	5.0
BH-6	Near K.K.Market	6.5
BH-7	Near Vishweshawar Bank	2.0
BH-8	Dhankawade Patil Society	6.5
BH-9	Rajiv Gandhi Zoological Park	3.0

The geological stratum for this site is majorly categorized in 2 stratum as shown in table below.

Table 60 Summary of geological units

Soil Type	Stratum	Description
SOIL	Stratum – 1	Filled up & Silty Clay/Silty Sand/Sandy Silty/Sandy Clay (CI & CH/SM/SP/SC)
ROCK	Stratum – 2	Completely to Moderately weathered basalt Rock

Stratum-1 SOIL: This layer is majorly encountered at top of the ground and underlain by Completely weathered basalt rock/Moderately weathered basalt rock. Filled up soil is majorly encountered at top layer varying from 1.0m to 2.0m thickness below that silty clay/silty sand layer is present. This Soil stratum is available varying from 1.0m to 5.0m depth below ground level.

Stratum-2 ROCK: Completely to Moderately weathered basalt rock is available below soil stratum. This layer is encountered at the shallow depth of 1.0m to 2.0m from boreholes BH-2, BH-4, BH-7, BH-8 & BH-9.

5.6 Civil Engineering

5.6.1 Construction of Tunnels for Underground Alignment

For underground alignment, tunnelling arrangements are decided based upon following objectives: -

- Minimization of the surface settlement to maintain all metropolitan activities without adverse effect.
- Expeditious tunnel execution to minimize duration and space of the surface effects due to tunnelling.
- Economy in tunnelling costs.

To achieve the above-mentioned objectives, use of Tunnel Boring Machine (TBM) is the prime method of tunnelling. Locations where deployment of TBM is not possible (tunnelling of short length, cross passages, underground stations which are not possible by cut and cover method etc.) are tackled by NATM method.

5.6.2 Selection of TBM

Choice of appropriate TBM depends upon the detailed geological studies and soil conditions. In the rocky strata, heavy disc cutters are required in the cutter head, whereas for excavating soft soils, scrappers are required in the cutter head. In mixed soil conditions, the TBM should be capable of excavating soils and rocks both, hence combination of scrappers and disc cutters shall be used under such situations.

The most important issues to be addressed in selecting a Shield tunnelling method are

- face stability and
- minimum displacement/settlement of ground and structures.

Suitable TBM for this project shall be the mixed shield can be run in open or closed mode as per geology. The Closed type TBM shall further be categorized as Earth- Pressure Balanced (EPB) TBM and Slurry type TBM. EPB shall be further categorized into Earth-pressure type TBM and Mud-pressure type TBM.

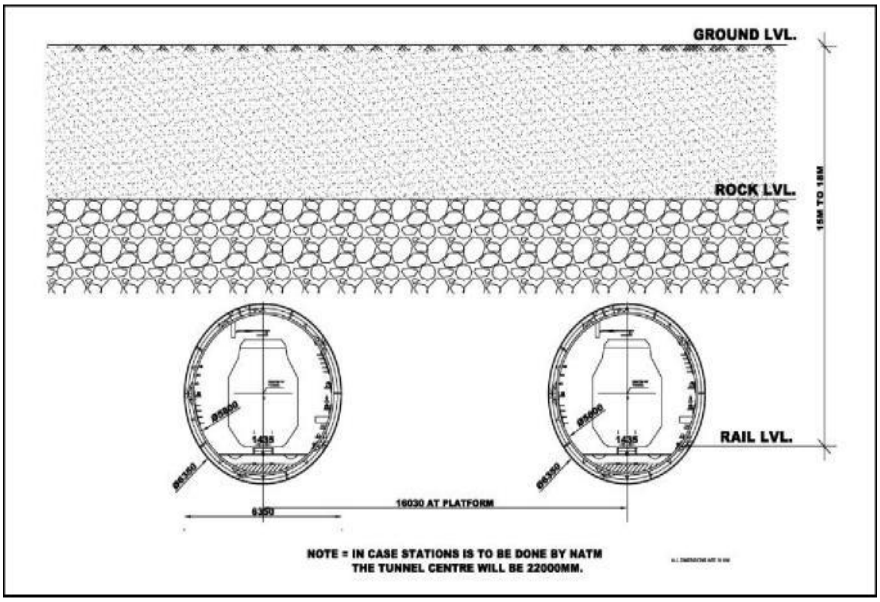


Figure 48. Typical Twin Tunnel Arrangement

5.6.2.1 *Earth-pressure type TBM*

The Earth-pressure type TBM is suitable for certain types of soil that can be directly fluidized. Fluidized soil fills the cutter chamber and the screw conveyor is used for discharge of muck, thereby keeping the cut face stable. The shield machine can simultaneously excavate soil during shield advance, so not only is the face well stabilized, but also the effects on the surrounding ground are minimized.

Figure 49. Typical Twin Tunnel Arrangement

5.6.2.2 Mud-pressure type TBM

The TBM turns the excavated soil into mud pressure and holds it under soil pressure to stabilize the cutting face, efficient to ground that is high in sand content and low in fluidity through the addition of water, mud, and additives. It is applicable to a large range of soils, including soft ground with low solidity such as alluvial sand/gravel, sand, silt and clay, alluvial deposits, and alternating hard and soft soil layers. The only limitation is that the soil discharge screw conveyor is unable to operate when the ground has high hydrostatic pressure. For this reason, it is necessary to closely study the soil properties before implementation.

5.6.2.3 Slurry type TBM

Slurry type TBM (Air tunnel-boring machine) is used for tunnel-boring in highly permeable unstable terrain, or under civilian structures sensitive to ground disturbances.

When digging in highly unstable or liquid terrain, the pressure exerted by the terrain is directly governed by the depth at which digging is performed. It is therefore necessary to balance the pressure exerted by the terrain: the front shield of the Slurry TBM is filled with excavated material, with the exception of one air-filled part. The pressure within this air bubble is subject to fine control. Bentonite injection waterproofs the working face and improves its resistance.

5.6.2.3.1 Proposed Dimensions

DIMENSIONS OF TBM

Parameter	Proposed dimension
Tunnel internal diameter	5800 mm
Tunnel external diameter	6350 mm
Tunnel excavation diameter	6700 mm
TBM cutter head diameter	6770 mm
Number of segments/rings	5 + 1 Key
Width of segments	1.2m/1.4m/1.5m
Thickness of segments	275 mm
Weight to segments	Normal segments Approx. 3.0 T each Key segment 1 T
Grade of concrete	M - 45

5.6.3 Sequence of Tunnelling by TBM

In the underground stretch of 5.464 km, Three UG stations are proposed i.e. Market Yard near Gultekdi, Padamavati and Katraj. Tentative arrangement for TBM movement is attached in **Exhibit 1 at the end of the chapter**. TBM will be launched from launching shaft. TBM is dragged in station area or is retrieved for one end of station and continues from other side of station. Ground settlement analysis and monitoring is required during the tunnelling using TBM. Two separate tunnels are constructed by two different TBM. Depending upon the soil/rock strata, suitable type of TBM shall be used for tunnelling.

5.6.3.1 Pre-Assembly Activities

The following construction sequence is necessary before assembly of TBM can be taken up:

1) Construction of Head Wall & Installation of rubber seal ring

This is a concrete structure designed to hold the main frame of the Entrance ring of TBM and prevent water and slurry flowing into the shaft during the assembly and operation of the TBM. Rubber Seal (25 mm thick) and seal retainers keep full contact with the shield TBM. Three air ventilation tubes are installed near the tunnel crown and one at the invert, to release the air, when the void is being filled with grout while launching the TBM. These can also be used for grouting.

2) Construction of Cradle

This is a Pre-fabricated steel structure over which the TBM is assembled in– situ. This also acts as guide to help TBM oriented in the required direction, while in operation. After the TBM becomes operational, the cradle will be carefully dismantled so that the same material can be used at different shaft.

3) Construction of Reaction Frame

This is a steel structure consisting of the frame and supports, which is fixed to the shaft floor and is designed to safely bear the thrust applied by the TBM during its working (force required by the cutting edge). The machine is to be assembled in- situ on a platform called Cradle and a Reaction frame is to be constructed in advance to bear the reaction of the force exerted by the main drive of the TBM for cutting the rock. Once the TBM becomes operational, the steel work in the Reaction Frame will be carefully dismantled as the same material is to be used repeatedly at subsequent assemblies at different sites.

5.6.3.2 Assembly of TBM

After the Head Wall, Entrance ring, Cradle, Reaction Frames are constructed, and other preparatory works are completed, the TBM can be assembled in-situ in a launching chamber on the cradle and launched for tunnelling.

Figure 50. Launching Chamber

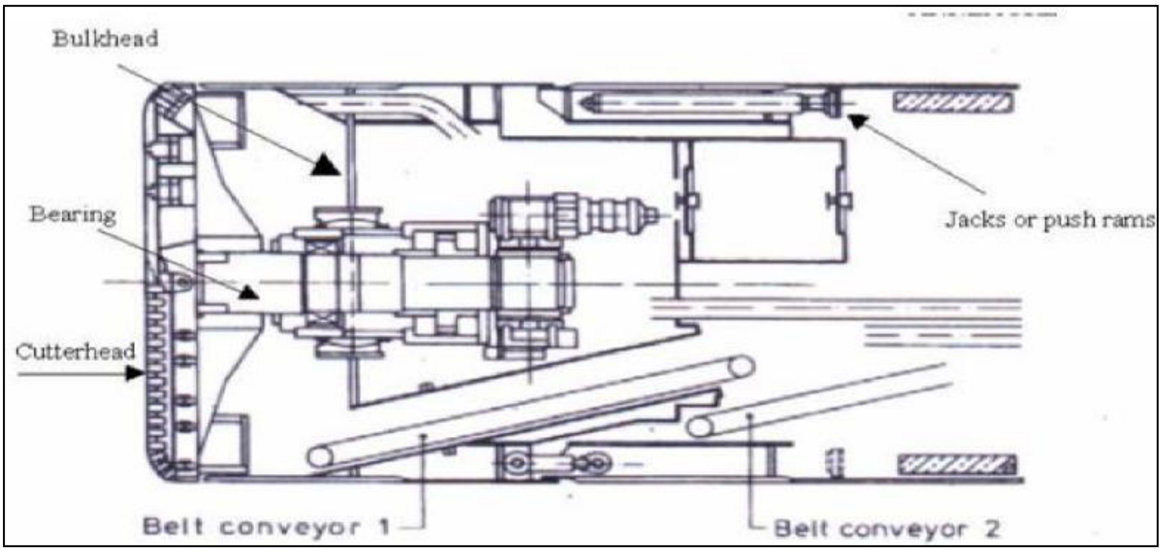


Figure 51. Report for Chennai Metro Rail Phase-II Corridors

Following steps are involved in the assembly of TBM:

1) Lowering of the shield,
2) Lowering of Cutter Head and fixing the same to the shield,
3) Fixing Segment erector and screw conveyor erection,
4) Lowering and Assembly of back up gantries.

Figure 52. Erector, Screw Conveyor & Backup System

It takes about three-four weeks each for completing the preparatory work and actual assembly of TBM in position, before it could be launched.

Figure 53. Main Shield Erection

The cradle and the reaction Frames are specially designed for every situation depending upon the machine characteristics and the ground characteristics. Cranes will be required for assembling and shifting the TBM.

5.6.3.3 Excavation

A belt weighing device will be included on conveyor belt. This measures the weight of the excavated material as it is transported on the conveyor belt.

Figure 54. Excavation

5.6.3.4 *Ring Erection*

As the machine advances, the construction of the permanent lining takes place behind the excavation face of the machine and typically consists of 6 segments which makes one ring.

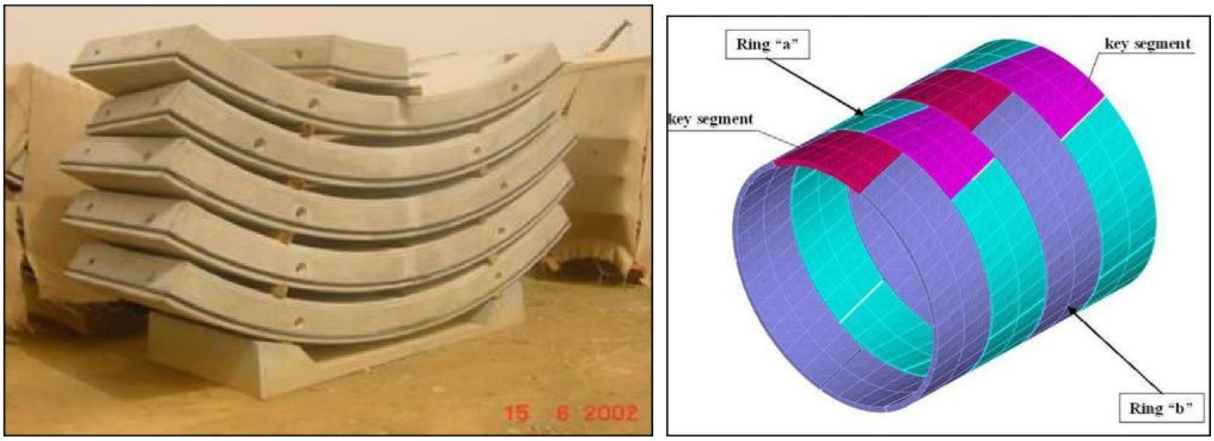


Figure 55. Ring Segment

5.6.3.5 *Settlement Control*

Settlement is primary caused by over excavation by TBM and the failure to fill annular voids behind the segments. To prevent over excavation during the TBM drives, the following actions shall be carried out: -

- Surface monitoring scheme to be agreed and installed prior to TBM launch.
- Provision of belt weighing device to measure excavated material weight.

- Ground treatment of launch area & receiving area (if required)
- Display in TBM drivers cabin to show actual excavated volume vs. theoretical excavated volume in real time. Data to be recorded by TBM data logger.

To ensure settlement do not occur due to the annulus ring not being filled by grout, the following actions will be carried out:

- Grouting system based on pressure control.
- Recording of grout volumes & pressure by TBM data logger.
- Tabulation of grout volumes to be done weekly showing running 10 ring averages. Grout pressure will be adjusted as necessary.

The above actions should ensure that all annular voids are filled during the initial drive, thereby controlling settlement caused by poor grouting practices.

5.6.3.6 Grouting and Waterproofing

After ring installation, theoretical void distance between the excavated radius and the external radius of the precast ring needs to be filled up. Grouting fills the voids and it also controls the ground settlement. Grouting pressure is calculated on the basis of overburden pressure. Structures shall be watertight if the leakage does not exceed 5 ml/m2/hour. Inside surface above the spring line of the tunnel shall always be kept in dry condition.

5.6.3.6.1 Cavity grouting of segmental lining

Cavity grout shall be executed during the tunnelling in order to:

- Secure the waterproofing of the tunnel
- Maintain the tunnel ring shape
- Limit the surface settlement
- Distribute ground pressures evenly onto the lining

The grouting can be distinguished into two types. These are single compound type and the two compounds type. The hardening time of the one compound type is relatively slow, and its strength is also low. On the other hand, it is relatively easy for the two compounds type to adjust the hardening time and strength. Hence, it is recommended to use the two compounds type for the cavity grout.

The two compounds type is further distinguished into two types - liquid type and plastic type. The liquid type can be sometime diluted by the underground water and is segregated. However, the plastic type is changed instantly into gel and is kept very stable until it gets its own strength. Thus, plastic type grout shall be recommended. The major materials of the liquid-A for the plastic type are mainly cement, fly-ash and bentonite. And the major material of the liquid-B for the plastic type is sodium silicate.

Primary grouting is the initial cavity grouting, which is applied simultaneously or immediately after a unit of lining has been built. Where primary grouting does not completely fill all the cavities, secondary grouting shall be carried out. Primary grouting shall be undertaken at a pressure sufficient to place the grout properly but not greater than 1 bar above the prevailing hydrostatic pressure at the location of grouting. Primary grouting shall be timed so as to minimize ground movement and be injected through grout holes provided in the linings or via shield tail skin injection pipes.

Secondary grouting shall be undertaken in selected rings by means of removing grout plugs from the tunnel lining and drilling a hole to the back of the existing grout. Secondary grouting is the re-grouting of lining and shall be completed as soon as practicable but within 14 days of the primary grouting, or when the face has advanced 50 m from the location of primary grouting, whichever first occurs. Secondary grouting shall be at a pressure consistent with filling all voids. Automatic grouting system as TBM advances shall be equipped.

5.6.3.6.2 Segment Gasket

It is recommended to apply the three layers of gasket to the perimeter of the segment. The materials for the gasket are mainly distinguished into chloroprene rubber type and natural rubber type. It should be tested for durability and water swelling ratio before using. The natural rubber type is suitable for the tunnel under high water pressure and the chloroprene rubber type is suitable for the tunnel under low water pressure.

- Gaskets shall be fitted into the grooves provided in the edges of the segment to be sealed in the manner recommended by the gasket manufacturer. The gasket dimensions shall match the groove width, subject to the specified tolerance.
- Sealing strips of the hydrophilic or gasket type, or a combination of the two, shall be provided at all faces between segments to provide a seal against ingress of ground water. Gaskets must be capable of withstanding the anticipated water pressure when in use in the tunnel. Test certificates or other information shall be provided to demonstrate this capability.
- Elastomeric gasket materials shall comply with the requirements of BS 2494, including resistance to chemical attack and microbiological degradation.
- Immediately prior to the erection of a gasketed segment, the gasket shall be checked for cleanliness and position. The gasket shall be lubricated as recommended by the gasket manufacturer.

5.6.3.7 TBM in Station Area

Cradle will be installed to drag the TBM in station area and again drive to the other end of the station by cutting Head wall. One end of the station is receiving chamber and the other end is launching chamber

Figure 56. TBM Through the Diaphragm Wall

Completed tunnel with linings. From here, 1st stage concrete, rail track, ventilation, electrical and other cables, etc., starts installation.

Figure 57. TBM Through the Diaphragm Wall

5.6.4 New Austrian Tunnelling Method (NATM)

The term New Austrian Tunnelling Method, popularly known as NATM, was first used by Mr. Rabcewicz in 1962. This method has been evolved as a result of experience gained in Austrian Alpine tunnelling condition. The first use of NATM in soft ground tunnelling is done in Frankfurt metro in 1969. The basic aim of NATM is for getting stable and economic tunnel support systems. Providing flexible primary lining in shape of shotcrete, wire mesh, rock bolts, lattice girder. In case of weaker rock mass, the use of pipe forepole/pipe roofing is also resorted for crown support, which in turn leads to less over-break as well as ensure safety during the execution. The main aspect of the approach is dynamic design based on rock mass classification as well as the in-situ deformation observed. This method has been very useful in complex diversified geological condition where forecasting of the rock mass is difficult due to rapidly changing geology.

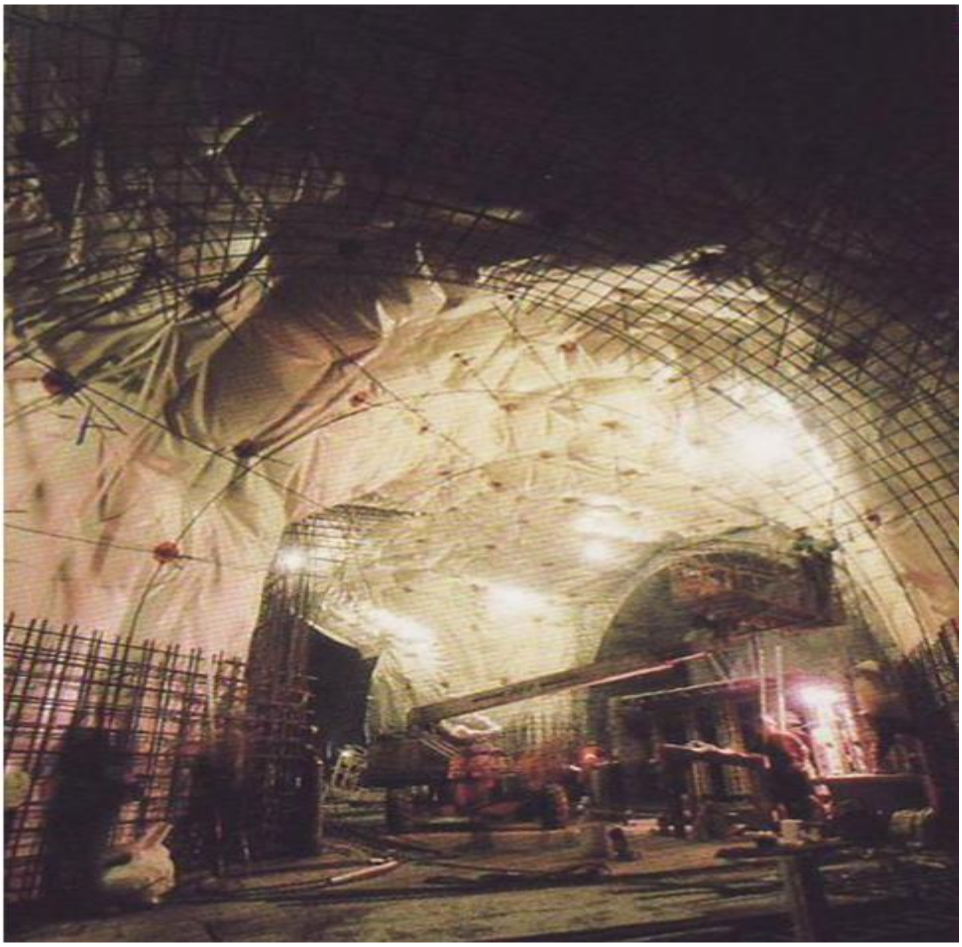


Figure 58. NATM Method

5.6.4.1 Cross Passage

It is recommended to follow NFPA 130, which is an international standard for the underground structures. Cross passageways shall not be further than 244m (800ft) apart according to the NFPA 130. At least one cross passage shall be required in each underground section between the stations. Construction method of cross passage is briefly explained below:

- The SGI segment is sometimes used at the locations of the cross passage in order to strengthen the segment lining, because some parts of the segment lining must be dismantled during the construction of the cross passage.
- Ground treatment is carried out from the ground surface. Usually the jet grout is applied. The jet grout is much more effective than other methods for the ground treatment because the original soil is totally replaced by the improved soil.
- Ground treatment is also carried out from the tunnel after the jet grouting above ground. The purpose of the grouting from the tunnel is supplementary grouting for the jet grouting above ground.

- Dismantling of the piece of the segments is commenced one piece by one piece together with carefully confirming the soil condition. Additional grouting shall also be done, if necessary.
- Excavation to the other tunnel with lagging or shot circuiting.
- Structural work

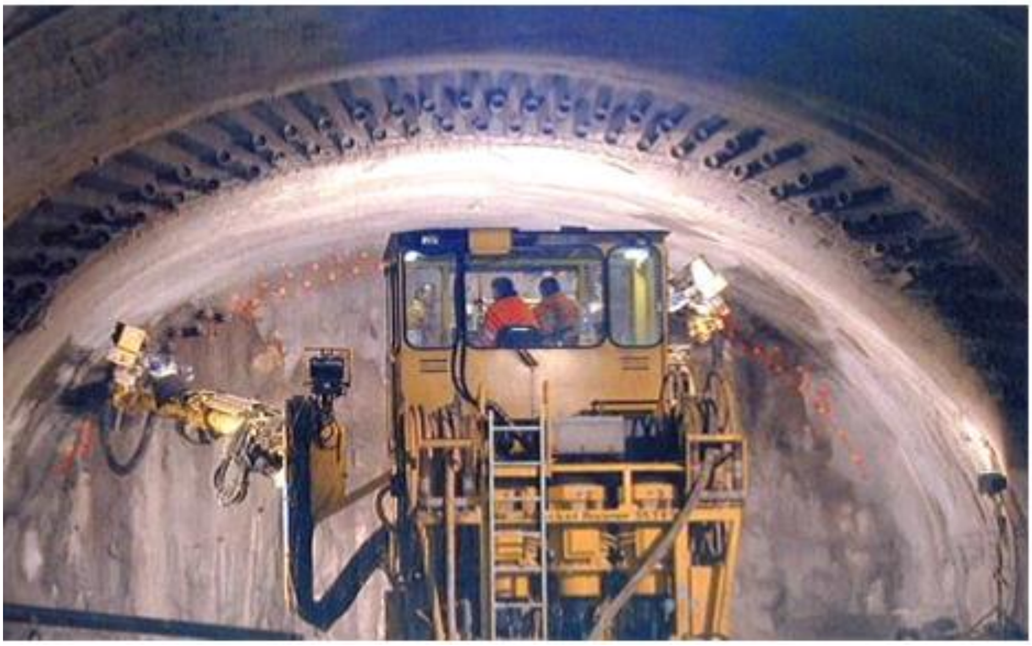


Figure 59. NATM support tubes installation (double Layer)

Figure 60. NATM support tubes installation (single Layer)

5.6.5 Construction of Underground Stations

Construction of underground station is mostly done by **Cut and Cover Method** where adequate ROW is available to support the excavation width to cover the width of station including protection work. Margin for road traffic also need to be available beyond the excavation line. Where ROW is restricted, only half width of station will be tackled at a time. In cases where ROW is extremely restricted and cut & Cover method is not possible, excavation will be done by **New Austrian Tunnelling Method (NATM).**

In Corridor 2A – Swargate to Katraj – All Three UG stations are proposed to be constructed using cut and cover method i.e. Market Yard near Gultekdi, Padmavati and Katraj.

5.6.5.1 Cut and Cover Method

In this method, entire volume required to accommodate structure is first excavated, structures are casted followed by backfilling. The open cut excavation with slope but without support is not suited due to large depths of excavation involved. Hence, support of excavated sides by way of diaphragm wall/sheet pile/soldier pile/secant pile is essentially done in cut and cover method. The support walls are often braced to effectively resist the huge earth pressure. The braced cut and cover method involve following steps: -

- Identification and diversion of utilities
- Construction of support walls
- Excavation between support walls along with bracing, ties or anchors
- Concrete construction
- Removal of temporary supports
- Backfilling and restoration of surface/utilities

There are two methods for cut and cover construction: -

i) Bottom Up Construction: This is the conventional construction method in which excavation is carried out through to the design depth and then construction starts from bottom most floor slab and proceeds upwards. In this method, the restoration of top surface is possible only after all the structures are constructed upto the top level and hence it involves longer restoration time.

ii) Top Down Construction: In this method, after excavation of first stage, floor slabs are constructed. These floor slabs are permanent structures which replace temporary steel struts in the braced excavation method to counteract the earth pressure from the back of retaining wall. In this way, the underground structure construction is finished with the completion of excavation process. The floor slabs used in this method are heavier than the steel struts used in conventional excavation method. In addition, superstructure being constructed simultaneously during excavation puts more weight on the column. Hence, bearing capacity of the column is to be considered. Typical construction procedure of top down construction method is as under: -

- Construct the retaining wall.
- Construct piles. Place the steel columns where piles are constructed.
- Proceed to the first stage excavation.
- Cast the floor slab.
- Begin to construct superstructure.
- Proceed deeper to second stage of excavation. Cast the floor slab.
- Repeat the same procedure till designed depth is achieved.
- Cast bottom most slab.

The merit and de-merit of this method are given in following table.

Table 61 : Merits and Demerits of Top-Down Method

MERITS	DE-MERITS
• Shortened construction period due to simultaneous construction of underground structures and superstructures. • Faster restoration of ground surface and utilities as topmost slab of underground construction is casted first. • Higher stiffness of floor slabs compared to steel struts improves the safety of excavation	• Higher cost. • Possibility of lateral displacement of retaining wall or ground settlement is more due to longer construction period of bottommost slab. • Natural ventilation and illumination are affected due to construction of first slab.

5.6.5.2 New Austrian Tunnelling Method (NATM)

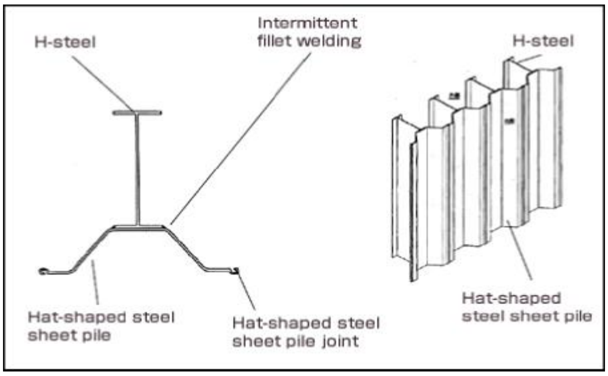
Where ROW is extremely restricted, and it is not possible to adopt cut and cover method, stations are constructed by NATM. In this method, two separate tunnels consisting of one track and one platform are constructed by NATM method and are connected by means of cross passages. This method requires overburden of about 2-2.5 times diameter of tunnel. In this method, progress is slow. This method is described in detail in tunnelling sub-section.

Earth retaining structures for underground stations

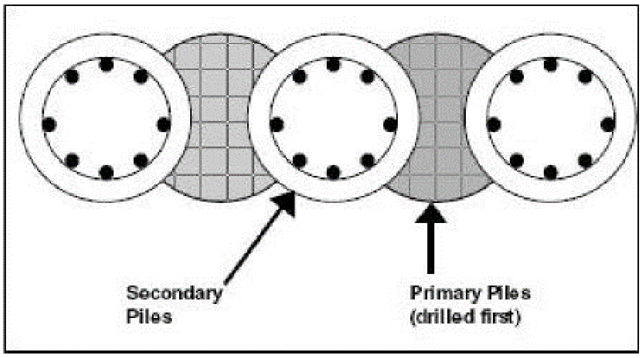
Following earth-retaining structures are used to support excavation for construction of underground stations: -

A. **Soldier Piles**: H/I section steel piles are driven in the ground at an interval of 1-1.5 m and the gap between the two piles is filled by using laggings of timber planks/steel sheets/GI sheets. These piles are re-usable, can be easily pulled out and results into less ground disturbance while driving and pulling out. However, these piles are not watertight and dewatering measures are required. Void between soldier piles and surrounding soil need filling.

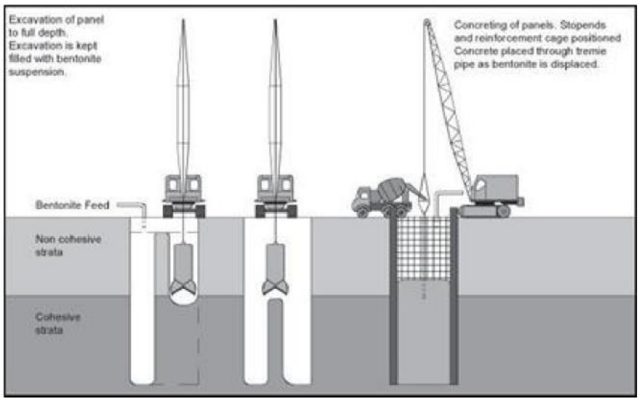
B. **Sheet Piles:** Sheet piles of 'Z' or 'U' shape are driven into soil by striking or static vibrating. The sheet pile is interconnected with adjoining piles to achieve interlocking and water sealing. Sheet piles can be used again and again and hence becomes economical. Driving of sheet piles require considerable efforts and cause vibrations to ground and adjoining structures. Sheet piles have higher stiffness than soldier piles.



C. **Secant Piles:** It is series of piles cutting into adjoining piles to achieve water tight retaining structure. In this method, alternate soft piles, called female piles, of dia (D) 800 to 1000 mm (without reinforcement) are cast at an inter-distance of less than D and when these piles are still green, hard piles (containing reinforcement) are bored by cutting female piles. Thus, a series of alternate and interconnected hard and soft pile is achieved which acts as rigid earth retaining structure. It has all the advantages of diaphragm wall, except that it cannot be used as a part of permanent structure.



D. **Diaphragm Wall**: It is a rigid support system ensuring maximum safety against settlement/lateral displacement. Typically diaphragm wall of 0.6 to 1 m thickness is sufficient to retain the earth pressure in a cut and cover construction. The diaphragm wall can be used as a part of permanent structure. With diaphragm wall, it is possible to adopt top-down construction method.



5.6.5.3 MUCK DISPOSAL

Construction of underground tunnel for metro projects is a specialized and complex task. The construction activity involves tunnelling, cut and cover, foundation, fill and embankment in which large quantity of muck needs to be disposed off.

Protective measures shall be undertaken during construction phase for reduction of dust generation. Owing to paucity of space in the city, elaborate measures need to be adopted for collection, transfer, storage and disposal of excavated muck. Muck collection, transportation, disposal and its treatment need to be carried out in a systematic manner. Muck collection should be transported in containers from the tunnel excavation sites. These containers should be such that muck should not spill during movement to disposal site.

To avoid impact on land due to muck disposal, project proponent has identified options for disposal of muck by utilizing the muck for various purposes as described in following section.

- **Recycle and Reuse**: Muck generated can be reused as aggregate material for road beds, ballast for railways, construction material and graded material can be used in concrete. The re-use can be decided only after thorough geotechnical investigation, testing of the muck and choice of TBM. This alternative will require land for setting up a plant to convert the muck to a useful form.

5.7 Identification of existing services/utilities

Apart from the detailing of various other aspects involved in Detailed project report (DPR) such as Existing transportation system in the city, Major transport nodes ,Transport demand analysis, Civil engineering and alignment, Station locations, System design, Geometric design, Viaduct structure, Geo-technical investigations etc as acknowledged in previous chapters, there are several other engineering issues, which need to be analysed in enough details at the inception of such a mega infrastructure project. Accordingly, following engineering items have been studied and described in this chapter:

- Chartered utilities and planning for their diversion during construction, if necessary.
- Land acquisition necessary for the project both on permanent basis as well as temporary, including its breakup between Government and private ownership.

5.7.1 Utility and Services

While Planning for diversion of utilities viz. Sewer Lines, Water pipelines, Cables etc. during construction of metro alignment following guideline have been adopted:

- Utility services must be kept operational during the construction process and even after the completion of the project.
- All proposal should therefore ensure there uninterrupted functioning.

Large number of sub-surfaces, surface and overhead utility services viz. sewers, water mains, storm water drains, telephone cables, O.H electrical transmission lines, electric poles, traffic signals, etc. are existing along the proposed alignment. These utility services are essential and must be maintained in working order during different stages of construction, by temporary/permanent diversions or by supporting in position. Since these may affect construction and project implementation time schedule/costs, for which necessary planning/action needs to be initiated in advance.

Organizations/Departments with concerned utility services in Pune are mentioned in the table below.

Table 62 : Utility Responsibility Departments

S. No	ORGANIZATION/DEPARTMENT	UTILITY SERVICE
1.	Pune Municipal Corporation.	Surface water drains, nallahs, Water supply pipelines, Sewerage and drainage conduits, street lights.
2.	Telecommunication Department	Telecommunication cables, junction boxes, telephone posts, O.H. lines, etc.
3.	Traffic Police	Traffic signal posts, junction boxes and cable connections, etc.
4.	Electricity Board	OH & underground electric cables and electric poles
5.	BSNL	Optical Fibre

S. No	ORGANIZATION/DEPARTMENT	UTILITY SERVICE
6.	Maharashtra Natural Gas Limited	Gas Pipe Lines

5.7.1.1 Underground Utilities

The sewer/drainage/Water lines etc. generally exist in the service lanes and footpaths i.e. away from main carriageway. However, at certain points these utilities are crossing the main carriageway.

The major sewer/drainage/Water lines etc. running across the alignment and likely to be affected at certain location due to metro column foundations and are proposed to be taken care of by relocating on 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.

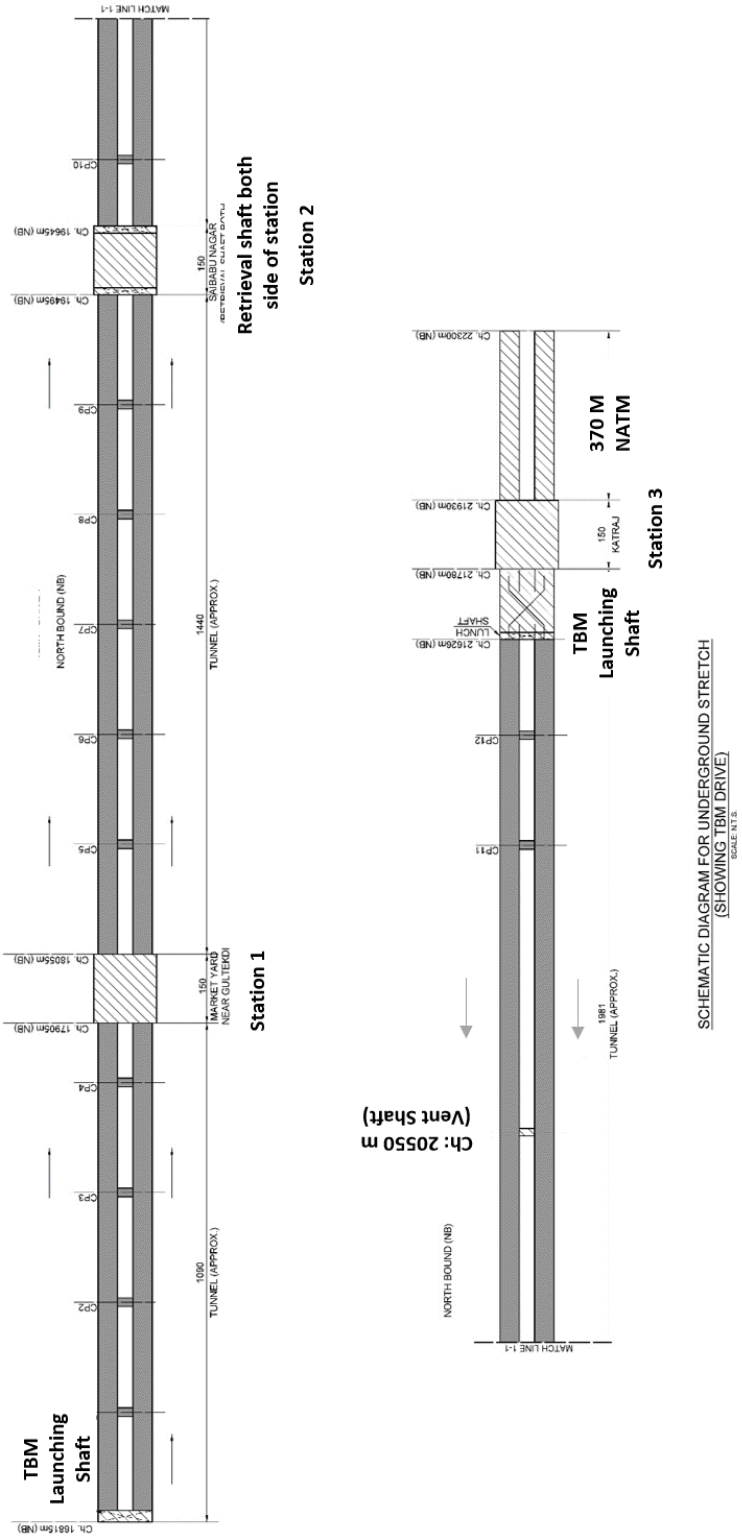
5.7.1.2 Above Ground Utilities

Above ground utilities namely street light, poles, traffic signal posts, telecommunication posts, junction boxes, trees etc., are also required to be shifted and relocated suitably during construction at locations where cut and cover methodology is proposed like station boxes , crossover location etc. Since these will be interfering with the proposed alignment.

Figure 61. Affected Over ground utilities

S.No	Utilities Affected	Location	Units
1	Light Poles	At Station and Entry Exits	31
2	Traffic Signals	At Station	5
3	Sign Boards	At Entry Exits	31
4	Hoarding Boards	At Station and Entry Exits	5
5	Electric Poles	At Station and Entry Exits	23
6	Trees	At Station and Entry Exits	146
TOTAL			241

Exhibit 1 - Tentative arrangement for TBM movement



6. STATION PLANNING

6.1.1 Overview of corridor and proposed stations

This study comprises Phase 2A, for which 3 numbers of Underground stations are proposed:

S.No	Corridor	Approx. Length of Corridor	Number of proposed Stations
Phase 2A	Swargate to Katraj	5.464 km	3

6.1.2 Station locations

This section aims at presenting the stations locations, showing their sequencing and analyzing their local catchment areas.

General

Stations have been located to serve major passenger catchment areas/destinations and to enable convenient integration with other modes of transport. The proposed route would have 3 numbers of underground stations, in continuation to the existing Metro Line (Phase 1), starting at Swargate station of Line 1, Phase 1 and terminating at Katraj. Stations vary in complexity along the route and have been located by an interactive process influenced by ridership forecasts, requirements with different modes of transport, station spacing, alignment, utilities, roads and pedestrian requirements, etc.

The following map provides an overview of the proposed corridor as well as proposed stations locations,

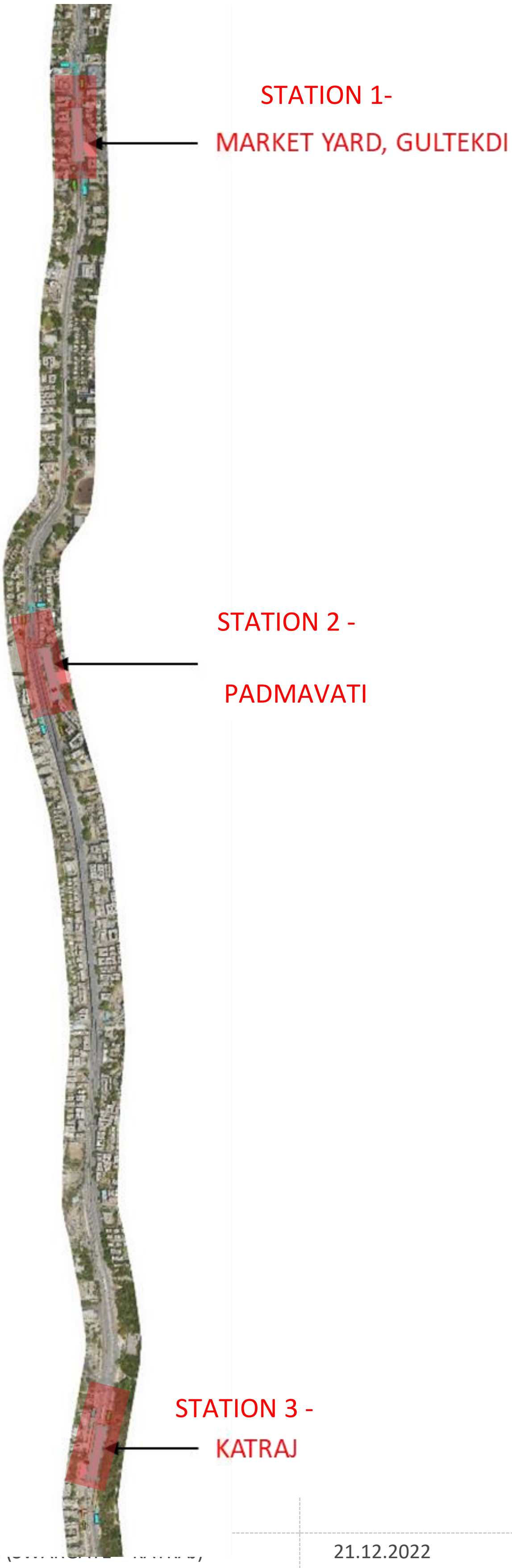

STATION 1-
MARKET YARD, GULTEKDI
STATION 2 -
PADMAVATI
STATION 3 -
KATRAJ

Figure 62. **Swargate to** Katraj **Alignment** (**Source**: SYSTRA)

6.1.3 Sequence of stations and types of proposed stations

The tables and map below present the sequence of stations and type for proposed Phase 2A :

SN	Station Name	Inter-station Distance (m)	Elevated/ Underground	Chainage
1	Market Yard, Gultekdi	1372	Underground	17982
2	Padamavati	1586	Underground	19568
3	Katraj	2291	Underground	21860

6.1.4 Stations areas characteristics

This section provides a general overview of the proposed corridor extension and the proposed station locations, existing and future local urban fabric, landmarks, access etc.;

For each station an analysis has been conducted regarding:

- The station location;
- The main roads to access the station;
- The land use around the station;
- The issues and concerns identified;
- The potential for improvements.

6.1.5 Phase 2A: Swargate to Katraj

The Phase 2A Swargate to Katraj is a 5.464 km long extension to the phase 1A line, that will run from Swargate to Katraj. It is proposed on Pune-Satara Highway.

3 Nos of Underground stations are proposed on this corridor (see figures below):

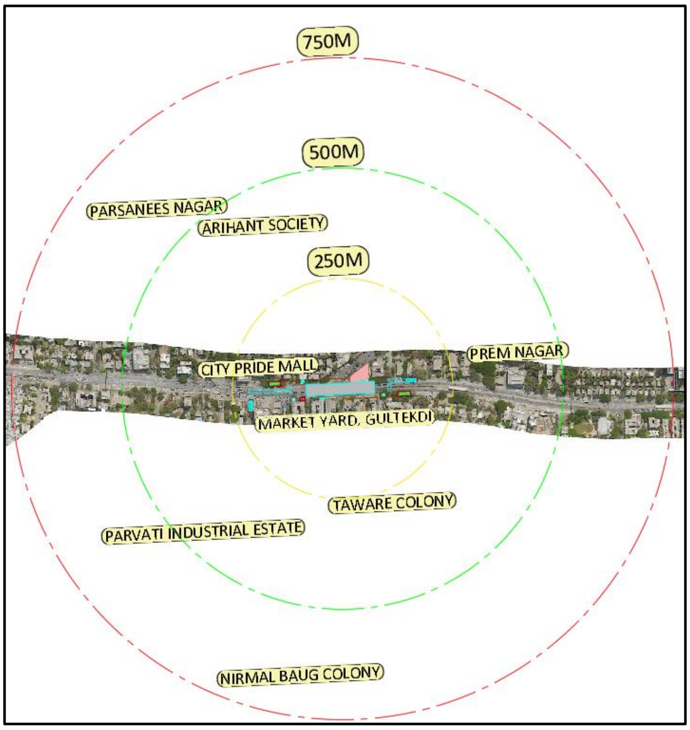


Figure 63. Station 1 (Market Yard, Gultekdi)

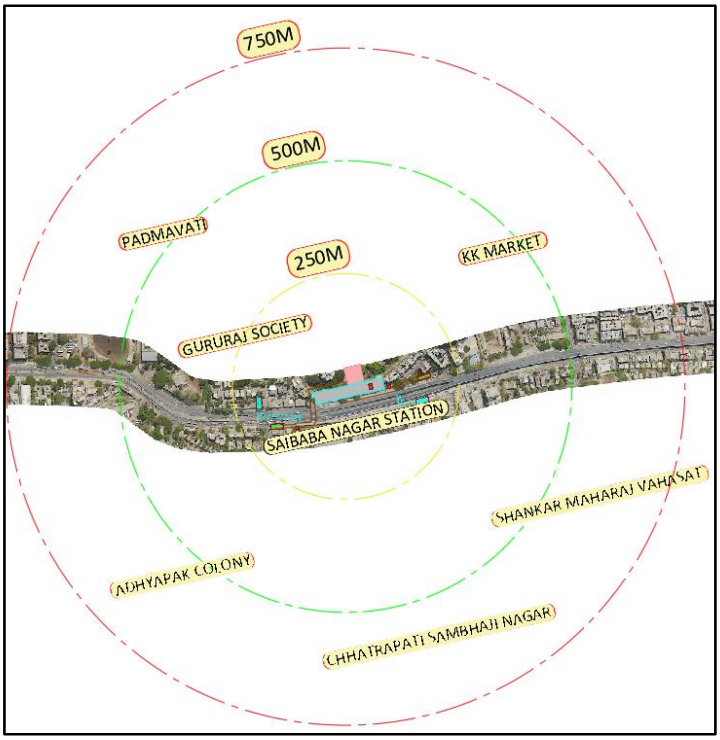


Figure 64. station 2 (Padmavati)

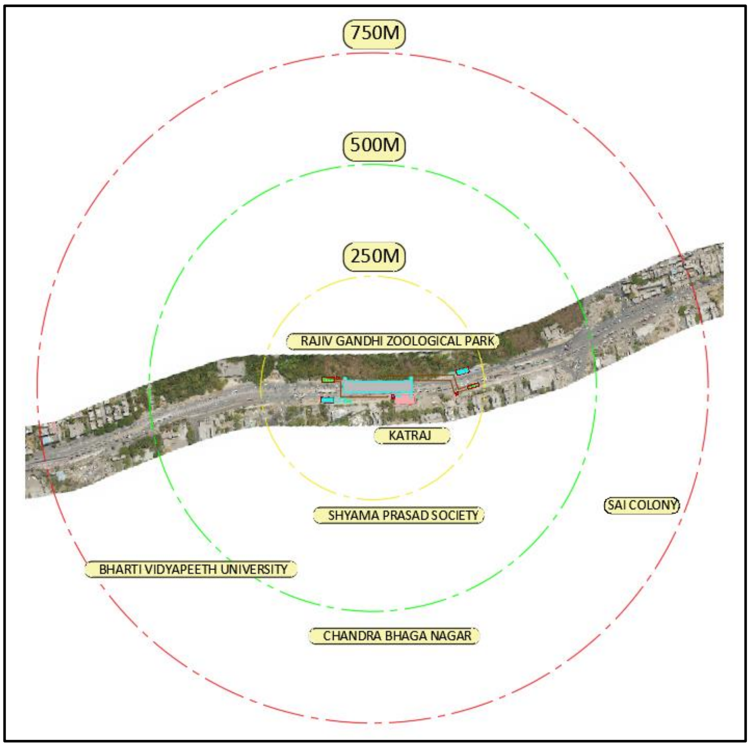


Figure 65. Station 3 (Katraj)

Local area along corridor:

- This corridor is populated with Commercial, Residential as well as Recreational establishments and is crowded (both in terms of population density and road congestion).
- Road contains flyovers / underpasses.

Areas covered by stations:

- Stations at the proposed locations cover an existing Zoological Park, an Educational campus, Residential Societies, places of worship and Commercial centers;
- Stations at the proposed locations also cover office areas as well as future developments proposed by respective local authorities.

Access to stations:

- Access to and egress from the stations will be guaranteed by the implementation of:
  - Pick-up and drop-off areas for different modes of transport (bus stops when relevant, IPT modes and car)
  - Pedestrians facilities (footpaths, pedestrian crossings, foot over bridge etc.)
  - Bicycle tracks / cycle stands etc.

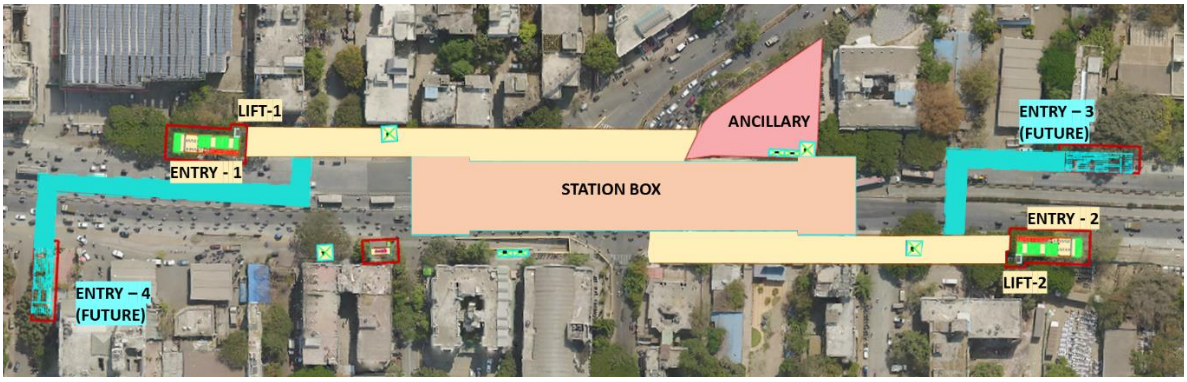
General recommendations for access/egress to/from stations will also be made;

- For optimal access to stations:
  - Four (4) entries are proposed for all stations, out of four, two entry shall be future entries.
  - Entries/exits are mostly proposed between service roads and highways;
- Entries shall be covered;
- Station entries shall be also used for crossing the road for safety purpose;
- The proposed stations shall be differently abled.

Station 1 : (Market Yard, Gutekdi)

STATION INTRODUCTION: This is the first station on the proposed extention of the Swargate-Katraj corridor. It is an underground station proposed on the Pune-Satara Highway near City Pride Mall. The major roads connecting the station are Bibwewadi Road and Bengaluru-Pune Highway. The station caters the public, semi-public, commercial, residential areas of Gultekdi and Maharshi Nagar, Walvekar Garden etc. There shall be four (4) entries to this station out of four, two entry shall be future entries.

ISSUES & CONCERN	POTENTIAL FOR IMPROVEMENT
• Lack of pedestrian facilities like footpath, pedestrian for crossing road along the road results in pedestrian spill-over on road; • Improper street Parking leads to a reduction of effective road width which eventually slows down the traffic movement.	• Dedicated pedestrian friendly footpath and FOB to ensure pedestrian safety. • Proposal to have bicycle stands. • Planning of dispersal activities through feeder modes will cater to a larger catchment.



Station Box Size : 23.73m X 153.4 m

Entry No. 1	**Entry No. 2**
	

ENTRY NO. 3	ENTRY NO. 4
	

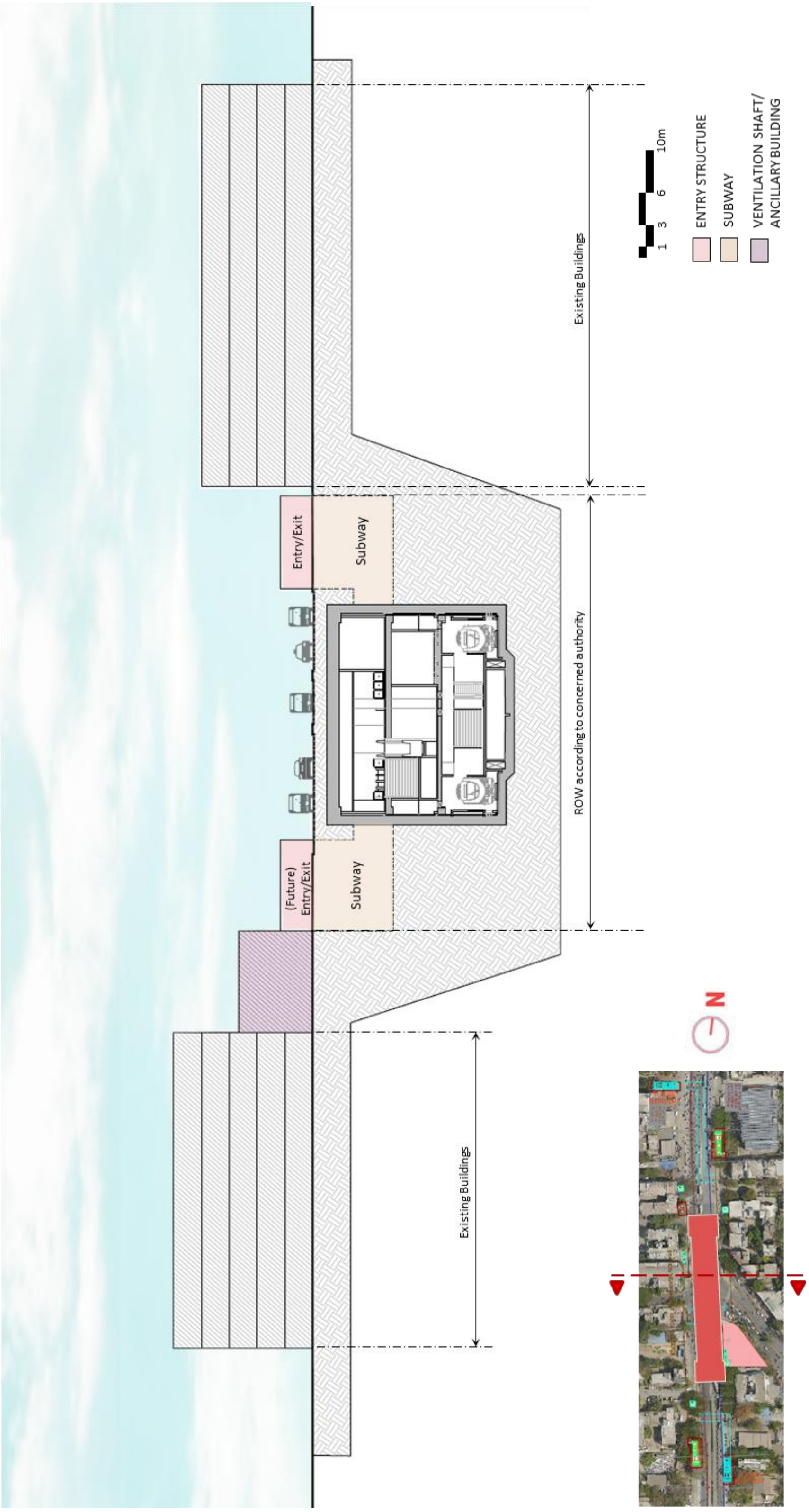
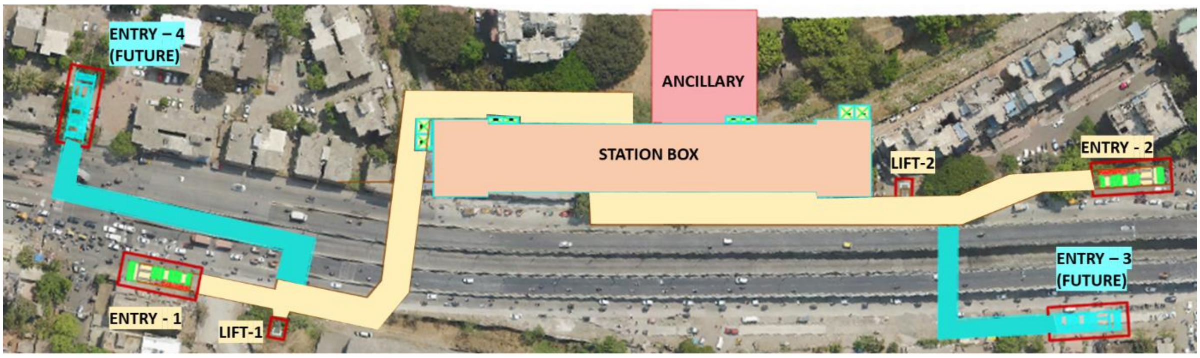


Figure 66. Station Market Yard, Gultekdi - Road Section

Station 2 (Padamavati)

STATION INTRODUCTION: This is an underground station proposed on Pune-Satara Highway near Padmavati Chowk. The major roads connecting the station is Padmawati – Shahakar Nagar Road and the KK Market road. The station provides dispersal connectivity to public, semi-public and the residential like Sant Eknath Nagar, Santosh society, Sahakar Nagar, KK Market, Padmavati. Meeta Nagar and Padmavati Mandir areas. There shall be four (4) entries to this station out of four, two entry shall be future entries.

ISSUES & CONCERN	POTENTIAL FOR IMPROVEMENT
• Lack of pedestrian facilities like footpath, pedestrian for crossing road along the road results in pedestrian spill over on road; • Improper street Parking leads to a reduction of effective road width which eventually slows down the traffic movement.	• Dedicated pedestiran friendly footpath to ensure pedestrian safety. • Planning of dispersal activities through feeder modes will cater to a larger catchment. • Removal of encroachments and optimal usage of ROW.



Station Box Size : 23.73m X 153.4 m

ENTRY NO. 1	ENTRY NO. 2
	
ENTRY NO. 3	**ENTRY NO. 4**
	

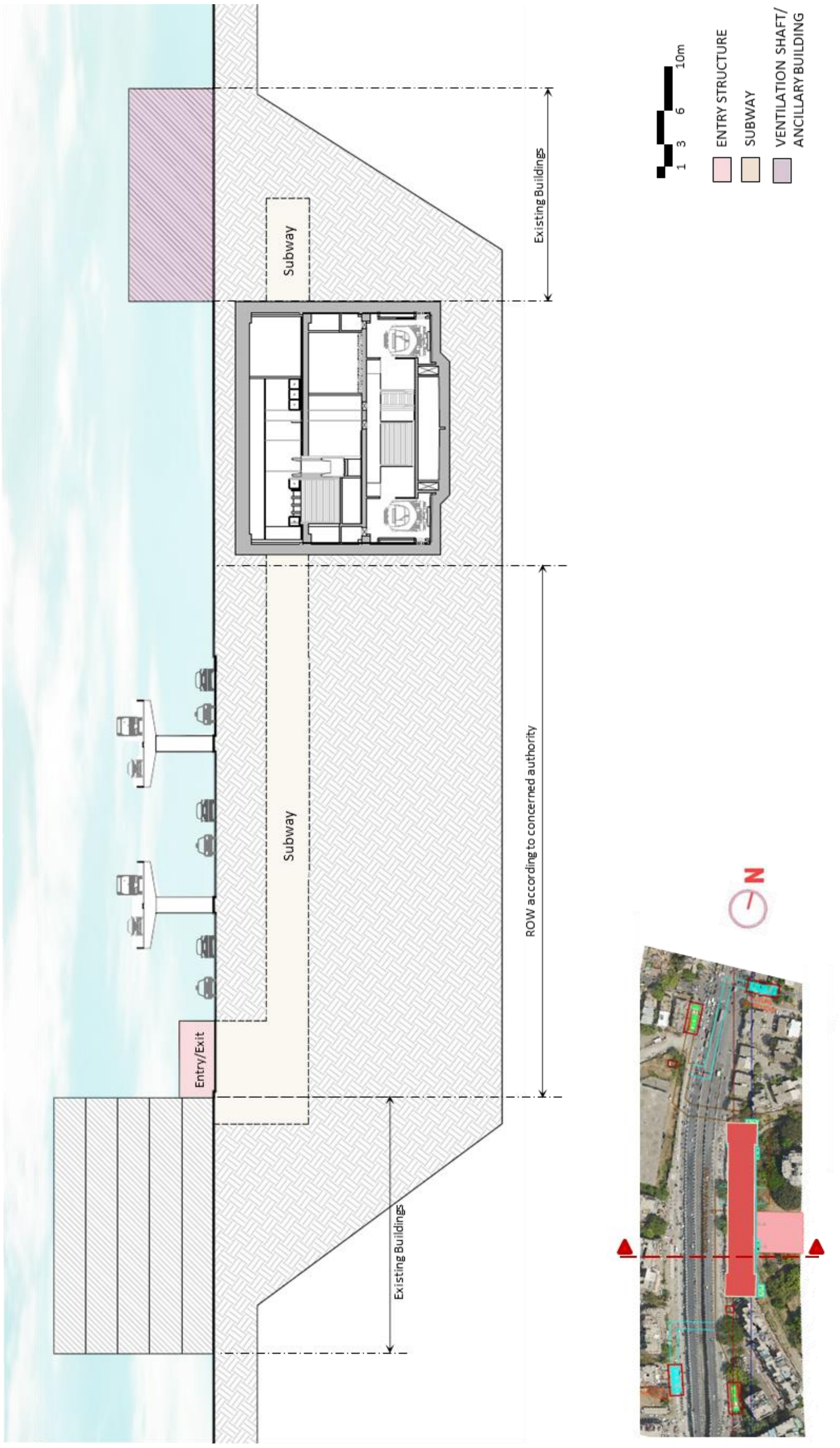
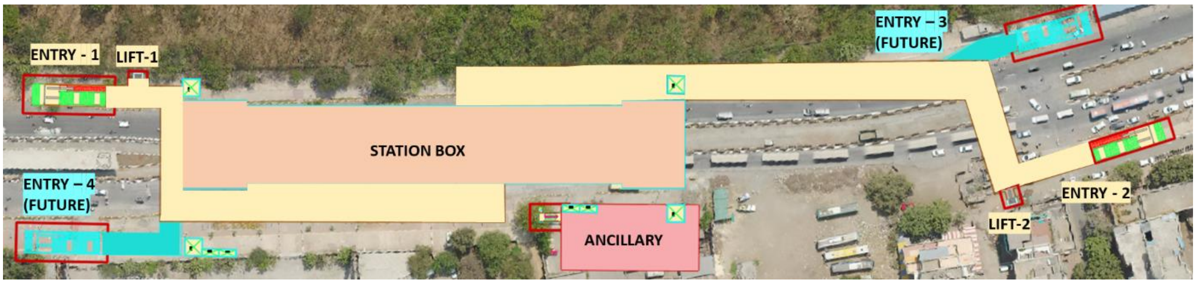


Figure 67. **Station Padamavati - Road Section**

Station 3 (Katraj)

STATION INTRODUCTION: Like other stations on the proposed extenstion, Katraj will also be an Underground station. This will be a Terminal station proposed on the junction of Pune-Satara Highway and Pune-Mumbai bypass road near Rajiv Gandhi Zoological Park and Katraj Bus Station. The station provides dispersal connectivity but not limited to the residential areas of Katraj, Tanaji Nagar, Chaitraban and Kasat Nagar. There shall be four (4) entries to this station out of four, two entry shall be future entries.

ISSUES & CONCERN	POTENTIAL FOR IMPROVEMENT
• Due to the location of the station in close proximity of the Zoological park and a Bus stations, and proximity to the cross junction of two Highways, there shall be heavy vehicular/pedestrain movement, pedestrian risk increases.	• Dedicated non-motorized modes pedestrian friendly facilities like footpath and cycle stands. • Planning of dispersal activities through feeder modes will cater to a larger catchment.



Station Box Size : 23.73 m X 153.4 m

ENTRY NO. 1	ENTRY NO. 2
	
ENTRY NO. 3	**ENTRY NO. 4**
	

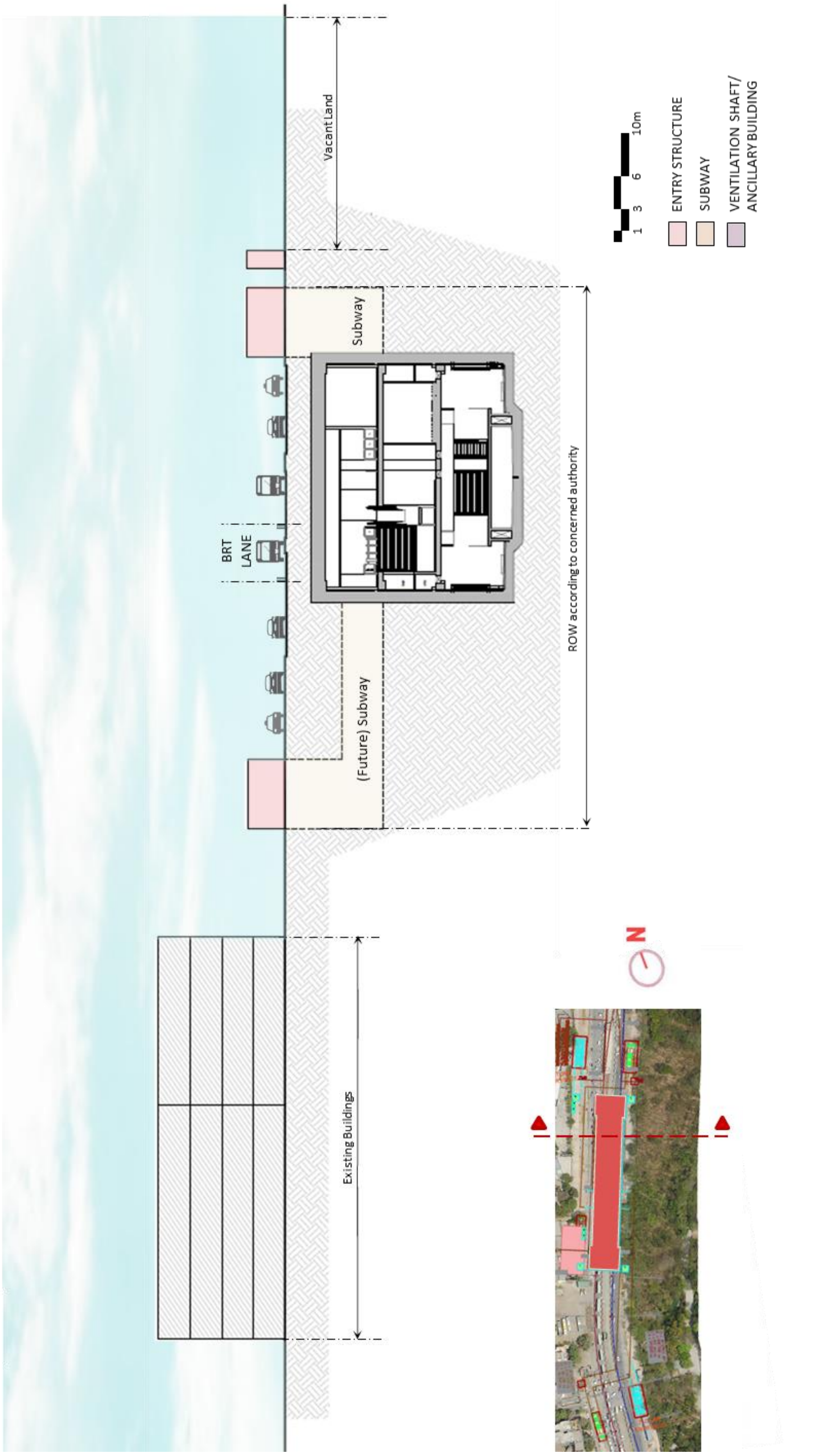


Figure 68. **Station Katraj - Road Section**

6.2 Station Planning and Design

6.2.1 Planning Parameters

The basic design of any station is based on Peak Hour loads. Single mode of authorization (token/card/ticket), which shall conform to the already existing Metro corridor of Line 1 of Phase 1, and would suffice to travel to any destination within the existing and proposed metro network shall be used.

The Station planning is dependant on the following factors :

- Underground stations are mostly planned around Island Platforms, in some cases based on the Alignment, the side platforms can also be designed.
- Ingress/egress and the boarding/alighting requirements.
- Structural requirements.
- Flexibility in design to allow stations to respond to site specific requirements.
- Station utilities like – Ventilation system
    - Fire fighting system
    - Water supply & Sewage requirements
    - Other requirements
- Provisions for future expansions, if any.

A good station design comprises of adequate movement spaces from the station entrance to the platform and vice versa in a more logical way.

6.2.2 Passengers experience

One of the main objectives of station planning and design is to maximize passengers experience. This is done by ensuring at stations :

- **Attractiveness**: The station experience shall be positive;
- **Integration with urban realm**: The station will be well integrated with the existing street and its surroundings;
- **Intermodal integration**: Design will integrate the station entries with other modes of transport;
- **Passengers-oriented**: Patrons shall experience a simple system, easy to use and accessible;
- **Comfort**: The station atmosphere will be comfortable;
- **Safe and secure**: The station will be provided with sufficient safety features

6.2.3 Salient Features of a Typical Station

- Station entrances are located with particular reference to passenger catchment points which includes buses, IPTs, pick/drop by private modes.
- Following criterion have been taken into account while planning the stations
  a. Sizing of station passenger facilities.
  b. Stipulated design standards
  c. Emergency evacuation
  d. Passenger circulation, comfort, ease of use, safety and security.
  e. Accomodation of BOH areas.
  f. Electrical and Mechanical Plant and equipment space requirements.

Table 63 STATION BOARDING/ALIGHTING IN DESIGN YEAR 2057

S.No.	STATIONS	PEAK HOUR BOARDING	PEAK HOUR ALIGHTING
1	Station 1 (MARKET YARD, GULTEKDI)	1750	1720
2	Station 2 (PADAMAVATI)	2020	1690
3	Station 3 (KATRAJ)	7130	6790

- Concourse/Mezzanine shall form the link between streets and Platforms, all the passenger amenities are provided at this level.
- Plant room, operational rooms and offices are provided in the non-public areas of the station.
- The platform level shall be designed in a way to cater for the emergency scenario as well as to operate in normal conditions.
- The Ancillary spaces like DG, Bore well pump house, water tanks (UG/overhead) must be preferably located at Ground level.

6.2.4 Platform sizing and egress calculations

- Platform areas should be designed in such a manner that it will comfortably cater normal operations as well as delayed operations. Based on Annexture J-5.1 C (**Platform Evacuation Time – NBC-2016**) -There shall be sufficient egress capacity to evacuate the platform occupant load as defined in the Annexture J-5.1 C (NBC2016) from the station platform in 4 mins or less.

TL - 6 -Train Crush Load for 6 coach rolling stock (Crush Load capacity taken from rolling stock specs)	1574	persons	Refer section 11.1.2
PL - Platform length (For 6 car train)	153.4	meters	Pune DPR, Phase 1
SF - Surge Factor	1.2	times	Assumed
ET - Time limit to evacuate platform as per NBC 2016	4	minutes	NBC, 2016 Edition ,annx - J (J-5.1, b)
ERT - Time limit to evacuate platform load from most remote point to a point of safety as per NBC 2016	6	minutes	NBC, 2016 Edition ,annx - J (J-5.1,c)
STRC - Capacity of Stairs as per NBC 2016	0.0555	persons per mili meter per minutes	NBC, 2016 Edition ,annx - J (J-5.4.4,e)
ECN - Capacity of Escalators in stopped condition as per NBC 2016	0.0555	persons per mili meter per minutes	NBC, 2016 Edition ,annx - J (J-5.4.5,g)
ECE - Capacity of Escalators in moving condition in direction of egress (it is to be ensured that such elevators will be of reversible type, emergency powered with ability to be restared again from stopped position in line with NFPA 130)	0.12	persons per mili meter per minutes	NBC, 2016 Edition ,annx - J(J-5.4.5, h)
SD - Service Disruption Period (Two headway)	2	period	NBC, 2016 Edition ,annx - J (J-4.1, g)
SI-Service Interval	3	minutes	Pune DPR
Maximum mean of egress travel speed along platform, corridors and ramp	38	meter/minute	NBC, 2016 Edition ,annx - J (J-5.4.3,d)
Time taken in afc gate	50	persons per minutes	
Vertical travel speed	14.6	meter/minute	NBC, 2016 Edition ,annx - J (J-5.4.4,e)

Platfrom Occupant Load

Station Name	Peak Hour Boarding	Peak Hour Alighting	Normal Load (Boarding /50)	F1 (Boarding /50 X 1.2)	Train Crush Load(T.L.)	Platform Occupant Laod POL({F1(3XS1)}+TL)
CORRIDOR 2A (Swargate to Katraj)						
Station 1 (MARKET YARD, GULTEKDI)	1750	1720	35	42	1574	1952
Station2 (PADAMAVATI)	2020	1690	40	48	1574	2010
Station 3 (KATRAJ)	7130	6790	143	171	1574	3114

NFPA 130 (2017) Station Egress Analysis

Station name : **STATION 1 (NEAR MARKET YARD)**
Station occupant load : 1952

Egress Element	units	mm	p/mm-min		p/min
Platform to Concourse					
Stairs	2	4000	0.0555		444.00
Moving Escalators	1	1000	0.12		120.00
Emergency Stairs	2	1500	0.0555		166.50
				Total	730.50
Concourse to Mezzanine					
Stairs	2	4000	0.0555		444.00
Moving Escalators	1	1000	0.12		120.00
Emergency Stairs	2	1500	0.0555		166.50
				Total	730.50
Through Fare Barriers					
Fare Gates	14		50		700.00
Service Gates	2	1000	81.9		163.80
Emergency Gates	0	1000	81.9		0.00
				Total	863.80
Fare Barriers to Safe Area					
Stairs	4	4500	0.0555		999.00
Moving Escalators	3	1000	0.12		360.00
				Total	1359.00

Walking Time for Longest Exit Route			m	m/min		Minutes
Central Platform						
On Platform	T1	horizontal	45.00	38		1.18
Platform to Concourse	T2	vertical	5.00	14.6		0.34
On Concourse	T3	horizontal	35.00	38		0.92
Concourse to Mezzanine	T4	vertical	5.60	14.6		0.38
T (total walking time) = T1+T2+T3+T4					Total	2.83
On Mezzanine(Till AFC)	T5	horizontal	30.00	38		0.79
On Mezzanine(AFC to Stairs)	T6	horizontal	45.00	38		1.18
Mezzanine to grade	T7	vertical	8.49	14.6		0.58
On grade to safe area	T8	horizontal	3.00	38		0.08
T' (total walking time) = T1+T2+T3+T4+T5+T6+T7+T8					Total	5.47

*one escalator discounted

Test No. 1 : Evacuate platform occupant load(s) from platform(s) in 4 minutes or less

Fp (time to clear platform) = $\frac{\text{Platform occupant load}}{\text{Platform exit capacity}}$ Fp= $\frac{1952}{730.50}$ = **2.67** min

Test Fp <= 4.0

Test No. 2 : Evacuate platform occupant load from most remote point on platform to a point of safety(Mezzanine) in 6 minutes or less

Wp (waiting time at platform exits) = Fp-T1
Wp = 1.49 min
Concourse occupant load - (Fp - emergency stair capacity)
Concourse occupant load = 1786
Wc (waiting time at Concourse exits) = [Fc-max(Ffb or Fp)]

Fc(Mezzanine exit flow time) = $\frac{\text{Concourse occupant load}}{\text{Concourse exit capacity}}$ Fc = $\frac{1786}{863.80}$ = 2.07 min

Wc = Fc - max(Ffb or Fp) (if Wc<0 ---- Wc=0)
Wc = -0.61 min

Total exit time = T + Wp+ Wc Total = **4.32** min

Test <= 6

Test No. 3 : Evacuate Platform occupant load from most remote point on Platform to a point of safety (Ground) in 6 minutes or less

Wp (waiting time at platform exits) = Fp-T1
Wp = 1.49 min
Mezzanine occupant load - (Fp - emergency stair capacity)
Mezzanine occupant load = 1786
Wf (waiting time at fare barriers) = Ffb - Fp

Ffb (fare barrier flow time) = $\frac{\text{Mezzanine occupant load}}{\text{Fare barrier exit capacity}}$ Ffb = $\frac{1786}{700}$ = 2.55 min

Wf = Ffb - Fp
Wf = -0.12 min
Wc (waiting time at Mezzanine exits) = [Fc-max(Ffb or Fp)]

Fc(Mezzanine exit flow time) = $\frac{\text{Mezzanine occupant load}}{\text{Mezzanine exit capacity}}$ Fc = $\frac{1786}{1359.00}$ = 1.31 min

Wc = Fc - max(Ffb or Fp) (if Wc<0 ---- Wc=0)
Wc = -1.36 min
Total exit time = T + Wp + Wf + Wc Total = **6.95** min

Test <= 6

Hence, As per given above calculation Point of safety will be Mezzanine.

NFPA 130 (2017) Station Egress Analysis

Station name : **STATION 2 (NEAR SAI BABA NAGAR)**
Station occupant load : 2010

Egress Element	units	mm	p/mm-min		p/min
Platform to Concourse					
Stairs	2	4000	0.0555		444.00
Moving Escalators	1	1000	0.12		120.00
Emergency Stairs	2	1500	0.0555		166.50
				Total	730.50
Concourse to Mezzanine					
Stairs	2	4000	0.0555		444.00
Moving Escalators	1	1000	0.12		120.00
Emergency Stairs	2	1500	0.0555		166.50
				Total	730.50
Through Fare Barriers					
Fare Gates	16		50		800.00
Service Gates	2	1000	81.9		163.80
Emergency Gates	0	1000	81.9		0.00
				Total	963.80
Fare Barriers to Safe Area					
Stairs	4	4500	0.0555		999.00
Moving Escalators	3	1000	0.12		360.00
				Total	1359.00

Walking Time for Longest Exit Route			m	m/min		Minutes
Central Platform						
On Platform	T1	horizontal	45.00	38		1.18
Platform to Concourse	T2	vertical	5.00	14.6		0.34
On Concourse	T3	horizontal	35.00	38		0.92
Concourse to Mezzanine	T4	vertical	5.60	14.6		0.38
T (total walking time) = T1+T2+T3+T4					**Total**	2.83
On Mezzanine(Till AFC)	T5	horizontal	30.00	38		0.79
On Mezzanine(AFC to Stairs)	T6	horizontal	45.00	38		1.18
Mezzanine to grade	T7	vertical	10.07	14.6		0.69
On grade to safe area	T8	horizontal	3.00	38		0.08
T' (total walking time) = T1+T2+T3+T4+T5+T6+T7+T8					**Total**	5.57

*one escalator discounted

Test No. 1 : Evacuate platform occupant load(s) from platform(s) in 4 minutes or less

Fp (time to clear platform) = $\frac{\text{Platform occupant load}}{\text{Platform exit capacity}}$ Fp= $\frac{2010}{730.50}$ = 2.75 min

Test Fp <= 4.0

Test No. 2 : Evacuate platform occupant load from most remote point on platform to a point of safety(Mezzanine) in 6 minutes or less

Wp (waiting time at platform exits) = Fp-T1
Wp = 1.57 min
Concourse occupant load - (Fp - emergency stair capacity)
Concourse occupant load = 1844
Wc (waiting time at Concourse exits) = [Fc-max(Ffb or Fp)]

Fc(Mezzanine exit flow time) = $\frac{\text{Concourse occupant load}}{\text{Concourse exit capacity}}$ Fc = $\frac{1844}{963.80}$ = 1.91 min

Wc = Fc - max(Ffb or Fp) (if Wc<0 ----- Wc=0)
Wc = -0.84 min

Total exit time = T + Wp+ Wc Total = 3.56 min

Test <= 6

Test No. 3 : Evacuate Platform occupant load from most remote point on Platform to a point of safety (Ground) in 6 minutes or less

Wp (waiting time at platform exits) = Fp-T1
Wp = 1.57 min
Mezzanine occupant load - (Fp - emergency stair capacity)
Mezzanine occupant load = 2010
Wf (waiting time at fare barriers) = Ffb - Fp

Ffb (fare barrier flow time) = $\frac{\text{Mezzanine occupant load}}{\text{Fare barrier exit capacity}}$ Ffb = $\frac{2010}{800}$ = 2.51 min

Wf = Ffb - Fp
Wf = -0.24 min
Wc (waiting time at Mezzanine exits) = [Fc-max(Ffb or Fp)]

Fc(Mezzanine exit flow time) = $\frac{\text{Mezzanine occupant load}}{\text{Mezzanine exit capacity}}$ Fc = $\frac{2010}{1359.00}$ = 1.48 min

Wc = Fc - max(Ffb or Fp) (if Wc<0 ----- Wc=0)
Wc = -1.27 min
Total exit time = T + Wp + Wf + Wc Total = 6.90 min

Test <= 6

Hence, As per given above calculation Point of safety will be Mezzanine.

NFPA 130 (2017) Station Egress Analysis

Station name : **STATION 3 (NEAR KATRAJ)**

Station occupant load : 3114

Egress Element	units	mm	p/mm-min		p/min
Platform to Concourse					
Stairs	2	2400	0.0555		266.40
Moving Escalators	3	1000	0.12		360.00
Emergency Stairs	2	1500	0.0555		166.50
				Total	792.90
Concourse to Mezzanine					
Stairs	2	2400	0.0555		266.40
Moving Escalators	3	1000	0.12		360.00
Emergency Stairs	2	1500	0.0555		166.50
				Total	792.90
Through Fare Barriers					
Fare Gates	15		50		750.00
Service Gates	2	1000	81.9		163.80
Emergency Gates	0	1000	81.9		0.00
				Total	913.80
Fare Barriers to Safe Area					
Stairs	4	4500	0.0555		999.00
Moving Escalators	3	1000	0.12		360.00
				Total	1359.00

Walking Time for Longest Exit Route			m	m/min		Minutes
Central Platform						
On Platform	T1	horizontal	45.00	38		1.18
Platform to Concourse	T2	vertical	5.00	14.6		0.34
On Concourse	T3	horizontal	35.00	38		0.92
Concourse to Mezzanine	T4	vertical	5.60	14.6		0.38
T (total walking time) = T1+T2+T3+T4					**Total**	2.83
On Mezzanine(Till AFC)	T5	horizontal	30.00	38		0.79
On Mezzanine(AFC to Stairs)	T6	horizontal	45.00	38		1.18
Mezzanine to grade	T7	vertical	8.06	14.6		0.55
On grade to safe area	T8	horizontal	3.00	38		0.08
T' (total walking time) = T1+T2+T3+T4+T5+T6+T7+T8					**Total**	5.44

*one escalator discounted

Test No. 1 : Evacuate platform occupant load(s) from platform(s) in 4 minutes or less

$$\text{Fp (time to clear platform)} = \frac{\text{Platform occupant load}}{\text{Platform exit capacity}} \qquad Fp = \frac{3114}{792.90} = \boxed{3.93} \text{ min}$$

Test Fp <= 4.0

Test No. 2 : Evacuate platform occupant load from most remote point on platform to a point of safety(Mezzanine) in 6 minutes or less

Wp (waiting time at platform exits) = Fp-T1

Wp = 2.74 min

Concourse occupant load - (Fp - emergency stair capacity)

Concourse occupant load = 2947.58

Wc (waiting time at Concourse exits) = [Fc-max(Ffb or Fp)]

$$\text{Fc(Mezzanine exit flow time)} = \frac{\text{Concourse occupant load}}{\text{Concourse exit capacity}} \qquad Fc = \frac{2948}{792.90} = 3.72 \text{ min}$$

Wc = Fc - max(Ffb or Fp) (if Wc<0 ---- Wc=0)

Wc = -0.21 min

Total exit time = T + Wp+ Wc — Total = $\boxed{5.57}$ min

Test <= 6

Test No. 3 : Evacuate Platform occupant load from most remote point on Platform to a point of safety (Ground) in 6 minutes or less

Wp (waiting time at platform exits) = Fp-T1

Wp = 2.74 min

Mezzanine occupant load - (Fp - emergency stair capacity)

Mezzanine occupant load = 3114

Wf (waiting time at fare barriers) = Ffb - Fp

$$\text{Ffb (fare barrier flow time)} = \frac{\text{Mezzanine occupant load}}{\text{Fare barrier exit capacity}} \qquad Ffb = \frac{3114}{750} = 4.15 \text{ min}$$

Wf = Ffb - Fp

Wf = 0.22 min

Wc (waiting time at Mezzanine exits) = [Fc-max(Ffb or Fp)]

$$\text{Fc(Mezzanine exit flow time)} = \frac{\text{Mezzanine occupant load}}{\text{Mezzanine exit capacity}} \qquad Fc = \frac{3114}{1359.00} = 2.29 \text{ min}$$

Wc = Fc - max(Ffb or Fp) (if Wc<0 ---- Wc=0)

Wc = -1.64 min

Total exit time = T + Wp + Wf + Wc — Total = $\boxed{8.18}$ min

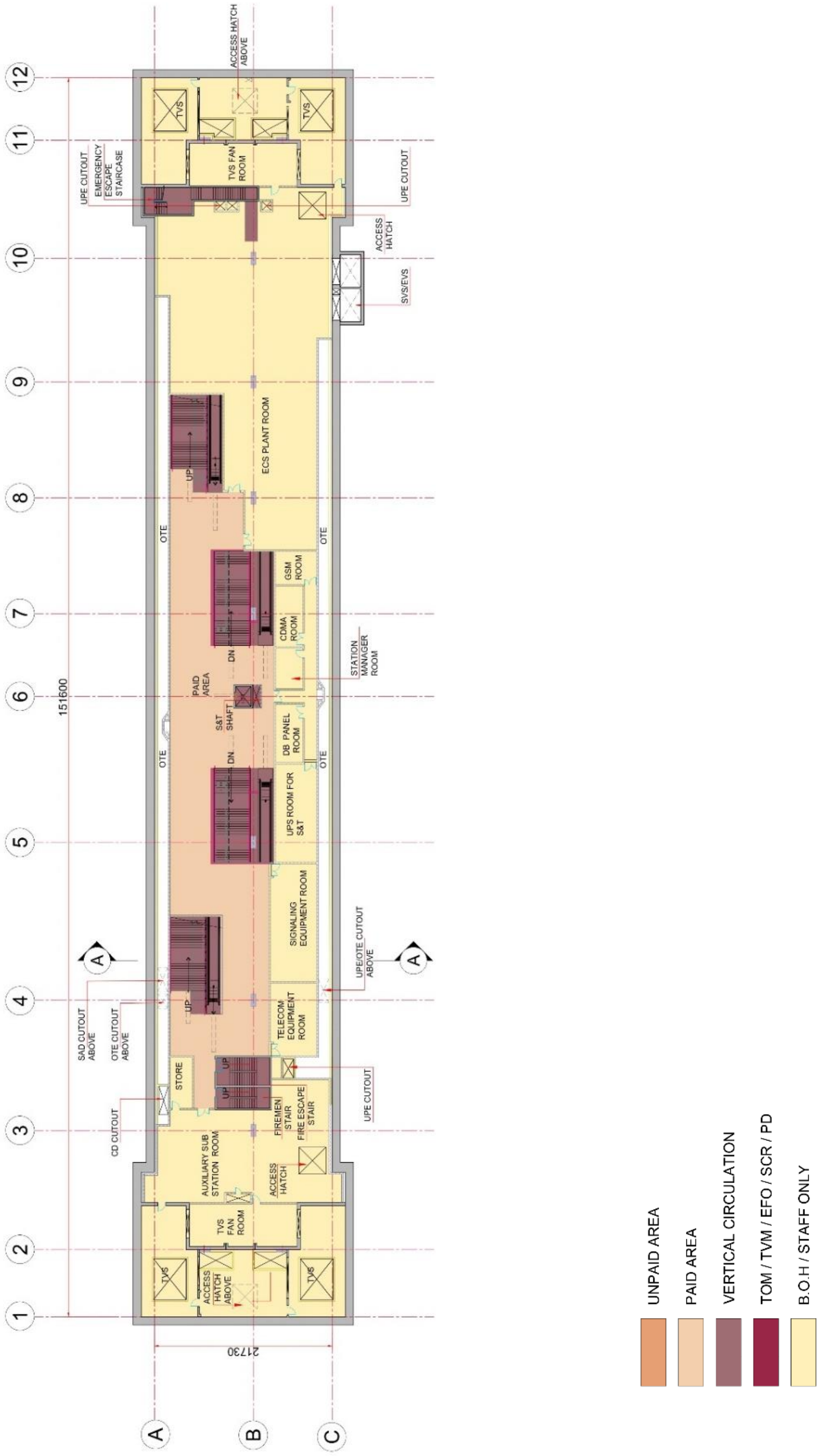
Test <= 6

Hence, As per given above calculation Point of safety will be Mezzanine.

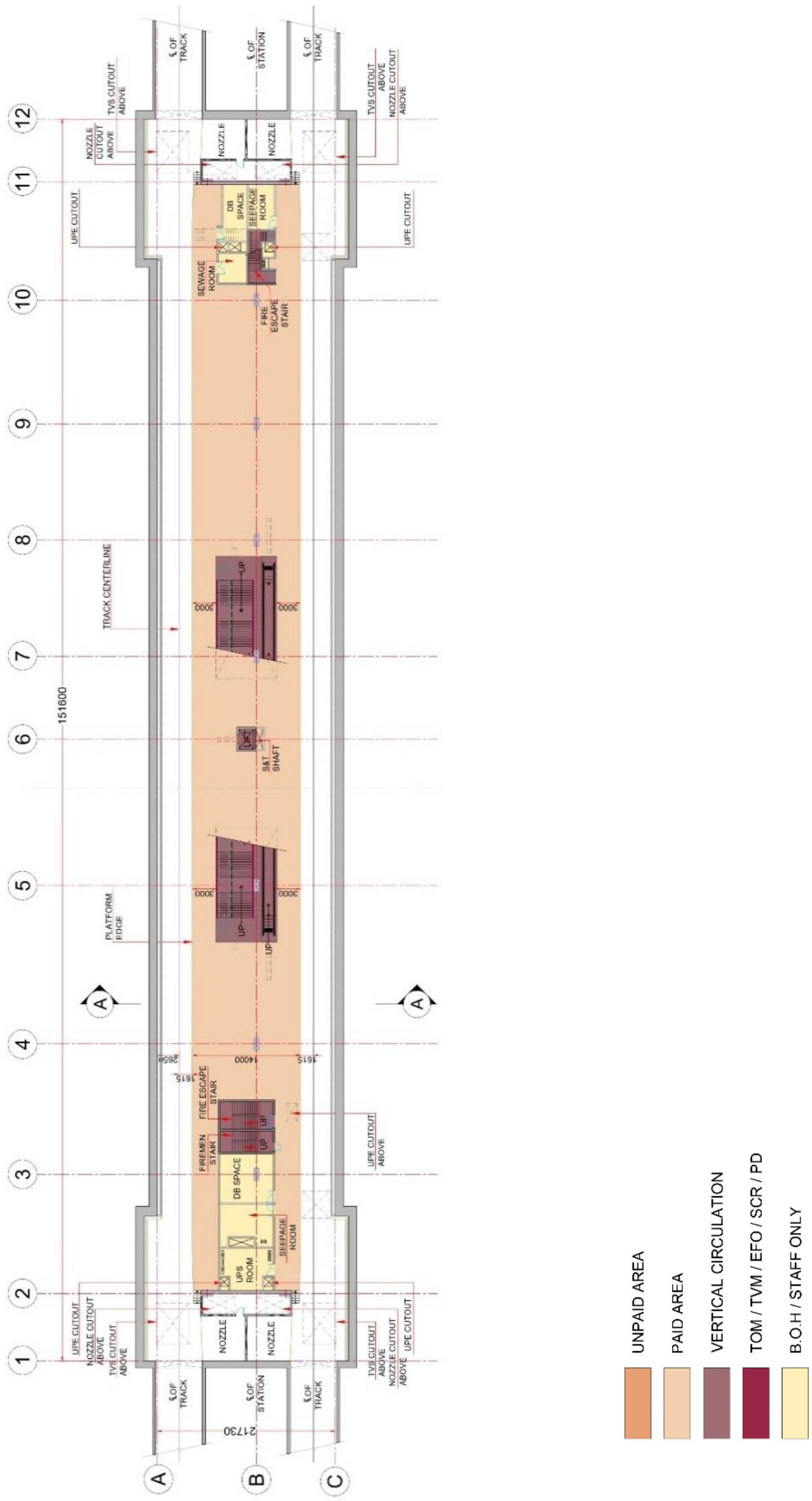
- **Typical Station 151.6 m (internal length)**

MEZZANINE LEVEL FLOOR PLAN

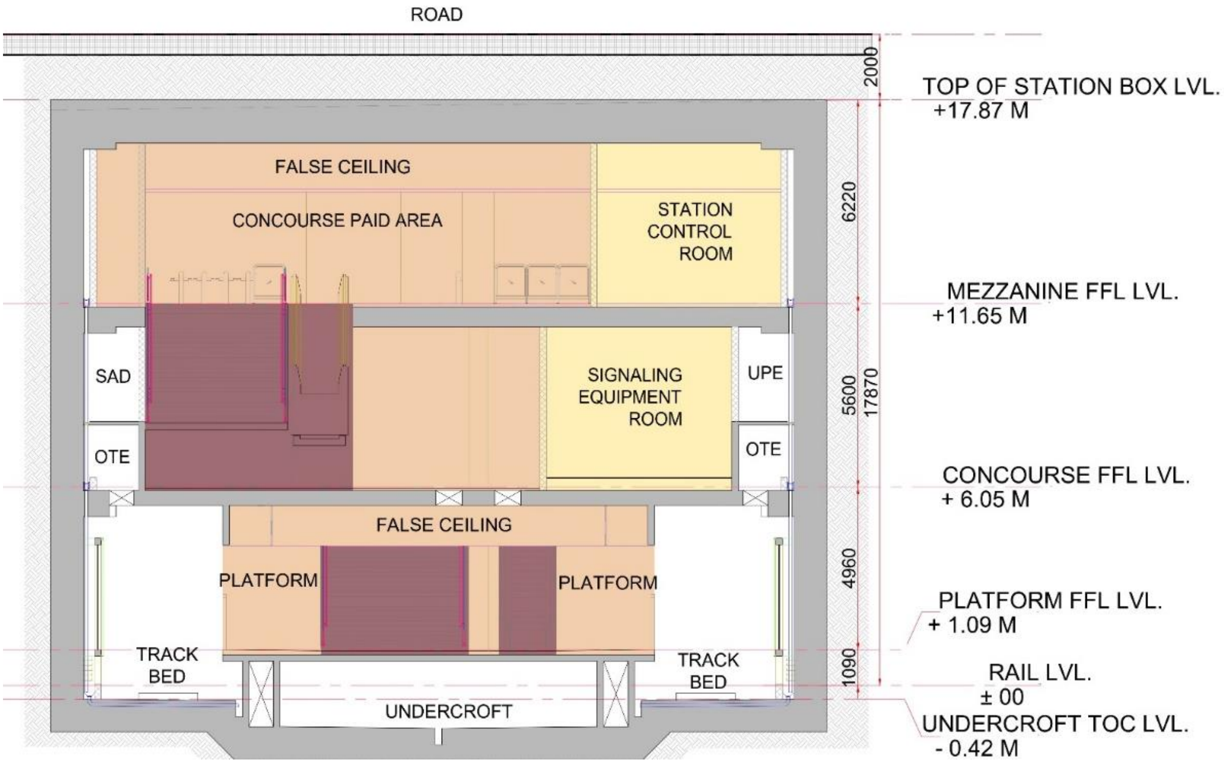
CONCOURSE LEVEL FLOOR PLAN



PLATFORM LEVEL FLOOR PLAN



Typical Cross Section



STATION	LENGTH (in m)	WIDTH (in m)
Station 1 (MARKET YARD, GULTEKDI)	153.4	23.73
Station 2 (PADAMAVATI)	153.4	23.73
Station 3 (KATRAJ)	153.4	23.73

- **AREA CHART**

S.No.	Room Name	Area (SQM)
AREA FOR UNDERGROUND STATION (MEZANNINE LEVEL)		
1	ECS Plant Room	693
2	Station Control Room (SCR)	48
3	Emergency Equipment Room	26
4	Security Room	20
5	First Aid Room	20
6	Staff/ Mess Room	40
7	ASS Room	230
8	Women's Toilet	12
9	Men's Toilet	14
10	Handicapped Toilet	9
11	Changing Room	4
12	Ticket Office Machine (TOM)	18
13	EFO	10
AREA FOR UNDERGROUND STATION (CONCOURSE LEVEL)		
1	Auxiliary Sub Station Room	267
2	UPS Room for S&T	60
3	TER	51
4	Signaling Equipment Room (SER)	81
5	DB Panel Room	24
6	Station Manager Room	16
7	CDMA Room	25
8	GSM Room	20
9	ECS Plant Room	668
10	Store	17
AREA FOR UNDERGROUND STATION (PLATFORM LEVEL)		
1	DB Space (1)	20
2	DB Space (2)	38
3	Seepage Room (1)	17
4	Seepage Room (2)	29
5	Sewage Room	12
6	UPS Room for S&T	31

Note : All room sizes to be finalized at subsequent detail stage.

6.3 Planning Norms & Standards

General

- The design year maximum PHPDT (Peak Hour Peak Direction Traffic) of about 28170 passengers between Swargate and Katraj is considered for planning the passenger facilities at stations.
- The platform is designed for 6 Nos of cars train.
- Based on Annexture J-5.1 C (**Platform Evacuation Time – NBC-2016**) -There shall be sufficient egress capacity to evacuate the platform occupant load as defined in the Annexture J-5.1 C (NBC2016) from the station platform in 4 mins or less.
- The station planning shall be in compliance to "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 and National Building Code (NBC).

a. Entry / Exit

- All entrances to the stations shall comply to the predicted passenger flows and emergency requirements.
- The locations of the Entrances have been decided after aligning the station box on the proposed alignment and roadway, footpath width and catchment areas.
- The width of the entrances shall be determined by the passenger flow and available space.
- The station entrances shall be protected against flooding and hence it is proposed to have a higher landing at the entrance (+450mm min from the Road/footpath level).

b. Walkways / Ramps

- Walkways / Ramps are planned to reduce the walking distances and the passenger movements. Efforts to be taken to design in a way that cross flows are avoided.

- Minimum Corridor width

i. Unidirectional Movement	1.8m
ii. Bi-directional Movement	2.4m
iii. Where the length of the corridor is more than 30m	3.0m
iv. For Staff	1.2m

- Ramps

i. Preferred Gradient	1:20
ii. Maximum Gradient	1:12
iii. Minimum width (unidirectional movement)	1.2m
iv. Minimum width (bi-directional movement)	1.5m

v. For Ramps exceeding 10m, rest platform 1.5m

c. Concourse / Mezzanine Planning Standards

i. The arrangements of the Concourse / Mezzanine depends on an individual station, the space constraints, the requirements and site issues all add to the determination of the final Concourse. Concourse / Mezzanine are designed in a way to have maximum surveillance by the hall supervisor over the ticket machines and houses the following,
- Ticket Machines
- AFC gates
- Stairs
- Escalators

There must be enough queuing space at the AFC gates for the passengers and the arrangement is planned in a way to avoid cross flows of traffic.

ii. The Concourse / Mezzanine consist of 'Public Areas' and 'Non-Public Areas', which are described in the following way,
- Non Public areas house the BOH areas – Power Supply & Traction (PST)
- System Rooms
- Operations
- Staff Facilities
- Tunnel Ventilation System
- Station Ventilation System
- Water supply & Drainage system
- Miscellaneous requirements

The 'Public Areas' are further divided in to 'Paid Areas' and 'Unpaid Areas'. In 'unpaid areas' Passengers obtain travel informaton, tickets and gain access to the system, whereas in the 'Paid Areas' includes access to the Platform after obtaining tickets.

iii. Passenger Handling Capacities: these facilities are provided at the concourse and act as a medium between 'Paid' and 'Unpaid' areas, these include stairs, escalators, lifts, ticket counters, automatic ticket vending machines and ticket gates. These facilities also enable the evacuation of the station under Emergency.

Operation Rooms for Public Use

Ticketing Gates

a. The requirement of the number of Gates is based on the Peak Hour passenger traffic at the station.
b. Ticketing Gates' requirements have been calculated taking the gate capacity as 28 persons per minute per gate (80% of the assumed capacity of 35 persons per gate).

Minimum of 2 (two) numbers of Ticketing gates shall per provided per station. In case of any breakdown the spare gate can serve the purpose, even if the requirement is for just one gate at any particular station.

c. The Gate design shall depend upon
- Check in and check out
- Smart card, magnetic or paper ticket.

d. Special gates shall be designed for,
- Physically disabled
- Customers with luggage
- Customers with strollers.

Ticket counters and Ticket Vending Machines (TVMs)

a. Initially manual ticket issuing counters shall be provided at the stations which shall be replaced by automatic TVMs at the concourse (provision shall be made in the design)

b. The number of TVMs required is governed by the peak house passenger traffic, the fare policy and the ticketing. The numbers of TVMs can change depending upon the numbers of users for smart cards, single ticket users. In general, 7 to 10 TVMs are provided for stations with heavy footfall and 2 to 5 TVMs are provided for other stations.

Figure 69. Tentative TVMs (Ticket Vending Machines) at stations

Ticket Office

a. The numbers of Ticket office is determined by the passenger traffic and the operation policy.

b. 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 70. Ticket office at stations

First Aid Room
This room is not a station specific room but is made for Technical provisions of the Project, can be used as a detention room , if needed.

Passenger Amenities
Toilet for the physcially disabled to be in the 'Paid Area'.

Operations Rooms for Staff Use Only

Safe Deposit
A safe deposit room next to the main ticket office, TVM back store & SMCR with restricted and monitored access, connected with the operational area shall be provided.

Male / Female Toilet.
It is recommended to fit the stations with specific toilets for the employees/ passengers. Separate male and female toilets are proposed for each station. The Toilets shall only be located in the 'Paid Area'.

Operations Rooms in Terminal Stations or Intermediate Terminal Station

Train Drivers rooms
In case of start and shut down operation directly in Terminals with stabled trains during the night, train driver rooms are required. These rooms allow the conductors to sign on/sign off and receive special orders. These rooms are preferably located at the platform level and include,

- Train drivers dispatch office,
- Training room / emergency room,
- Operation storage room
- Male and female separate lockers rooms

- Restrooms

d. Passenger Handling Facilities

Escalator Requirements

Standards, Codes and Regulations

The following standards shall form a basis of the design,

- Indian Standards (IS)
- American National Standard Institute (ANSI)
- American Society of Testing Materials (ASTM)
- International Electro Technical Commission (IEC)
- European Norm (EN)
- National Electrical Manufaturers Association (NEMA)
- National Fire Protection Association (NFPA)
- Underwriter's Laboratories (UL)

Design Criteria

The Escalators shall be heavy duty 'Public Service Escalators', capable of operating safely, smoothly and continously in either direction, for a period of not less than 16 hours a day, seven days a week. The following criteria shall be adopted :

- Energy saving system
- Protective barriers
- NFPA 130 standards

Escalators shall be used as emergency staircases in case of power failure.

Interfacing requirements

Elevator Requirements

Standards, Codes and Regulations

The following regulations and standards will form the basis for planning and elevator system.

- Indian Standards (IS)
- American National Standard Institute (ANSI)
- American Society of Testing Materials (ASTM)
- International Electro Technical Commission (IEC)
- European Norm (EN)
- National Electrical Manufaturers Association (NEMA)
- National Fire Protection Association (NFPA)
- Underwriter's Laboratories (UL)

Design Criteria

The Lifts shall be goods/passenger public service type, the following criterion shall be followed,

- Working period of 20 hours a day, 7 days a week.
- Sized comfortably for a stretcher / wheel chair.
- Lift shall be machine room less type
- Provision of intercom within the car

Interfacing requirements

Stairs Requirements

- If the stair width is 4.5m or more, central handrail shall be provided.
- Risers per flight: 3 minimum, 12 maximum
- All steps in a flight if stairs to have similar dimensions
- Tread width of the stairs to be 300mm
- Risers shall be 150mm
- Length of the intermediate landing: lesser of 2m or width of stairs
- Handrail: 0.9m high, 50mm dia, 45mm clearance to wall
- Step nosing shall be rounded and color contrasted.
- Minimum stair width for public use: 2400 mm
- Enclosed staircase in the means of egress shall be minimum 1200mm wide.

e. Platform Design Standards

i. The length of the Platform shall be 140m,to allow for the length of 6 car train.

ii. The nominal platform edge of any continous fixed structure (length more than 2m) shall be min 3000mm. The minimum distance from the platform edge to an isolated obstruction like column (length less than 2m) shall be not less than 2000mm.

iii. The Platform edge shall have a safety margin of 600mm wide with a non slip surface and a yellow warning strip of 100 mm side of contrasting texture.

iv. Platform ends shall be provided with a 1200 mm side security gate and shall be installed with a Pressure Mat Alarm system.

v. Platform widths shall cater to the following,
  - Normal Service: platform width = (peak minute flow x 0.5 sqm/person & headway) / Platform Length
  - Delayed / Emergency Service: The Platform width shall be determined by the peak minute flow, allowing for 2 headways. The cursh load is assumed as sectional load between 2 stations. For an Island platform, the areas between the boundaries of 2 platforms can be included in the calculation.

vi. Platforms shall be laid to fall at 1:100 from the inner face of the platform towards the back of the platform.

vii. There shall be markings on the platforms to assist and control the flow of traffic for boarding and alighting the trains.

viii. Stairs, escalators, structure, seating, platform supervisor accomodation shall not be included as a part of Platform area.

f. Emergency Evacuation Standards

i. Evacuation of people from platform to another location (level below/above and then to street), without hindrance shall be followed on following principles,
  - The max travel distance on the platform to a point of safety at which a means of egress route leaves the platform shall not be more than 100m.
  - Time required walking from farthest point on a Platform to the Escalator or stair landing must be considered. Walking speed is assumed to be 1m/s.
  - The Emergency is assumed to be occuring in one direction of travel only at any given point of time.

ii. Waiting passengers at the Platform (including two missed headways) and section load is expected to be evacuated during any unforeseen emergency. The Platform area, stair widths, additional emergency evacuation stairs shall be designed and decided accordingly.

iii. 500mm uncoccupied zone adjacent to the Platform edge shall be included in the calculations.

g. Commercial Programs

Advertising Areas

i. Advertising has a huge commercial benefits for the products which are advertised. Station with bigger footfall has better benefits for the product.

ii. The following shall be considered for advertising,
  - Passenger traffic
  - Space and location requirements for the advertisement
  - Importance of light and colours around the advertisement posters
  - A sales agency shall manage and maintain the advertisement space.

iii. Preferable locations may include the following,
  - On the walls behind the escalators
  - On the walls of the first level of the escalators
  - Inside the Rolling Stock
  - On the Platforms (20% spaces on the Platforms can be used for Advertising).

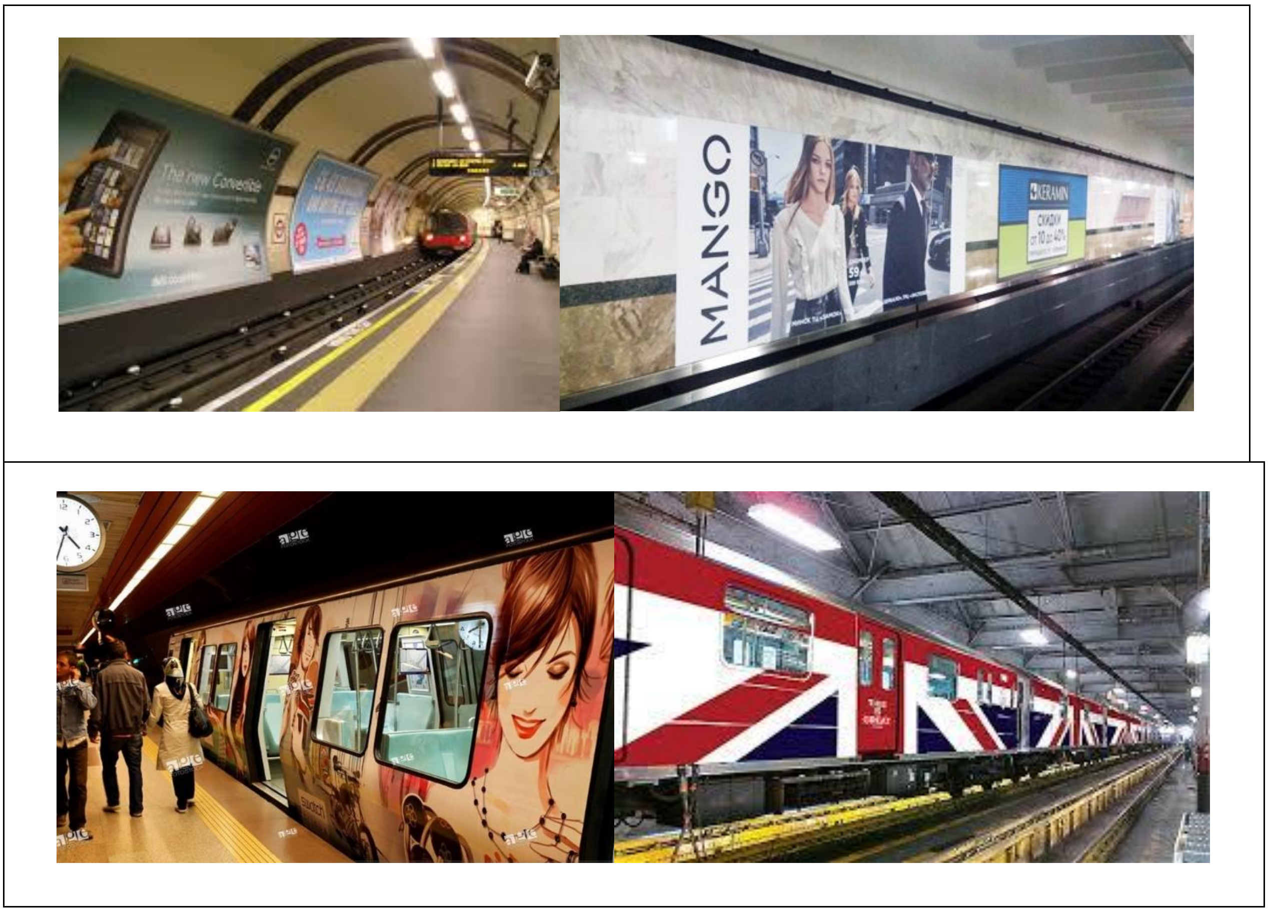


Figure 71. Tentative Advertisements On Rolling Stock and Station

<u>Commercial Areas for Retail Shops</u>

i. The footfall on the passengers to a station is a great potential for commercial benefits as a retail area. Like the advertising, an agency to manage the commecial activites in a station, or a corridor.

ii. Possible locations for Retails shops shall be as under,
   - Within the station (Paid/Unpaid Areas): 3.5m depth across all stations, 50sqm for smaller stations.
   - On the Platforms: 15sqm per platform for Automatic Vending Machines.
   - Space for Shopping Mall can be created depending upon the Market potential.
   - Outside the Station: Kiosks

6.3.1 Planning of Metro Stations

- The Station Design has numerous factors of influence, the availability of Land, the existing corridor, the Entry / Exits, Concourse, Platforms, ancilliary buildings etc. The design has been carried out in a way to accommodate the possible vacant land for the development.

However, in cases where there is no availability of a vacant land, land aquisition has been proposed.

- Efforts have been made to provide a safe and comfortable environment for the passengers during any form of operation. The station design includes numerous parameters such as, the peak traffic flow, the width of the Stairs, the number of AFC gates, number of services like Escalators in compliance with NFPA 130.
- Efforts have been made to design the station complying to the best International standards and built environment. Design has been made so that the station in future can be upgraded, maintained and operated. Auxilliary substations & ECS Plant room accomodated at the Concourse / Mezzanine levels at ends of Station Box. Tunnel vetilation System/ Shafts provided at each end of Platform & most of the S&T rooms are provided at Concourse level.
- Care has been taken to keep the BOH areas fully organised while the Plant accomodation is clearly distinct from habitable rooms.
- The Underground station proposed with 4 levels i.e. Mezzanine, Concourse, Platform and undercroft.
- Mezzanine level has all the passenger amenities, entry/exits, AFC's, Ticketing, ECS plant rooms, Auxilliary substation, Station Control room, Staff Mess, first aid room and other BOH spaces.
- Concourse level has most of S&T rooms, SER, TER, UPS & Battery room, GSM/CDMA room, Store room, ECS plant rooms, Auxilliary substation and other BOH spaces.
- Platform has seepage sump, pump room and Tunnel vetilation System/ Shafts provided at each ends. Two banks of staircases and 4 Escalators (2 for future) have been planned from Concourse to Platform to meet the peak traffic demands.
- Ancillary building (cooling towers, DG, Water tanks, Pump Room and chiller plants for ECS plant), Ventilation shafts are provided at open spaces along road side.
- Four entrances are provided to the station, two at each end of station box (one from the either side of the road). Out of four entries/exits two entries/exits shall be proposed as future entry/exits.

6.3.2 STATION WISE DESCRIPTION

1. Station 1 (Near Market yard, Gultekdi)

This Station is an extension to the Line 1, located in the vicinity of Gultekdi Fruit Market and Buldana Urban bank areas. This is proposed as an Underground station on the Pune-Bengaluru Highway and will be a 3 level station, with a total 4 number of entry/exit from either side of the roads and the station, leading directly to the Mezzanine. The total width of the Station shall be 23.73M whereas the Length of the Station shall be 153.4 M, consisting of operational, functional, public and Non-Public areas with a planned Ancilliary structure along the road. The Entrance/exits to the station have been located to cater to the local passenger requirements. One entry/exit shall be next to the City

Pride Mall, similarly the other three (3) entries/exits are planned to bring the passengers to the station and suitably located to address the local area requirements. Out of four entry/exits two entry shall be proposed as future entry/exits.

2. Station 2 (Padamavati)

Padmavati Station is another station on the Swargate-Katraj extention, which is located in the vicinity of Residential neighborhood of Balaji Society and Teen Hatti Chowk. This proposed station is also part of the Swargate-Katraj extension and is an Underground station similar to the Swargate Station. This will be a 3 level station, with a total 4 number of entry/exits from either side of the roads and the station, leading directly to the Mezzanine. The total width of the Station shall be 23.73M, whereas the Length of the Station shall be 153.4 M, consisting of operational, functional, public and Non-Public areas with a planned Ancilliary structure on the road. All the 4 entries/exits are planned to bring the passengers to the station and suitably located to address the local area requirements. Out of four entry/exits two entry/exits shall be proposed as future entry/exits.

3. Sation 3 (Near Katraj)

This is the third and the last station on the Swargate-Katraj extension Phase 2A. Like the other two stations proposed within this extention, this too shall be an Underground station, which has been located very close to the Rajiv Gandhi Zoological Park, Katraj Bus Stop. This station is proposed at Mumbai-Pune bypass road and the Pune-Satara road. Owing to location at the junction of the two highways, heavy passenger flow is anticipated at this Station, accordingly all the entries/exits have been located strategically leading to the Mezzanine. The total width of the Station shall be 23.73M, whereas the Length of the Station shall be 153.4 M, consisting of operational, functional, public and Non-Public areas with a planned Ancilliary structure on the road. All the 4 entries/exits are planned to bring the passengers to the station and suitably located to address the local areas requirements. Out of four entry/exits two entry/exits shall be proposed as future entry/exits.

6.4 Station Area Planning of NMT

- The following non-motorized vehicles facilities including pedestrian 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 to keep in view the major growth centres/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-up and drop-off zones and bays for feeder modes like buses, IPT have been proposed near the station.
- 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.
- 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 have been designed for pedestrians. 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

6.5 Accessibility for differently abled

6.5.1 Introduction

The objective of making this chapter is to create a user-friendly mass transport system in Pune which can ensure accessibility to persons with disabilities, people travelling with small children or are carrying luggage, as well as people with temporary mobility problems (e.g. a leg in plaster) and the elderly persons.

The design standards for universal access to Public Transport Infrastructure including related facilities and services, information, etc. would benefit people using public transport.

Further, it has also been attempted to provide guidelines/ standards for alighting and boarding area, approach to station, car parking area, drop-off and pick-up areas, taxi/auto rickshaw stand, bus stand/stop, footpath (sidewalk), kerb ramp, road intersection, median/pedestrian refuge, traffic signals, subway and foot over bridge etc. to achieve a seamless development around metro stations.

6.5.2 Rail transport

General

- Whether over-ground or grade or underground, rail travels is a highly effective mode of transport.
- Every train should contain fully accessible carriages.
- Staff should be trained in methods of assistance and be at hand on request.

- Stations for all rail travel should be fully accessible with extra wide turnstiles where possible alongside wheelchair accessible doorways.
- Staff should be on hand to assist persons with disabilities and elderly to enter or exit through convenient gates.
- All new metro stations should be designed to be fully accessible.
- For persons with hearing impairments, an electronic sign board (digital display) should be displayed on each platform at conspicuous location for all announcements made by the railways.
- For persons with visual impairments audio system announcing the station names and door location should be available.

Accessible railway cars

The metro cars should have the following features:

- Railway car doors should be at least **900 mm** wide;
- The gap between the car doors and the platform should preferably be less than **12 mm;**
- Identification signage should be provided on the doors of wheelchair accessible coach
- If the car door and the platform cannot be at the same level, then at least one car doors should have apparatus such as a hydraulic lift or pull-out ramp installed in the doorway for wheelchair users.

Wheel Chair Space

- Space for a wheel chair should be available at the side of the door;
- The space should be indicated inside and outside the car by using the international symbol of access
- Wheel stopper and ring-strap or other appropriate safety grip should be provided for wheelchair users.
- Emergency communication is accessible to person in wheel chair.

Seats

- An appropriate number of designated seats for passengers with disabilities and elderly people should be provided near the doors

Aisles

- Aisles should be at least 900 mm wide.

6.5.3 Metro railway station

6.5.3.1 Information signs and announcements

A map of train routes should be installed. This should be in Braille/raised numbers as well. In each car, there should be an announcement and provision of a visual display of the names of stations route. This display should be in raised numbers with sharp contrast from the background.

6.5.3.2 Level approach

- Approach route should not have level differences. If the station is not on the same level as the walkway or pathway, it should a ramp.
- Walkway surfaces should be non-slip.
- Approach walkway should have tactile pavements for persons with visual impairments.

6.5.3.3 Station entrances and exits

- These should have a minimum width of 1800mm and is level or ramped.

6.5.3.4 Reservation and information counters

- Should have clear floor space of at least 900 mm x 1200 mm in front of the counters; There should be at least one low counter at a height of 750 mm to 800 mm from the floor with clear knee space of 750 mm high by 900 mm wide by 480 mm deep.
- At least one of the counters should have an induction loop unit to aid people with hearing impairments.
- The counters should have pictographic maps indicating all the services offered at the counter and at least one of the counter staff should be sign language literate.

6.5.3.5 Toilet facilities

- There should be at least one unisex accessible toilet
- Ticket Gates

At least one of the ticket gates should:

- Be minimum 900 mm wide to allow a wheelchair user through and
- Have a continuous line of guiding paver for people with visual impairments.

6.5.3.6 Platforms

The Platforms should have the Following characteristics:
- Have non-slip and level flooring;
- Have a row of warning paver installed 600mm before the track edge

- Have seating areas for people with ambulatory disabilities
- Be well illuminated lux level of 200 lux
- There should be no gap or difference in level between the train entry door and the Platform.
- All platforms should inter-connect by means of an accessible routes or lifts and provide accessible level entrance to the train coach.

6.5.3.7 Way finding

- Way finding references should be available at decision points.
- Color can be used to identify routes and aid in locating doors, walls and hazards. Proper color contrast between different elements greatly improves visibility for all users and is critical for persons with low vision. For example, color contrasting of door frames can assist in locating doors, and likewise floors should be contrasted with walls. In addition, furniture should contrast with walls and floors so as not to create an obstacle.
- Structural elements such as columns should be color contrasted or brightly marked so as to be visible to those who may have a visual disability.
- Generally, patterns on flooring should be avoided or else should be minimal and small to avoid visual confusion.
- In addition to identifying hazards or warnings, tactile floor surfaces can also be used to inform that there is a change in area (e.g. leaving a corridor and entering a boarding area).
- Tactile systems should be consistent throughout the building. For example, terminals should not have carpeting in some boarding areas and tile in others as this may create confusion for those who rely on tactile surfaces to guide them to their destination.
- Good lighting assists those with a visual disability to see better and allows people who have a hearing impairment to lip read easier. However, care should be taken to properly direct lighting and to use matte finishes on floors, walls and signage, so as not to create glare which may create difficulties for all travelers.
- Blinds can be used to adjust lighting levels in areas where the natural lighting changes significantly throughout the day.

6.5.3.8 Signage

Signs must be clear, concise, and consistent. All travelers need clear information about the purpose and layout of terminals to maintain a sense of direction and independent use of all facilities. Using internationally and nationally established symbols and pictograms with clear lettering and Braille ensures universal accessibility cutting across regional/cultural and language barriers. A cohesive information and signage system can provide visual (e.g. signs, notice boards), audible (e.g. public address and security systems, induction loops, telephones, and infrared devices), and/ or tactile information (e.g. signs with embossed lettering or Braille).

6.5.3.9 Sign design specifications

- The sign should be in a prominent position.
- The face of the sign should be well-illuminated by natural or artificial light.
- Letters should be simple such as Arial, Helvetica medium, and san serif or similar and numbers should be Arabic.
- The color of the text should be in a color that contrasts with the sign board.
- The sign board should also contrast with the wall on which it is mounted.
- Some signs such as those adjacent to or on a toilet door may be embossed so that they can be read by touch.
- Illuminated signs should not use red text on a dark background.
- Signs should be supplemented by Braille where possible.
- The surface of the sign should not be reflective.

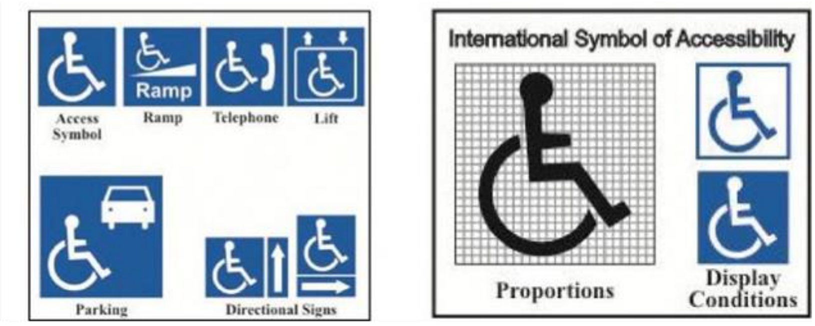


Figure 72. Way finding signage and International Symbol of accessibility

6.5.3.10 Automated kiosks

- Automated kiosks should be accessible for wheelchair users.
- Should be clearly marked with international symbol of accessibility.
- Should have Braille buttons and audio announcement system for persons with vision impairments.
- Operations should be easy to understand and operate for persons with learning disabilities, intellectual disabilities, and elderly persons.

6.5.3.11 Public dealing counters

- Ticketing, Information, Check-in, help desk, Restaurants, Shops, etc. should have Information or help desks should be close to the terminal entrance, and highly visible upon entering the terminal. In addition, they should be clearly identified and accessible to both those who use wheelchairs and those who stand.
- It should provide information in accessible formats, viz. Braille leaflets for persons with vision impairments.

- Ideally, these desks should have a map of the facility that desk attendants can view with
  passengers, when providing directions.
- Staff manning the counters should know sign language.
- Information desk acoustics should be carefully planned and controlled as a high level of background noise is confusing and disorienting to persons with hearing impairment.
- Lighting should be positioned to illuminate the receptionist/person manning the counter
  and the desk top without creating glare.
- Lighting should not create shadows over the receptionist staff, obscuring facial detail and
  making lip reading difficult.
- There should be a hearing enhancement system such as a loop induction unit, the availability of which is clearly indicated with a symbol.
- One of the counters should not be more than 800mm from the floor, with a minimum
  clear knee space of 650mm high and 280mm- 300mm deep.

6.5.3.12 Audio-visual displays

- Terminal maps should be placed so that they are readily visible to persons who are standing and persons who use wheelchairs. They should also be accessible to persons with a visual disability (i.e. tactile maps). Other alternatives include electronic navigation systems or audio maps.
- Enable captioning always on all televisions and other audiovisual displays that are capable of displaying captions and that are in any portion of the terminal.
- The captioning must be in high contrast for all information concerning travel safety, ticketing, check-in, delays or cancellations, schedule changes, boarding information, connections, checking baggage, individuals being paged by bus railway or airlines, vehicle changes that affect the travel of persons with disabilities, and emergencies (*e.g.*, fire, bomb threat).

6.5.3.13 Rest areas/seating

- Seating area / benches should be provided along the circulation path at regular intervals so that passengers do not need to walk more than 50 to 60 meters before being able to sit and rest.
- Where seating is provided, designated seating for passengers with disabilities is to be
  provided at boarding gates and departure areas within viewing distance of communication boards and/or personnel and identified by the symbol of access.

- Public transit operators should provide seating in passenger service areas where there may be long waiting lines or times, including at ticket sales counters, check-in counters, secured screening and during inter-country travel in customs areas and baggage retrieval areas.
- Designated seating should be provided for at boarding gates and departure areas within viewing distance of communication boards, and within hearing range of audio announcements as well. Such seating areas should be identified by the symbol of accessibility and shelter should be provided where this seating is outdoors.
    - In outdoor settings, seating should be provided along with the planned hawker spaces.
    - At waiting lounges for persons with disabilities chairs should have armrests and backrest.

6.5.3.14 Tactile paving – guiding & warning

- **Tactile Guiding Paver (Line-Type)**

It is recommended to install a row of tactile guidance paver along the entire length of the proposed accessible route for visual impaired persons. Care must be taken to ensure that there are no obstacles, such as wall, pillar, uneven surfaces, Soffit (underside /open area under the stairs, along the route traversed by the guidance paver. Also, there should be clear headroom of at least 2.1 meters height above the tactile guidance paver, free of protruding objects such as overhanging advertisement panel and signage, along the entire length of the walk.

- **Tactile Warning Paver (Dot-Type)**

Indicate an approaching potential hazard or a change in direction of the walkway, and serve as a warning of the approaching danger to persons with visual impairments, preparing them to tread cautiously and expect obstacles along the travel path, traffic intersections, doorways, stairs, etc. They are used to screen off obstacles, drop-offs or other hazards, to discourage movement in an incorrect direction, and to warn of a corner or junction. Two rows of tactile warning paver should be installed across the entire width of the designated accessible passenger pathway at appropriate places such as before intersections, terminal entrances, obstacles such as signage, and each time the walkway changes direction.

- **Places to install warning paver**

- In front of an area where traffic is present.
- In front of an entrance/exit to and from a staircase or multi-level crossing facility.
- Entrances/exits at public transport terminals or boarding areas.

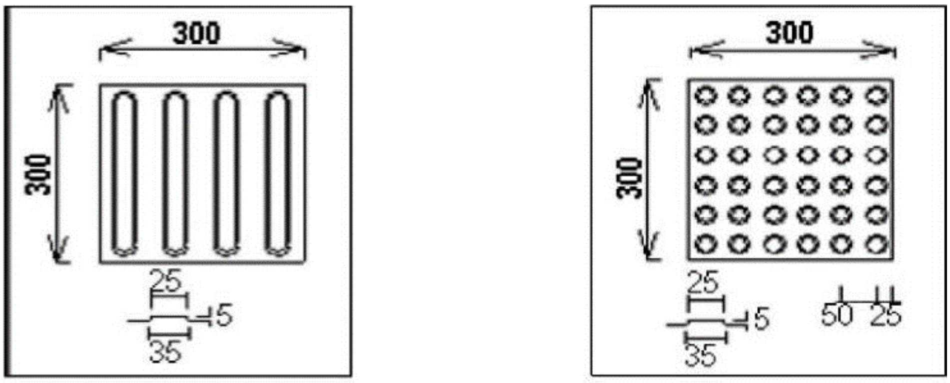


Figure 73. Guiding paver and warning paver

6.5.3.15 Doors

- Whatever the type of entrance door, it must be wide enough to accommodate passenger traffic comfortably.
- The recommended minimum clear opening width of an internal door is 900mm minimum.
- Where doors comprise two leaves (i.e. double doors), each leaf should be 900mm min. wide, so that persons carrying large items and people using wheelchairs do not have to open both leaves.
- Manual doors should incorporate kick plates 300-400mm high to withstand impact of wheelchair footrest (this is especially important where doors are glazed).
    - Also, be fitted with vision panels at least between 900mm and 1500mm from floor level.
    - Be color contrasted with the surrounding wall and should not be heavier than 22N to open.
    - Lever handles and push type mechanisms are recommended. When a sliding door is fully open, handles should be usable from both sides.
    - Where revolving doors or turnstiles are used, an alternative wheelchair-accessible entrance must also be provided.
- 400mm should be provided beyond the leading edge of door to enable a wheelchair user to maneuver and to reach the handle.
- To ensure maximum clarity for persons with visual impairments, the entrance should be easily distinguishable from its surroundings by the effective use of landscaping, signage, color (preferably yellow/orange), tonal contrast and tactile surfacing.
- Door hardware should be positioned between 900-1000mm above floor.
- Operable devices such as handles, pulls, latches and locks should:
    - Be operable by one hand

- Not require fine finger control, tight grasping, pinching or twisting to operate

- Glazed doors and fixed glazed areas should be made visible by use of a clear, color and
  tone contrasted warning or decorative feature that is effective from both inside and outside and under any lighting conditions, e.g. a logo, of minimum dimensions 150mm by 150mm (though not necessarily square), set at eye level.

6.5.3.16 Steps and stairs

- Steps should be uniform with the tread not less than 300mm and the risers 150mm.
- The risers should not be open.
- The steps should have an unobstructed width of 1200mm minimum.
- All steps should be fitted with a permanent color and tone contrasting at the step edge, extending the full width of the step, reaching a minimum depth of 50mm on both tread and riser.
- Have continuous handrails on both sides including the wall (if any) at two levels
- Warning paver to be placed 300mm at the beginning and at the end of all stairs.
- Nosing to be avoided.
- The staircase should be adequately and uniformly illuminated during day and night (when
  in use). The level of illumination should preferably fall between 100-150 lux.
- The rise of a flight between landings must be no more than 1200mm.
- There should be no more than 14 risers in one flight run.
- The stair covering, and nosing should be slip-resistant, non-reflective, firmly-fixed and easy
  to maintain.
- Soffit (underside /open area under the stairs) of the stairs should be enclosed or protected.

6.5.3.17 Handrails

- Handrails should be circular in section with a diameter of 38-45mm and formed from materials which provide good grip such as timber, nylon or powder coating, matt finish metal finishes.
- The handrail should contrast in color (preferably yellow/orange) with surrounding surfaces.
- At least 50mm clear of the surface to which they are attached and should be supported on brackets which do not obstruct continuous hand contact with the handrail.
- The handrail should be positioned at two levels- 760mm and 900mm above the pitch-line of a flight of stairs.

- Handrail at foot of the flight of stairs should extend 300mm beyond the stairs in the line of travel and returning to the wall or floor or rounded off, with a positive end that does not project into the route of travel.

6.5.3.18 Ramps

- Ramps gradient should ideally be 1 in 20 and no greater than 1 in 12.
- Width of the ramp should not be less than 1200mm and preferred width is 1800mm.
- The steeper the gradient, the shorter the length of ramp between landings.
- On long ramps, a horizontal resting space should be provided every 6 meters.
- Surface materials should be slip-resistant, non-reflective, firmly-fixed and easily maintained
- The edge of the ramp should have an edge protection with a minimum height of 100mm.
- Landings every 750mm of vertical rise.
- A tapping or lower rail should be positioned so that its bottom edge is no higher than 200mm above ground level.
- Handrails on the ramps should be on both sides at two levels: upper at 900mm and lower at 760mm; both end to be rounded and grouted; extend 300 mm beyond top and bottom of ramp.
- A row of tactile warning paver should be placed 300mm beginning and end of each run.
- Landings should be provided at regular intervals as indicated in the table.

6.5.3.19 Lifts

A carefully designed lift makes a huge contribution to the accessibility of a station for persons with disabilities.

- Lift locations should be clearly signposted from the main pedestrian route and recognizable through design and location.
- The color and tone of the lift doors should contrast with the surrounding wall finish to assist in their location. Lift doors with metallic finishes such as steel grey and silver should be avoided as they are difficult to identify by persons with low vision.
- The lift lobby shall be of an inside measurement of 1800mm X 2000mm or more. A clear landing area in front of the lift doors of minimum dimensions 1500mm x 1500mm should be provided.
- By making the landing area distinguishable by floor surface and contrast, it will aid location and recognition of core areas. This could comprise a change in floor finish from thin carpet to vinyl/PVC, or cement/mosaic floor to carpet.

- Changes in floor finish must be flushed. There should be no level difference between lift
  door and the floor surface at each level; the gap if unavoidable should not be more than 12mm.
- The floor level/location should be indicated on the wall adjacent to or just above the call buttons, and opposite the lift doors where possible.

Lift dimensions

Provisions of at least one lift shall be made for people using wheelchairs with the following car dimensions:

- Clear internal depth - 1500 mm minimum
- Clear internal width - 1500 mm minimum
- Entrance door width - 900mm minimum

Lift controls

- The lift call button should be wall-mounted adjacent to the lift and should contrast with
  wall finish, either by using a contrasting panel, or a contrasting border around the button panel.
- The call buttons should be located within the range 800-1000mm above floor finish.
- Buttons should not be touch sensitive, but should require a light positive pressure and
  should ideally be large enough to be operable by the palm of the hand if required.
- The control buttons inside the lift should be positioned on the side wall rather than front
  wall to allow access from the back and front of the lift car, by mobility aid users like wheelchair users.
- The control buttons should contrast with their surroundings and illuminate when pressed
  and should incorporate highly visible tactile embossed (NOT engraved) characters and in Braille.
- Time of closing of an automatic door should be more than 5 seconds and the closing speed should not exceed 25 meters per second. There should be a provision of censor enabled closing.
- In larger lifts, controls should be positioned on both side walls, at least 400mm from front wall and between 800-1000mm above floor level.

Car design

- Internal walls should have a non-reflective, matt finish in a color and tone contrasting with the floor, which should also have a matt, non-slip finish.
- Use of reflective materials such as metal (stainless steel for example) can be problematic
  in creating sufficient contrast with control buttons, emergency telephone cabinet, etc. for persons with low vision and the use of such materials should be avoided wherever possible.
- A mirror (750mm above floor level) on the rear wall can be useful to persons using wheelchairs and other mobility aids should they need to reverse safely out of the lift car or view the floor numbers.
- Internal lighting should provide a level of illumination of minimum 100 lux (approximately 50-75 lux at floor level), uniformly distributed, avoiding the use of spotlights or down lighters.
- A grab bar should be provided along both sides and the back wall, 900mm above floor level.
- Handrails should be of tubular or oval cross section, to be easily gripped and capable of providing support.
- Handrails should be positioned so that there is a clear space behind the handrail to allow it to be grasped i.e. knuckle space should be 50mm.

Information systems

- Lifts should have both visual and audible floor level indicators
- Audible systems are also usually capable of incorporating additional messages, such as door closing, or, in the case of an emergency, reassurance (with manual over-ride allowing communication with lift occupants).
- Announcement system should be of 50 decibels.
- The display could be digital or segmented LED, or an appropriate alternative. A yellow or light green on black display is preferred to a red on black display as it is easier to read.

6.5.3.20 General and accessible toilets

Signages

- All signage of general toilets should be in bold and contrasting colors.
- For persons with low vision and vision impairments: male pictogram in triangle and female pictogram in circle, marked on plates along with Braille & raised alphabets, to be mounted on wall next to door near the latch side, at a height between 1400mm-1600mm.
- Warning strip/ thin rubber door mat to be provided 300mm before and after the toilet entrance.

- Tactile paver to be provided for urinals, WC and washbasins for persons with vision impairments.

Accessible Toilets

- Should have the international symbol of accessibility displayed outside for wheelchair access.
- The toilet door should be an outward opening door or two ways opening or a sliding type and should provide a clear opening width of at least 900mm.
- It should have a horizontal pull-bar, at least 600mm long, on the inside of the door, located so that it is 130mm from the hinged side of the door and at a height of 1000mm.

WC (WC) Compartment Dimensions

- The dimensions of a unisex toilet are critical in ensuring access. The compartment should be at least 2200mm and 2000mm. This will allow use by both manual and motorized wheelchair users.
- Layout of the fixtures in the toilet should be such that a clearing maneuvering space of 1500mm x 1500mm in front of the WC and washbasin.

Water Closet (WC) Fittings

- Top of the WC seat should be 450-480mm above finished floor level, preferably be of wall hung or corbel type as it provides additional space at the toe level.
- An unobstructed space 900mm wide should be provided to one side of the WC for transfer, together with a clear space 1200mm deep in front of the WC.
- WC should be centered 500mm away from the side wall, with the front edge of the pan 750mm away from the back wall. Have a back support. The WC with a back support should not incorporate a lid, since this can hinder transfer.
- L-shape grab bar at the adjacent wall and on the transfer side (open side) swing up grab bar shall be provided.
- The cistern should have a lever flush mechanism, located on the transfer side and not on
  the wall side and not more than 1000mm from the floor.

Grab Bars

- Grab bars should be manufactured from a material which contrasts with the wall finish (or use dark tiles behind light colored rails), be warm to touch and provide good grip. - It is essential that all grab rails are adequately fixed, since considerable pressure will be placed on the rail during maneuvering. Grab bars should sustain weight of 200kgs minimum.

- A hinged type moveable grab bar should be installed adjacent to the WC on the transfer side. This rail can incorporate a toilet tissue holder. 320mm from the center line of the WC between heights of 200-250mm from the top of the WC seat. It should extend 100-150mm beyond the front of the WC.
- A fixed wall-mounted L- shape grab bar (600mm long horizontal and 700mm long vertical)
  on the wall side should be provided. It should be placed at a height of 200-250mm above the WC seat level.

Washbasins

- The basin should be fixed no higher than 750mm above the finished floor level.
- Be of dimensions 520mm and 410mm, mounted such that the top edge is between 800 - 900mm from the floor; have a knee space of at least 760mm wide by 200mm deep by 650-680mm high.
- The position of the basin should not restrict access to the WC i.e. it should be located 900mm away from the WC.
- A lever operated mixer tap fitted on the side of the basin closest to the WC is useful as it allows hot and cold water to be used from a seated position on the WC.
- The hand drying facilities should be located close to the hand washbasin between 1000-1200mm.
- Hand washbasins should be fitted on cantilevered brackets fixed to the wall.
- Lever type handles for taps are recommended.
- Mirror's bottom edge to be 1000mm from the floor and may be inclined at an angle.

Fixtures and Fittings

- Contrast between fittings and fixtures and wall or floor finishes will assist in their location. For example, using contrasting fittings, or dark tiles behind white hand washbasins and urinals, contrasting soap dispensers and toilet roll holders. Contrast between critical surfaces, e.g. floors, walls and ceilings help to define the dimensions of the room.
- Towel rails, rings and handrails should be securely fixed to the walls and positioned at 800-1000mm from the floor.
- The mirror should be tilted at an angle of 300 for better visibility by wheelchair users.
- It should have lower edge at 1000mm above floor finish and top edge around 1800mm above floor finish.
- Hooks should be available at both lower-1200mm and standard heights- 1400mm, projecting not more than 40mm from the wall.
- Where possible, be equipped with a shelf of dimensions 400mm x 200mm fixed at a height of between 900mm and 1000mm from the floor.

- Light fittings should illuminate the user's face without being visible in the mirror. For this reason, most units which have an integral light are unsatisfactory.
- Large, easy to operate switches are recommended, contrasting with background to assist location, at a maximum height of 1000mm above floor finish.
- All toilet facilities should incorporate visual fire alarms.
- Alarms must be located so that assistance can be summoned both when on the toilet pan i.e. at 900mm height and lying on the floor i.e. at 300mm, from floor surface. Alarms should be located close to the side wall nearest the toilet pan, 750mm away from rear wall and at 900mm and 200mm above floor finish.

1. Signage of Accessible Toilets

- All unisex accessible toilets to have access symbol in contrast colors. A distinct audio sound (beeper/clapper) may be installed above the entrance door for identification of the toilets.

Figure 74. Signage for accessible washroom

6.5.3.21 Accessible urinal

- At least one of the urinals should have grab bars to support ambulant persons with disabilities (for example, people using mobility aids like crutches).
- A stall-type urinal is recommended.
- Urinals shall be stall-type or wall-hung, with an elongated rim at a maximum of 430mm
  above the finish floor. This is usable by children, short stature persons and wheelchair users.
- Urinal shields (that do not extend beyond the front edge of the urinal rim) should be provided with 735mm clearance between them.
- Grab bars to be installed on each side, and in the front, of the urinal.
- The front bar is to provide chest support; the sidebars are for the user to hold on to while standing.

6.5.3.22 Drinking water units

- Drinking water fountains or water coolers shall have up front spouts and control.
- Drinking water fountains or water coolers shall be hand-operated or hand and foot-operated.

- Conventional floor mounted water coolers may be convenient to individuals in wheelchairs if a small fountain is mounted on the side of the cooler 800mm above the floor.
- Fully recessed drinking water fountains are not recommended.
- Leg and knee space to be provided with basin to avoid spilling of water. This allows both front and parallel access to taps for persons using mobility aids like wheel chair, crutches etc.

6.5.3.23 Visual contrasts

- Visual contrasts mean adequate contrast created by difference of at least 30 LRV (Light Reflectance Value) of the two surfaces/ objects and it helps everyone especially persons with vision impairments.
- Visual contrast should be provided between:
    - Critical Surfaces (walls, ceiling and floor),
    - Signage and background sign frame/ wall,
    - Step edges and risers/ treads on steps,
    - Handrails and background walls,
    - Doors and surrounding walls,
    - Switches/ sockets and background wall,
    - Toilet fixtures and critical surfaces in toilet.
- Barriers and hazards should be highlighted by incorporating colors and luminance contrast.

6.5.3.24 Emergency egress/evacuation

- Placement (accessibility) and visibility of such devices is very important. The following is to be considered for the installation of such alarm devices; fire alarm boxes, emergency call buttons and lit panels should be installed between heights of 800mm and 1000mm from the furnished floor surface. These should be adequately contrasted from the background wall and should be labelled with raised letters and should also be in Braille.
- A pre-recorded message, alerting an emergency to the control room or reception should be installed in the telephone and this should be accessible by a 'hotkey' on the phone keypad. This 'hotkey' should be distinct from the rest of the keypad.

6.5.3.25 Alert systems

- In emergency situations, it is critical that people are quickly alerted to the situation at hand, for persons with disability the following needs to be considered.

- Consider having audible alarms with 'voice instructions' that can help guide them to the nearest emergency exit. As an alternative to the pre-recorded messages, these alarms may be connected to the central control room for on-the-spot broadcasts.
- 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.).

6.5.3.26 Written evacuation procedure

A written evacuation procedure that details the egress plan for people with disability should be installed behind the entrance door in the accessible rest rooms. The evacuation procedure should be detailed in large print letters that contrast strongly against the background. Where possible, it should also incorporate raised letters and Braille. The evacuation route should be displayed on a high contrast tactile map for benefit of persons with vision impairments.

6.5.3.27 Emergency evacuation route

- Designate routes that are at least 1200mm wide, to ensure that a person using a wheelchair and a non-disabled person can pass each other along the route. The route should be free of any steps or sudden changes in level and should be kept free from obstacles such as furniture, coolers, AC units and flower pots.
- Use Exit signage along the route. Orientation and direction signs should be installed frequently along the evacuation route and these should preferably be internally illuminated. The exit door signage should also be internally illuminated.
- A 'way guidance lighting system' consisting of low mounted LED strips to outline the exit route (with frequent illuminated direction indicators along the route) should be installed along the entire length of the evacuation route. Way guidance systems allow persons with vision impairments to walk significantly faster than traditional overhead emergency lighting. Moreover, emergency exit lights in green color and directional signals mounted near the floor have been found to be useful for all people in cases where a lot of smoke is present.

6.5.3.28 Way guidance system

- Luminance on the floor should be 1lux minimum provided on along the center line of the route and on stairs.
- Install clear illuminated sign above exit and directional signage along the route.
- The directional exit signs with arrows indicating the way to the escape route should be provided at a height of 500mm from the floor level on the wall and should be internally illuminated by electric light connected to corridor circuits.

6.5.3.29 Fire resistant doors

Fire resistant doors and doors used along the emergency evacuation route are generally heavy and the force required to open these is much higher than 25 Newtons, making it difficult for people with disability to negotiate these doors independently. There are, however, magnetic and other types of door holders available that can be connected to fire alarms so that they will hold the doors open normally but will release the doors when the fire alarm is activated.

6.5.3.30 Street design

Footpath (Sidewalk)

Footpaths should be regarded as a transportation system which is connected and continuous, just like roadways and railways. They should not be sporadically placed where ever convenient, but instead should be provided consistently between all major attractions, trip generators, and other locations where people walk.

Footpath should have the following characteristics:

- Have height of a standard public step riser i.e. 150 mm maximum;
- Be at least 1800 mm wide.
- Have non-slip surface;
- Be along the entire length of the road;
- Have tactile guiding paver for persons with visual impairments.
- Preferably have well defined edges of paths and routes by use of different colors and textures
- Have no obstacles or projections along the pathway. If this is unavoidable, there should be clear headroom of at least 2200 mm from the floor level
- The minimum 1.8m (width) x 2.2m (Height) Walking Zone should be clear of all obstructions– both horizontally and vertically.
- Have kerb ramps where ever a person is expected to walk into or off the pathway.
- Have tactile warning paver installed next to all entry and exit points from the footpath.

Kerb Ramp

- Kerb should be dropped, to be flush with walk way, at a gradient no greater than 1:10 on both sides of necessary and convenient crossing points. Width should not be less than 1200mm. If width (X) is less than 1200mm, then slope of the flared side shall not exceed 1:12.
- Floor tactile paving- Guiding & Warning paver shall be provided to guide persons with vision impairment so that a person with vision impairment does not accidentally walk onto the road.

- Finishes shall have non-slip surface with a texture traversable by a wheel chair.

Road Intersections

- Pedestrian crossings should be equipped with traffic control signal.
- Traffic islands to reduce the length of the crossing are recommended for the safety of all road users.
- Warning pavers should be provided to indicate the position of pedestrian crossings for the benefit of people with visual impairments.
- Table tops (raised road level to the sidewalk height) are helpful in reducing the speed of traffic approaching the intersection.

Median/Pedestrian Refuge

Raised islands in crossings should:

- Cut through and level with the street; or Have kerb ramps on both the sides and have a level area of not less than 1500 mm long in the middle; and
- A colored tactile marking strip at least 600 mm wide should mark the beginning and end of a median/ pedestrian refuge to guide pedestrian with visual impairments to its location.

6.5.3.31 Traffic signals

- Pedestrian traffic lights should be provided with clearly audible signals for the benefit of pedestrians with visual impairments;
- Acoustic devices should be installed on a pole at the point of origin of crossing and not at the point of destination;
- The installation of two adjacent acoustic devices such as beepers is not recommended to avoid disorientation;
- The time interval allowed for crossing should be programmed according to the slowest crossing persons; and
- Acoustical signals encourage safer crossing behavior among children as well.

6.5.3.32 Subway and Foot Over Bridge

Subways and foot over bridges should be accessible for people with disabilities. This may be achieved by:

- Provision of signage at strategic location;
- Provision of slope ramps or lifts at both the ends to enable wheelchair accessibility;
- Ensuring that the walkway is at least 1500 mm wide;
- Provision of tactile guiding and warning paver along the length of the walkway;
- Keeping the walkway; free from any obstructions and projections; and

- Providing for seats for people with ambulatory disabilities at regular intervals along the walkway and at landings.

6.5.3.33 Alighting and boarding areas

All areas and services provided in the station that are open to the public should be accessible.

6.5.3.34 Approach

- Passenger walkways, including crossings to the bus stops, taxi stands, terminal / station building, etc. should be accessible to persons with disabilities.
- Uneven surfaces should be repaired and anything that encroaches on corridors or paths of travel should be removed to avoid creating new barriers. Any obstructions or areas requiring maintenance should be white cane detectable.
- Access path from plot entry and surface parking to terminal entrance shall have even surface without any steps.
- Slope, if any, shall not have gradient greater than 5%. The walkway should not have a gradient exceeding 1 :20. It also refers to cross slope.
- Texture change in walk ways adjacent to seating by means of tactile warning paver should be provided for persons with vision impairment.
- Avoid gratings in walks.

6.5.3.35 Car park

- **Signage**

- International symbol of accessibility (wheelchair sign) should be displayed at approaches and entrances to car parks to indicate the provision of accessible parking lot for persons with disabilities within the vicinity.
- Directional signs shall be displayed at points where there is a change of direction to direct persons with disabilities to the accessible parking lot.
- Where the location of the accessible parking lot is not obvious or is distant from the approach viewpoints, the directional signs shall be placed along the route leading to the accessible parking lot.
- Accessible parking lot should be identifiable by the International Symbol of Accessibility. The signs should not be obscured by a vehicle parked in the designated lot.
- Vertical signs shall be provided, to make it easily visible, the sign should be at a minimum height of 2100 mm.

- **Symbol**

International Symbol of Accessibility should be clearly marked on the accessible parking lot for drivers/riders with disabilities only.

- A square with dimensions of at least 1000 mm but not exceeding 1500 mm in length;
- Be located at the center of the lot; and
- The color of the symbol should be white on a blue background.

Car Park Entrance

- The car park entrance should have a height clearance of at least 2400 mm. Location;
- Accessible parking lots that serve a building should be located nearest to an accessible entrance and / or lift lobby within 30 meters. In case the access is through lift, the parking shall be located within 30 meters.
- The accessible route of 1200 mm width is required for wheelchair users to pass behind vehicle that may be backing out.

Accessible Car Parking Lot

The accessible car parking lot should:

- Have minimum dimensions 5000 mm × 3600 mm
- Have a firm, level surface without aeration slabs
- Wherever possible, be sheltered
- Where there are two accessible parking bays adjoining each other, then the 1200 mm side transfer bay may be shared by the two parking bays. The transfer zones, both on the side and the rear should have yellow and while cross-hatch road markings
- Two accessible parking lots shall be provided for every 50 no of car spaces.

Drop-off and pick-up areas

- Designated drop-off and pick-up spaces, to be clearly marked with international symbol of accessibility.
- Kerbs wherever provided, should have kerb ramps.

7. INTERMODAL INTEGRATION

The Multi-modal Integration Plan shall include requirements in respect of integrated transport and how the System must integrate into the existing transport modes at metro station, including non-motorized trips, viz. walking and cycling. All the physical elements necessary to ensure seamless connectivity between the metro and the broader transport network shall be accommodated.

While Pune Metro provides a high capacity transport system to carry the passengers, the need for integration with other transport modes is essential to ensure a seamless transfer. This concept is to provide first mile and last mile connectivity to the commuters within their places of residence/ business. At present the various modes of commute in Pune region comprise of State Transport buses, City bus services, Mini buses, Auto Rickshaws, Private cars, Two Wheelers and Bi-Cycles.

The new Metro Rail Policy (2017) also highlights provision of infrastructure for integration of various modes of transport, last mile connectivity, seamless transfer between various modes through common payment instrument and universally accessible infrastructure.

A world-class public transport system, incorporating best practice interchange hubs, will also help to meet the social, economic and environmental needs of a thriving and growing city, including;

- Improve public transportation provision, mobility, reliability, connectivity and accessibility in Pune region;
- Easing congestion and tackling climate change by promoting more sustainable modes of transport;
- Encourages a mode shift from private to public transportation use;
- Meeting the increasing demand for travel by public transport;
- Attracts existing public transport users to the Metro system;
- Improving access to facilities and services in urban centres;
- Takes into consideration the needs of the various stakeholders and the environment, and is socially and environmentally sensitive and sustainable;
- Improving quality of life by improving air quality and by reducing noise and other environmental impacts;
- Providing links between neighbourhoods and employment, education and other opportunities;
- Provides commercial opportunities that reap positive benefits for Maha Metro and Pune;
- Effectively and efficiently interfaced and integrated into the existing public transport services, community infrastructure, buildings and activity centres at an economical cost;

- Easily customizable, modifiable and upgradable for the whole of its life to accommodate and support future expansion, demand and growth for the Metro system at an economical cost;
- Improves the overall image of Pune.
- Multi Modal Integration refers to transportation and land use planning that considers diverse transportation options, typically including walking, cycling, public transit and private transport modes, and accounts for land use factors that affect accessibility. Multi Modal transportation accounts for the integration of different capabilities of different modes, including their availability, speed, costs, limitations, and therefore their most appropriate uses. To be efficient and fair, a transportation system must serve diverse demands. For example, would be inefficient, if inadequate sidewalks force parents to chauffeur children to local destinations to which they would rather walk or bicycle, or if inadequate mobility options force urban commuters to drive although they would prefer to rideshare or use transit. Physically, economically and socially challenged people in particular need diverse mobility options; walking and cycling for local travel, public transit for longer trips, and automobiles (ridesharing, chauffeuring and taxi travel) when necessary. As a result, to be efficient and fair, transportation must be Multi Modal.
- Before about 1980, walking and bicycling were recognized as important travel modes, but for most of the last century transport planning was automobile-oriented. As a result, most communities now have well developed road systems that allow motorists to drive to most destinations with relative convenience and safety; at worst they may be delayed by peak period congestion and pay tolls and parking fees at some destinations.
- From the past case experience, it is evident that integration plays a very vital role in emphasizing the commuters to shift from private mode of transportation to public transportation. The main tools of any public transportation system must be Multi Modal. As there is constant change in the requirement / advancement of infrastructure, other essential tools of integration are promoting active mobility (cycling and walking) users, providing safe and reliable infrastructure to reach primary mode of public transportation system, through feeder services, park & ride system, education and public outreach to commuters (marketing strategy), etc.
- Transport Integration Plan shall enable maximum number of passengers with ease of accessibility which ensures, safe, quick, convenient and seamless connectivity among the various modes of transport. Making streets safe, clean and walkable reduce impact on the natural environment, making less harm and to retain the natural resources. Access modes to transit stations is presented in below.

Figure 75. Access Modes to the Transit Station

Integration of modes should be planned in such a way that the people using various modes are integrated well by providing footpath for pedestrians, bicycle racks/parking for cyclists, bus bays for buses, taxi ranks and stands for Taxi and auto rickshaw, kiss & ride for Car users. Approach for safe access is presented below.

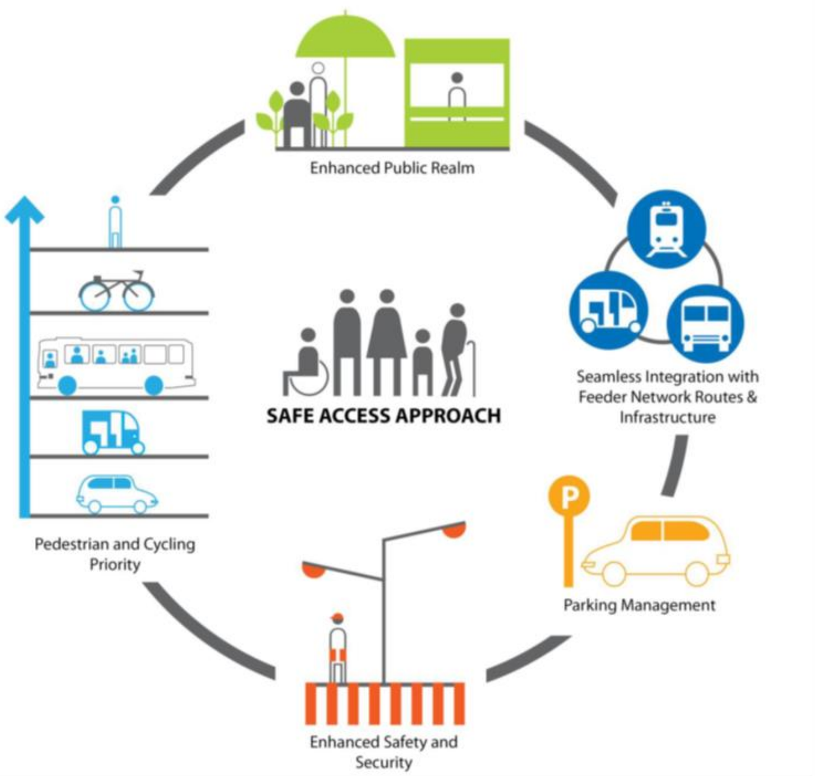


Figure 76. Approach of Safe Access

7.1 Intermodal Integration with Existing Modes

Maharashtra Metro Rail Corporation Limited (MAHA-METRO), a 50:50 jointly owned company of Government of India and Government of Maharashtra, is implementing Pune Mass Rapid Transit system on selected corridors.

7.1.1 Transport Integration Requirements

Transport Integration Plan is a combination of a coordinated integration of different modes, coordination of different other public transport authorities and transport operators for future coordination of operations ensuring safe, secure, convenient, quick and seamless transfers with the provision of transport infrastructure within the interchange and its precincts. Transport Integration Plan for the overall alignment shall focus on connectivity of different modes of transport at all stations, with a focus on the following precincts.

- **Pedestrians (including passenger connections)-** Pedestrian facilities are considered as important measure under this Plan. At elevated Metro stations, access shall be provided through staircases, lifts/elevators and/or escalators and Foot Over Bridges, as applicable and at specified locations only.
- **Bicycle parking, bicycle end of trip facilities and cycle-ways-** Space for the bicycle users in the area surrounding all stations and interchanges shall be provided which will ensure last mile connectivity.
- **Drop-off and pick-up locations-** The basic aim of any Mass Rapid Transit System is to encourage modal shift from private vehicles and other modes to public transport, ensuring an easy and convenient modal transport facilities like drop-off/pickup and park & ride facilities.
- **IPT access-** another important access mode from/ to Metro station are Taxi & Auto. Taxi/Auto ranks are proposed at all the stations to enable last mile connectivity.
- **Local road connections-** to ensure first mile and last mile connectivity, the immediate surrounding road network nearby the interchange, shall be enhanced to have an uninterrupted connectivity.

Below figure shows the alignment proposed metro extension towards south, which consists four stations with a total length of 5.464 km along the Pune-Satara Road. Following figure shows the description of each of the proposed stations.

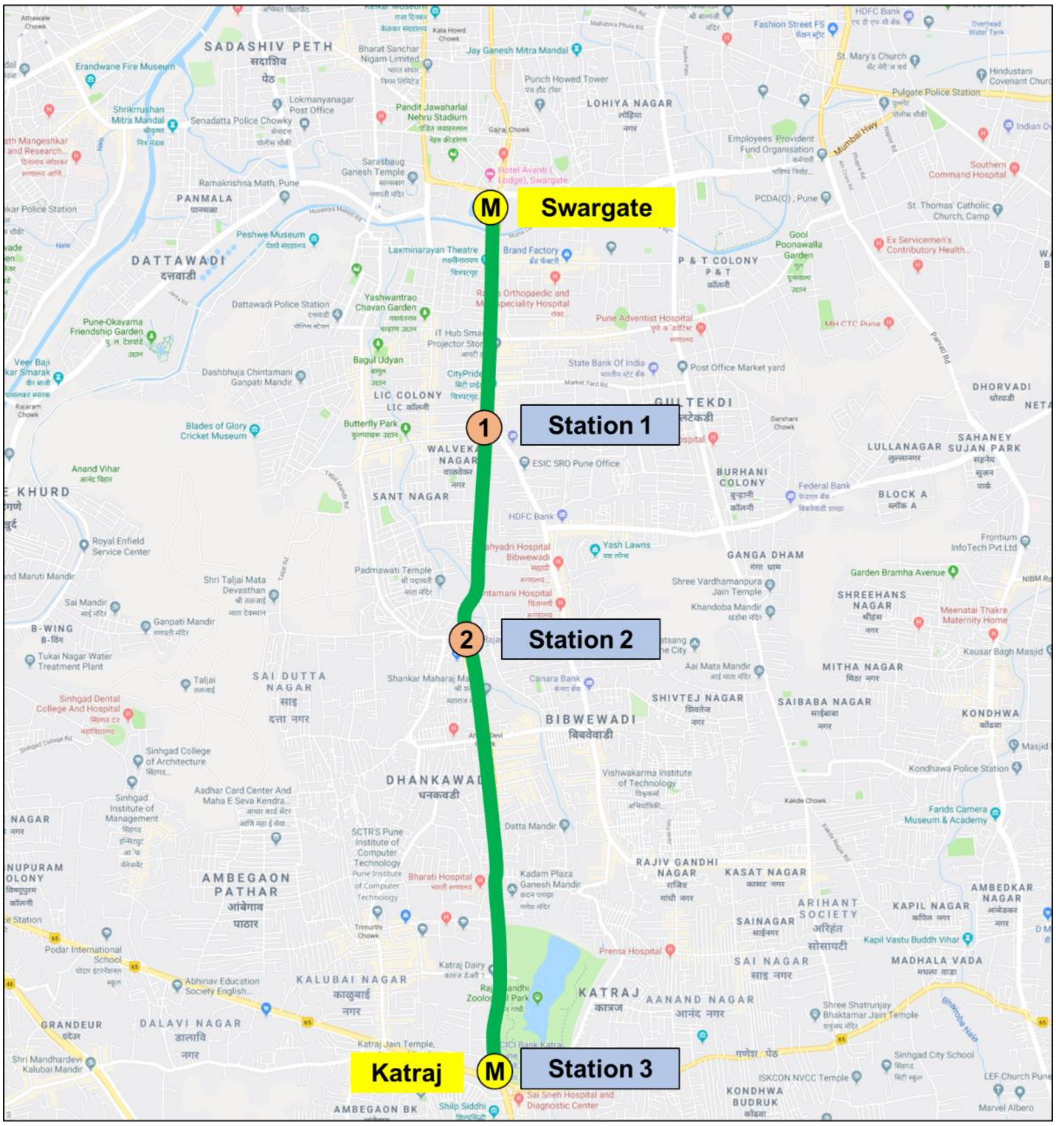


Figure 77. Proposed Stations along Swargate - Katraj Metro Corridor

Table 64 : Connectivity with Other Public Transport Systems - Swargate - Katraj Corridor

Station Name	Connectivity with City Bus System and Other Features
Station 1	• Station 1 is the first station of Swargate-Katraj South extension. It is proposed to be underground. • At station 1, the estimated number of boarding and alighting passengers during peak hour are 1750 and 1720 respectively in the year 2057. • This station is surrounded by public area, residential buildings, commercial area etc. • Roads near Metro station are Pune-Satara Highway & Swami Vivekananda Road. • The transport integration plan for station 1 would facilitate a seamless connectivity for passengers by providing proper facilities like, footpath, bus stop, parking, pick up /drop off area. Staircase, ramps & escalators are proposed for seamless transfer of passengers.
Station 2	• Station 2 is proposed as an underground metro station near Padmavati Bus Stand. • The land use around the station are commercial (Mangal Murti Complex, Manomayy Technologies etc.), public • At this station, the estimated number of boarding and alighting passengers during peak hour are 2020 and 1690 respectively in the year 2057. • Station 2 is proposed near Pune-Satara Highway X Golvalkar Guruji Path Intersection which has 3 arms. • The proposed transport integration plan of Metro Station facilitates smooth and safe interchange of passengers by providing proper facilities like pedestrian pathway, cycle track, bus stop, parking, pick up & drop off area, etc.

Station Name	Connectivity with City Bus System and Other Features
Station 3	• Station 3 is located near Katraj depot, which is one of the main bus depots on the corridor. Near the 4-arm intersection formed by conjunction of roads i.e. Pune-Satara Road and Mumbai-Pune Bypass Road. Katraj station is the major point of interchange as it is the last station/terminal of the metro corridor. It is one of the major entry points to the city. Most of the passengers are the business passengers and daily workers/employees from the surrounding rural areas. • The surrounding area is equally dominated by residential developments (i.e. high-rise apartments) and commercial development (i.e. JSMP group of institutes, Manik Moti Complex etc.). The expected peak hour boarding and alighting at the station by year 2057 will be 7130 and 6790 respectively.

7.2 Feeder Service

Feeder services are the most vital secondary public transportation systems as it enables the users with last mile connectivity and contributes to build a stronger patronage for Metro system. Usually, the coverage of feeder service is about 2 to 4 Kms in radius.

Fleet requirement is based on the passenger demand who are likely to use the proposed feeder service after metro line is operational. The assessment is made considering existing bus routes complementing to the metro shall continue. Feeder service has been planned for the areas which are not served by any public transit system to provide first & last mile connectivity.

Route planning is done targeting passengers in radial distance of 2-4 km from the metro stations and complementing the other public transit and Bicycle Schemes. There are a good number of bus services already serving the commuters in the influencing area. The number of feeder buses required has been estimated considering the peak demand of the horizon years viz. 2027, 2037, 2047 and 2057. The additional Feeder routes proposed on Swargate-Katraj corridor are presented below. The feeder buses requirement for respective years for South extension (Swargate-Katraj) is presented in below.

In Delhi, DMRC has deployed feeder buses with a sitting capacity of 18 passengers and total capacity of 30 passengers. However, feeder bus service facility has long way to go as the bus conditions are not so good to travel. Since it is handled by the private operators who normally waits to fetch more passengers, the headway become long and passengers must wait for longer time. Because of this, passengers shift to other modes of transport (i.e. Auto/Taxi) to access the metro station. These things should be kept in mind while implementing feeder services at any metro station.

The roads on which the metro feeder routes are proposed are presented below.

Route 1: Station 1 (Swargate-Katraj Corridor)

Route 2: Station 3 (Swargate-Katraj Corridor)

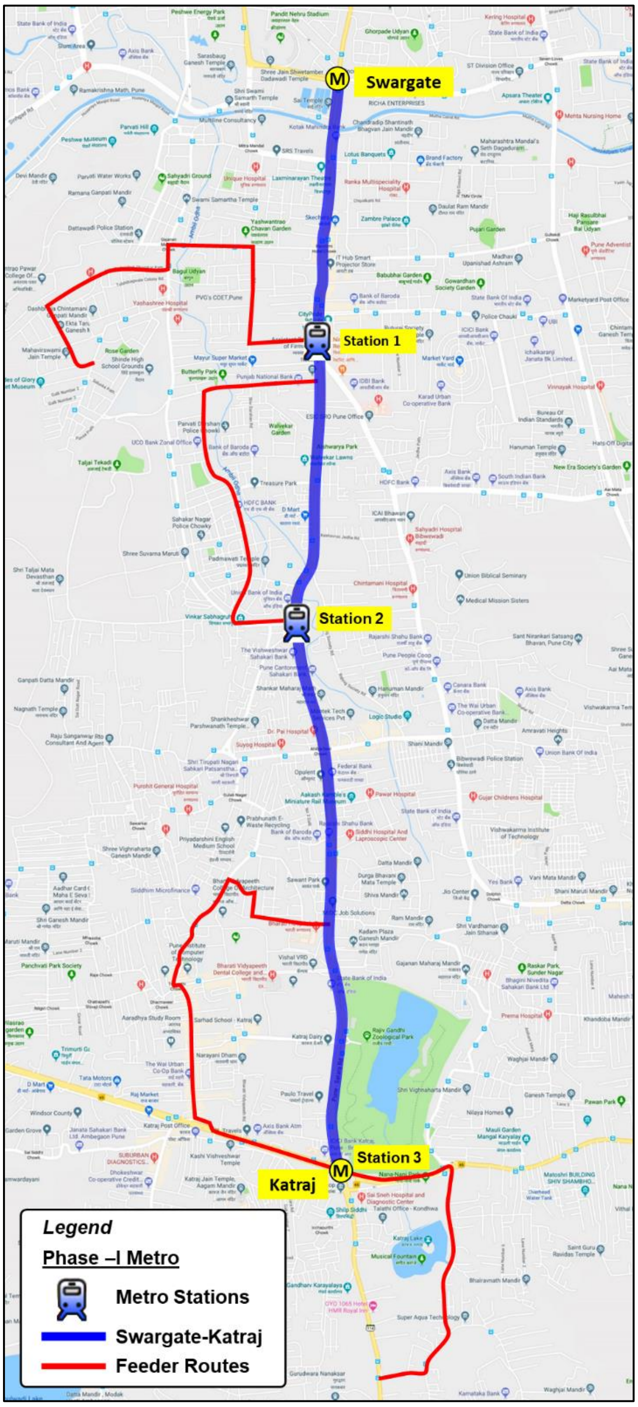


Figure 78. Proposed Metro Feeder Bus Routes – Swargate -Katraj Corridor

Table 65 : Feeder Bus System - Swargate-Katraj Metro Corridor

SN	Metro Station	Route No	Feeder Bus Route Name	Length (Km)	Required No. of Buses in Peak Hour			
					2027	2037	2047	2057
1	Station 1 (Market Yard, Gultekdi)	R1	Station 1 to Chintamani Nagar via Late Raghunath Genuji Taware Path, Shiv Darshan Road & Late Dadasaheb Dhomkar Path	2.5	1	2	3	4
2	Station 2 (Padmavati)	R1	Station 2 to Station 1 via Golvalkar Guruji Path-Chandrashekhar Azad Path	2.43	1	2	3	4
3	Station 3 (Katraj)	R1	Station 3 to Bhartiya Vidyapeeth via Akshay Nagar, Chandrabhaga Nagar Road & Mumbai Pune Road	2.96	1	2	3	5
		R2	Station 3 to Katraj Ghat Road via Katraj Kondhwa Road - Katraj Lake Road & Gujarwadi Road	1.95	1	2	4	5
Year Wise Total Buses Required					**4**	**8**	**13**	**18**

7.3 Physical infrastructure requirement for integration with other modes

7.3.1 Integration with Active Mobility Users

To enhance accessibility to Metro stations, passengers are encouraged to commute to stations by walk / bicycles. This action will not only beneficial for managing authorities, but also promotes the healthy living of citizens. Hence, the planners must create the urban living into eco-friendly zone with basic amenities.

Vulnerable user groups like differently abled, the elderly and their accessibility measures must be taken care meticulously. Some of the facilities include longer crossing time for senior citizens (Pelican signal upgradation), pedestrian sidewalks of about 1.8 m - 3 m width, bicycle lanes of 1 m - 1.2 m, walking shelters to protect commuters from rain and heat, etc. Tactile paving, elevators and ramps need to be provided within the MRT stations. Ramps with gentle slope shall be designed for pedestrians and wheelchair users. Cycle parking shall be planned at all the stations to safely park the private cycles (Docked /Turnstile). Junctions and intersections should be proposed with proper pedestrian crossings. Proper road markings, Traffic Signages, Zebra Crossings and Pedestrian Signals shall be proposed to provide safe and uninterrupted pedestrian movement.

7.3.2 Park-and-ride Facilities

A limited number of parking slots should be provided in selected stations to discourage the usage of private modes of transportation. This action encourages car/ two-wheeler commuters to use public transport automatically with a great comfort and satisfaction due to high congestion of roads during peak hours. Transport planners strive to attract huge number of users towards MRT by different modes such as walking, cycling or feeder services only.

7.3.3 Access to Stations with IPT

Auto Rickshaws contribute a significant modal share in Indian Cities. Since, autorickshaws play a very vital role, it is very important to provide well designed pick up and drop off zones near to the metro stations. The design of site-specific pick up and drop off points seem to be a most wanted feature as per current scenario in the city of Pune.

7.4 Institutional integration

Institutional integration is used to create an organizational framework for joint planning and operation of transit services. For smooth operation of metro, different groups of association (e.g. tariff associations, transit communities, transit federations etc.) merge/integrate with each other to provide seamless public transport infrastructure.

7.5 Physical integration

Physical (or spatial) integration describes efforts to co-locate the various parts of a transport system. This generally occurs at stations, but also happens elsewhere in the network. Examples include taxi stands outside metro stations, walkways connecting stations directly to adjacent buildings, stations serving various bus and train lines, and bikeways along Metro routes, among others.

The first priorities for physical integration within a Metro network, essentially pre-requisite of good system design, is with the pedestrian and cycling environment surrounding the station, terminal or Multi Modal facility and with the different lines and services of the metro system itself by creating an easy transfer within.

Metro can be integrated with short and long-distance public transport infrastructure e.g., Bus/ BRT/ Train Stations, and, in some cases, airports. Again, physical planning is key to making this option viable. Travellers from such modes often are carrying luggage or goods and need a convenient transfer mechanism.

Please refer **Annexure 1** for Physical Integration Plans for both Swargate – Katraj metro corridor.

7.6 Fare integration

The absence of an integrated public transportation system causes problems and inconvenience for commuters and authorities in terms of compromising the necessities such as Comfort, Transparency, Travel time and Costs. It improves the experience of seamless mobility. Rechargeable Smart Card is the efficient fare collection system in most of the public transportation systems around the World. Integrated fare system enables the users to transit between two different modes of transport / interchange in same mode at lower cost and high comfort. Handling cash can be lessened which in turn reduces the theft complaint in Public Transportation Systems. To avoid large queue in the counters, the fare collection systems could be outsourced to a third-party operator within a radius of 1 Km to 2 Km from all the metro stations.

7.7 Operational integration

The operational integration is an application of management techniques to optimize allocation of transit resources and coordinate services. The techniques of the operational integration are enlisted below:

- Rationalization of redundant services
- Matching modes to service requirements
- Development & Scheduling of feeder route services

- Unification of fare structure
- Fare discounts
- Coordinated public information system
- Reserved bus lanes and streets
- Parking controls

7.8 Technology integration

Technology plays a very crucial role in the public transport. Technology integration deals with the information on routes, schedules, fares and transfer points for all transit modes and services throughout the urban limits which is provided by concerned authorities. Providing integrated and real time information during the journey and before the journey, with the help of intelligent transport system (ITS), helps to attracts commuters. Smartphone apps can be used to obtain the information with few clicks.

7.9 Public Bicycle Sharing Scheme

Cycle sharing provides an ideal transport solution for short trips and a feeder to other public transport options. Cycle sharing can help reduce pollution, reduce traffic noise, improve safety on the roads. For users, it is a healthy mode of transport, often quicker than other modes for short distances, without the need to maintain the cycle or worrying about where to park.

Some of the private players like Yulu, Ofo, Pedal Saddle have come forward to promote and make the commuters utilize bicycle sharing scheme. These schemes will be predominantly used by commuters around 1 km to 2 km around metro stations. Also, Government has been constantly encouraging the commuters to use free and shared bicycles for a short rental period. The main motto of encouraging is for the convenience of passengers as well as for increasing the ridership of metro.

The requirement of bicycles along the Swargate-Katraj corridor is estimated and is presented in table below. The requirement of bicycles may increase as it wholly depends on how the authorities make the policy and implement bicycle sharing scheme throughout the city.

Table 66 : Bicycle Sharing Scheme - Swargate-Katraj Corridor

S No	Metro Station	No. of Cycles			
		2027	2037	2047	2057
1	Station 1 (Market Yard, Gultekdi)	26	47	52	53
2	Station 2 (Padamavati)	29	53	59	61
3	Station 3 (Katraj)	115	182	203	214
	Year Wise Total Bicycles Required	170	283	314	327

Annexure 1

Station wise **Schematic Physical Integration Plans** as mentioned below are presented in the next pages.

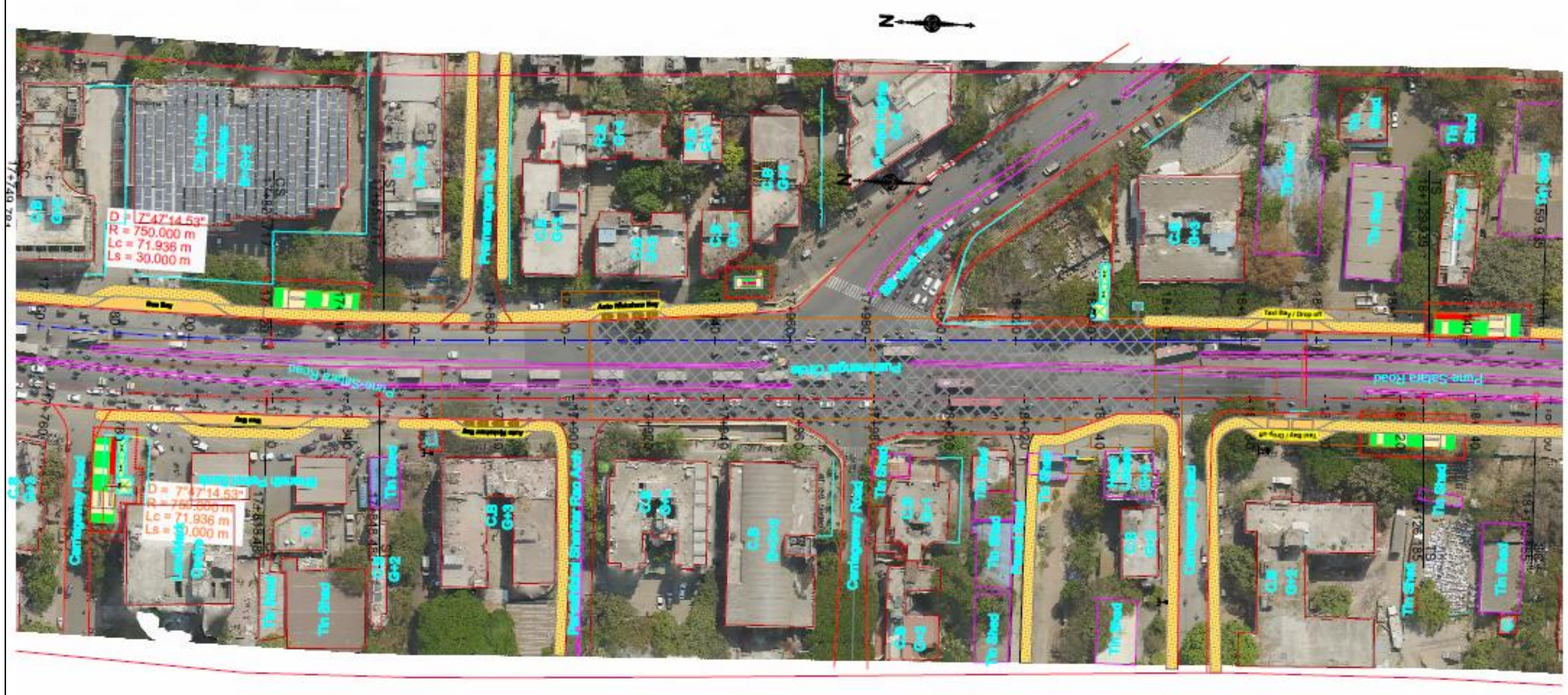
Swargate-Katraj Corridor

1) Station 1
2) Station 2
3) Station 3

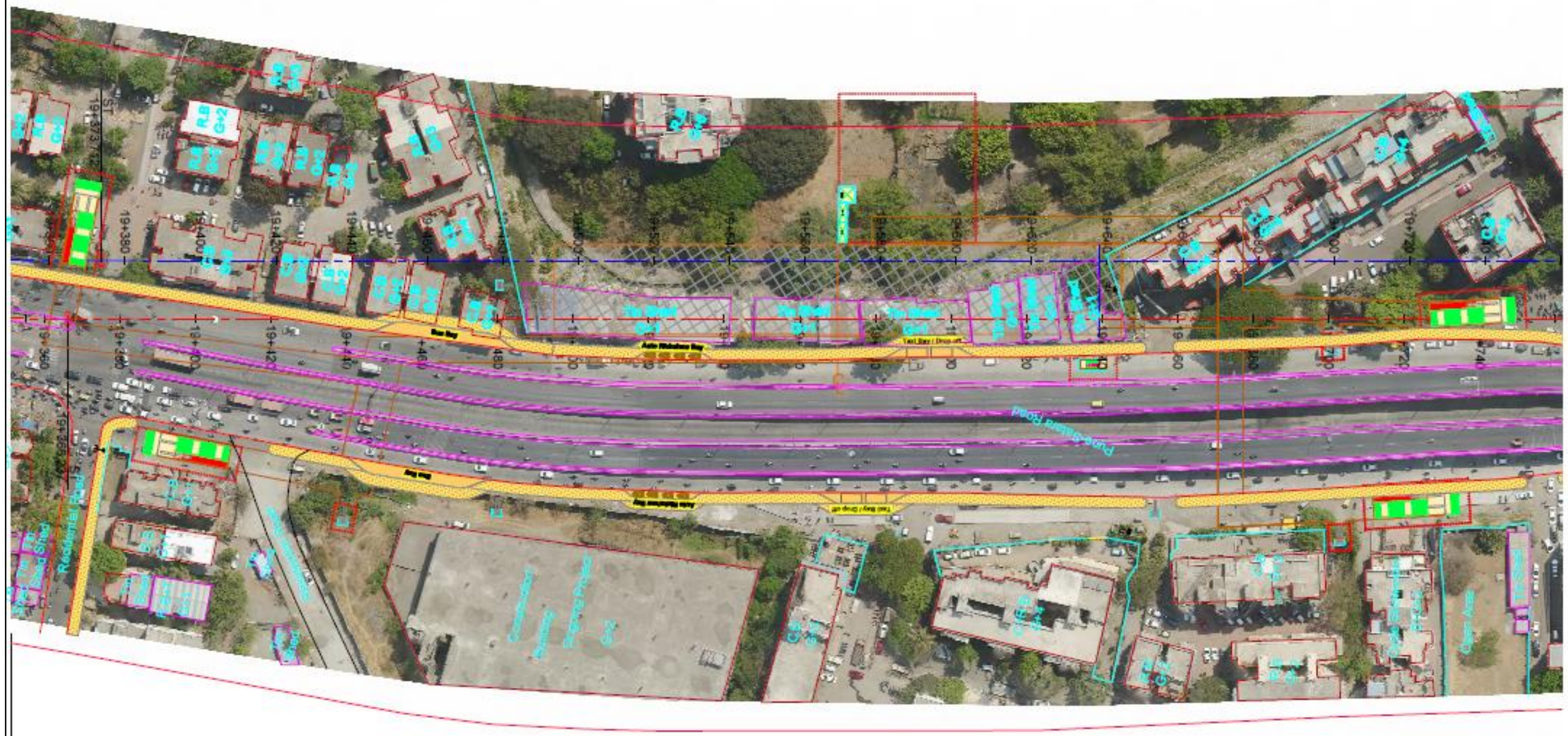
< SWARGATE

STATION 1- NEAR MARKET YARD, GULTEKDI

KATRAJ >



SWARGATE STATION 2 - **PADMAVATI** KATRAJ




SWARGATE
STATION 3 - NEAR KATRAJ
KATRAJ

8. TRAIN OPERATION PLAN

8.1 System Operation Approach

The underlying operation philosophy is to make the MRT system more attractive and economical, the main features being:

- Selecting the most optimum frequency of train services to meet sectional capacity requirement during peak hours on most of the sections;
- Economical & optimum train service frequency not only during peak period, but also during off-peak period;
- Short trains consist of 3 coaches with high frequency service in initial years. Later, some of 3-car trains converted to 6 coaches to meet peak hour demand in high PHPDT section;
- Multi-tasking of train operation and maintenance staff;
- Introduction of short loop services to cater to increased passenger load during peak hours with minimum no. of trains.

8.1.1 Stations

Swargate-Katraj extension of Corridor-1 (Phase 2A) includes 3 stations listed in table hereunder.

Table 67 : Stations on line corridor - (Nigdi-Katraj)

Phase	S.No	Name of stations	Chainage (in m)	Inter-station distance (in m)	Remarks
Phase -II (1A)	1	Nigdi	-5489	-	Elevated
	2	Akurdi	-3459	2030	Elevated
	3	Chinchwad	-1789	1670	Elevated
Phase-I	4	PCMC	-340	1449	Elevated
	5	ST Tukaram Nagar	1763	2103	Elevated
	6	Bhosari	2500	737	Elevated
	7	Kasarwadi	3818	1318	Elevated
	8	Fugewadi	4846	1028	Elevated
	9	Dapodi	5712	866	Elevated
	10	Bopodi	7334	1622	Elevated
	11	Khadki Station	8205	871	Elevated
	12	Range Hill	9680	1475	Elevated
	13	Shivaji Nagar	11729	2049	Underground
	14	Civil Court	12849	1120	Underground
	15	Budhwar Peth	14157	1308	Underground

Phase	S.No	Name of stations	Chainage (in m)	Inter-station distance (in m)	Remarks
	16	Mandai	15018	860	Underground
	17	Swargate	16541	1523	Underground
Phase II (2A)*	18	Station 1 (Market Yard, Gultekdi)	17982	1372	Underground
	19	Station 2 (Padamavati)	19568	1586	Underground
	20	Station 3 (Katraj)	21860	2292	Underground

*This report deals with this section

8.2 Station Yard Planning

Provision of front and rear crossovers at terminal station (at Katraj) are advise for better operational performance and flexibility. In case rear cross-overs cannot be accommodated due to certain unavoidable circumstances, front crossovers shall be provided to make operation from both platforms feasible. The crossovers shall be provided as near to the terminal station as possible to achieve better headways when required.

Provision of train stabling facility is recommended on mainline

- for future stabling requirements to minimize empty running of train and
- to stable train got faulty during service.

Recommended locations from operations perspective are minimum one near Katraj and one near Swargate

8.3 Train Operation

8.3.1 Salient Features

- Running of services for 19 hours of the day (05:00Hrs to 24:00Hrs) with a maximum station dwell time of 40 seconds;
- Make up time of 5-10% with 8-12% coasting;
- Schedule speed has been taken as 33 km/hr.

8.3.2 Traffic demand

Peak hour peak direction traffic demands (PHPDT) for the Pune Metro Corridor-1 Phase-2A for the horizon years for the purpose of planning the network capacities are summarised hereunder. Station Boarding/ Alighting figures and Sectional PHPDT is detailed in subsequent tables in this section.

Summary of Ridership and PHPDT figures for horizon years :

Table 68 : Stations on Corridor -Nigdi-Katraj

PUNE METRO DPR - PHASE-II CORRIDOR - 2A					
Scenario 2A	**Ridership**	2027	2037	2047	2057
Nigdi - Katraj	**Peak Hour**	64100	85200	98700	100800
	Daily	668000	888000	1028000	1050000
	PHPDT	18070	22980	27020	28170

Sectional Boarding and Alighting figures for horizon years are detailed in table hereunder.

Table 69 : Boarding- Alighting figures for Corridor - Nigdi-Katraj

Nigdi to Katraj		Peak-Hour-Boarding/Alighting							
Sl No	**Station**	**2027**		**2037**		**2047**		**2057**	
		Boarding	Alighting	Boarding	Alighting	Boarding	Alighting	Boarding	Alighting
1	Nigdi	1020	1090	1360	1830	1570	2210	1610	2260
2	Akurdi	1310	1450	1530	2130	1760	2530	1800	2580
3	Chinchwad	1140	1390	1630	2110	1890	2580	1940	2640
4	PCMC	4970	3390	6230	4770	7030	5460	7180	5580
5	Tukaram Nagar	2670	2630	3610	3900	4090	4560	4180	4660
6	Bhosari	3750	3680	4840	4970	5460	5660	5580	5790
7	Kasarwadi	2390	2330	3260	3350	3660	3760	3740	3840
8	Fugewadi	2100	1820	2860	2650	3200	3080	3270	3150
9	Dapodi	4480	4000	5310	5030	5920	5910	6050	6040
10	Bopodi	4420	4380	5370	5510	6100	6360	6240	6500
11	Khadki Station	2140	2370	2780	2980	3090	3420	3160	3490
12	Range Hill	2610	3080	3310	3880	3740	4460	3820	4550
13	Shivaji Nagar	5180	5350	6600	6550	7630	7750	7790	7920
14	Civil Court	7990	8730	10240	11120	11690	12560	11940	12830
15	Budhwar Peth	3570	2860	4550	3660	5400	4330	5510	4420
16	Mandai	2670	2520	3430	3260	4180	3940	4270	4020
17	Swargate	6100	7180	8830	8830	11830	10340	12090	10570
18	Station 1	880	880	1580	1480	1740	1690	1750	1720

Nigdi to Katraj		Peak-Hour-Boarding/Alighting							
SI No	Station	2027		2037		2047		2057	
		Boarding	Alighting	Boarding	Alighting	Boarding	Alighting	Boarding	Alighting
19	Station 2	950	1000	1780	1610	1950	1630	2020	1690
20	Station 3	3820	3970	6060	5570	6760	6470	7130	6790
Total Ridership		64160	64100	85160	85190	98690	98700	100860	100850

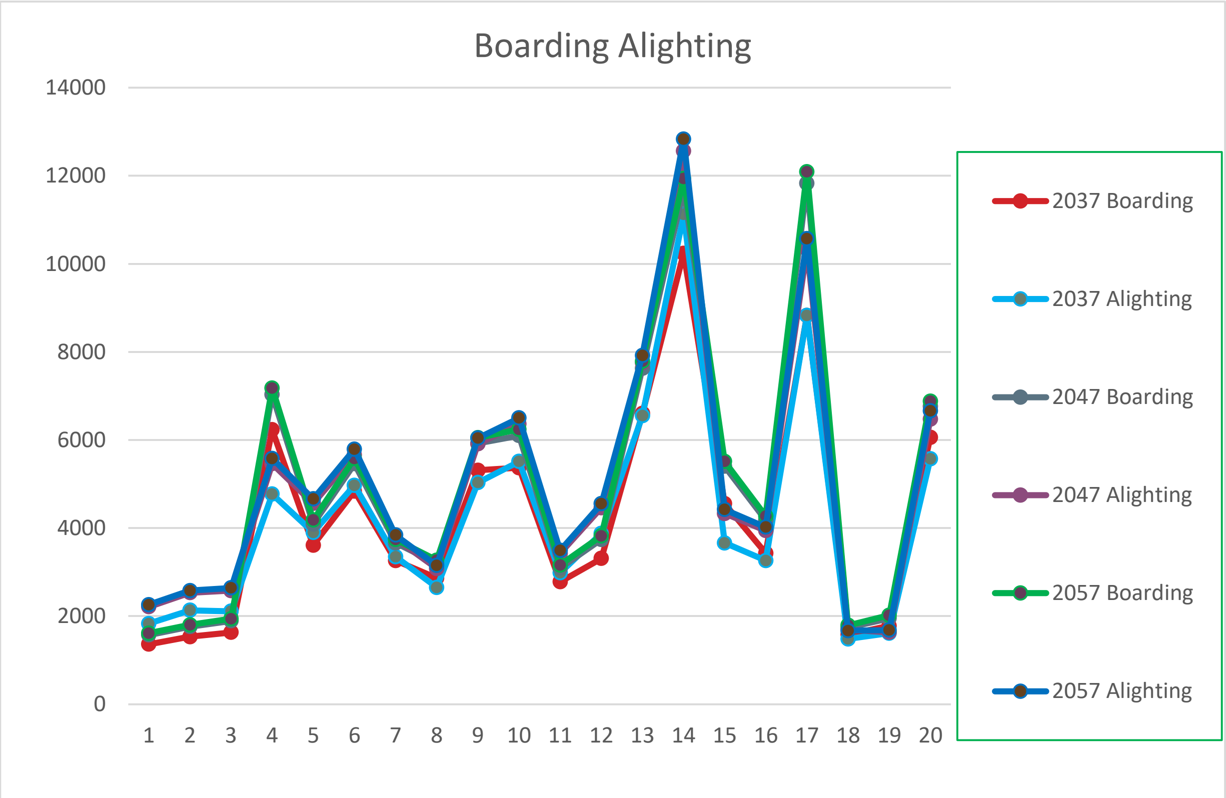


Figure 79. Boarding- Alighting Chart – Corridor-Nigdi-Katraj

Sectional Traffic Demand for horizon years is given the table hereunder:

Table 70 : Traffic Demand - Corridor-Nigdi-Katraj

Traffic Demand in PHPDT					
Section		Year			
From	To	2027	2037	2047	2057
Nigdi	Akurdi	1090	1830	2210	2300
Akurdi	Chinchwad	2520	3940	4700	4900
Chinchwad	PCMC	3750	5490	6560	6840

PCMC	Tukaram Nagar	6600	9430	10990	11460
Tukaram Nagar	Bhosari	8700	12370	14400	15010
Bhosari	Kasarwadi	11250	15800	18330	19110
Kasarwadi	Fugewadi	12520	17660	20360	21230
Fugewadi	Dapodi	13770	19320	22240	23190
Dapodi	Bopodi	15020	21020	24380	25420
Bopodi	Khadki Station	15960	22390	26120	27240
Khadki Station	Range Hill	16230	22760	26630	27770
Range Hill	Shivaji Nagar	16380	22980	27020	28170
Shivaji Nagar	Civil Court	14730	20890	24840	25900
Civil Court	Budhwar Peth	13710	19780	23480	24480
Budhwar Peth	Mandai	11290	16770	20260	21130
Mandai	Swargate	8820	13720	16920	17640
Swargate	Station 1	4160	6790	7680	8010
Station 1	Station 2	4140	6600	7430	7810
Station 2	Station 3	3820	6060	6760	7130
Maximum PHPDT		16380	22980	27020	28170

Figure 82: Traffic Demand Chart – Corridor-Nigdi-Katraj

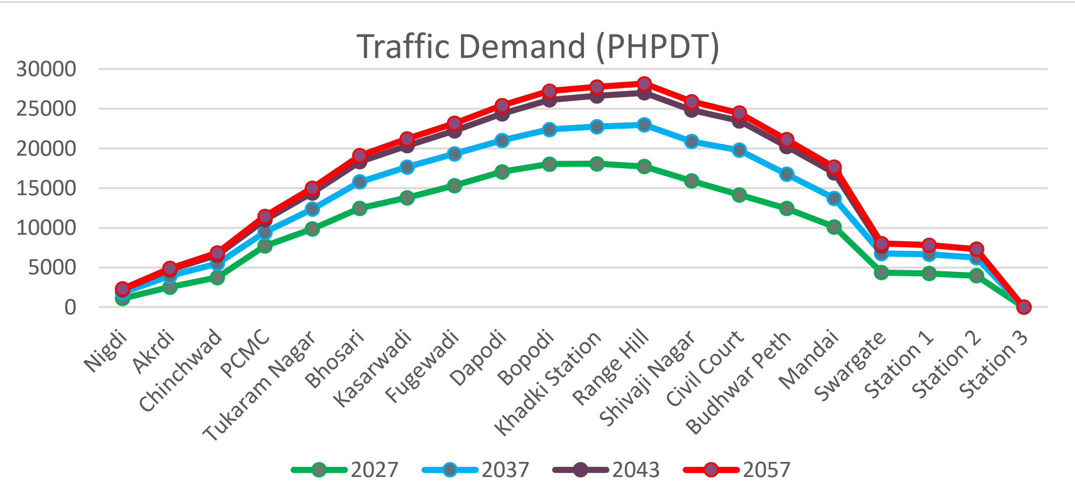


Figure 80. Traffic Demand Chart – Corridor-Nigdi-Katraj

8.3.3 Train Formation

To meet the projected traffic demand, the possibility of running trains with different headways has been examined.

Accordingly, for Corridor-1, 3-car trains are proposed for the year 2027 whereas a mix of 3-car and 6-car trains is proposed for year 2037, 2047 and 2057.

Composition
DMC : Driving Motor Car
MC : Motor Car
TC : Trailer Car

3 Car Train Composition	DMC + TC + DMC
6 Car Train Composition	DMC + TC + MC + MC + TC + DMC

Capacity

3 Car Train:	6p/sqm standee- 764 Passengers;
	8p/sqm standee- 975 Passengers
6 Car Train:	6p/sqm standee- 1574 Passengers;
	8p/sqm standee- 2004 Passengers

8.3.4 Train Operation Plan of Corridor - Nigdi to Katraj

Based on the projected PHPDT demand, Train operation for Pune Metro Corridor-1 Phase-2A is planned with train carrying capacity calculated @6 persons per square meter of standee area in train and is detailed in following sections for years 2027, 2037, 2047 and 2057.

- **Year 2027**

Corridor-1 (Nigdi to Katraj) has peak traffic with PHPDT of **18000** in section Khadki Station-Range Hill. To cater the traffic, Train operation with **3-car trains** with headway of **2.7** min in section PCMC-Swargate is planned with Peak Hour Peak Direction Capacity of **16800** @6 persons per square meter of standee area (Capacity of **21500** @8 persons per square meter of standee area under crush loading conditions)**.**

As PHPDT in sections beyond PCMC-Swargate is very low (PHPDT of 4370), peak headway of only 5.4 min is considered sufficient in this section. Accordingly, every alternate train is planned to be short looped from PCMC and Swargate, at least during peak hours. This has minimized Rolling Stock and Train Operator requirement.

The planned capacity of **16800** (**21500** under crush loading) is less than the PHPDT demand in four sections out of twenty sections. With this planned PHPDT capacity, optimum utilization of Rolling Stock will be achieved, and empty running of trains will be considerably reduced. However, the Rolling Stock is designed for carrying higher density loading @ 8 standee passengers per square meter. The sections in which PHPDT capacity exceeds the planned capacity, overloading during these peak hours is tolerable. Traffic demand and train capacity for this corridor in the year 2027 is tabulated and represented on a chart provided hereunder

Table 71 : Traffic Demand and Capacity - Corridor-Nigdi-Katraj

Year					**2027**
Headway (Sec)					**164**
S No.	From	To	PHPDT	Capacity @6p/sqm	Capacity @8p/sqm
1	Nigdi	Akurdi	1090	8404	10725
2	Akurdi	Chinchwad	2520	8404	10725
3	Chinchwad	PCMC	3750	8404	10725
4	PCMC	Tukaram Nagar	7720	16808	21450
5	Tukaram Nagar	Bhosari	9860	16808	21450
6	Bhosari	Kasarwadi	12470	16808	21450
7	Kasarwadi	Fugewadi	13800	16808	21450
8	Fugewadi	Dapodi	15320	16808	21450
9	Dapodi	Bopodi	17060	16808	21450
10	Bopodi	Khadki Station	18030	16808	21450
11	Khadki Station	Range Hill	18070	16808	21450
12	Range Hill	Shivaji Nagar	17740	16808	21450
13	Shivaji Nagar	Civil Court	15910	16808	21450
14	Civil Court	Budhwar Peth	14150	16808	21450
15	Budhwar Peth	Mandai	12450	16808	21450
16	Mandai	Swargate	10110	16808	21450
17	Swargate	Station 1	4370	8404	10725
18	Station 1	Station 2	4250	8404	10725
19	Station 2	Station 3	3970	8404	10725

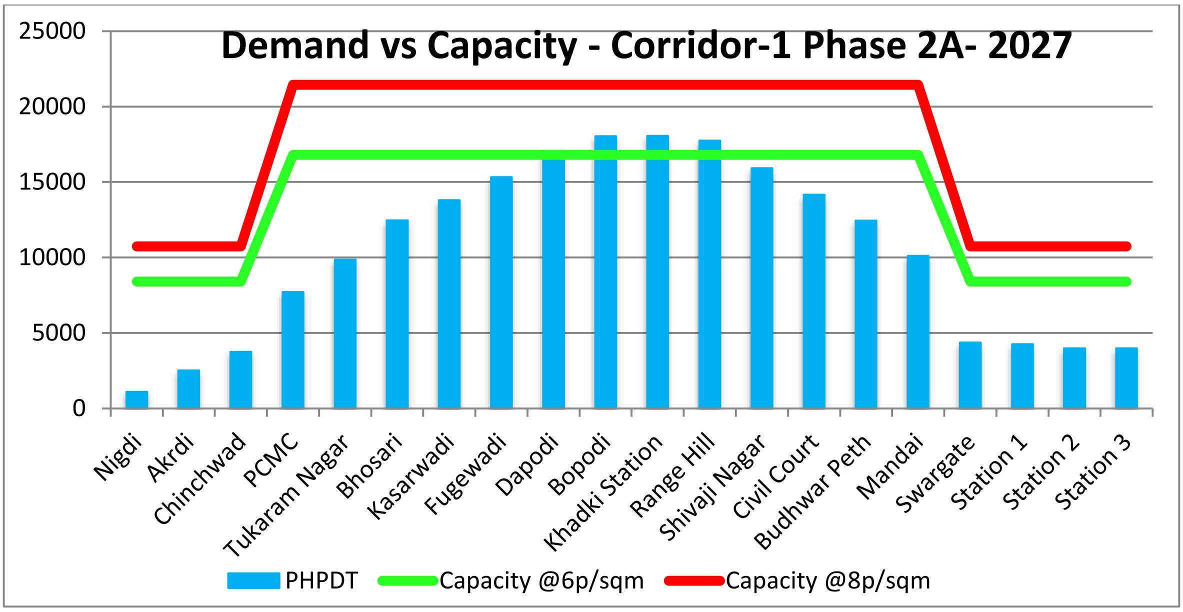


Figure 81. Demand vs Capacity Chart- 2027- Corridor-Nigdi-Katraj

- **Year 2037**

Corridor-1 (Nigdi to Katraj) has peak traffic with PHPDT of **23000** in section Khadki Station-Range Hill. To cater the traffic, Train operation with 3-car & 6-car trains with headway of **2.5** min in section PCMC-Swargate is planned with Peak Hour Peak Direction Capacity of **20000** @6 persons per square meter of standee area (Capacity of **25500** @8 persons per square meter of standee area under crush loading conditions).

As PHPDT in sections beyond PCMC-Swargate is very low (PHPDT of 6750), peak headway of only 5 min is considered sufficient in this section. Accordingly, every alternate train is planned to be short looped from PCMC and Swargate, at least during peak hours. This has minimized Rolling Stock and Train Operator requirement.

The planned capacity of 20000 (25500 under dense loading) is less than the PHPDT demand in five sections out of twenty sections. With this planned PHPDT capacity, optimum utilization of Rolling Stock will be achieved, and empty running of trains will be considerably reduced. However, the Rolling Stock is designed for carrying higher density loading @ 8 standee passengers per square meter. The sections in which PHPDT capacity exceeds the planned capacity, overloading during these peak hours is tolerable. Traffic demand and train capacity for this corridor in the year 2037 is tabulated and represented on a chart provided hereunder.

Table 72 : Traffic Demand and Capacity – Corridor-Nigdi-Katraj

Year					2037
Headway (Sec)					**150**
S No.	From	To	PHPDT	Capacity @6p/sqm	Capacity @8p/sqm
1	Nigdi	Akurdi	1830	9978	12729

Year					2037
Headway (Sec)					150
2	Akurdi	Chinchwad	3940	9978	12729
3	Chinchwad	PCMC	5490	9978	12729
4	PCMC	Tukaram Nagar	9430	19956	25458
5	Tukaram Nagar	Bhosari	12370	19956	25458
6	Bhosari	Kasarwadi	15800	19956	25458
7	Kasarwadi	Fugewadi	17660	19956	25458
8	Fugewadi	Dapodi	19320	19956	25458
9	Dapodi	Bopodi	21020	19956	25458
10	Bopodi	Khadki Station	22390	19956	25458
11	Khadki Station	Range Hill	22760	19956	25458
12	Range Hill	Shivaji Nagar	22980	19956	25458
13	Shivaji Nagar	Civil Court	20890	19956	25458
14	Civil Court	Budhwar Peth	19780	19956	25458
15	Budhwar Peth	Mandai	16770	19956	25458
16	Mandai	Swargate	13720	19956	25458
17	Swargate	Station 1	6790	9978	12729
18	Station 1	Station 2	6600	9978	12729
19	Station 2	Station 3	6060	9978	12729

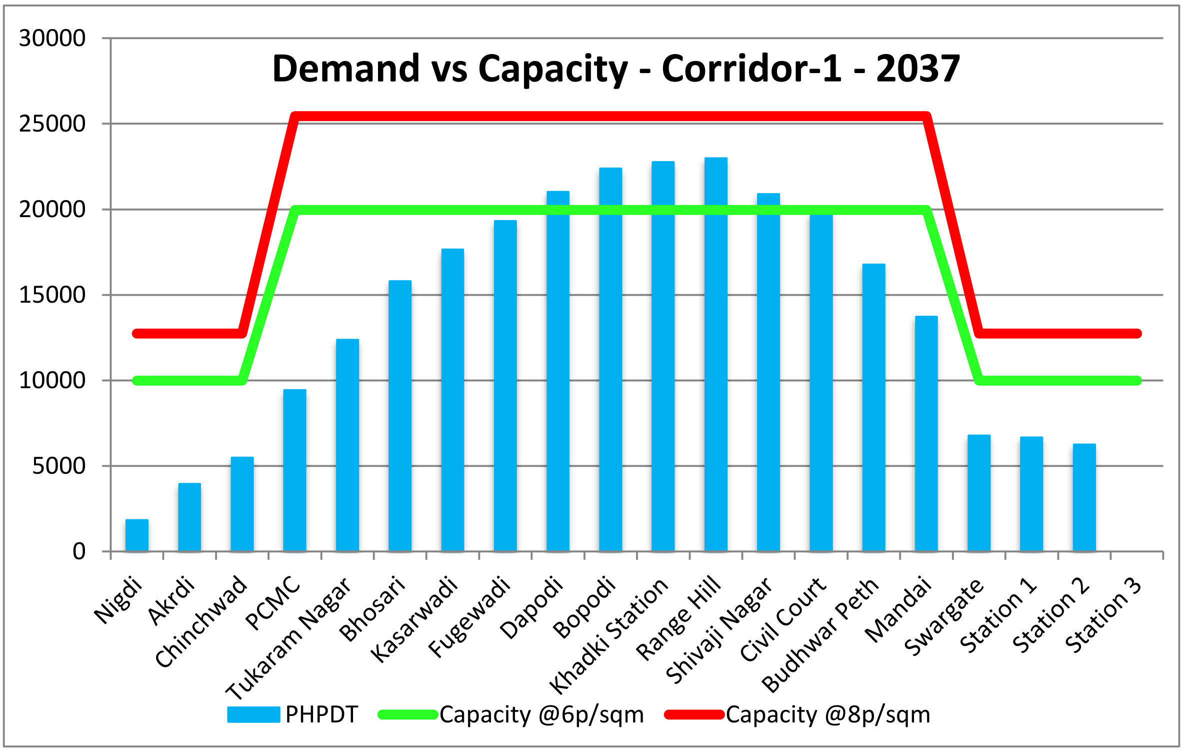


Figure 82. Demand vs Capacity Chart- 2037- Corridor-Nigdi-Katraj

In case of any mismatch in the capacity provided and the actual traffic, the capacity can be moderated suitably by either varying the rake composition or adjusting the headway. E.g. in case of higher demand, headway may be reduced easily by injecting more trains out of reserve trains

- **Year 2047**

Corridor-1 (Nigdi to Katraj) has peak traffic with PHPDT of 27000 in section Range Hill to Shivaji Nagar. To cater the traffic, Train operation with 3-car and 6-car trains with headway of 2.5 min in section PCMC-Swargate is planned with Peak Hour Peak Direction Capacity of 24000 @6 persons per square meter of standee area (Capacity of 30600 @8 persons per square meter of standee area under crush loading conditions).

As PHPDT in sections beyond PCMC-Swargate is very low (PHPDT of 7700), peak headway of only 5 min is considered sufficient in this section. Accordingly, every alternate train is planned to be short looped from PCMC and Swargate, at least during peak hours. This has minimized Rolling Stock and Train Operator requirement.

The planned capacity is less than the PHPDT demand in four sections out of twenty sections. With this planned PHPDT capacity, optimum utilization of Rolling Stock will be achieved, and empty running of trains will be considerably reduced. However, the Rolling Stock is designed for carrying higher density loading @ 8 standee passengers per square meter. The sections in which PHPDT capacity exceeds the planned capacity, overloading during these peak hours is tolerable. Traffic demand and train capacity for this corridor in the year 2047 is tabulated and represented on a chart provided hereunder.

Traffic Demand and Capacity - Corridor-Nigdi-Katraj

Year					**2047**
Headway (Sec)					**150**
S No.	From	To	PHPDT	Capacity @6p/sqm	Capacity @8p/sqm
1	Nigdi	Akurdi	2210	12003	15302
2	Akurdi	Chinchwad	4700	12003	15302
3	Chinchwad	PCMC	6560	12003	15302
4	PCMC	Tukaram Nagar	10990	24006	30603
5	Tukaram Nagar	Bhosari	14400	24006	30603
6	Bhosari	Kasarwadi	18330	24006	30603
7	Kasarwadi	Fugewadi	20360	24006	30603
8	Fugewadi	Dapodi	22240	24006	30603
9	Dapodi	Bopodi	24380	24006	30603
10	Bopodi	Khadki Station	26120	24006	30603
11	Khadki Station	Range Hill	26630	24006	30603
12	Range Hill	Shivaji Nagar	27020	24006	30603

Year					2047
Headway (Sec)					**150**
S No.	From	To	PHPDT	Capacity @6p/sqm	Capacity @8p/sqm
13	Shivaji Nagar	Civil Court	24840	24006	30603
14	Civil Court	Budhwar Peth	23480	24006	30603
15	Budhwar Peth	Mandai	20260	24006	30603
16	Mandai	Swargate	16920	24006	30603
17	Swargate	Station 1	7680	12003	15302
18	Station 1	Station 2	7430	12003	15302
19	Station 2	Station 3	6760	12003	15302

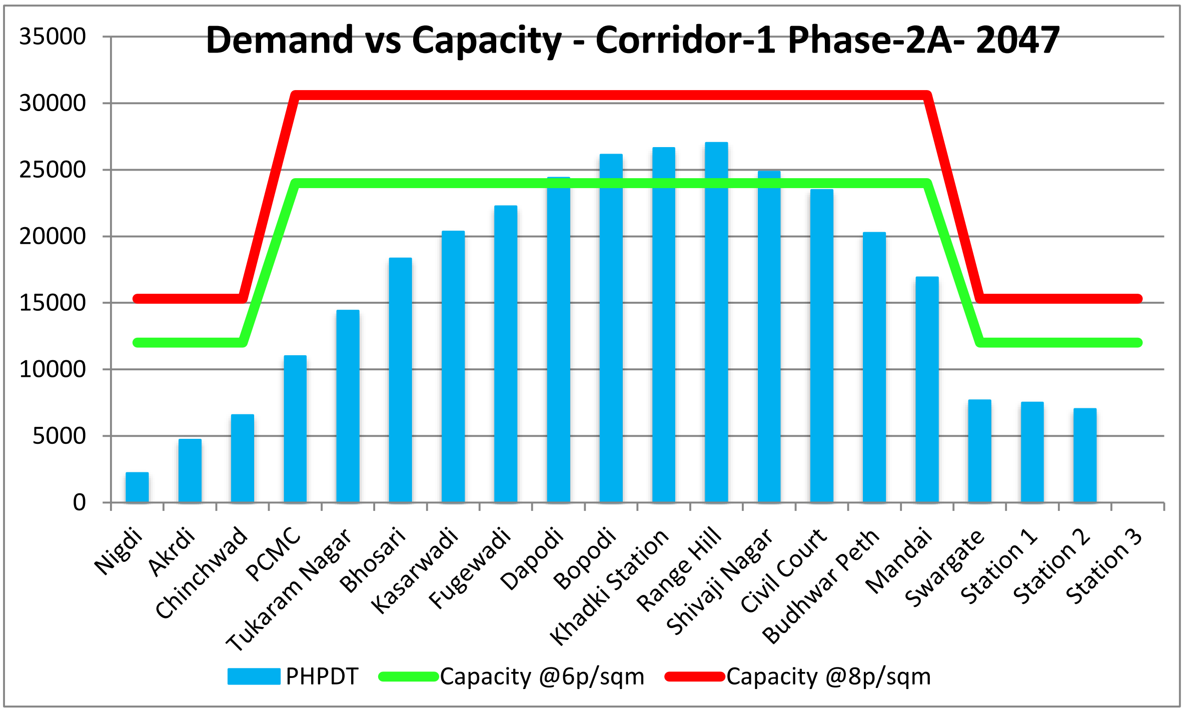


Figure 83. Demand vs Capacity Chart- 2047- Corridor-Nigdi-Katraj

In case of any mismatch in the capacity provided and the actual traffic, the capacity can be moderated suitably by either varying the rake composition or adjusting the headway. E.g. in case of higher demand, headway may be reduced easily by injecting more trains out of reserve trains.

- **Year 2057**

Corridor-1 (Nigdi to Katraj) has peak traffic with PHPDT of 28000 in section Range Hill- Shivaji Nagar. To cater the traffic, Train operation with 3-car trains with headway of 2.5 min in section PCMC-Swargate is planned with Peak Hour Peak Direction Capacity of 25500 @6 persons per square meter of standee area (Capacity of 32500 @8 persons per square meter of standee area under crush loading conditions).

As PHPDT in sections beyond PCMC-Swargate is very low (PHPDT of 8000), peak headway of only 5 min is considered sufficient in this section. Accordingly, every alternate train is planned to be short looped from PCMC and Swargate, at least during peak hours. This has minimized Rolling Stock and Train Operator requirement.

The planned capacity at crush loading is less than the PHPDT demand in four sections out of twenty sections. With this planned PHPDT capacity, optimum utilization of Rolling Stock will be achieved, and empty running of trains will be considerably reduced. However, the Rolling Stock is designed for carrying higher density loading @ 8 standee passengers per square meter. The sections in which PHPDT capacity exceeds the planned capacity, overloading during these peak hours is tolerable. Traffic demand and train capacity for this corridor in the year 2057 is tabulated and represented on a chart provided hereunder.

Table 73 : Traffic Demand and Capacity - Corridor-Nigdi-Katraj

Year					**2057**
Headway (Sec)					**150**
S No.	From	To	PHPDT	Capacity @6p/sqm	Capacity @8p/sqm
1	Nigdi	Akurdi	2300	12813	16331
2	Akurdi	Chinchwad	4900	12813	16331
3	Chinchwad	PCMC	6840	12813	16331
4	PCMC	Tukaram Nagar	11460	25626	32661
5	Tukaram Nagar	Bhosari	15010	25626	32661
6	Bhosari	Kasarwadi	19110	25626	32661
7	Kasarwadi	Fugewadi	21230	25626	32661
8	Fugewadi	Dapodi	23190	25626	32661
9	Dapodi	Bopodi	25420	25626	32661
10	Bopodi	Khadki Station	27240	25626	32661
11	Khadki Station	Range Hill	27770	25626	32661
12	Range Hill	Shivaji Nagar	28170	25626	32661
13	Shivaji Nagar	Civil Court	25900	25626	32661
14	Civil Court	Budhwar Peth	24480	25626	32661
15	Budhwar Peth	Mandai	21130	25626	32661
16	Mandai	Swargate	17640	25626	32661
17	Swargate	Station 1	8010	12813	16331
18	Station 1	Station 2	7890	12813	16331
19	Station 2	Station 3	7130	12813	16331

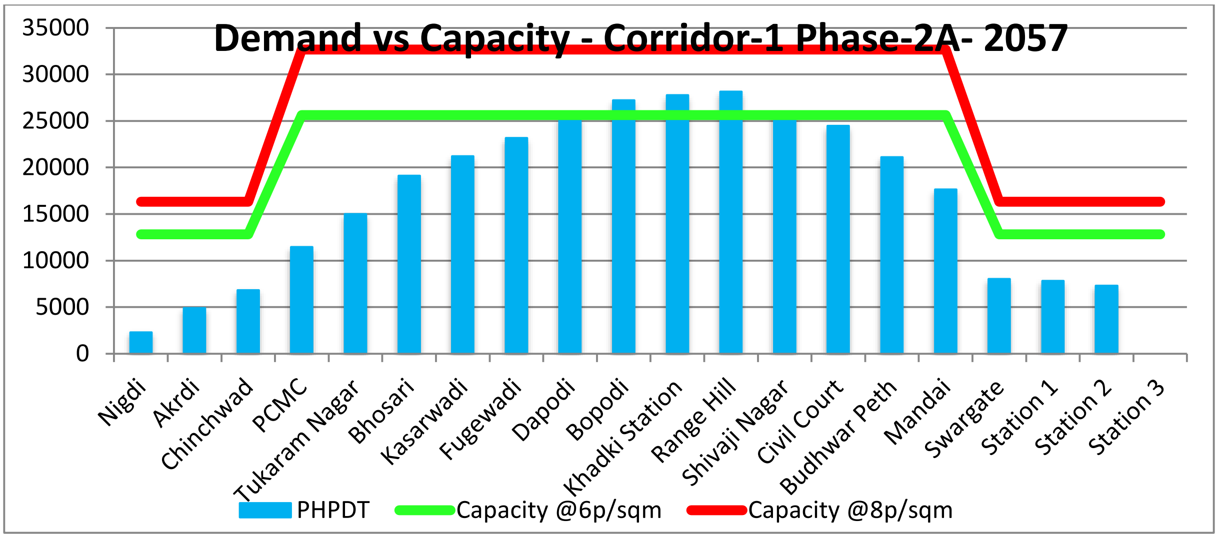


Figure 84. Demand vs Capacity Chart- 2057- Corridor-Nigdi-Katraj

In case of any mismatch in the capacity provided and the actual traffic, the capacity can be moderated suitably by either varying the rake composition or adjusting the headway. E.g. in case of higher demand, headway may be reduced easily by injecting more trains out of reserve trains.

The Summary of Peak Hour Headway and Traffic capacity provided on line 1 Phase 2A in horizon years of operation is tabulated in Table 74.

Table 74 : Capacity Provided for Nigdi – Katraj Corridor

Demand (PHPDT) and Capacity Plan – line 1 Phase 1A (Nigdi- Katraj)								
Year	2027		2037		2047		2057	
Section / Peak Hour characteristics	Nigdi-PCMC & Swargate-Katraj	PCMC-Swargate	Nigdi-PCMC & Swargate - Katraj	PCMC-Swargate	Nigdi-PCMC & Swargate-Katraj	PCMC-Swargate	Nigdi-PCMC & Swargate-Katraj	PCMC-Swargate
Headway (seconds)	327	164	300	150	300	150	300	150
No. of 3- Cars trains/ Hr	11	22	12	10	12	5	12	3
No. of 6- Cars trains/ Hr	0	0	0	2	0	7	0	9
Peak Demand	4370	18070	6770	22980	7680	27020	8010	28170
Total Capacity @6p/sqm of standee area	8404	16808	9168	19956	9168	24006	9168	25626
Total Capacity @8p/sqm of standee area	10725	21450	11700	25458	11700	30603	11700	32661

8.3.5 Train frequency

The train operation of Pune Metro provides the train headway:

Table 75 : Train frequency/ Headway provided for Corridor – Nigdi to Katarj

Train Frequency – Corridor 1 Phase 2A (Nigdi- Katraj)								
Year	2027		2037		2047		2057	
Section	Nigdi-PCMC & Swargate-Katraj	PCMC-Swargate	Nigdi-PCMC & Swargate -Katraj	PCMC-Swargate	Nigdi-PCMC & Swargate-Katraj	PCMC-Swargate	Nigdi-PCMC & Swargate-Katraj	PCMC-Swargate
Peak Headway (Min.)	5.4	2.7	5	2.5	5	2.5	5	2.5
Off-Peak Headway (Min.)	6-15	6-15	5-15	5-15	5-15	5-15	5-15	5-15

No services are proposed between 24:00 hrs to 05:00 hrs, which are reserved for maintenance of infrastructure and rolling stock.

Peak hours: Morning – 08:00Hrs to 11:00Hrs

Evening – 17:00Hrs to 20:00Hrs.

8.3.6 Hourly Train Operation plan

The hourly distribution of daily transport capacity for Corridor 1 Phase 2A for horizon years are provided in following tables and represented in graphically in following charts.

Table 76 : Hourly Train Operation Plan for Corridor – Nigdi to Katraj

Time		Year 2027					
		PCMC- Swargate			PCMC- Nigdi & Swargate		
From	To	Headway (Min.)	No. of Trips		Headway (Min.)	No. of Trips	
			UP	DN		UP	DN
05:30	06:00	15	2	2	15	2	2
06:00	07:00	12	5	5	12	5	5
07:00	08:00	6	10	10	6.0	10	10
08:00	09:00	2.7	22	22	5.5	11	11
09:00	10:00	2.7	22	22	5.5	11	11
10:00	11:00	2.7	22	22	5.5	11	11

Time		Year 2027					
		PCMC- Swargate			PCMC- Nigdi & Swargate		
11:00	12:00	6	10	10	6	10	10
12:00	13:00	9	7	7	9	7	7
13:00	14:00	9	7	7	9	7	7
14:00	15:00	9	7	7	9	7	7
15:00	16:00	9	7	7	9	7	7
16:00	17:00	6	9	9	6	9	9
17:00	18:00	2.7	22	22	5.5	11	11
18:00	19:00	2.7	22	22	5.5	11	11
19:00	20:00	2.7	22	22	5.5	11	11
20:00	21:00	6	10	10	6	10	10
21:00	22:00	9	7	7	9	7	7
22:00	23:00	12	5	5	12	5	5
23:00	23:30	15	2	2	15	2	2
Total Trips			**220**	**220**		**154**	**154**

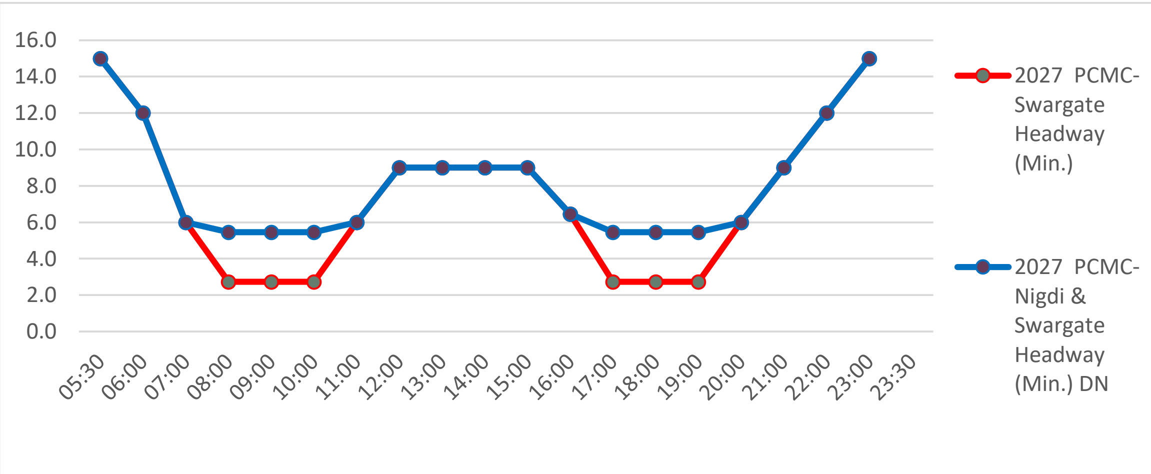
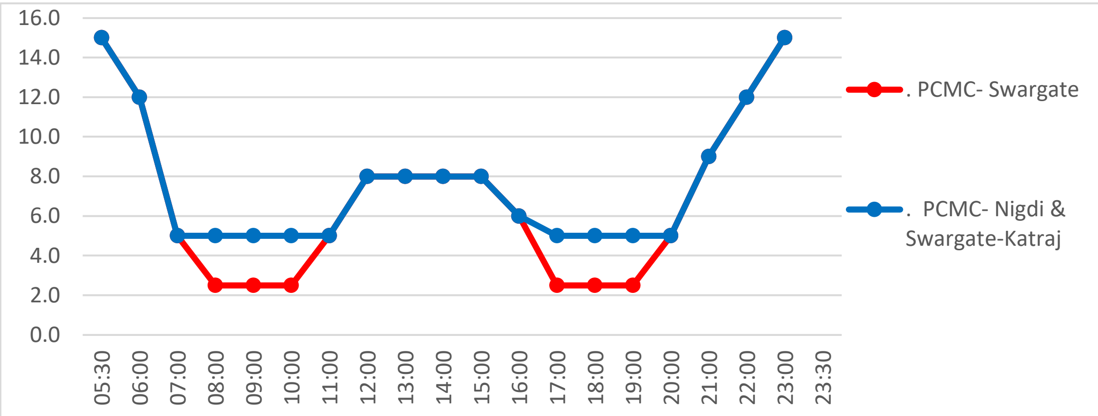


Figure 85. Hourly Train Operation Chart- 2027- Corridor-Nigdi-Katraj

Table 77 : Hourly Train Operation Plan for Corridor-Nigdi-Katraj

Time		Year 2037, 2047, 2057					
		PCMC- Swargate			PCMC- Nigdi & Swargate		
From	To	Headway (Min.)	No. of Trips UP	No. of Trips DN	Headway (Min.)	No. of Trips UP	No. of Trips DN
05:30	06:00	15	2	2	15	2	2
06:00	07:00	12	5	5	12	5	5
07:00	08:00	5	12	12	5.0	12	12
08:00	09:00	2.5	24	24	5.0	12	12
09:00	10:00	2.5	24	24	5.0	12	12
10:00	11:00	2.5	24	24	5.0	12	12
11:00	12:00	5	12	12	5	12	12
12:00	13:00	8	8	8	8	8	8
13:00	14:00	8	8	8	8	8	8
14:00	15:00	8	8	8	8	8	8
15:00	16:00	8	8	8	8	8	8
16:00	17:00	6	10	10	6	10	10
17:00	18:00	2.5	24	24	5.0	12	12
18:00	19:00	2.5	24	24	5.0	12	12
19:00	20:00	2.5	24	24	5.0	12	12
20:00	21:00	5	12	12	5	12	12
21:00	22:00	9	7	7	9	7	7
22:00	23:00	12	5	5	12	5	5
23:00	23:30	15	2	2	15	2	2
Total Trips			**243**	**243**		**171**	**171**

Figure 86. Hourly Headway Chart- 2037-2057 Corridor- (Nigdi-Katraj)



8.4 Vehicle kilometre

Based on the above planning, Vehicle Kilometres for Pune Metro corridor-1 Phase 2A are given in tables enclosed hereunder.

Table 78 : Vehicle Kilometre for Corridor-Nigdi-Katraj

Pune Metro Corridor-1 Phase 2A			Nigdi to Katraj		
Section		Year			
		2027	2037	2047	2057
Nigdi to Katraj	Trip length (KM)	27.4	27.4	27.4	27.4
	No. of 3-Car Train Trips	305	337	337	337
	No. of 6-Car Train Trips	0	0	0	0
PCMC-Swargate	Trip length (KM)	16.9	16.9	16.9	16.9
	No. of 3-Car Train Trips	132	120	60	36
	No. of 6-Car Train Trips	0	24	84	108
No. of Trips (Nigdi to Katraj)		305	305	337	337
No. of Trips (PCMC- Swargate)		132	132	144	144
Daily Train KM		10723	10595	11677	11677
Annual Train KM (10^5)		39	39	43	43
Annual Car KM (10^5)		**117**	**116**	**132**	**143**

The calculation for vehicle kilometre is based on assumption that 50% trains will be short looped only during peak-hours. Vehicle kilometres can be further reduced by introducing short looping during off-peak hours such that headway in Phase 2A is not too high for passenger convenience.

8.5 Year-wise rake requirement

Based on train formation and headway as determined above to meet PHPDT, rake requirement has been estimated and tabulated below in brief:

Table : Rake Requirement for Corridor-Nigdi-Katraj

Year	Total Car Requirement	Total Trains Required	
		3-Car	6-Car
2027	108	36	0
2037	132	36	4
2047	150	30	10
2057	156	28	12

Note: Total Car Requirement' includes 90 cars already planned for earlier phases. The detailed calculations of Rolling Stock Requirement in the year 2027 is shown at end of this chapter.

Assumptions:

Requirements of coaches is calculated based on following assumptions:

- Train composition planned as specified in section §11.3.3 Train Composition;
- Coach requirement has been calculated based on headway during peak hours;
- Traffic reserve is taken as one train per corridor to cater to failure of train on mainline and to make up for operational time lost;
- Repair and maintenance reserve have been estimated as 10 % of total requirement (Bare +Traffic Reserve);
- The calculated number of rakes in fraction is rounded off to next higher number;
- Schedule speed is taken as 33 KMPH for corridor 1;
- Total turn-back time at terminals is taken as 3 minutes (90 second each terminal) using front cross-overs.

8.6 Stabling requirement

Stabling capacity in existing depot at Range Hill is not sufficient to accommodate 156 cars (28 numbers of 3-car train and 12 numbers of 6-car trains) required for design year (2057).

Phase-II augmentation of the Range Hill depot is planned to accommodate 22 numbers of 6-car trains or equivalent number of 3-car and 6-car trains which is sufficient for planned Phase-2A requirement upto year 2037.

However, for planned requirement in Phase-2A in year 2047 & 2057, i.e. additional 8 number of 3-car trains, additional stabling facility is required.

Detailed Calculation of Rolling Stock Requirement in the Year 2027

A) Rolling Stock Requirement for PCMC to Swargate section (Yr 2027)

PHPDT **16380**

Capacity of one car train /rak 764 passenger

Trains /hr = (16380/764) = 21.44

Hence, Headway = 2.80 Min

No of Trains = $\frac{\text{Turn around time (TO)}}{\text{Headway}}$

Turn Around Time = $\left(\frac{\text{Length of Corridor * 2}}{\text{Headway}} \right)$ + Switching Time

Turn Around Time = $\left(\frac{17.8 * 2}{33} \right)$ + 10 mins

TO 74.7 mins

Hence, No. of Trains = 26.68 = 27 Nos.

B) Rolling Stock Requirement for PCMC to Nigdi section (Yr 2027)

PHPDT **3750**

Capacity of one car train /rak 764 passenger

Trains /hr = (3750/764) 4.91

Hence, Headway = 12.22 Min

No of Trains = $\frac{\text{Turn around time (TO)}}{\text{Headway}}$

Turn Around Time = $\left(\frac{\text{Length of Corridor * 2}}{\text{Headway}} \right)$ + Switching Time

Turn Around Time = $\left(\frac{4.413 * 2}{33} \right)$ + 10 mins

TO 26.0 mins

Hence, No. of Trains = 2.13 = 2 Nos.

C) Rolling Stock Requirement for Swargate to Katraj section (Yr 2027)

PHPDT **4160**

Capacity of one car train /rak 764 passenger

Trains /hr = (4160/764) 5.45

Hence, Headway = 11.02 Min

No of Trains = $\frac{\text{Turn around time (TO)}}{\text{Headway}}$

Turn Around Time = $\left(\frac{\text{Length of Corridor * 2}}{\text{Headway}} \right)$ + Switching Time

Turn Around Time = $\left(\frac{5.464 * 2}{33} \right)$ + 10 mins

29.9 mins

Hence, No. of Trains = 2.7 = 3 Nos.

Total Trains Requires in 2027 A + B + C 27+2 +3 = 32nos.

trains spares @10% = = 4 Nos trains required

Total trains to be procured = **36 Nos of 3 car trains =** **108 Coaches**

1. The requirement of Rolling Stock for Nigdi – Swargate section is 90 coaches in year 2025.
2. The requirement of Rolling Stock for Nigdi – Kataraj is 108 in year 2027 (mentioned in DPR pg no. 266 (8.5)).
Accordingly, additional requirement 18 coaches (108 minus 90 required for Nigdi – Swargate) is considered.

9. SIGNALLING AND TELECOMMUNICATION SYSTEM

9.1 Signalling System

The Signalling system shall provide the means for an efficient train control, ensuring safety in train movements. It assists in optimization of MRT infrastructure investment and running of efficient train services on the network.

9.1.1 Signalling and train control

9.1.1.1 Overview

Metro carries large number of passengers at a very close headway requiring a very high level of safety enforcement and reliability. At the same time, heavy investment in infrastructure and rolling stock necessitates optimization of its capacity to provide the best services to the public.

These requirements of the metro are planned to be achieved by adopting 'CATC' (Continuous Automatic Train Control System) based on "CBTC" (Communication based Train Control System) which includes ATP (Automatic Train Protection), ATO (Automatic Train Operation) and ATS (Automatic Train Supervision) sub-systems using radio communication between Track side and Train. This will:

- Provide high level of safety with trains running at close headway ensuring continuous safe train separation and for bidirectional working;
- Eliminate accidents due to driver passing signal at danger by continuous speed monitoring and automatic application of brake in case of dis-regard of signal / warning by the driver;
- Provide safety and enforce speed limit on section having permanent and temporary speed restrictions;
- Improve capacity with safer and smoother operations. The driver will have continuous display of Target Speed / Distance to Go status in his cab, enabling him to optimize the speed potential of the track section. It provides signal / speed status in the cab even in bad weather;
- Increase productivity of rolling stock by increasing line capacity and train speeds and enabling train to arrive at its destination sooner. Hence, more trips will be possible with the same number of rolling stocks;
- Improve maintenance of signalling and telecommunication equipments by monitoring system status of trackside and train borne equipment's and enabling preventive maintenance.

Signalling & Train Control system on the line shall be designed to meet the required headway during peak hours.

Note: Radio for CBTC shall work in License free ISM band.

9.1.1.2 System description and specifications

The Signalling and Train Control system shall be as below. Sub-system/components will conform to international standards like CENELEC, IEEE, IEC, BS, ITU-T etc:

- **Continuous Automatic Train Control**

Continuous Automatic Train Control based on CBTC will consist of - ATP (Automatic Train Protection), ATO (Automatic Train Operation) and ATS (Automatic Train Supervision) sub-systems:

- **Automatic Train Protection (ATP)**

Automatic Train Protection is the primary function of the train control systems. This sub-system will be inherently capable of achieving the following objectives in a fail-safe manner. Line side signals will be provided at diverging routes (i.e. at points & crossings) as well as other required locations, which shall serve as backup signalling in case of failure of ATP system.

- Cab Signalling;
- Track Related Speed Profile generation based on line data and train data continuously along the track;
- Continuous monitoring of braking curve with respect to a defined target point;
- Monitoring of maximum permitted speed on the line and speed restrictions in force;
- Detection of over-speed with audio-visual warning and application of brakes, if necessary;
- Maintaining safety distance between trains;
- Monitoring of stopping point;
- Monitoring of Direction of Travel and Rollback.

The cab borne equipment will be of modular sub-assemblies for each function for easy maintenance and replacement. The ATP assemblies will be fitted in the vehicle integrated with other equipment of the rolling stock.

- **Automatic Train Operation (ATO)**

This system will operate the trains automatically from station to station while remaining within the safety envelope of ATP & open the train doors. Driver will close the train doors and press a button when ready to depart. In conjunction with ATP/ ATS, ATO can control dwell time at stations and train running in accordance with headway/timetable.

- **Automatic Train Supervision (ATS)**

A train supervision system will be installed to facilitate the monitoring of train operation and remote control of the station. The train supervision will log each train movement and display it on the workstations with each Traffic Controller at the OCC and on one workstation placed in the Station Control Room (SCR) with each Station Controller.

The centralized system will be installed in the Operation Control Centre. The OCC will have a projection display panel showing a panoramic view showing the status of tracks, points, signals and the vehicles operating in the relevant section/ whole system. ATS will provide the following main functionalities:

- Automatic Route setting;
- Automatic Train Regulation;
- Continuous Tracking of train position;
- Display Panel & Workstation interface;
- Link to Passenger Information Display System for online information;
- Computation of train Schedule & Time table.

Interlocking system

- **Computer Based Interlocking (CBI)**

The entire line including turnback track, transfer track and sidings will be equipped with CBI system for operation of points and crossings and setting of routes.

The setting of the route and clearing of the signals will be done by workstation, which can be either locally (at station) operated or operated remotely from the OCC.

This sub-system is used for controlling vehicle movements into or out of stations automatically from a workstation. All stations having points and crossings will be provided with workstations for local control. Track occupancy, point position, etc. will be clearly indicated on the workstation. It will be possible to operate the workstation locally if the central control hands over the operation to the local station. The interlocking system design will be based on fail-safe principle.

The equipment will withstand tough environmental conditions encountered in a Mass Rapid Transit System. Suitable IEC, IEEE, BS and CENELEC standards or equivalent international standards will be followed in case wiring, installation, earthing, cabling, power supply and for material used in track circuits, axle counters, relays, point operating machines, power supply etc.

- **Track Vacancy Detection**

Primary mode for track vacancy detection system on main line may be through radio and for secondary detection it can be through Track circuit / Axle Counter.

- **Signals**

Line side signals: Multi Aspect Colour Light (LED) type Line side signals shall be installed on the Main Line and depot entry/exit.

  - At stations with point and crossing for point protection catering for bidirectional working;
  - At departure location at stations for normal direction of working.

- **Point Machines**

Non-Trailable Electrical Point Machine capable of operating with either 110V DC or 3-phase 380V AC will be used on main line. The depot point machine will preferably be trailable type.

- **Train Depot : signalling**

One depot at the end of Chakan area (Opposite to Swapna Nigdi). All depot lines except the one which is used for shunting and in the workshop shall be interlocked. A workstation shall be provided in the Depot Control Centre for electrical operation of the points, signals and routes of the depot yard. Audio Frequency Track Circuits will be used in the depot.

9.1.2 Standards

The standards to be adopted for the signalling system are shown in the Table 79.

Table 79: Standards of Signalling System

S/No.	Description	Standards
1	Interlocking	Computer based Interlocking adopted for station having switches and crossing. All related equipment as far as possible will be centralised in the equipment room at the station. The depot shall be interlocked except for lines mainly used for shunting, workshop/inspection shed areas.
2	Operation of Points	With Direct current 110V D.C. point machines or 380 volts 3 phase, 50 Hz. AC point machines.
3	Train Detection	Primary train detection system to use bidirectional digital transmission of signal/data by radio transponder and to be provided on Main Line, sidings, test track and transfer track (Entry & Exit of Depot). Secondary train detection system to use Axle counters and to be provided at entry and exit of each station and in mid sections as required

S/No.	Description	Standards
4	Signals at Stations with point & crossings	Line Side signals to protect the points (switches). LED type signals for reliability and reduced maintenance cost.
5	UPS (uninterrupted power at stations as well as for OCC)	For Signalling and Telecommunications
6	Train protection system	Automatic Train Protection system.
7	Train Describer System	Automatic Train Supervision system. Movement of all trains to be logged on to a central computer and displayed on workstations in the Operational Control Centre and at the SCR. Remote control of stations from the OCC.
8	Redundancy for TP/Train Describer	Redundant Train borne equipment and ATS equipment at OCC.
9	Cables	Outdoor cables will be steel armoured as far as possible.
10	Fail Safe Principles	SIL-4 safety levels as per CENELEC standard for signal application.
11	Immunity to External Interface	All data transmission on telecom cables/OFC/Radio. All Signalling and telecom cables will be separated from power cables. CENELEC standards to be implemented for EMC.
12	Train Working under emergency	Running on site with line side signal with speed automatically restricted between 15-25 kmph.
13	Environmental Conditions	Air-conditioners for all equipment rooms.
14	Maintenance philosophy	Philosophy of continuous monitoring of system status and preventive & corrective maintenance of Signalling equipment's 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.

9.1.3 Space requirement for signalling installations

Adequate space for proper installations of all signalling equipment at each of the stations has to be provided keeping in view the case of maintenance and use of instrumentation set up for regular testing and line up of the equipment/system. The areas required at each of the stations for signalling equipment shall be generally as follows:

- Space for UPS Room (common for signalling and telecom) - 60 sq. m

- Space for Signalling Equipment Room - 50 sq. m at interlocked station with points
- Space for Signalling Equipment Room – 20 sq. m at other stations.

9.1.4 Maintenance philosophy for signalling systems

The philosophy of continuous monitoring of system status and preventive & corrective maintenance of signalling and telecommunication equipment's shall be followed. Card / module / sub-system level replacement shall be done in the field.

Maintenance personnel shall be suitably placed at intervals and they shall be trained in multi-disciplinary skills. Each team shall be equipped with a fully equipped transport vehicle for effectively carrying out the maintenance from station to station.

The defective card / module / sub-system taken out from the section shall be sent for diagnostic and repair to a centralized S&T repair lab suitably located on the section. This lab will be equipped with appropriate diagnostic and test equipment's to rectify the faults and undertake minor repairs. Cards / modules / equipment's requiring major repairs as specified in supplier's documents shall be sent to manufacturer's workshop.

9.1.5 Technology selection and choice of automation

The CBTC system is an efficient way to increase the capacity by allowing to decrease the headway between trains with the use of moving blocks.

In urban transport systems, automation refers to the process by which responsibility for operation management of the trains is transferred from the driver to the train control system.

There are various degrees of automation (or Grades of Automation, GoA). These are defined according to which basic functions of train operation are the responsibility of staff, and which are the responsibility of the system itself.

For example, a Grade of Automation 0 would correspond to on-sight operation, like a tram running on street traffic. Grade of Automation 4 would refer to a system in which vehicles are run fully automatically without any operating staff on board.

For this project, the choice of automation is same as that of the phase I and to be made fully compatible with the proposed system of signalling and train control as in phase I.

Hence, increasing the level of GoA, will allow implicitly to:

- Guarantee a high level of safety enforcement;
- Maximise the train capacity;
- Have a more efficient energy system and train movement on the network & also
- To optimize the operating costs.

9.2 Telecommunication

The telecommunication system acts as the communication backbone for Signalling systems and other systems such as SCADA, AFC etc and provides telecommunication services to meet operational and administrative requirements of metro network.

For efficient Metro railway management and operation, it is essential to have a well-organized telecommunication network covering strategic locations like OCC, BCC, passenger platforms, depot and it is equally essential to have reliable links between the strategic locations and moving trains or working staff along the railway track/tunnel.

9.2.1 Telecommunication overview

The telecommunication facilities proposed are helpful in meeting the requirements for:

- Supplementing the signalling system for efficient train operation;
- Exchange of managerial information;
- Crisis management during emergencies;
- Passenger information system.

The proposed telecom system will cater to the following requirements:

- Train Traffic Control;
- Assistance to Train Traffic Control;
- Maintenance Control;
- Emergency Control.

9.2.2 Station to station dedicated communication

Following are the major communication requirements from station to station or station to OCC/BCC/Depot or vice versa:

- Telephone System;
- Passenger Announcement System and Passenger Information and Display System within the station and from Central Control to each station;
- Centralized Clock System;
- Radio Communication between Central Control and Moving Cars and maintenance personnel;
- CCTV Systems;
- Access Control System;
- Integrated SCADA for Telecom;
- Data Channels for Telecom subsystems, Signalling, SCADA, Automatic Fare collection etc.
- Forensic Debriefing Analysis and Cyber Security System

9.2.3 Telecommunication System and Transmission Media

- **Fibre Optic System - Main Telecommunication Bearer**

The main bearer of the bulk of the telecommunication network is proposed with optical fibre cable system. Considering the channel requirement and keeping in view the future expansion requirements, four optical fibre cables of minimum 144 fibres are proposed to be laid in ring configuration with path diversity.

IP based min 10G Wide Area Network being provided under FOTS Sub-system of contract shall provide all necessary communication channels for carrying voice, data, and video signals for Metro railway management and operation from Station/Depot TER to OCC/BCC CER.

The Transmission Backbone is also to be used for Communication Based Train Control system therefore redundancy at every level must be maintained.

- **Telephone System**

The telephone system shall also consist of a direct line or intercom telephone communication network exclusively for the train operation and maintenance functions.

There is one main node at OCC which should be in primary cluster with dual server. In the case of a failure of one of the servers, the other server will take over the load of the failed server. The main node shall be connected with FOTS to the secondary cluster with servers at individual stations.

The IP PBX's shall be installed in TER at all locations. The IP PBX switches shall be connected to each other through ethernet links of the FOTS to form the IP PBX switch network. The ethernet channels shall be provided by FOTS.

CDRS facility shall be provided in OCC & BCC. CDRS shall provide multichannel voice recording and indexing of direct line communication including communication from all direct line consoles and emergency telephone lines, two-way radio communications, emergency or fire messages broadcast on station PAS initiated from OCC/BCC and on train borne PAS initiated from OCC/BCC.

- **Mobile Radio Communication**

Mobile Radio Communication system having adequate logical channels is proposed for on-line emergency communication between moving train (Front end and Rear end of 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/BCC/Depot will be provided with fixed radio sets. Mobile communication facility for maintenance parties and Security Personnel will be provided with handheld sets to communicate with each other as well as with central control.

The frequency band for operation of the system will be that for TETRA in 400/800 MHz band, depending on frequency availability.

The system shall provide Instant 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. The train radio system shall also be used for depot operation. Train Radio communication shall also be used for making PAS announcements from OCC & BCC to the passengers on the train.

A Centralized Digital Voice Recording System shall record all communication from OCC controller to personal having radio fixed or handheld devices.

- **Passenger Announcement System**

The system shall be capable of announcements from the local station as well as from OCC. Announcements from OCC will have over-riding priority in all announcements.

At OCC, Integrated PIDS/PAS system shall be provided.

At the stations, a suitable Public-Address System shall be provided for making announcements to passengers regarding train arrival / departure and shall work as the primary means of communication with passengers and staff during emergencies. In the normal case, audio-broadcast shall be made from Station Control Room or Platform Supervisor's Booth/Panel and in a train by the driver/attendant. However, it shall also be possible for the OCC & BCC to make announcement to any station, group of stations or all stations.

- **Centralized Clock System**

This will ensure an accurate display of time through a synchronization system of slave clocks driven from a Master Clock at the operation control centre. Master Clock System shall also provide reference timing signals for all telecom and other systems for network synchronization Redundancy shall be maintained for master clock. NTP based clocks shall be provided and sub master clocks are not required. The System will ensure identical display of time at all locations. Clocks are to be provided at platforms, concourse, Station Master's Room, and any other location as desired at stations, Depot, OCC & BCC and other service establishments etc.

Self-illuminated analogue façade clock with hour and minutes hands shall be proposed. These clocks will be installed at station entry/ exits.

Passenger Information Display System

These shall be located at convenient locations at all stations to provide multi lingual visual indication of the status of the running trains and will typically indicate information such as destination, arrival/departure time, and also special messages in emergencies. The boards shall be provided at all platforms and concourses of all stations.

At OCC, Integrated PIDS/PAS system shall be provided.

A Passenger Information Display system triggered by Signalling & train control system shall automatically provide real time visual information about train arrival/departure throughout the station. The PIDS display shall be coordinated with PAS for real time passenger audio broad casts for train arrival/departure. PIDS shall enable the operator in SCRs , OCC & BCC to display routine and special emergency messages for passengers and staff in stations. Display boards shall be provided for each platform side at all stations and in concourse at all stations.

Wi-Fi

A Wireless communication system is proposed at stations separate from any signalling Wireless Communication System. The system shall be used to connect all staff devices and laptops to a central network. The Wireless communication system shall be standard commercial-off-the-shelf system and will conform to Wi-Fi standard – 802 series of communication protocols.

The System should be secure, reliable and offer sufficient bandwidth to cater to current and future needs of the system.

CCTV System

CCTV surveillance system shall be built through CCTV sub-system for supervising strategic operational locations like station car park, AFC gates, ticketing offices and lobby, escalator, lifts and staircase exits, platform operational area and PF ends, to ensure safe operation of the metro and security locations at stations.

It shall be supervised from the station control room and security room at each station simultaneously, and this video shall also be transmitted to the OCC & BCC, both as live and as recorded, from the stations/depot for remote supervision. Similarly, a CCTV depot surveillance system shall also be built.

It shall be supervised locally from DCC & Security Control room and remotely from OCC & BCC.

A Centralized Digital Recording System is to be provided in CER at the OCC & BCC for minimum 30 days.

Access Control System

The Access Control System shall be provided at Stations, OCC & BCC, Depots & Administrative Building. It shall be provided in important rooms like SCR, Ticket Office, Service gates (near AFC gate array), Technical rooms (Power Supply, Signalling and Low Voltage technical rooms), ASS and other important rooms. In Depots, OCC & BCC & Admin building, it shall, as a minimum, be provided in Technical rooms (Power Supply, Signalling, Telecom, AFC and Low Voltage technical rooms), DCC & OCC & BCC theatre, Security room including main entry & exit gates to control access into important equipment rooms and critical areas. Location of the ACIDS system shall be finalized during detailed design stage.

The functions of the system shall be access management, alarm management and intrusion detection. The Human Machine Interfaces (HMI) shall be located in the SCR of each station, the guard room at depot and the OCC & BCC to ensure the safety of major equipments. The HMI of Access control shall be integrated with HMI of the CCTV system.

Network Monitoring and Management

For efficient and cost-effective maintenance of the entire communication network, it is proposed to provide Integrated SCADA network, which will help in diagnosing faults of all systems in single screen 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. The proposed system will be covering all the telecom subsystems.

Forensic Debriefing Analysis and Cyber Security System

Metro Rail faces new security challenges as system has become more interconnected, integrates more and more digital technologies and increasingly uses data to deliver higher capacity & performance and thus cybersecurity is essential to the safe and reliable operation of modern Metro Rail System. Cybersecurity is required to ensure end-to-end information security, not only to prevent and to detect attacks, but also to react rapidly if they occur. Objective of Cybersecurity for Metro includes availability, integrity, confidentiality, reliability and safety of information and process of entire Metro Rail Eco-System.

Metro Rail uses heterogeneous IT technologies and software solutions and consists of following core sub-systems:

- On-Board Train Control & Management System
- Centralized Signalling & Train Control System
- Power SCADA System
- Building Management System
- Fibre Optic Transmission System
- Train Radio System
- Telephone System

- Passenger Information Display System
- Passenger Announcement System
- Video Surveillance System
- Master Clock System
- Digital Voice Recording System
- Automatic Fare Collection System
- Automatic Platform Screen Door system

Additionally, Metro Rail employs other information technologies services for various uses:

- Office Network and Internet Connectivity for staff
- Email Exchange Service & website
- Enterprise Resource Services
- Document Management System
- Wi-Fi system
- Metro Mobile & Web Applications

To meet the Cyber Security threats, a security policy and framework is recommended for Pune Metro to manage the cyber security needs and mitigate the project risks. The Cyber Security System shall be an integral part of the Telecom system.

9.2.4 Standards

The standards proposed to be adopted for telecommunication systems are shown in below table:

Table 80: Standards of Telecommunication System

SYSTEM	STANDARD
Transmission System	IP based for the entire telecom network.
Transmission Media	Optical Fibre system as the main bearer for bulk of the telecommunication network,
Telephone Exchange	IP based Voice Communication System
Train Radio System	Digital Train radio (TETRA) communication between motorman of moving cars, stations, maintenance personnel, depots and central control.
Passenger Information Display System	LCD based boards with adequate visibility to be provided at convenient location at all stations to provide multi lingual visual indication of the status of the running trains, and also special messages in emergencies.

SYSTEM	STANDARD
Centralized clock system	Accurate display of time through a synchronization system of slave clocks driven from a master clock at the OCC/BCC and in station/depots. This shall also be used for synchronization of other systems.
Passenger Announcement System	Integrated PIDS/PAS System at OCC/BCC/Depot and stations covering all platform and concourse areas with local as well as central announcement.
Access Control System	The access control system shall use contact-less smart card with ID as the access media for smart card reader. Biometrics shall also be used for high security zones.
Redundancy (Major System)	Redundancy on major equipments. Path Redundancy for Optical Fibre Cable by provisioning in ring configuration.
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 co-ordination. Card/module level replacement shall be done in the field and repairs undertaken in the central laboratory/manufacture's premises.

9.2.5 Space requirement for telecom installations

The following equipment rooms will be provided to install the telecommunication equipment:

- Telecommunication Equipment Room at station and Depot;
- Central Equipment Room at OCC & BCC. In present case, space already provided for existing system shall be used, provided provision for expansion is there.

Electric power to the equipment room shall be drawn from the central UPS which will not be in scope of Telecom.

Adequate space for proper installations of all Telecommunication equipment at each of the stations should be provided keeping in view the case of maintenance and use of instrumentation set up for regular testing and line up of the equipment/system. The areas required at each of the stations for only telecom equipment shall be generally 40 sq.m each for Telecom Room and 60 sq.m. for UPS Room (common for signal, telecom and AFC). These areas shall also cater to local storage and space for maintenance personnel to work.

9.2.6 Maintenance philosophy for telecom systems

The philosophy of continuous monitoring of system status and preventive & corrective maintenance of Signalling and telecommunication equipment shall be followed.

Card / module / sub-system level replacement shall be done in the field.

Maintenance personnel shall be suitably placed at intervals and they shall be trained in multidisciplinary skills. Each team shall be equipped with a fully equipped transport vehicle for effectively carrying out the maintenance from station to station.

The defective card/module/sub-system taken out from the section shall be sent for diagnostic and repair to a centralized repair lab suitably located on the section. This lab will be equipped with appropriate diagnostic and test equipment to rectify the faults and undertake minor repairs. Cards / modules / equipment requiring major repairs as specified in supplier’s documents shall be sent to manufacturer's workshop.

9.3 Platform Screen Doors

Platform screen doors are mainly provided at metro stations to ensure safety and comfort of the passengers. In case of Underground stations, PSDs saves considerable amount of energy and improves climate control within the stations (heating, ventilation and air conditioning are more effective when station is physically isolated from the tunnel). In case of Phase 2A, the complete stretch is underground , thus PSD are proposed at all the stations.

10. AUTOMATIC FARE COLLECTION SYSTEM

10.1 Overview

The Automatic Fare Collection System forms a vital part of operations of a transit system. The main objectives of an AFC system are that it shall:

- Be capable of issuing single and multiple journey tickets;
- Ensure efficient and proper operation of the system in terms of passenger flow;
- Minimize Fare Revenue evasion and fraud and maximize fare revenue protection;
- Be simple and easy to use/operate and maintain;
- Allow for easy accounting;
- Allow for fare changes easily and quickly;
- Require lesser manpower overall.

In view of the above and since the previous phase of the project has an already approved AFC system, a computer based Automatic Fare collection system is proposed for this phase of the project as well to ensure easy integration and interoperability of the new system with the one already proposed/implemented.

The System shall be capable for open loop transactions as well to further integrate the mobility solution with the advancements in technology and to allow for seamless transition from dedicated cards to common multi-use stored value fare media that can be used for financial transactions such as making purchases at shops etc. as well as a fare media in the system.

To accommodate the same the system shall conform to the following standards as a minimum:

ii. EMV (Euro Mastercard Visa)
iii. PCI-DSS ((Payment card Industry / Data Security Standard)
iv. ISO-IEC 14443

The system shall be of open architecture to allow for the integration of multiple fare products and shall be capable of interfacing with cards from different vendors. Additionally, the system shall not be proprietary as far as possible to allow multiple types of fare media from multiple sources to be integrated into the system.

The AFC system for this phase shall be of contactless smart card & token type. For multiple journeys, stored value smart cards shall be available and for single journeys, smart tokens shall be available, which shall be deposited at the exit gates at the time of exit validation.

Automatic Fare Collection Systems are proposed as the Semi-Automatic (Manual) Systems have some inherent disadvantages and the Automatic Fare Collection Systems have some advantages:

- **Disadvantages of Manual Fare Collection System**
  - Large Number of staffs are required for ticket issue and validation activities;
  - Changes in fare structure and policies are time consuming as changes have to be made at each station individually;
  - System is susceptible to fare revenue evasion and frauds through tampering/vandalism of the mechanical components of the equipments;
  - 100% ticket validation and authentication at entry/exit is not possible in this system;
  - Manual System which results in greater transaction time both for fare media purchase and authentication.

- **Advantages of Automatic Fare Collection System**
  - Fewer staff required for fare media sales and validation/authentication;
  - System offers greater flexibility both in terms of scalability and changes in fare structure to be incorporated;
  - System offers increased fare revenue protection and minimizes fare revenue evasion/fraud;
  - Data collection regarding system operation and ridership is simpler and easier;
  - System allows fare structure to be changed from the central processing server across the entire system quickly;
  - System is efficient and easy to operate and allows degraded and disaster mode operations to deal with emergency situations;
  - System has capability to integrate multiple modes of transport via interoperability. In addition, smart cards can be used for other applications such as payments at third party vendors/outlets etc.

The AFC system shall be of contactless smart token/card type. The equipment for the same shall be provided at each station at convenient locations.

The equipment shall be connected by a local area network to the station control unit in the Equipment Room with a terminal in the station control room (SCR).

- **Control Gates**

Control Gates shall be retractable flap type. These types of gates offer high throughput and require less maintenance. Tripod turnstile type gates and flap type gates offer less throughput and require more maintenance.

- **Passenger Operated Machine (POM)**

A minimum of two Passenger Operated Machines (Automatic Ticket Vending Machines) each are proposed at all stations. The POM's shall provide a convenient way for passengers to buy fare media and avoid standing in queues at Ticket Offices and provide services of international standard.

10.1.1 Standards

The standards to be adopted for AFC systems are shown in the table below:

Standards	Description
Fare Media	**Contactless Smart Token** – For single journey. They shall have stored value amount for a particular journey. Tokens shall be captured at the exit gates. **Contactless smart cards –** for multiple journeys.
Gates	Computer Controlled retractable flap type automatic gates at entry and exit. Gates shall be classified in the following categories: • Entry • Exit • Reversible – can be set to entry or exit. • Wide Reversible - Gate for disabled people.
Station Computer, Central Computer and AFC Network.	All fare collection equipment shall 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 Operations Control Centre through the optic fibre communications 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 shall be installed in the stations for selling cards/tokens to the passengers.
Ticket Readers and Portable Ticket Decoders	Ticket reader shall be installed near EFO for passengers to check information stored in the token / cards.
UPS (uninterrupted power at station as well as for OCC)	Common UPS of S&T system will be utilized.
Maintenance Philosophy	Being fully Contactless systems, manpower requirement for maintenance is much less compared to system with magnetic tickets. However, adequate facilities to be provided similar to that of S&T systems.

10.1.2 Equipment requirement (Automatic Fare Collection System)

Assumptions:

- Each station has two accesses;

- Minimum arrangement at each access is 1 entry gate, 1 exit gate, 1 reversible gate, 1 EFO;
- Throughput of gate is 30 PPM. For Ticket Office Machine (TOM) it is 10 PPM;
- 50% passengers are assumed on smart card and 50% on single journey token;
- Each station has 1 wide gate for disabled. Exact equipment arrangement depends on final station layout;

10.1.3 AFC Space Requirements

Each station shall be designed with enough space to allow for the installation of AFC equipment such as Gates, RCTM, TR, TOM and TVMs. The design should also consider adequate space for specific rooms such as EFOs to be provided in station architecture.

For Central Equipment at the OCC/BOCC, existing equipment at these locations shall be utilized provided adequate provision for expansion was considered in phase I of Pune Metro. No additional equipment shall be required to be installed at OCC/BOCC in case the central equipment was sized with provision of expansion. In case additional equipment is required the existing space provided at OCC/BOCC locations shall be utilized, provided the provision for expansion was provided.

AFC equipment requirements based on available data and assumptions are given in Table 81.

Swargate-Katraj Section														
Swargate- Katraj		BOARDING	ALIGHTING	AFC REQUIREMENT 2057		Gates			TOM	EFO	TVM	RCTM	TR
SI NO	Station	2057	2057	Entry	Exit	Entry	Exit	Reversible					
1	Station 1	1750	1720	3	3	3	2	2	2	2	2	2	2
2	Station 2	2020	1690	3	3	3	2	2	2	2	2	2	2
3	Station 3	7130	6790	7	2	4	3	2	2	2	2	2	2

Table 81 : AFC Equipment Requirements

11. ROLLING STOCK

11.1 Introduction

The required transport demand forecast is the governing factor for the choice of the Rolling Stock. The forecasted Peak Hour Peak Direction Traffic (PHPDT) calls for a Mass Rapid Transit System (MRTS).

11.1.1 Optimization of coach size

The following optimum size of the coach has been chosen in line with existing corridor design as mentioned in table:

Table 82: Size of the coach

	Length*	Width	Height
Driving Motor Car (DMC)	21.64m	2.9m	3.9m
Trailer Car (TC)/Motor Car (MC)	21.34m	2.9m	3.9m

**Maximum length of coach over couplers/buffer:22.6m (Depending upon the Kinematic Envelop).*

11.1.2 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 3 persons per square meter of standing floor area in normal state and 6 persons in crush state of peak hour.

Therefore, for the Metro Rail Vehicles (MRV) with 2.9m maximum width and longitudinal seat arrangement, conceptually the crush capacity of 43 seated, 204 standing thus a total of 247 passengers for a Driving motor car, and 50 seated, 220 standing thus a total of 270 for a trailer/motor car is envisaged.

Train composition is recommended as 3-car DMC+TC+DMC & 6-car DMC+TC+MC+MC+TC+DMC, below table shows the carrying capacity of medium rail vehicles.

Table 83: Carrying Capacity of Medium Rail Vehicles

Particulars	Driving Motor car			Trailer car / Motor car			3 Car Train		
	Normal*	#Crush	$Engg. Load	Normal*	#Crush	$Engg. Load	Normal*	#Crush	$Engg. Load
Seated	43	43	43	50	50	50	136	136	136
Standing	102	204	273	110	220	293	314	628	839
Total	145	247	316	160	270	343	450	764	975

Particular	Driving Motor car			Trailer car / Motor car			6 Car Train		
	Normal *	#Crush	$Engg. Load	Normal *	#Crush	$Engg. Load	Normal *	#Crush	$Engg. Load
Seated	43	43	43	50	50	50	286	286	286
Standing	102	204	273	110	220	293	644	1288	1718
Total	145	247	316	160	270	343	930	1574	2004

** Normal Load - 3 Person/sqm of standee area*
 # Crush Load - 6 Person/sqm of standee area
$ Engineering Load - 8 Person/sqm of standee area

11.1.2.1 Weight

The weights of driving motor car and trailer car have been estimated as in table below, referring to the experiences in existing Metro in India. The average passenger weight has been taken as 65 kg.

Composition
DMC : Driving Motor Car
MC : Motor Car
TC : Trailer Car
3 Car Train Composition DMC + TC + DMC
6 Car Train Composition DMC + TC + MC + MC + TC + DMC

Table 84: Weight of Metro Rail Vehicles (tons)

	DMC (ton)	TC (ton)	3 Car Train (ton)
Tare Load (Maximum)	42	40	124
Passenger Load			
Normal Load@3p/sqm	9.425	10.4	29.25
Crush Load@6p/sqm	16.055	17.55	49.66
Engg. Load @8p/sqm	20.54	22.295	63.375
Gross Load			
Normal Load @3p/sqm	52.425	51.4	156.25
Crush Load@6p/sqm	59.055	58.55	176.66
Engg. Load @8p/sqm	63.54	63.295	190.375
Crush Axle Load @6 p/sqm	14.52	14.40	
Engg. Axle Load @8 p/sqm	15.63	15.58	

** AW0 - Without any passenger*

	DMC (ton)	TC (ton)	MC(ton)	6 Car Train (ton)
Tare Load (Maximum)	42	40	42	244
	Passenger Load			
Normal Load@3p/sqm	9.425	10.4	10.4	60.45
Crush Load@6p/sqm	16.055	17.55	17.55	102.31
Engg. Load @8p/sqm	20.54	22.295	22.295	130.26
	Gross Load			
Normal Load @3p/sqm	52.425	51.4	52.4	156.25
Crush Load@6p/sqm	59.055	58.55	59.55	176.66
Engg. Load @8p/sqm	63.54	63.295	64.295	190.375
Crush Axle Load @6 p/sqm	14.52	14.40	14.88	
Engg. Axle Load @8 p/sqm	15.63	15.58	16.07	

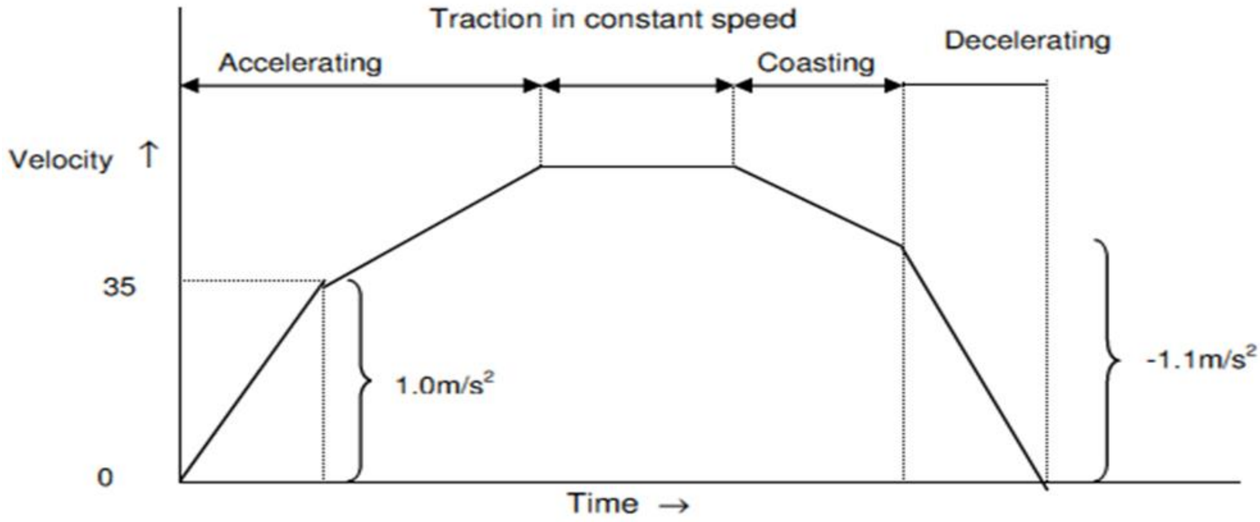
** AW0 - Without any passenger*

The axle load @ 6persons/sqm of standing area works out in the range of 14.40T to 14.52T. Heavy rush of passenger, having 8 standees per sq. meter can be experienced occasionally. It will be advisable to design the coach 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 16T axle load.

11.1.2.2 Performance parameters

Following values of acceleration and deceleration are assumed in consideration of riding comfort, adhesion and requirement of make-up time.

- Maximum Design Speed: 90Kmph;
- Maximum Operating Speed: 80Kmph;
- Maximum Acceleration: 1.0m/s^2;
- Maximum Deceleration: 1.1 m/s^2 (Service Brake) ;
- Maximum Deceleration: 1.3 m/s^2 (Emergency Brake) ;
- Maximum Jerk rate: 0.75m/s^3;



Since the track on a viaduct could possibly be constructed on a level and the traction motors could be operated with overload for a short time, 8 traction motors with about 220 KW installed on a three-car train would be enough, even if the equivalent gradients on a curved section of track are considered. The train shall be propelled by a 3-phase AC asynchronous motor drive system with variable voltage and variable frequency (VVVF) Control.

11.1.2.3 Coach design and basic parameters

The important criteria for selection of rolling stock are as under:

- Proven equipment with high reliability;
- Passenger safety feature;
- Energy efficiency;
- Light weight equipment and coach body;
- Optimized scheduled speed;
- Aesthetically pleasing interior and exterior;
- Low Life cycle cost;
- Flexibility to meet increase in traffic demand;
- Anti-telescopic.

The controlling criteria are reliability, low energy consumption, lightweight and high efficiency leading to lower annualized cost of service. The coach should have high rate of acceleration and deceleration.

11.1.3 Selection of technology

11.1.3.1 Low life cycle cost

Low life cycle cost is achieved by the way of reduced scheduled and unscheduled maintenance and high reliability of the sub-systems. It is possible to achieve these objectives by adopting suitable proven technologies. Following essential aspects will be considered for the achievement of low life cycle cost;

- Life Cycle cost plan with an aim to minimize the overall life cycle cost whilst meeting the safety, quality and reliability requirements;
- Life Cycle cost will include, the capital cost, cost of operation (including energy consumption), maintenance (both material and labour), depreciation, refurbishment, inflation etc. per unit energy consumption.

11.1.3.2 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 a standard practice to adopt stainless steel or aluminium for car body.

The car bodies with aluminium require long and complex extruded sections which are still not manufactured in India. Therefore, aluminium car body has not been considered for use. Stainless steel sections are available in India and therefore stainless-steel car bodies have been specified. No corrosion repair is necessary on stainless steel cars during their service life.

Stainless steel car body leads to energy saving due to its lightweight. It also results in cost saving due to easy maintenance and reduction of repair cost from excellent anti corrosive properties as well as on improvement of riding comfort and safety in case of a crash or fire.

11.1.3.3 Bogies

Bolster less lightweight fabricated 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 4,20,000km.

Use of air spring at secondary stage is considered with a view to keep the floor level of the cars constant irrespective of passenger loading unlike those with coil spring.

Perturbation from the track are also dampened inside the car body on account of the secondary air spring along with suitable Vertical Hydraulic Damper.

The primary suspension system improves the curve running performance by reducing lateral forces through application of conical rubber spring. A smooth curving performance with better ride index is being ensured by provision of above type of bogies.

11.1.3.4 Braking system

The braking 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. In addition, speed sensors mounted on each axle, control the braking force of the axles with anti-skid valves, prompting re-adhesion in case of a skid.

The brake actuator shall operate either a tread brake or a wheel disc brake, preferably a wheel disc brake for better braking effectiveness and wheel life.

11.1.3.5 Propulsion System Technology

In the field of Electric Rolling Stock, DC series traction motors have been widely used due to their ideal characteristics and good controllability for traction applications. But these required intensive maintenance because of commutators and electro-mechanical contractors, resistors etc

The brush less 3 phase A.C. induction motors has now replaced the DC 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' (VVVF) 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 this corridor, 3 phase A.C. traction drive that are self-ventilated, highly reliable, robust construction and back up by slip/slide control have been recommended for adoption.

The AC catenary voltage is stepped down through a transformer and converted to DC voltage through converter and supply voltage to DC link, which feeds Inverter operated with Pulse Width Modulation (PWM) control technology and using Insulated Gate Bipolar Transistors (IGBT). Thus 3 phase variable voltage variable frequency output drives the traction motors for propulsion.

Recently advanced IGBT has been developed for inverter units. The advanced IGBT contains an Insulated Gate Bipolar Transistor (IGBT) and gate drive circuit and protection. The advanced IGBT incorporates its own over current protection, short circuit protection, over temperature protection and low power supply detection. The IGBT has internal protection from over current, short circuit, over temperature and low control voltage.

The inverter unit uses optical fibre cable to connect the control unit to the gate interface. This optical fibre cable transmits the gate signals to drive the advanced IGBT via the gate interface. This optical fibre cable provides electrical isolation between the advanced IGBT and the control unit and is impervious to electrical interference. These are recommended for adoption in Trains of MRTS.

11.1.3.6 Auxiliary power System Technology

This shall consist of static converter-inverter(s) together with back-up batteries and battery charger. Auxiliary Converter shall be suitable for operation at 25kV ac single phase for the frequency variation from 48 to 52Hz.

There will be at least two auxiliary power supply equipment in the 3-car train. When any train operator's cab is activated, all the auxiliary power supply equipment in the train shall operate. In the event of failure of an auxiliary power supply equipment in the train, the remaining auxiliary power supply equipment must be capable of supplying all auxiliary power to complete 3-car train except for HVAC load which may be restricted to one HVAC per car.

11.1.3.7 Interior and gangways

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.

11.1.3.8 Passenger doors

For swift evacuation of the passenger in short dwell period, four doors of adequate width, on each side of the coach have been 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. Passenger doors are operated electrically by a switch in the driver cab.

Electronically controlled door operating mechanism has been preferred over pneumatically operated door to avoid cases of air leakage and sluggish operation of doors.

**View shown below is one of the examples for saloon interior.

Figure 87. Example for Interior view of the car**

The door shall be of bi-parting sliding type.

**View shown below is one of the examples for bi-parting door.

Figure 88. Example for view of the passenger door**

11.1.3.9 Air-conditioning

With heavy passenger loading of 6 persons/sqm for standing area and doors being closed from consideration of safety and with windows being sealed type to avoid transmission of noise, air conditioning of coaches is considered essential.

Each coach shall be provided with two air conditioning units capable of cooling, heating and dehumidifying and thus automatically controlling interior temperature throughout the passenger area at 25°C with 65% RH all the times under varying ambient conditions up to full load.

For emergency situations such as power failure or both AC (of the same car) failures etc., ventilation provision supplied from battery will be made. Provision shall be made to shut off the fresh air intake and re-circulate the internal air of the coach, during an emergency condition, such as fire outside the train causing excessive heat and smoke to be drawn in to the coach.

11.1.3.10 Cab layout and emergency detrainment door

The modem stylish driver panel shall be FRP (Fibre Reinforced Plastic) moulded which gives maximum comfort and easy accessibility of different monitoring equipment to the driver along with clear visibility. The driver seat shall be in the cabin.

An emergency door for easy detrainment of the passenger on the track has been provided at the centre of the front side of each cabin which has an easy operation with one handle type master controller.

**View shown below is one of the examples for Driver's Cab.

Figure 89. Example view of the driving cab

11.1.3.11 Communication

The driving cab of the cars are provided with continuous communication with base Operational Control Centre and station control for easy monitoring of the individual train in all sections at all the time.

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.

11.1.3.12 Noise and vibration

The trains will pass through heavily populated urban areas. The noise and vibration for an MRT become an important criterion from public acceptance viewpoint. The source of noise is (i) rail-wheel interaction (ii) noise generated from equipment like blower, compressor, air conditioner, door, inverter etc. (iii) traction motor in running train. For elimination and reduction of noise following feature are incorporated:

- Provision of anti-drumming floor and noise absorption material;
- Low speed compressor, blower and air conditioner;
- Mounting of under frame equipment on anti-vibration pad;
- Smooth and gradual control of door;
- Provision of GRP baffle on the viaduct for elimination of noise transmission;
- Provision of sound absorbing material in the supply duct and return grill of air conditioner;
- Sealing design to reduce the aspiration of noise through the gap in the sliding doors and piping holes.

The lower vibration level has been achieved by provision of bolster less type bogies having secondary air spring.

11.1.4 Passenger safety features

- ATP
  The rolling stock is provided with continuous Automatic Train Protection to ensure absolute safety in the train operation. It is an accepted fact that 60-70% of the accidents take place on account of human error. Adoption of this system reduces the possibility of human error.

- Fire
  The rolling stock is provided with fire retarding materials having low fire load, low heat release rate, low smoke and toxicity inside the cars. The electric cables used are also normally low smoke zero halogen type which ensures passenger safety in case of fire.

- Emergency door
  The rolling stock is provided with emergency doors at both ends of the cab to ensure well directed evacuation of passengers in case of any emergency including fire in the train.

- Crash worthiness features
  The rolling stock is provided with inter car couplers having crashworthiness feature which reduces the severity of injury to the passengers in case of accidents.

- Gangways
  Broad gangways are provided in between the cars to ensure free passenger movement between cars in case of any emergency.

The salient features of the proposed Rolling Stock are detailed in Table 85.

Table 85: Salient features of Rolling Stock for MRT's parameter details

S.No.	Salient Features of Rolling Stock for MRT's Parameter Details	
1 **2**	**Gauge** (Nominal) **Traction system**	1435mm
2.1	Voltage	25 KV AC
2.2	Method of current collection	Overhead Current Collection System
3	**Train composition:**	
3.1	3 car trainsets	DMC+TC+DMC
	6 car trainsets	DMC + TC + MC + MC + TC + DMC
4	**Coach Body**	Stainless Steel
5	**Coach Dimensions**	
5.1	Height	3.9 m
5.2	Width	2.9 m
5.3	Length over body (approx.)	21.64 m
5.4	Locked down Panto height (if	4048 mm
5.5	Floor height	1100mm
6	**Designed - Passenger Loading**	
6.1	Design of Propulsion	8 Passenger/ m^2
6.2	Design of Mechanical systems	10 Passenger/ m^2
7	**Carrying capacity- @ 6**	
7.1	Coach carrying capacity	
	DMC	247 (seating - 43 ; standing - 204)
	TC	270 (seating - 50 ; standing - 220)
	MC	270 (seating - 50 ; standing - 220)
7.2	Train Carrying capacity	
	3 car train (with the future consideration of adding Trailer car to make the rake of 6 car)	764 (seating - 136 ; standing - 628) 1574 (seating - 286 ; standing - 1288) : Train of 6 car (2-DMC, 2-TC, 2-MC)
8	**Weight (Tonnes)**	
8.1	Tare weight (maximum) in	
	DMC	42
	TC	40

S.No.	Salient Features of Rolling Stock for MRT's Parameter Details	
	MC	42
8.2	Passenger Weight in tons @ 6	@ 0.065 T per passenger
	DMC	16.00
	TC	17.55
	MC	17.55
8.3	Gross weight in tons	
	DMC	51.43 (Normal), 58.05 (Crush)
	TC	50.40 (Normal), 57.55 (Crush)
	MC	52.4 (Normal), 59.55 (Crush)
9	**Axle Load (Ton)**	16
10	**Maximum Train Length -**	
10.1	3 car train set	65 m approx.
10.1	Maximum Design Speed	90 Kmph
10.2	Maximum Operating Speed	80 Kmph
12	**Wheel Profile**	UIC 510-2
13	**Noise Limits (ISO 3381 and 3095 - 2005)**	
13.1	Stationary (Elevated and at	
13.1.1	Internal (cab and saloon)	L_{pAFmax} 65 dB(A)
13.1.2	External (at 7.5 mtr from	L_{pAFmax} 68 dB(A)
13.2	Running at 80 kmph (Elevated	Based upon applicable standard.
13.2.1	Internal (cab and saloon)	L_{pAFmax} 72 dB(A)
13.2.2	External (at 7.5 mtr from	L_{pAFmax} 85 dB(A)
13.3	Stationary (Underground)	Based upon applicable standard.
13.3.1	Internal (cab and saloon)	L_{pAFmax} 72 dB(A)
14	**Traction Motors Ventilation**	3 Phase Induction motor
15	**Acceleration on level tangent**	1.0 m/sec^2
16	**Deacceleration on level**	1.1 m/sec^2 (>1.3 m/sec^2 during emergency brake)
17	**Type of Bogie**	Fabricated
18	**Secondary Suspension springs**	Air
19	**Brakes**	- An electro-pneumatic (EP) service friction brake- An -Provision of smooth and continuous blending of EP and
		Brake Electronic Control Unit (BECU) - Independent for
20	**Coupler**	
20.1	Driving cab end of DMC	Automatic coupler with mechanical and & pneumatic
20.2	Between cars of	Semi-permanent coupler
21	**Detrainment Door**	DMC Front end
22	**Type of Doors**	Sliding (Electrically operated electronically controlled- 4 doors per side per car)
23	**Passenger Seats**	Stainless Steel
24	**Cooling**	

S.No.	Salient Features of Rolling Stock for MRT's Parameter Details	
24.1	Transformer	Forced
24.2	CI & SIV	Self/Forced
24.3	Traction Motor	Self-ventilated
25	**Control System**	Train based Monitor & Control System (TCMS/TIMS)
26	**Traction Motors**	3 phase VVVF controlled
27	**Temperature Rise Limits**	
27.1	Traction Motor	Temperature Index **minus** 70 deg C
27.2	CI & SIV	10 deg C temperature margin for Junction temperature
27.3	Transformer	IEC specified limit **minus** 20 deg C
		- Cooling, Heating & Humidifier (As required)
		- Automatic controlling of interior temperature
28	**HVAC**	throughout the passenger area at 25°C with
		65% RH all the times under varying ambient conditions up
29	**PA/PIS including PSSS (CCTV)**	Required
30	**Passenger Surveillance**	Required
31	**Battery**	Ni-Cd Maintenance free
32	**Headlight type**	**LED**
33	**Propulsion Equipment**	
	Pantograph	2 No. on T car
	VCB	2 No. on T car
	Transformer	1 No. on T car
	SIV	1 No. on T car
	Battery and Charger	1 No. on T car
	CI	Car bases in each DMC & MC
	Traction Motor	Axle bases in each DMC & MC
34	**Gradient (max)**	4%

12. POWER SUPPLY AND TRACTION

12.1 Selection of traction system

For Traction System, it is standard practice in India to follow and to adopt 25 KV single phase AC Traction. In addition, it has the following merits:

- Lower initial cost;
- Lower operating and maintenance cost as in case of 25 KV ac traction the regeneration is up-to 30% and the line losses are around 0.5% in comparison to D.C. losses up-to 6 – 7%;
- A.C. system poses lesser Fire hazards as current levels are much lower than DC system.
- No Stray current problems and hence the corrosion is controlled.

As this is an extension of existing line, system with existing design or compatibility shall be used.

12.2 Total Projected Power Demand

Electricity is obtained from the utility supply systems, at transmission or sub transmission voltage level, through traction feeding substation. This electricity is required for operation of Metro system for running of trains, station services (e.g. lighting, lifts, escalators, signalling & telecom, firefighting etc.) workshops, depots & other maintenance infrastructure within premises of the metro system.

The power requirements of a metro system are determined by peak-hour demands of power for traction and auxiliary applications. Broad estimation of auxiliary and traction power demand is made based on the following requirements:

- Specific energy consumption of rolling stock – 70 KWhr/1000 GTKM;
- Regeneration by rolling stock – 30%;
- Elevated station load – For Year 2027, 2037, 2047 and 2057 – 300 kW load is considered;
- Underground station load – For Year 2027,2037, 2047 and 2057 - 2500 kW load is considered;
- Depot auxiliary load - For Year 2027,2037, 2047 and 2057 - 2500 KW load is considered.
- Mid shaft auxiliary load near Katraj is considered as 500 kW.

Keeping in view the train operation plan, the demand of auxiliary and traction power requirements projected for the years 2027, 2037, 2047 and 2057 are summarized in the following table.

Table 86: Power Demand (MVA) for PCMC-NIGDI extension

Corridor		Year			
		2027	2037	2047	2057
Extension Corridor-1A(PCMC-NIGDI)	Traction	0.9 MVA	1.0 MVA	1.0 MVA	1.0 MVA
	Auxiliary	1.1 MVA	1.1 MVA	1.1 MVA	1.1 MVA
	Total	**2.0 MVA**	**2.1 MVA**	**2.1 MVA**	**2.1 MVA**

Detailed calculations of power demand estimation for PCMC – NIGDI is as below:

Table 87: Detailed Power Estimation for PCMC-NIGDI extension

POWER REQUIREMENTS - For year 2027 , 2037, 2047 and 2057 for PCMC to Nigdi								
A. Traction Power Requirements	Year 2027		Year 2037		Year 2047		Year 2057	
No of Cars	3	(DMC-TC-DMC)	3	(DMC-TC-DMC)	3	(DMC-TC-DMC)	3	(DMC-TC-DMC)
Tare weight of train	124	T	124	T	124	T	124	T
Passenger weight	50	T	50	T	50	T	50	T
Total Train weight	174	T	174	T	174	T	174	T
Section length	4.413	KM	4.413	KM	4.413	KM	4.413	KM
Average Speed	33.00	KM/H	33.00	KM/H	33.00	KM/H	33.00	KM/H
Headway	5.4	min	5	min	5	min	5	min
Specific Energy Consumption	70	KWhr/1000 GTKM	70	KWhr/1000 GTKM	70	KWhr/1000 GTKM	70	KWhr/1000 GTKM
No. of Trains/hr	22	Nos.	24	Nos.	24	Nos.	24	Nos.
Peak traction power requirement	1.2	MW	1.3	MW	1.3	MW	1.3	MW
Less Regeneration @ 30%	0.4	MW	0.4	MW	0.4	MW	0.4	MW
Depot Power Requirement	0.0	MW	0.0	MW	0.0	MW	0.0	MW
Net Traction Power Requirement	0.9	MW	0.9	MW	0.9	MW	0.9	MW
Total Traction Power Requirement (MVA) assuming 5% energy losses and .95 pf for traction loads.	**0.9**	**MVA**	**1.0**	**MVA**	**1.0**	**MVA**	**1.0**	**MVA**
Yearly Traction Energy Consumption with 18hrs a day, 365 days working and 30% regen	**5.6**	**Million units**	**6.1**	**Million units**	**6.1**	**Million units**	**6.1**	**Million units**
B. Station Aux. Power Requirement								

POWER REQUIREMENTS - For year 2027 , 2037, 2047 and 2057 for PCMC to Nigdi								
Elevated Station	0.30	MW	0.30	MW	0.30	MW	0.30	MW
Station at underground	2.50	MW	2.50	MW	2.50	MW	2.50	MW
No. of Elevated Stations	3		3		3		3	
No. of Station at underground	0		0		0		0	
Total Station Aux Power requirement	0.9	MW	0.9	MW	0.9	MW	0.9	MW
Depot Aux. power requirement	0.0	MW	0.0	MW	0.0	MW	0.0	MW
Total Aux. Power requirement	0.9	MW	0.9	MW	0.9	MW	0.9	MW
Total auxiliary power requirement (MVA) assuming 5% energy losses and .85 pf for auxiliary loads.	**1.1**	**MVA**	**1.1**	**MVA**	**1.1**	**MVA**	**1.1**	**MVA**
Total traction & aux power requirement (MW)	1.75	MW	1.82	MW	1.82	MW	1.82	MW
Diversity Factor	0.50		0.50		0.60		0.60	
Yearly Auxiliary Power Consumption with 20hrs a day, 365 days working	**3.3**	**Million units**	**3.3**	**Million units**	**3.9**	**Million units**	**3.9**	**Million units**
C. Total Power Requirement								
Total power requirement (MVA) assuming 5% energy losses and .95 & .85 pf for traction & aux loads respectively	**2.0**	**MVA**	**2.1**	**MVA**	**2.1**	**MVA**	**2.1**	**MVA**

Note: The requirement of Property development is not considered in estimation of power calculation.

For the Phase 1A (Nigdi to PCMC) the OHE is taken into consideration.

Diversity factor is considered 0.50 in 2027 & 2037 and 0.60 in 2047 and 2057 for auxiliary power requirements.

Also, the power demand calculation for the Existing corridor (PCMC to Swargate) of auxiliary and traction power requirements projected for the years 2027, 2037, 2047 and 2057 are summarized in table below due to increased headway.

Table 88 : Auxiliary and Traction Power supply PCMC – SWARGATE requirements till year 2057

Corridor		Year			
		2027	2037	2047	2057
Existing Corridor- 1 PCMC-Swargate	Traction	8.5 MVA	9.9 MVA	10.9 MVA	11.1 MVA

	Auxiliary	21.9 MVA	21.9 MVA	21.9 MVA	21.9 MVA
	Total	**30.4 MVA**	**31.8 MVA**	**32.8 MVA**	**33.0 MVA**

Detailed calculations of power demand estimation for PCMC – SWARGATE is as below:

Table 89 : Detailed calculations of power demand estimation for PCMC – Swargate

POWER REQUIREMENTS - For year 2027 , 2037, 2047 and 2057 for Swargate to PCMC								
A. Traction Power Requirements	**Year 2027**		**Year 2037**		**Year 2047**		**Year 2057**	
No of Cars	3	(DMC-TC-DMC)	3/6*	(DMC-TC-MC-TC-MC-DMC)	3/6*	(DMC-TC-MC-TC-MC-DMC)	3/6*	(DMC-TC-MC-TC-MC-DMC)
Tare weight of train	124	T	136.4	T	151	T	155.0	T
Passenger weight	50	T	54	T	60	T	62	T
Total Train weight	174	T	190	T	211	T	217	T
Section length	17.80	KM	17.80	KM	17.80	KM	17.80	KM
Average Speed	33.00	KM/H	33.00	KM/H	33.00	KM/H	33.00	KM/H
Headway	2.7	min	2.5	min	2.5	min	2.5	min
Specific Energy Consumption	70	KWhr/1000 GTKM	70	KWhr/1000 GTKM	70	KWhr/1000 GTKM	70	KWhr/1000 GTKM
No. of Trains/hr	44	Nos.	48	Nos.	48	Nos.	48	Nos.
Peak traction power requirement	9.6	MW	11.4	MW	12.6	MW	13.0	MW
Less Regeneration @ 30%	2.9	MW	3.4	MW	3.8	MW	3.9	MW
Depot Power Requirement	1.0	MW	1.0	MW	1.0	MW	1.0	MW
Net Traction Power Requirement	7.7	MW	9.0	MW	9.8	MW	10.1	MW
Total Traction Power Requirement (MVA) assuming 5% energy losses and .95 pf for traction loads.	8.5	MVA	9.9	MVA	10.9	MVA	11.1	MVA
Yearly Traction Energy Consumption with 18hrs a day, 365 days working and 30% regen	50.8	Million units	58.9	Million units	64.6	Million units	66.3	Million units
B. Station Aux. Power Requirement								
Elevated Station	0.30	MW	0.30	MW	0.30	MW	0.30	MW
Station at underground	2.50	MW	2.50	MW	2.50	MW	2.50	MW
No. of Elevated Stations	9		9		9		9	

POWER REQUIREMENTS - For year 2027 , 2037, 2047 and 2057 for Swargate to PCMC								
A. Traction Power Requirements	Year 2027		Year 2037		Year 2047		Year 2057	
No. of Station at underground	5		5		5		5	
Total Station Aux Power requirement	15.2	MW	15.2	MW	15.2	MW	15.2	MW
Depot Aux. power requirement	2.5	MW	2.5	MW	2.5	MW	2.5	MW
Total Aux. Power requirement	17.7	MW	17.7	MW	17.7	MW	17.7	MW
Total auxiliary power requirement (MVA) assuming 5% energy losses and .85 pf for auxiliary loads.	21.9	MVA	21.9	MVA	21.9	MVA	21.9	MVA
Total traction & aux power requirement (MW)	25.43	MW	26.67	MW	27.53	MW	27.78	MW
Diversity Factor	0.50		0.50		0.60		0.60	
Yearly Auxiliary Power Consumption with 20hrs a day, 365 days working	**64.6**	**Million units**	**64.6**	**Million units**	**77.5**	**Million units**	**77.5**	**Million units**
C. Total Power Requirement								
Total power requirement (MVA) assuming 5% energy losses and .95 & .85 pf for traction & aux loads respectively	**30.4**	**MVA**	**31.8**	**MVA**	**32.7**	**MVA**	**33.0**	**MVA**

Note: The requirement of Property development is not considered in estimation of power calculation.

For the Existing phase (PCMC to Swargate) the OHE/ROCS[8] is taken into consideration based on the elevated and underground Stations.

Diversity factor is considered 0.50 in 2027 & 2037 and 0.60 in 2047 and 2057 for auxiliary power requirements.

[8] ROCS is recommended for phase 2A whereas OHE is only used as a reference for calculation purpose.

Assuming 3/6 car trains as per train operation plan is running in year 2037,2047 and 2057 respectively for calculating the power demand and the number of 3 cars and 6 cars in respective years is calculated as below:

Table 90 : Year wise Rake requirement for corridor 2A

Pune Metro Corridor-1 Phase 2A - Nigdi to Katraj			
Year	Total Car Requirement	Total Trains Required	
		3-Car	6-Car
2027	108	36	0
2037	132	36	4
2047	150	30	10
2057	156	28	12

According to the above data, Power calculation is calculated based on the number of 3 and 6 cars train in year 2037, 2047, 2057 respectively considering the average of total train weight with respect to the weightage of 3 and 6 car trains:

Table 91 : Traction and auxiliary Power supply for corridor 2A, Swargate to Katraj

Corridor		Year			
		2027	2037	2047	2057
Corridor- 2A Swargate - Katraj	Traction	1.1 MVA	1.2 MVA	1.2 MVA	1.2 MVA
	Auxiliary	9.9 MVA	9.9 MVA	9.9 MVA	9.9 MVA
	Total	**11.0 MVA**	**11.1 MVA**	**11.1 MVA**	**11.1 MVA**

Detailed calculations of power demand estimation for SWARGATE - KATRAJ is as below:

Table 92 : Detailed calculations of power demand estimation for Swargate to katraj

POWER REQUIREMENTS - For year 2027 , 2037, 2047 and 2057 for Swargate to Katraj								
A. Traction Power Requirements	Year 2027		Year 2037		Year 2047		Year 2057	
No of Cars	3	(DMC-TC-DMC)	3	(DMC-TC-DMC)	3	(DMC-TC-DMC)	3	(DMC-TC-DMC)
Tare weight of train	124	T	124	T	124	T	124	T
Passenger weight	50	T	50	T	50	T	50	T
Total Train weight	174	T	174	T	174	T	174	T
Section length	5.46	KM	5.46	KM	5.46	KM	5.46	KM
Average Speed	33.00	KM/H	33.00	KM/H	33.00	KM/H	33.00	KM/H

POWER REQUIREMENTS - For year 2027 , 2037, 2047 and 2057 for Swargate to Katraj								
Headway	5.4	min	5	min	5	min	5	min
Specific Energy Consumption	70	KWhr/1000 GTKM	70	KWhr/1000 GTKM	70	KWhr/1000 GTKM	70	KWhr/1000 GTKM
No. of Trains/hr	22	Nos.	24	Nos.	24	Nos.	24	Nos.
Peak traction power requirement	1.5	MW	1.6	MW	1.6	MW	1.6	MW
Less Regeneration @ 30%	0.4	MW	0.5	MW	0.5	MW	0.5	MW
Depot Power Requirement	0.0	MW	0.0	MW	0.0	MW	0.0	MW
Net Traction Power Requirement	1.0	MW	1.1	MW	1.1	MW	1.1	MW
Total Traction Power Requirement (MVA) assuming 5% energy losses and .95 pf for traction loads.	**1.1**	**MVA**	**1.2**	**MVA**	**1.2**	**MVA**	**1.2**	**MVA**
Yearly Traction Energy Consumption with 18hrs a day, 365 days working and 30% regen	**6.8**	**Million units**	**7.3**	**Million units**	**7.3**	**Million units**	**7.3**	**Million units**
B. Station Aux. Power Requirement								
Elevated Station	0.30	MW	0.30	MW	0.30	MW	0.30	MW
Station at underground	2.50	MW	2.50	MW	2.50	MW	2.50	MW
No. of Elevated Stations	0		0		0		0	
No. of Station at underground	3		3		3		3	
Total Station Aux Power requirement	7.5	MW	7.5	MW	7.5	MW	7.5	MW
Mid shaft Aux. power requirement	0.5	MW	0.5	MW	0.5	MW	0.5	MW
Total Aux. Power requirement	7.5	MW	7.5	MW	7.5	MW	7.5	MW
Total auxiliary power requirement (MVA) assuming 5% energy losses and .85 pf for auxiliary loads.	**9.9**	**MVA**	**9.9**	**MVA**	**9.9**	**MVA**	**9.9**	**MVA**
Total traction & aux power requirement (MW)	9.03	MW	9.12	MW	9.12	MW	9.12	MW
Diversity Factor	0.50		0.50		0.60		0.60	

POWER REQUIREMENTS - For year 2027 , 2037, 2047 and 2057 for Swargate to Katraj								
Yearly Auxiliary Power Consumption with 20hrs a day, 365 days working	**29.2**	**Million units**	**29.2**	**Million units**	**35.0**	**Million units**	**35.0**	**Million units**
C. Total Power Requirement								
Total power requirement (MVA) assuming 5% energy losses and .95 & .85 pf for traction & aux loads respectively	**11.0**	**MVA**	**11.1**	**MVA**	**11.1**	**MVA**	**11.1**	**MVA**

Note: The requirement of Property development is not considered in estimation of power calculation.

As all the stations are underground in Phase 2A (Swargate to Katraj) the ROCS is taken into consideration.

Mid shaft has been introduced between Gultekdi Metro station and Katraj metro station with assumption of Auxiliary load of 500 kW.

Diversity factor is considered 0.50 in 2027 & 2037 and 0.60 in 2047 and 2057 for auxiliary power requirements.

The total power Requirement for the complete corridor (NIGDI - KATRAJ) is as below:

Table 93 : Total power requirement for complete corridor – Nigdi-Katraj

Corridor		Year			
		2027	2037	2047	2057
PCMC-NIGDI	Traction	0.9 MVA	1.0 MVA	1.0 MVA	1.0 MVA
	Auxiliary	1.1 MVA	1.1 MVA	1.1 MVA	1.1 MVA
PCMC-SWARGATE	Traction	8.5 MVA	9.9 MVA	10.9 MVA	11.1 MVA
	Auxiliary	21.9 MVA	21.9 MVA	21.9 MVA	21.9 MVA
SWARGATE - Katraj	Traction	1.1 MVA	1.2 MVA	1.2 MVA	1.2 MVA
	Auxiliary	9.9 MVA	9.9 MVA	9.9 MVA	9.9 MVA
Total Power Demand (NIGDI-SWARGATE)	**Traction**	**10.5 MVA**	**12.1 MVA**	**13.1 MVA**	**13.3 MVA**
	Auxiliary	**32.9 MVA**	**32.9 MVA**	**32.9 MVA**	**32.9 MVA**

12.3 Need for high reliability of power supply

Corridor-1 (Nigdi to Katraj) has peak traffic with PHPDT of 28000 in section Range Hill- Shivaji Nagar. To cater the traffic, Train operation with 3-car trains with headway of 2.5 min in section PCMC-Swargate is planned with Peak Hour Peak Direction Capacity of 25500 @6 persons per square meter of standee area (Capacity of 32500 @8 persons per square meter of standee area under crush loading conditions).

As PHPDT in sections beyond PCMC-Swargate is very low (PHPDT of 8000), peak headway of only 5 min is considered sufficient in this section. Accordingly, every alternate train is planned to be short looped from PCMC and Swargate, at least during peak hours. This has minimized Rolling Stock and Train Operator requirement.

Incidences of any power interruption, apart from affecting train running, will cause congestion at stations. Interruption of power at night during train operation hours is likely to cause alarm and increased risk to travel public. Lack of sufficient illumination at stations, non-visibility of appropriate signage, disruption of operation of lifts and escalators is likely to cause confusion, anxiety and ire in commuters, whose tolerance level are low on account of stress. Effect on signal and communication may affect train operation and passenger safety as well. Therefore, reliable and continuous power supply is mandatory for efficient metro operations.

To ensure reliability of power supply, it is essential that both the sources of Power Supply and connected transmission & distribution networks are reliable and have adequate redundancies built in itself. It is desirable to obtain power supply at grid voltage of 220KV, 132 KV or 66 kV from stable grid sub-stations of Power Supply authority and further transmission & distribution is done by the Pune Metro.

12.4 Sources of power supply

The high voltage power supply network of Pune City has only 220kV and 132kV network on the periphery of the city to cater to various types of power supply demand in vicinity of the proposed corridor. 220/132 kV substations are far away from the alignment and therefore, it involves substantial cable and it’s laying cost.

12.4.1 For extension of line 1 (PCMC to Swargate)

Keeping in view the reliability requirements, three input sources of 220 kV or 132KV Voltage level are normally considered for each corridor. Therefore, to achieve the desired reliability, two existing receiving substations (132/33/25 kV) are there to feed extension corridors i.e. PCMC to Nigdi. The intersection of the extension corridors will be at PCMC for extension of PCMC to Nigdi and intersection of extension corridor Swargate to Katraj is at swargate.

Table 94: Sources of Power Supply

Corridor	Grid sub-station (with Input voltage)	Location of RSS of Metro Authority	Approx. length of cables
NIGDI - KATRAJ	132 kV Chinchwad SS	Near PCMC	4.5 km approx. from Chinchwad to PCMC
	132 kV Ganeshkhind SS	Near Agri. College	3 km approx. from ganeshkhind to Range hill
	200 kV Parvati SS	Near Swargate	3 km approx. from Parvati GSS to Swargate

*the exact length of cables from GSS to RSS will be provided after the cable route survey, if required

The above sub-stations are being considered as a conventional sub-station. In case a 132 kV GIS to be provided, there will be an additional cost of Rs. 45 Crores per sub-station respectively.

Summary of expected power demand at various sources is given in Table 95.

Table 95: Power demand projection for various source

Extension Corridor and New Corridor	Input Source / Receiving Sub Station (RSS)	Peak Demand - Normal* (MVA)		Peak Demand - Emergency (MVA)		Peak Demand - Emergency (MVA)		Peak Demand - Emergency (MVA)	
		2027	2057	2027	2057	2027	2057	2027	2057
Nigdi-PCMC – Swargate-Katraj	**RSS near PCMC**								
	Traction	5.8	7.5			5.8	7.5	5.8	7.5
	Auxiliary	8.4	8.4			16.8	16.8	16.8	16.8
	Sub – Total (A)	14.2	15.9			22.6	24.3	22.6	24.3
	Range hill Depot RSS								
	Traction	4.9	5.9	10.6	13.4			4.9	5.9
	Auxiliary	8.4	8.4	16.8	16.8			16.1	16.1
	Sub – Total (B)	13.3	14.3	27.4	30.2			20.9	21.9
	RSS Near Swargate								
	Traction	0	0	0	0	4.9	5.9		
	Auxiliary	16.1	16.1	16.1	16.1	16.1	16.1		
	Sub - Total (C)	16.1	16.1	16.1	16.1	20.9	21.9		

It is assumed that in normal operation the traction load for Nigdi to Range Hill shall be fed by PCMC RSS and Traction Load for Rangehill to Katraj shall be fed by Range Hill RSS. However, for Auxiliary Load it is assumed that the complete Auxiliary Load shall be fed by all 3 RSS in approximate equal portion of total load for Normal case.

The above table represents the peak power demand for each RSS as a complete Traction load of corridor Nigdi to Katraj shall be cater by any of RSS (near PCMC or Range hill) in normal condition while in emergency condition any of one RSS can cater the full Traction load requirements of complete corridor (NIGDI - Katraj).

The above calculation represents the power load calculation in normal and emergency conditions. For the traction power requirement as the peak traction power requirement is 13.4 MVA in year 2057 which shall be taken care by any of the traction transformer of 21.6 MVA capacity in any of 3 RSS. While for the auxiliary power requirement is 32.9 MVA in year 2057 which shall be taken care by the 2-auxiliary transformer of 20 MVA rating in 3 RSS. So, in case of any outage of any 1, remaining 2 shall be capable to cater the complete auxiliary as well as traction load of the corridor from Nigdi – PCMC – Swargate – Katraj.

The 132 KV power supply will be stepped down to 25kV single phase for traction purpose at the RSS of Pune Metro and the 25kV traction supply will be fed to the OHE at viaduct and ROCS at underground through cable feeders.

For feeding the auxiliary loads, the 132/33 kV or 132/33 KV power supply received will be stepped down to 33 kV and will be distributed along the alignment through 33kV Ring main cable network. These cables will be laid along the viaduct/tunnel. If one RSS trips on fault or input supply failure, train services can be maintained from the other RSS

In case of total grid failure, all trains may come to a halt, but station lighting & other essential services can be catered to by stand-by DG sets. Therefore, while the proposed scheme is expected to ensure adequate reliability, it would cater to emergency situations as well.

Figure 90. Typical high voltage receiving sub-station

The 132 KV cables will be laid through public pathways of Maharashtra Grid Sub-stations to RSS of Metro Authority.

For corridor – 1A extension PCMC- NIGDI, both existing substations viz PCMC RSS and Depot RSS shall be provided with 2nos. (one as standby) 220/132/25 kV, 21.6 MVA single-phase traction transformers for feeding traction and 2nos. (one as standby) 220/132/33 KV, 20 MVA three phase transformers for feeding auxiliary loads.

For existing corridor PCMC- Swargate, both existing substations viz PCMC RSS and Depot RSS shall be provided with 2nos. (one as standby) 220/132/25 kV, 21.6 MVA single-phase traction transformers for feeding traction and 2nos. (one as standby) 220/132/33 KV, 20 MVA three phase transformers for feeding auxiliary loads.

For corridor – 2A extension Swargate - Katraj, 1 new Receiving Substation shall be provided near swargate with area approximate 4000 sq.m GIS type with 2nos. (one as standby) 220/132/25 kV, 21.6 MVA single-phase traction transformers for feeding traction and 2nos. (one as standby) 220/132/33 KV, 20 MVA three phase transformers for feeding auxiliary loads.

Auxiliary supply arrangements for stations and depot Existing power supply arrangement at depot shall be considered for the extension line also as in the existing line the Auxiliary sub-stations (ASS) are envisaged to be provided at each station (1 ASS for elevated station and 2 ASS for underground Station) for stepping down 33 kV supply to 415 V for auxiliary applications. No extra ASS is required in depot for the extension line as the existing depot ASS can cater the 2.5 MW load in year 2057. The station ASS's will be located at mezzanine or platform level inside a room. The auxiliary load requirements have been assessed at 300kW for elevated / at-grade stations and 2500 kW for underground station for year 2027 to 2057. In order to meet the requirement of auxiliary power two dry type cast resin transformers (33/0.415kV) of 500 kVA capacity are proposed to be installed at the elevated stations (one transformer as standby) and two 2.5 MVA transformer for underground stations (one transformer as standby) also, two existing transformer of 2.5 MVA at Depot ASS.

Figure 91. Typical Indoor Auxiliary Sub-station

12.4.2 Incremental requirement of RSS

The implementation of Nigdi – PCMC & Swargate-Katraj metro corridor will increase the Power supply Load requirement on Phase 1 corridors as well. It is necessary to duly consider the incremental power supply load requirement while doing the Power load calculations. The incremental load requirement due to the extension of the corridor, viz. Nigdi – PCMC & Swargate-Katraj have been estimated considering the traction power requirement and Auxiliary power requirements for elevated & underground section from NIGDI to KATRAJ. To cater this incremental requirement with reliability of the Power Supply for traction as well as auxiliary load, One RSS is Proposed near Swargate to cater the Power supply load requirements for Phase 1 corridor from Nigdi to Katraj.

Power demand calculation		Year 2027	Year 2037	Year 2047	Year 2057
Total Power Demand (NIGDI-SWARGATE)	Traction	10.6 MVA	12.2 MVA	13.1 MVA	13.4 MVA
	Auxiliary	32.9 MVA	32.9 MVA	32.9 MVA	32.9 MVA

12.5 Electromagnetic interference (EMI) and electromagnetic compatibility (EMC)

25kV ac traction currents produce alternating magnetic fields that cause voltages to be induced in any conductor running along the track. Booster Transformer and Return Conductor

(BT/RC) System is proposed for EMI mitigation. Concrete structures of elevated viaducts /underground tunnels are not good electrical earths and therefore, Earthing and Bonding of the traction system shall be in accordance with the latest standards EN50122-1, IEEE80 and other relevant standards. Two earth conductors –Overhead Protection Cable (OPC) and Buried Earth Conductor (BEC) are proposed to be laid along with elevated viaduct/underground tunnels and all the metallic structures, structural reinforcement, running rails etc. will be connected to these conductors to form an equi-potential surface & least resistance path to the fault currents. The overhead protection cable will also provide protection against lightning to the 25kV OHE/ROCS[9] and the elevated viaduct/underground tunnels.

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, signalling & telecom, traction power supply, E&M system etc.) shall comply with the EMC requirements of international standards viz. EN50121, EN50123, IEC61000 series etc. A detailed EMI/EMC plan will be required to be developed during project implementation stage.

12.6 25KV flexible overhead equipment (OHE) system

25kV ac flexible OHE9 system shall comprise 150 sq.mm Hard drawn copper contact wire and 65 sq.mm Cd-copper catenary wire. Return conductor (RC) shall be All Aluminium Conductor (AAC) of 233 sq.mm cross section. From safety considerations, Hydraulic type Anti-Tensioning Device (ATDs) are proposed on mainlines which does not require use of balance weight for tensioning of OHE conductors. Proven catenary fittings are proposed similar to existing corridor under construction.

12.7 ROCS (Rigid Overhead Catenary System)

The ROCS above the tracks contains the Conductor Rail (CR): A contact wire (150 Sqmm Hard drawn copper) is clamped into the conductor rail profile. The CR is suspended from hinged or gliding supports provided with insulators.

The point of transition from the conventional overhead line to the conductor rail is equipped with a transition bar, contact wire anchoring bar and endpoint anchor.

The maximum span between two drop tubes is 11-12m. on overlap, the rigid catenary is supported at closer intervals, all the ROCS support bracket is earthed.

[9] ROCS is recommended for phase 2A whereas OHE is only used as a reference for calculation purpose.

12.8 Rating of major equipment

25kV ac Overhead Equipment (OHE)[10] shall comprise 150mm^2 HD-copper contact wire and 65 mm^2 Cd-copper catenary wire. Return conductor (RC) shall be all of OHE conductors.

25 kV ac ROCS shall comprises of 150mm2 HD-copper the maximum span between two drop tubes is 11-12m. on overlap, the rigid catenary is supported at closer intervals. There is a continuous Aluminium conductor of 93.3 Sq.mm (known as OPC) which runs all along the ROCS and it is clamped to each and every ROCS support bracket.

Based on emergency demand expected at each RSS as shown in above Table, two nos. 220 or 132/25kV traction transformers of 21.6 MVA capacity and 2 nos. 132/33 KV, 20MVA capacity Auxiliary transformers shall be provided at each RSS in Corridor NIGDI - Katraj . The 132kV incoming cable 3-phase single core XLPE insulated with 630 mm^2 Aluminium conductor and 220kV, 3-phase single core XLPE insulated with 800 mm^2 Aluminium conductor for corridor NIGDI - Katraj shall be used to meet the normal & emergency loading requirements and fault level of the 132 kV and 220 KV supply.

33kV and 25kV switchgear shall be rated for 1250 A being standard design. 33kV cable ring network shall be adequately rated to transfer requisite auxiliary power during normal as well as emergency situations and accordingly 3 number of Single core 300 mm^2 FRLS Aluminium conductor cable XLPE insulated 33kV cable is proposed for ring main network.

Adequate no. of cables are required for transfer of traction power from Metro's RSS to 25kV OHE/ROCS[10]. Single-phase XLPE insulated cables with 240 mm^2 copper conductor are proposed for traction power. Based on current requirements, 2 cables are required for each of the two circuits to feed power to OHE/ROCS[10].

The above capacities of transformers, switchgear, cables etc. have been worked out based on the conceptual design. Therefore, these may be required to be revised for better accuracy during design stage of project implementation.

12.9 Standby Diesel Generator (DG) sets

In the unlikely event of simultaneous tripping of all the input power sources or grid failure, the power supply to stations as well as to trains will be interrupted. It is, therefore, proposed to provide a standby DG set of 500 KVA capacity at the elevated stations and 800 KVA capacity of DG set at underground station in DG room to cater to the following essential services:

(i) Essential lighting
(ii) Signalling & telecommunications

[10] ROCS is recommended for phase 2A whereas OHE is only used as a reference for calculation purpose.

(iii) Firefighting system
(iv) Lift operation
(v) Fare collection system
(vi) Tunnel Ventilation (for Underground Stations)

Silent type DG sets with low noise levels are proposed, which do not require a separate room for installation.

12.10 Supervisory Control and Data Acquisition (SCADA) system

For the smooth functioning, high reliability and safety of the transit system the SCADA system plays a vital role in supervision, control and acquisition of various specified data from the 'controlled station' along the line such as receiving substation(RSS), auxiliary substation(ASS), traction substation (TSS), metro stations, OHE/ROCS[11] system switching stations along the line, depot etc. Modern SCADA system with intelligent remote terminal units (RTUs) shall be provided for control and monitoring of the whole power supply system from a centralized Operation Control Centre (OCC). Existing OCC & BOCC shall be updated based on the extension line phase 1A (PCMC-NIGDI) and extension corridor 2A (Swargate- Katraj).

Redundant Fibre optics transmission system is provided by telecommunications and shall be used as communication backbone carrier for SCADA system from field side to the central control centre. In addition, the system shall be fully integrated with the SCADA system implemented for Phase I.

The Digital Protection Control System (DPCS) is 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, 25kV ac switchgear and associated electrical equipment. DPCS will utilize microprocessor-based fast-acting numerical relays & Programmable Logic Controllers (PLCs) with interface with SCADA system.

SCADA system allows the Power Operator to control and monitor the HV (High Voltage), MV (Medium Voltage) and LV (Low Voltage) equipment. The purpose of this system is to manage: the incoming lines to provide reliable electrical supply to all the equipment, the Auxiliary power supply sub-stations: transformers from high voltage to medium and low voltage. The traction power supply sub-stations: transformers from high voltage to 25 kV traction power. The control of the Traction Power shall be done through the Traction Power Supply function. The Power as a whole is managed from the Energy Control Centre ECC, from where centralized Operation of the line is carried out.

[11] ROCS is recommended for phase 2A whereas OHE is only used as a reference for calculation purpose.

12.11 Solar Energy Harnessing System

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 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/sheds and buildings is proposed for MAHA MRTS.

12.11.1 Solar PV Power Generation Potential

The roof top on the elevated stations of Pune metro corridors and the different sheds and buildings of the depot viz. Stabling, Inspection and Heavy Repair Shed, Administrative Building, DCC/OCC Building etc is proposed to be used for SPV installation at suitable orientation and inclination to optimize the solar energy potential. The roof of the sheds should be south facing to maximize the Solar power generation in depot. 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/m2 . Based on the solar radiation intensity in the city of Pune, the peak solar power generation of Pune Metro corridor is expected to be about 200 kWp for the elevated stations and about 2000kWp for maintenance depot.

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 Pune metro corridors is required to be reviewed and finalized during detail design stage.

It is proposed that the solar PV installation for Pune metro shall be done on the basis of RESCO model which is also being followed by other metros in India. In the RESCO model, the MAHA Metro shall sublet the rooftop to the project developer who will be responsible for the solar PV installation. The power shall be purchased by MAHA metro on the basis of the unit rate specified by Power Purchase Agreement (PPA).

12.12 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 of Pune Metro 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 25kV ac OHE/ROCS[12] 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 (day or night, operation or maintenance hours etc.).

(iv) Machine-room less type lifts with gearless drive have 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.) has been incorporated in the system design.

(vii) Efficient energy management is possible with proposed modern SCADA system by way of maximum demand (MD) and power factor control.

(viii) LED lighting is proposed in certain areas.

12.13 Electric power tariff

The cost of electricity is a significant part of Operation & Maintenance (O&M) charges of the Metro System, which constitutes about 25 – 35% of total annual working cost. Therefore, it is the key element for the financial viability of the project. For Extension of line-1A, the annual energy consumption is assessed to be about 8.9 million units in initial years (2027), which will

[12] ROCS is recommended for phase 2A whereas OHE is only used as a reference for calculation purpose.

increase to about 10.0 Million Units by year 2057. For existing Corridor of line, the annual energy consumption is assessed to be about 115.4 million units in initial years (2027), which will increase to about 143.8 Million Units by year 2057. For another extension of corridor 2A the annual energy consumption is assessed to be about 34.2 million units in initial years (2027), which will increase to about 40.3 Million Units by year 2057. The total annual energy consumption for line 1, Phase 1 with extension 1A and 2A is assessed to be about 160.3 Million Units by year 2027 which will increase upto 196.1 Million units by year 2057. In addition to ensuring optimum energy consumption, it is also necessary that the electric power tariff be kept at a minimum in order to contain the O&M costs. Therefore, the power tariff for this Corridor should be at effective rate of purchase price (at 132/220 kV voltage level) plus nominal administrative charges i.e. on a no profit no loss basis. This is expected to be in the range of Rs. 7.6 per unit (Grid supply charges = Rs. 5.8 per unit and 20% of supplies from solar (@ Rs 4 per unit) as per RESCO model) with Rs. 270/KVA/month fixed charges. It is proposed that Government of Maharashtra will take necessary steps to fix power tariff for Pune Metro at “No Profit No Loss” basis. Financial analysis has been carried out based on this tariff for the purpose of finalizing the DPR. Similar approach is being pursued for Delhi Metro.

13. MAINTENANCE DEPOT

13.1 Depot Location and Number

Stabling capacity in existing depot at Range Hill is not sufficient to accommodate 156 cars (28 numbers of 3-car train and 12 numbers of 6-car trains) required for design year (2057).

Phase-II augmentation of the Range Hill depot is planned to accommodate 22 numbers of 6-car trains or equivalent number of 3-car and 6-car trains which is sufficient for planned Phase-2A requirement up to year 2037.

However, for planned requirement in Phase-2A in year 2047 & 2057, i.e. additional 8 number of 3-car trains, additional stabling facility is required.

For Phase -2A in year 2047 & 2057, stabling lines are proposed in table below to accommodate requirement of year 2047 & 2057.

Type	Elevated
Number of Stabling Lines	4
Capacity per stabling line	One 6-cars train or Two 3-car Train
Length of each Stabling Line	140m
Plot Area	0.29 Ha
Total Cost without land	**11.72 Cr**
Land Cost	**5.43 Cr**

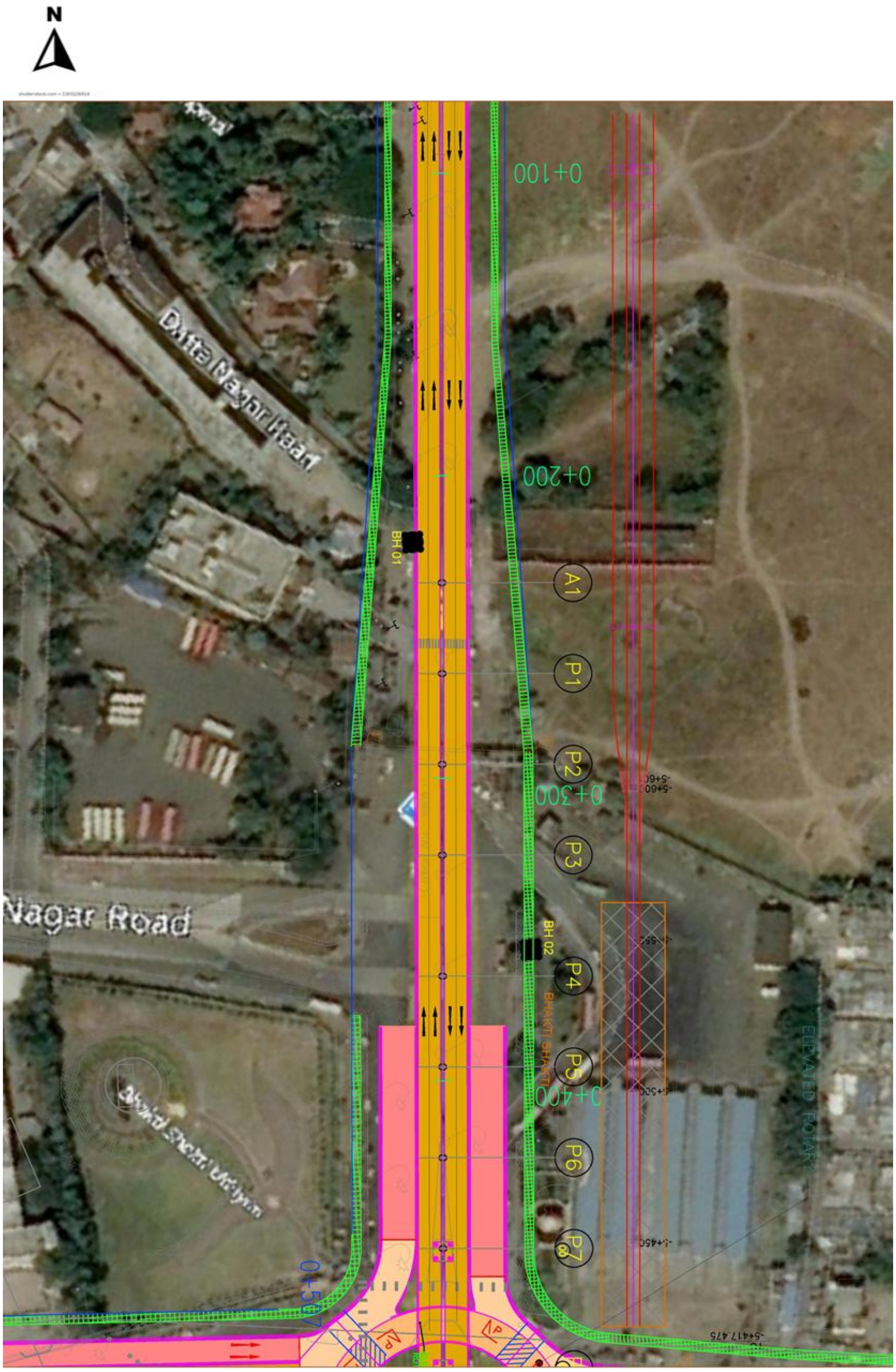
Elevated, 4 stabling lines are proposed for stabling of 6-car train on each line. However, all necessary maintenance activities(major/minor/scheduled/etc.) will be catered in Range Hill depot of Pune Metro Phase 1.

Layout for depot is attached exhibit 2 at the end of the chapter.

Exhibit 1 – Range Hill Depot

Figure 95: layout- Range hill depot

Exhibit 2 – NIGDI Depot (Elevated stabling)



14. ENVIRONMENTAL AND SOCIAL IMPACT ASSESSMENT

14.1 Preamble

Large-scale urbanization in IT/ITES and industrialization with rapid growth of vehicular population has laid severe stress on urban transport system in Pune City over the years. The City has a total of about 23 lakhs vehicles as per Maharashtra government vehicle statistics. The usage of private modes is increasing unabated mainly due to inadequate public transport facilities.

With a view of developing effective and efficient mass transit system towards improving the share of public transport trips, the Government of Maharashtra conceived and implemented Metro rail system. Phase I of the Metro Project was approved in 2016 and construction is currently taking place on the two lines.

Line 1 running from North to South from PCMC to Swargate. It is 17.8 km long and comprises 14 stations including 5 underground and 9 elevated stations;

Line 2 running from West to East from Vanaz to Ramwadi. It is 15.7 km long and comprises 16 elevated stations.

In addition, Line 3 is also planned under PPP model, being implemented by PMRDA, which will be running between Shivajinagar and Hinjewadi. Line 3 metro is 23.33 km long and comprises of 23 stations.

After experiencing the rapid growth, particularly in the out-growth areas of PMC & PCMC and Chakan area, the Government of Maharashtra/ Maha Metro – Pune Metro planned for further development of the metro network as an extension of Phase I.

The present chapter is dedicated to Environmental Impact Assessment of corridor 2-A Swargate to Katraj and the total length of this corridor is 5.464 km.

Corridor – 2A: Swargate to Katraj

- Proposed alignment of corridor-2A starts from Swargate and goes up to Katraj near the Katraj station along the Pune Satara road. Total length of the corridor is 5.464km which is completely underground
- 3 Stations have been proposed in Phase 2A, all of which are underground stations. Summary of the section is given below:

Table 96 : List of stations in Phase 2A

Swargate Katraj Underground Alignment		
Station	**Chainage (m)**	**Type**
Station 1 (Market Yard, Gultekdi)	17982	Underground

Swargate Katraj Underground Alignment		
Station 2 (Padmavati)	19568	Underground
Station 3 (Katraj)	21860	Underground

14.2 Scope of The Study

The Terms of Reference (TOR) for the present study were drawn up in accordance with the guidelines for Environmental Impact Assessment (EIA) studies issued by Ministry of Environment and Forests (MoEF), Government of India (GOI) for Transport Projects.

The Ministry of Environment and Forests (MoEF), Government of India issued notification on 14th September 2006 for getting Environmental Clearance. All new projects/expansion and modernization of existing projects or related activities listed in the schedule I of the notifications are required to obtain prior environmental clearance from MoEF. However, Rail projects are exempted from this list and hence environmental clearance will not be required for the present project.

Environmental Assessment Report is prepared for the present assignment in order to identify the baseline environmental status of the proposed Metro Rail alignment & stations, assessment of impact due to the proposed project on various Environmental parameters and preparation of Environmental Management Plan to mitigate the negative impact on these parameters. The broad scope of the study includes:

- Collection of baseline data on various components of the environment.
- Identification of the potential impacts during pre-construction, construction and operation phases.
- Developing mitigative measures to sustain and maintain the environmental scenario.
- Providing compensatory developments wherever necessary, including plans for tree plantation.
- Designing and monitoring the Environmental Management Plan.
- Suggesting the Environmental Enhancement Scheme and its monitoring.

14.3 Methodology

Suitable methodology was adopted to accomplish the study. As the first step, scoping exercise was undertaken to identify the parameters needed to be considered for the study and to outline the activities for collecting data on each parameter. Data pertaining to all facets of environment viz. physical, ecological and socioeconomic environment both through primary and secondary sources were collected. The step wise activities include:

- Review of legal requirements

- Reconnaissance survey for identification of key issues data requirement and preliminary consultation.
- Primary and secondary data collection
- Identification of impacts and mitigation measures
- Finalisation of EMP.

14.4 Applicable legal framework and policies

A review of the all applicable laws, regulations, notification and existing institutions relevant to the environmental issues in this project at the National/State levels policies are presented in this chapter.

India has a well-defined institutional and legislative framework. The legislation covers all components of environment viz air, water, noise, soil, terrestrial and aquatic flora and fauna, natural resources, and sensitive habitats. The environmental legislations in India are framed to protect the valued environmental components and comply with its commitment to the international community under various conventions and protocols as well. Review of Indian legal system has been carried out to identify its applicability to the project. WB/ADB has also defined their Environmental and Social Safeguard policies.

The Acts, Rules and Norms which are generally relevant to Metro rail projects are listed below;

- Amendment dated 9 December 2016 to EIA Notification 2006: Integration of environmental Conditions in local building byelaws;
- Workmen's Compensation Act 1923: The Act provides for compensation in case of injury by accident arising out of and during the course of employment;
- Contract Labour (Regulation and Abolition) Act, 1970: The Act provides for certain welfare measures to be provided by the contractor to contract Labour;
- Minimum Wages Act, 1948: The employer is supposed to pay not less than the Minimum Wages fixed by appropriate Government as per provisions of the Act;
- Payment of Wages Act, 1936: It lays down as to by what date the wages are to be paid, when it will be paid and what deductions can be made from the wages of the workers;
- Equal Remuneration Act, 1979: The Act provides for payment of equal wages for work of equal nature to Male and Female workers and not for making discrimination against Female employees;
- Child Labour (Prohibition and Regulation) Act, 1986: The Act prohibits employment of children below 14 years of age in certain occupations and processes and provides for regulation of employment of children in all other occupations and processes. Employment of child labour is prohibited in Building and Construction Industry;

- Inter-State Migrant Workmen's (Regulation of Employment and Conditions of Service) Act, 1979: The inter-state migrant workers, in an establishment to which this Act becomes applicable, are required to be provided certain facilities such as housing, medical aid, travelling expenses from home to the establishment and back, etc.;
- The Building and Other Construction Workers (Regulation of Employment and Conditions of Service) Act, 1996 and the Cess Act of 1996: All the establishments who carry on any building or other construction work and employs 10 or more workers are covered under this Act; the employer of the establishment is required to provide safety measures at the building or construction work and other welfare measures, such as canteens, first-aid facilities, ambulance, housing accommodation for Workers near the workplace, etc.;
- The Factories Act, 1948: The Act lays down the procedure for approval of plans before setting up a factory, health and safety provisions, welfare provisions, working hours and rendering information-regarding accidents or dangerous occurrences to designated authorities;
- Chemical Accidents (Emergency Planning, Preparedness and Response) Rules, 1996: The Rules provide for mandatory preparation of On-Site Emergency Plans by the industry and Off-Site Plans by the district collector and the constitution of four tier crisis groups at the centre, district, and local levels for the management of chemical disaster.
- Amendment dated 9 December 2016 to EIA Notification 2006: Integration of environmental Conditions in local building byelaws;
- The Air (Prevention and Control of Pollution) (Union Territories) Rules 1982, 1983 (Consent to establish and operate);
- The Water (Prevention and Control of Pollution) Rules 1975 (Consent to establish and operate);
- National Ambient Air Quality Standards, 2009;
- Guidelines for Ambient Air Quality Monitoring, CPCB, 2003;
- The Water (Prevention and Control of Pollution) Act 1974 amended 1988 Guide Manual – Water and waste water analysis, CPCB;
- Construction and Demolition Waste Management Rules, 2016;
- Hazardous and Other Wastes (Management and Transboundary Movement) Rules 2016 ;
- Solid Waste Management Rules 2016;
- Protocol for Ambient Level Noise Monitoring, CPCB, 2015;
- Drinking water – Specifications IS 10500: 2012 and CPHEEO Manual 2012;
- Energy Conservation Building Code 2017 & IGBC Green MRTS Abridged reference guide;

- Noise Pollution (Regulation and Control) Rules, 2000 amendment in 2010 ISO/ TC 108 (vibration);
- Metro Rail Transit System, Guidelines for Noise and Vibrations, RDSO, Ministry of Railways, September 2015;
- Forest (Conservation) Act, 1980, amended 1988;
- Forest (Conservation) Rules 2003 and Forest (Conservation) Amendment Rules, 2014 (procedure for FC);
- The Indian Wildlife (Protection) Act 1972 and The Wildlife (Protection) Amendment Act 2002;
- The Metro Railways (Operation and Maintenance) Act 2002 as amended vide. The Metro Railways (Amendment) Act 2009 (disaster management);
- The Ancient Monuments and Archaeological sites and Remain (Amendment and Validation Act) 2010;
- Groundwater (Regulation) Act, 1987 as amended till 2008 and Guidelines/Criteria for evaluation of proposals/requests for ground water abstraction (With effect from 16.11.2015), Central Ground Water Authority;
- World Bank, Operational policy OP 4.12 , involuntary resettlement
- World Bank, Environmental Assessment OP 4.01
- ADB Safeguard Policy Statement, July 2009

14.4.1 Key Applicable National Laws and Regulation

14.4.1.1 Environment (Protection) Act, 1986

This Act was passed as an overall comprehensive act "for protection and improvement of environment". According to this Act, the Central Government has the power to take all such measures as it deems necessary or expedient for the purpose of protecting and improving the quality of environment and preventing, controlling and abating environmental pollution. Under this act, rules have been specified for discharge/emission of effluents and different standards for environmental quality. These include Ambient Noise Standard, Emission from Motor Vehicles, Mass Emission Standard for Petrol Driven Vehicles, General Effluent Standards etc. especially important for Metro project.

14.4.1.1.1 EIA Notification 2006 and Subsequent Amendments

Metro rail projects are not included as a sector in the Schedule of the Environmental Impact Assessment (EIA) Notification 2006 that provides a list of projects which need to undergo EIA studies. However, Metro projects include components that may individually qualify for obtaining Environmental Clearance.

For metro rail projects, station buildings are required to be developed. If the built-up area of any of these station buildings is >20,000 square metres, then an Environmental Clearance is required to be obtained under Item 8(a) of the Schedule of EIA Notification 2006 & its amendment 15th November 2018.

Train maintenance depots would need to be developed as part of the projects. The depots would include administrative buildings and occupy a large area for undertaking maintenance of the rolling stock. If the built-up area of the buildings in the depot will be >20,000 square metres, then an Environmental Clearance may require to be obtained under Item 8(a) of the Schedule of EIA Notification 2006.

14.4.1.2 Forest (Conservation) Act, 1980

The Forest (Conservation) Act, 1960 came in to force with effect from October 25, 1980. Under the provision of this act, prior approval of the Central Government is essential for de-reservation of forest lands and / or diversion of forest lands for non-forestry purposes. There is no reserve/protected forest along the proposed project alignment.

14.4.1.3 Wild Life (Protection) Act, 1972

The Wildlife (Protection) Act, 1972 has allowed the Government to establish a number of National Parks and Sanctuaries to protect and conserve the flora and fauna of the state. The Wildlife Protection Act, (1972) is the first comprehensive act enacted to protect the wild animals and their habitats. It will improve protection measures of the existing National Parks and Sanctuaries and strengthen the Protected Areas (PA). The objectives of the act include to protect the rapidly declining wild animal and birds of the country, control trade in wildlife products, streamline and strengthen wildlife setup at Central and State level and establishment of Wildlife Advisory Board. In the extensive amendment in 1991, endangered wild plants have also been included within the protective umbrella of this Act.

Any Developmental Activities Will requires “Wildlife Clearance”, if it is Proposed to be located in or Within 10 Km of any “Wildlife Sanctuary” or “National Park” as Notified Under the Wildlife (Protection) Act (1972). There is no Wildlife protected area , along the proposed Metro Rail project alignment

14.4.1.4 Water and Air (Prevention and Control of Pollution) Acts

Water Act and Air Acts provide for the prevention and control of water and air pollution respectively. These acts empower the Pollution Control Boards to collect effluent and emission samples, entry to industrial units for inspection, power to prohibit on use of any water bodies for waste disposal and creation of new discharge outlets, provide consent to set up and operate certain facilities likely to create air and water pollution including power to give directions and prosecuting offenders.

The Air and Water Act are particularly applicable to all civil works activities. All construction work contractors need to obtain the consent-to-establish and consent-to-operate for plants and other machinery that they may be required for the purpose of construction. The NOC certificates need to be obtained from the regional offices of the SPCB. Wherein the existing plants are used, the contractor shall ensure that all applicable consents are obtained for operating the plant/equipment.

14.4.1.5 Central Motor Vehicle Act -1988 and Central Motor Vehicle Rules 1989

In 1988, the Indian Motor Vehicles Act empowered the State Transport Authority to enforce standards f or vehicular pollution and prevention control. The Authority also checks emission standards of registered vehicles, collects road taxes, and issues licenses. In August 1997, the Pollution Under Control Certificate (PUC) programme was launched in an attempt to crackdown on the vehicular emissions in the states.

Central Motor Vehicle Rules 1989 provide for working rules for licensing of drivers of motor vehicles, registration of motor vehicles, overall dimensions of motor vehicles, rules & regulations, etc.

14.4.1.6 Ancient Monuments and Archaeological Sites and Remains Rules, 1959 and 2010

As per the Act, area within a radius of 100m and 200m from the “protected property” are designated as “protected area” and “regulated area” respectively. No development activity (including mining operations and construction) is permitted in the “protected area” and all development activities likely to damage the protected property are not permitted in the “regulated area” without prior permission of the Archaeological Survey of India (ASI). Protected property entails the site/remains/ monuments are protected by ASI or the State Department of Archaeology.

Alignment does not pass through any prohibited, protected, restricted area of heritage structure/ Monument area’.

14.4.1.7 Environmental Assessment (OP 4.01)

Environmental Assessment is used in the World Bank to identify, avoid, and mitigate the potential negative environmental impacts associated with Bank’s lending operations early-on in the project cycle. The policy states that Environment Assessment (EA) and mitigation plans are required for all projects having significant adverse environmental impacts or involuntary resettlement. Assessment should include analysis of alternative designs and sites, or consideration of “no option” and require public participation and information disclosure before the Bank approves the project.

In World Bank operations, the purpose of Environmental Assessment is to improve decision making, to ensure that project options under consideration are sound and sustainable, and that potentially affected people have been properly consulted and their concerns addressed.

The World Bank's environmental assessment policy and recommended processing are described in Operational Policy (OP)/Bank Procedure (BP) 4.01: Environmental Assessment.

14.4.2 Summary of Statutory Clearance Requirement

The project requires a number of statutory clearances under different Acts and Rules a different stage of the project. These are listed in.

Table 97 : Summary of Environment Legislation Applicable for this Project

Act	Year	Objective	Applicability Yes/No	Responsible Institution
Environment (Protection) Act.	1986	To protect and improve the overall environment	Yes	MoEF&CC, CPCB
Notification on Environment Impact Assessment of Development projects (and amendments) (referred to as the Notification on Environmental Clearance)	2006 2009 2010 2013	To provide environmental clearance to new development activities following environmental impact assessment.	No	MoEF&CC, CPCB
Wildlife Protection Act	1972	To protect wild animals and birds through the creation of National Parks and Sanctuaries	No	MoEF&CC
Water (Prevention and Control of Pollution) Act (and subsequent amendments)	1974	To provide for the prevention and control of water pollution and the maintaining or restoring of	Yes	SPCB

Act	Year	Objective	Applicability Yes/No	Responsible Institution
		wholesomeness of water.		
Air (Prevention and Control of Pollution) Act (and subsequent amendments)	1981	To provide for the prevention, control and abatement of air pollution, and for the establishment of Boards to carry out these purposes.	Yes	SPCB and Metro Authority
Forest (Conservation) Act	1980	To protect and manage forests	No	MoEF&CC
Clearance for cutting trees and transporting	1964/ 71	Maharashtra Tree felling act. Tree removal will be guided as per state government rules.	Yes	Forest Department, /District Level Committee constituted by the State Govt.
Central Motor Vehicle Act Central Motor Vehicle Rules	1988 1989	To control vehicular air and noise pollution. To regulate development of the transport sector, check and control vehicular air and noise pollution.	Yes	State Transport Department
Dismantling of structure falling within right of way/Land Acquisition	2013	As per GOM act, Right to fair compensation and transparency in Land Acquisition, Rehabilitation and Resettlement Act, 2013	Yes	Competent Land Acquisition Authority

Act	Year	Objective	Applicability Yes/No	Responsible Institution
Ancient Monuments and Archaeological Sites and Remains Act	1958and 2010	Conservation of Cultural and historical remains found in India.	No	Archaeological Dept. GOI
Hazardous and Other Wastes (Management and Transboundary Movement)	2016	To handle & dispose Hazardous Wastes	Yes	SPCB
Construction and Demolition Waste Management Rules, 2016	2016	To handle & dispose Construction and Demolition Waste	Yes	SPCB
e-waste (Management) Rules, 2016	2016	To handle & dispose E waste	Yes	SPCB

14.5 Ambient Air Quality, Noise and Water Quality Standards

14.5.1 Ambient Air Quality Standards (AAQS)

Ambient air quality standards/limits provide a legal framework for the control of air pollution and the protection of public health.

The Ministry of Environment and Forest (MoEF&CC), Govt. of India, vide gazette notification, G.S.R826 (E), dated 16.11.2009 have notified/amended the National Ambient Air Quality Standards by amending the Environment (Protection) Rules 1986. The National Ambient Air Quality Standards (NAAQS) prescribed by CPCB are given in Table 98.

Table 98 : National Ambient Air Quality Standards (NAAQS)

	Concentration in Ambient Air			
Pollutants	**Time Weighted Average**	**Industrial, Residential, Rural and other areas**	**Ecologically sensitive area (notified by central government)**	**Method of Measurement**
1	**2**	**3**	**4**	**5**
Sulphur Dioxide (SO_2) µg/m^3	Annual*	50	20	Improved West & Gaeke method
	24 hours**	80	80	Ultraviolet fluorescence
Oxides of Nitrogen (NO_x) µg/m^3	Annual	40	30	Jacob & Hochheiser (Na-Arsenite)
	24 hours**	80	80	Gas Phase Chemiluminescence's
Carbon Monoxide (CO) mg/m^3	8 hours**	02	02	NonDispersive infraredspectroscopy
	1 hour	04	04	
PM_{10} µg/m^3 Particulate Matter size less than 10µm	Annual*	60	60	-Gravimetric - TOEM -Beta attenuation
	24 hours**	100	100	
$PM_{2.5}$ µg/m^3 Particulate Matter size less than 2.5µm	Annual*	40	40	-Gravimetric - TOEM -Beta attenuation
	24 hours**	60	60	

Source: *National Ambient Air Quality standards, CPCB Notification dated18thNovember 2009*

* Average Arithmetic mean of minimum 104 measurements in a year taken for a week 24 hourly at uniform interval.

** 24 hourly / 8 hourly values should meet 98 percent of the time in a year

14.5.2 Noise Quality Standards

Realizing the need to control and regulate noise levels, the Ministry of Environment & Forest, Government of India, have notified Noise Level Standards and Guidelines under Environment (Protection) Rules, 1986, known as Noise Pollution (Regulation & Control) Rules, 2000. The specific standards described in the rules are given in Table 99.

Table 99 : National Ambient Noise Quality Standards

Sr. No.	Area Code	Category of Zone	Leq*** in dB (A)	
			*Day	**Night
1	A	Industrial	75	70
2	B	Commercial	65	55
3	C	Residential	55	45
4	D	Silence Zone	50	40

* Day Time – 6.00 am – 10.00 pm (16 hours)
** Night Time – 10.00 pm – 6.00 am (8 hours)
*** Leq – Equivalent noise level
(Source: Noise pollution (Regulation and control) Rules, 2000)

14.5.3 Water Quality Standards

14.5.3.1 Surface Water Quality Standards

The CPCB has identified water quality requirements in terms of few chemical characteristics, known as primary water quality criteria. The "designated best uses" along with respective water quality criteria is given in Table 100.

Table 100 : Use Based Classification of Surface Waters in India

Designated Best Use	Class of Water	Criteria
Drinking Water source (with conventional treatment)	A	▪ Total Coliforms MPN/100 ml shall be 50 or less ▪ pH between 6.5 to 8.5 ▪ Dissolved Oxygen 6 mg / 1 or more ▪ Biological Oxygen demand (BOD) 5 days 200C, 2 mg/l or less
Outdoor bathing (organized)	B	▪ Total Coliforms Organism MPN/100 ml shall be 500 or less ▪ pH between 6.5 to 8.5 ▪ Dissolved Oxygen 5 mg / l or more ▪ Biological Oxygen demand (BOD) 5 days 200C 3 mg/1 or less

Designated Best Use	Class of Water	Criteria
Drinking Water source (without conventional treatment)	C	▪ Total Coliforms MPN/100 ml shall be 5000 or less ▪ pH between 6.5 to 8.5 ▪ Dissolved Oxygen 4 mg / 1 or more ▪ Biological Oxygen demand (BOD) 5 days 200C 3 mg/1 or less
Propagation of Wildlife	D	▪ pH between 6.5 to 8.5 for fisheries ▪ Dissolved Oxygen 4 mg / 1 or more ▪ Free Ammonia (as N) 1.2 mg/1 or less
Irrigation, Industrial Cooling, Controlled Waste	E	▪ pH between 6.0 to 8.5 ▪ Electrical Conductivity at 250C µmhos/cm Max. 2250 ▪ Sodium absorption ratio Max. 26 ▪ Boron, Max.2 mg/1

***(Source:** Guidelines for Water Quality Management – CPCB 2008)*

14.9.1.1 Ground Water Quality Standards

Since all groundwater resources of the State are classified for more than one use and therefore, the most stringent or protective criteria will be applicable. Therefore, its qualities have been compared with Bureau of Indian standards: IS :10500:1991 and WHO Guideline for Groundwater Sources for Drinking Water which is presented in the form of

Table 101 : Indian Standards for Drinking Water-Specification BIS:IS 10500:2012

Sr. No.	Substance or Characteristics/Parameter	BIS, Indian Standards (IS 10500:2012)	
		Desirable Limit	Permissible Limit in the absence of Alternate Source
(1)	**(2)**	**(3)**	**(4)**
Essential Characteristics			
1	Colour,(HazenUnits, Max)	5	15
2	Odour	Unobjectionable	---
3	Taste	Agreeable	---
4	Turbidity, NTU, Max	1	5
5	pH value	6.5 to 8.5	No relaxations
6	Total hardness (as CaCO2) mg/L, Max	200	600
7	Iron (as Fe) mg/L, Max	0.3	No relaxations
8	Chloramines (as Cl2), mg/l, Max	4	No relaxations
9	Chlorides (as Cl) mg/L , Max	250	1000

Sr. No.	Substance or Characteristics/Parameter	BIS, Indian Standards (IS 10500:2012)	
		Desirable Limit	Permissible Limit in the absence of Alternate Source
10	Free residual chlorine, mg/l, Min	0.2	1
Desirable Characteristics			
11	Dissolved solids mg/L, Max	500	2000
12	Calcium (as Ca) mg/L, Max	75	200
13	Copper (as Cu) mg/L, Max	0.05	1.5
14	Magnesium(as Mg),mg/L,Max	30	100
15	Manganese (as Me) mg/L, Max	0.1	0.3
16	Sulphide (as H2 S), mg/l, Max	0.05	No relaxation
17	Sulphate (as SO4) mg/L, Max	200	400
18	Silver (as Ag), mg/l, Max	0.1	No relaxation
19	Nitrate (as NO3) mg/L, Max	45	No relaxation
20	Fluoride (as F) mg/L, Max	1	1.5
21	Phenolic compounds (asC6H5OH) mg/L, Max	0.001	0.002
22	Mercury (as Hg) mg/L, Max	0.001	No relaxation
23	Cadmium (as Cd), mg/L, Max	0.003	No relaxation
24	Selenium (as Se), mg/L, Max	0.01	No relaxation
25	Total Arsenic (as As) mg/L, Max	0.01	0.05
26	Cyanide (as CN), mg/L, Max	0.05	No relaxation
27	Lead (as Pb), mg/L, Max	0.01	No relaxation
28	Zinc (as Zn), mg/L, Max	5	15
29	Amonic detergents (as MBAS) mg/L, Max	0.2	1
30	Total Chromium (as Cr6+) mg/L, Max	0.05	No relaxation
31	Polynuclear aromatic hydrocarbons (as PAH) g/L, Max	0.0001	---
32	Mineral oil mg/L, Max	0.01	0.03
33	Pesticides mg/L, Max	Absent	0.001
34	Radioactive Materials:	0.1	No relaxation
	a) Alpha emitters Bq/L, Max	1	
	b) Beta emitterspci/L, Max		
35	Total alkalinity as calcium carbonate mg/L, Max	200	600
36	Aluminum (as Al), mg/L, Max	0.03	0. 2
37	Ammonia (as total ammonia-N), mg/l, Max	0.5	No relaxation
38	Barium (as Ba), mg/l, Max	0.7	No relaxation
39	Boron, mg/L, Max	0.5	1

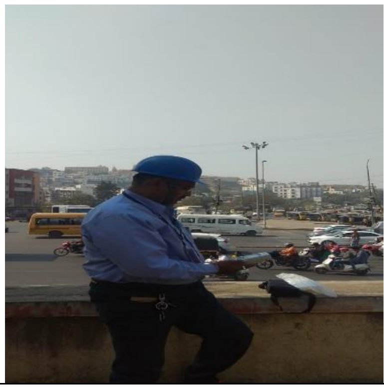
Sr. No.	Substance or Characteristics/Parameter	BIS, Indian Standards (IS 10500:2012)	
		Desirable Limit	Permissible Limit in the absence of Alternate Source
Bacteriological Quality of Drinking Water			
1	All water intended for drinking:	Shall not be detectable in any 100 ml sample	
	a)E. coli or thermotolerant coliform bacteria		
2	Treated water entering the distribution system:	Shall not be detectable in any 100 ml sample	
	a)E. coli or thermotolerant coliform bacteria		
	b)Total coliform bacteria		
3	Treated water in the distribution system	Shall not be detectable in any 100 ml sample	
	a)E. coli or thermotolerant coliform bacteria		
	b)Total coliform bacteria		

14.10 Description of the environment

Collection of baseline information on bio-physical, social and economic aspects of the project area is the most important reference for conducting EIA study, based on the existing environmental scenario, potential impacts of project will be identified and accordingly management plan will be proposed so as applicability of Government of India (GoI) regulatory requirements. The baseline environmental conditions will help in comparing and to monitor the predicted negative and positive impacts resulting from the project during construction and operation phases.

Data was collected from Primary & secondary sources for the macro-environmental setting like climate, physiography (Geology and slope), biological and socio-economic environment. First-hand information has been collected to record the micro-environmental features within and adjacent to the project corridor. Collection of first hand (Primary) information includes preparation of base maps, extrapolating environmental features on proposed Metro Track & Station design, tree inventories, location and measurement of socio-cultural features abutting proposed project. Scope of this exercise was 10 kilometres on both sides from the centre of the project location as per guidelines of Ministry of Environment and Forests, Government of India. However, the focus of the study was on the areas within and directly adjacent to the corridor of impact and ROW.

Following section describes the nature, type and characteristics of the physical, biological, cultural and socioeconomic components along the project Stretch.

	
Swargate Ambient Air Sampling	Katraj Ambient Air Sampling
	
Swargate Ambient Noise Sampling	Katraj Ambient Noise Sampling
	
Ground Water Sampling	Surface Water Sampling Katraj Lake

	
Soil Sampling	Meteorology Station

Figure 92. Nigdi Depot layout- Option 2 (At grade stabling)

14.10.1 Location and physiography

Pune is the second largest district of Maharashtra State in respect of area. The district has a geographical area of 15642 sq.km., which is 5.08% of the total area of State. It is situated in the western part of the State and lies between north latitude 17°54’ and 19°24’ and east longitudes 73°29’ and 75°10’.

It is bounded by Ahmednagar district in the north and east. Satara and Solapur districts in south and south east respectively and Thane and Raigarh districts in north west and west respectively. For administrative convenience it is divided in 14 talukas namely Pune City, Haveli, Khed, Ambegaon, Junnar, Shirur, Daund, Indapur, Baramati, Purandhar, Bhor, Velhe, Mulsi and Maval.

Figure 93. Pune district map
(Source : http://www.mrsac.gov.in)

Municipal Limit identified with length distribution of the project is shown in the Table 102 hereafter:

Table 102 : District wise distribution of the project alignment

State	District	Chainage	Tentative Length(km)	Taluka
Maharashtra	Pune	Swargate to Katraj	5.464	Haveli Taluka (Pune Municipal Corporation)

14.10.2 Geology and Soil Type

"The district forms part of Western Ghat and Deccan Plateau. Physiographically the district can be divided in to three distinct belts i.e.,

(1) The western belt stretching from 16 to 31 km. East of Sahayadri –an extremely rugged country cut by deep valleys, divided and crossed by hill ranges.

(2) The central belt extending for about 30 km. East of the western belt across the tract whose eastern boundary is roughly marked by a line drawn from Pabal in the north, southwards through Pune to Purandhar. In this belt a series of small hills stretch in to valleys and large spurs from Plateau and

(3) The eastern belt with a rolling topography and the low hills sinking slowly in to the plains with relatively broader valleys.

Therefore, the physiography of the district has given rise to four major characteristic land forms namely; (1) The hills and ghats (2) the foot hills (3) the plateau and (4) the plains." (Source: cgwb.gov.in/District Profile)

From the riverbed of Mutha, highest portion in the Pune City is Kedareshwar hill, which is about 612 meters from the riverbed. The Western portion from Mulshi, Maval, Tahsil in Pune District, contains black soil where the main crop is paddy. All lands to the north, west south and east have generally reddish soil.

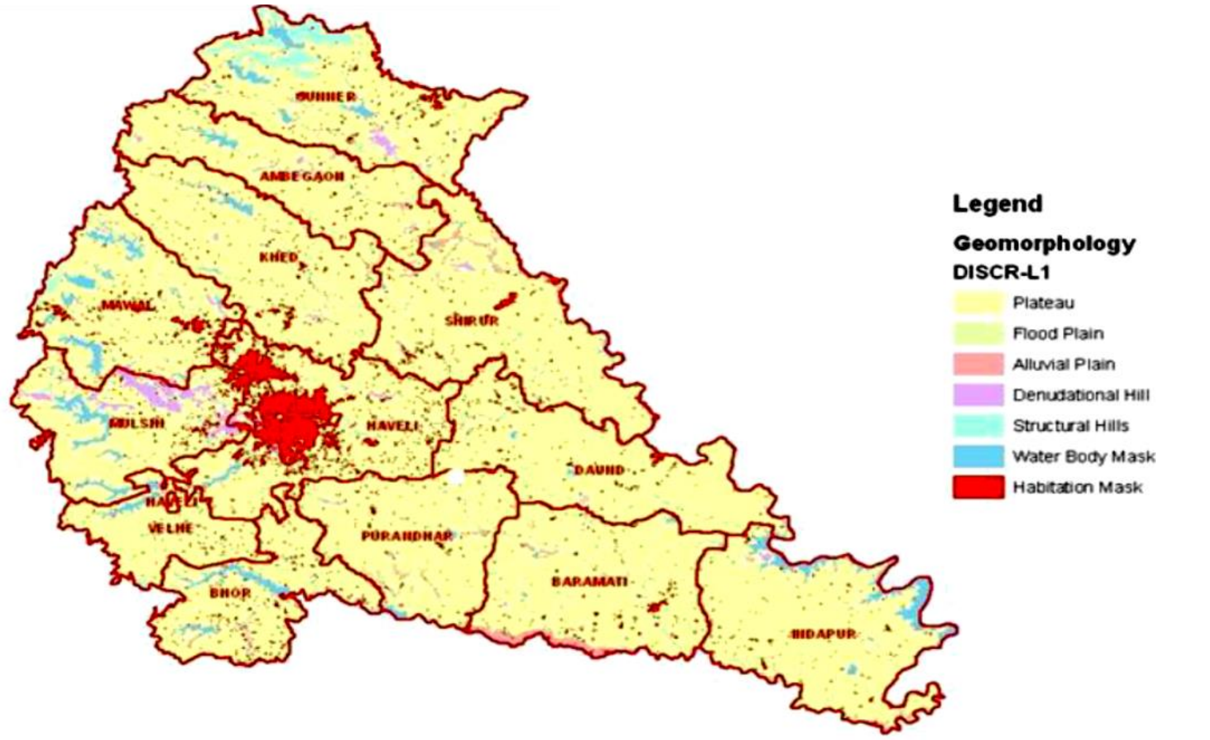


Figure 94. Geomorphology map of Pune District

(*Source: krishi.maharashtra.gov.in)*

To identify the actual condition of soil, soil quality analysis has been carried out by MoEF & NABL accredited, Shreeji Aqua Treatment Pvt. Ltd. Laboratory, located at Pune. Soil sample was collected along the project corridor. Laboratory analysis results are reported in Table 103. The result shows that the soil is slightly alkaline in nature.

Table 103 :Result of Soil Quality Monitoring of the Study Area

Sr. No.	Parameters	Unit	Reference Method	Result
1	pH	--	IS 2720 (Part 26):1987	7.98
2	Electrical Conductivity	µs/cm	IS 14767:2000	180.9
3	Soil Texture	--	Lab Manual on Agriculture Method	Sandy Clay
4	Bulk Density	g/cm^3	IS 2720 (Part 33):1995	1.6
5	Soil Porosity	%	IS 2720 (Part 2):2010	40.0
6	Permeability	cm/hr.	IS 2720 (Part 17):2002	0.25
7	Water Holding Capacity	%	IS 2720 (Part 2):2010	40.0
8	Organic Carbon	%	IS 2720(Part 22):1972	0.34

Sr. No.	Parameters	Unit	Reference Method	Result
9	Cation Exchange Capacity	meq/100	Lab Manual on Agriculture Method	14.4
10	Nitrogen	mg/kg	IS 14684:1999	242.70
11	Potassium	ppm	Protocol:105-001A	178.64
12	Phosphorous	mg/kg	Olsen's Method	29.93
13	Lead	mg/kg	EPA 3050 B 1996	BDL
14	Iron	mg/kg	EPA 3050 B 1996	4.40

14.10.3 Topography:

Pune district lies in the Bhima and Nira basins. It has a shape of triangle with its base in Sahyadri mountains on the West and its apex in the extreme South-East corner near Nira River. Taking into consideration the height from sea level, rainfall, soil pattern etc. it is divided into three zones viz. Western Zone, Central Zone and Eastern Zone. The Sahayadri ranges are spread from North to South in the district. Pune district lies in Seismic Zoning III. This zone is classified as Moderate Damage Risk Zone.

14.10.4 Land-use pattern and land holdings

It can be seen from the LULC map below that out of geographical area, about 23 percent of land is under non-agricultural usage i.e. forest, land under non-agricultural use, cultivable waste, permanent pasture and miscellaneous trees and groves.

About 7 percent land is as current and other fallow and about 64 percent of land is sown. Thus, altogether about 14.71 percent of land is available in the form of cultivable waste, permanent pastures, land under tree crops and grooves, current as well as other follows, which can be brought under productive use with a proper wasteland development programme.

The land use along the project corridor is principally of the Urban category passing through the open and commercial land.

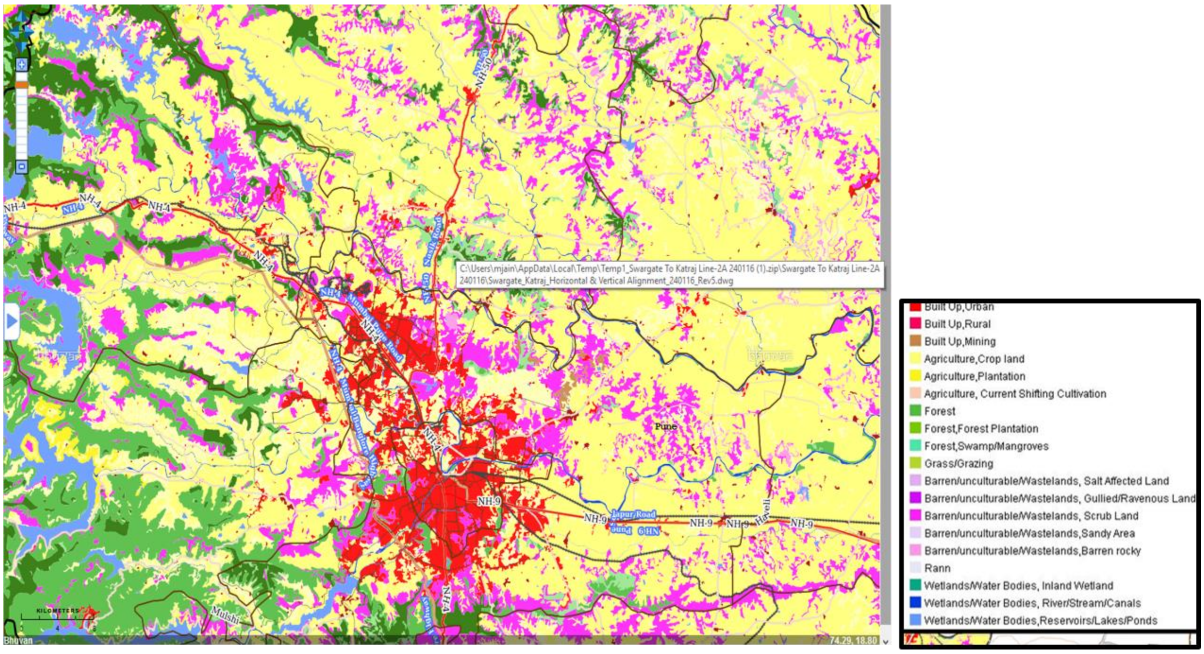
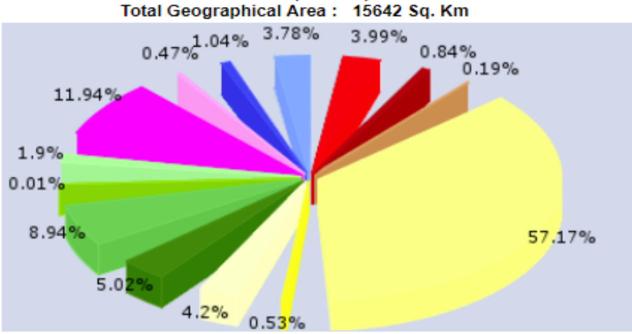


Figure 95. Land use Landcover map of Project Area

LULC Information (2011-12) for Pune
Total Geographical Area : 15642 Sq. Km



LULC Class	Area (Sq.Km)	LULC Class	Area (Sq.Km)
Builtup,Urban	623.43	Builtup,Rural	131.08
Builtup,Mining	29.39	Agriculture,Crop land	8942.82
Agriculture,Plantation	82.21	Agriculture,Fallow	657.21
Forest,Evergreen/ Semi evergreen	784.88	Forest,Deciduous	1398.96
Forest,Forest Plantation	1.59	Forest,Scrub Forest	296.49
Barren/unculturable/ Wastelands, Scrub land	1866.92	Barren/unculturable/ Wastelands, Barren rocky	72.74
Wetlands/Water Bodies, River/Stream/canals	163.1	Wetlands/Water Bodies, Reservoir/Lakes/Ponds	591.18
Total			15642.00

Figure 96. Land use Landcover Statistics of Pune District

14.10.5 Meteorology

The ambient environment is responsible for the health of human beings, animals, wildlife and vegetation. All air pollutants emitted by point and non-point sources are transported, dispersed or concentrated by meteorological and topographical conditions.

The meteorological parameters regulate the transport and diffusion of pollutants into the atmosphere. In order to assess the impact on existing ambient environment due to the project, it is necessary to have baseline status of ambient environmental parameters.

Pune District forms a part of the tropical monsoon land and therefore shows a significant seasonal variation in temperature as well as rainfall conditions. The climate of the Western region of Pune District is cool, whereas the Eastern part is hot and dry.

14.10.5.1 Seasons

The winter season is from December to about the middle of February followed by summer season which last up to May. June to September is the south-west monsoon season, whereas October and November constitute the post-monsoon season.

14.10.5.2 Temperatures

The mean minimum temperature is about 12°C and mean maximum temperature is about 39°C.

14.10.5.3 Rainfall

The normal annual rainfall over the district varies from about 468 mm to 4659 mm.

Table 104 : Rainfall for last five years in Pune District (in mm)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEPT	OCT	NOV	DEC
	R/F	R/F	R/F	R/F	R/F	R/F	R/F	R/F	R/F	R/F	R/F	R/F
2013	0.5	0.3	0.9	0	0.8	293	397	129	233	32	13.6	5.4
2014	1.2	1.2	36.9	4.3	21.8	42.6	386	345	105	29	22.7	12
2015	0	0.6	50.2	13	29.3	230	142	53.8	157	83	45.3	0
2016	0	0.2	4.4	0.5	13.9	77.8	446	418	197	58	0	0
2017	0	0	0	0	24.6	289	513	290	211	116	13.9	0.7

(Source: www.imd.gov.in)

14.10.5.4 Humidity levels

Humidity is low during the summer months due to increased evaporation losses from the atmosphere. The diurnal variations in humidity during this period are high, water vapour gets condensed due to falling night-time temperatures and the daytime temperatures are high.

In the summer months the relative humidity ranges from a minimum of 20% to maximum of 67% during the day.

During the monsoon period, the relative humidity varies from 68% to 87%. The relative humidity during winter shows maximum diurnal variation varying from 37% to 88%.

Table 105 : Met Data, Pune (1981-2010)

Month	Temperature		Humidity %		Monthly Rainfall (mm)
	Min	Max	08.30hr	17.30 hr	
January	11.2	29.8	85	34	1.1
February	12.2	32.1	72	26	0.3
March	15.7	35.6	55	21	2.2
April	19.6	37.6	48	24	8.5
May	22.6	36.9	59	37	16.8
June	23.1	31.9	77	66	173.4
July	22.4	28.3	83	76	181.4
August	21.7	27.6	86	79	145.2
September	20.9	29.4	84	73	146.1
October	18.4	31.5	79	53	86.3
November	14.5	30.4	76	43	25.0
December	11.5	29.2	82	39	7.0

Source: Environment Impact Assessment Report for proposed expansion of IT Park Infosys Limited November 2017

14.10.5.5 Site Specific Metrological Data

The site-specific Meteorological data collected by MoEF & NABL accredited, Shreeji Aqua Treatment Pvt. Ltd. Laboratory by installing Met station, adjacent to the project corridor. Site specific Meteorological data & Windrose diagram is given below .

Table 106 : Site Specific Meteorological Data

Date	Wind Speed (Kmph)	Wind Direction	Temp. ^{0}C	Relative Humidity %	Barometric Pressure Kpa	Rainfall
31.12.2018	3.7	206.3	17.9	33.5	101.6	0.0
01.01.2019	2.2	135.0	21.0	26.7	100.8	0.0
02.01.2019	2.2	135.0	21.9	29.0	101.3	0.0

Date	Wind Speed (Kmph)	Wind Direction	Temp. ^0C	Relative Humidity %	Barometric Pressure Kpa	Rainfall
03.01.2019	3.8	131.3	22.1	37.3	101.2	0.0
04.01.2019	3.8	191.3	24.7	29.4	101.0	0.0
05.01.2019	2.5	176.3	23.2	27.4	97.3	0.0
06.01.2019	2.9	150	22.6	24.5	101.1	0.0

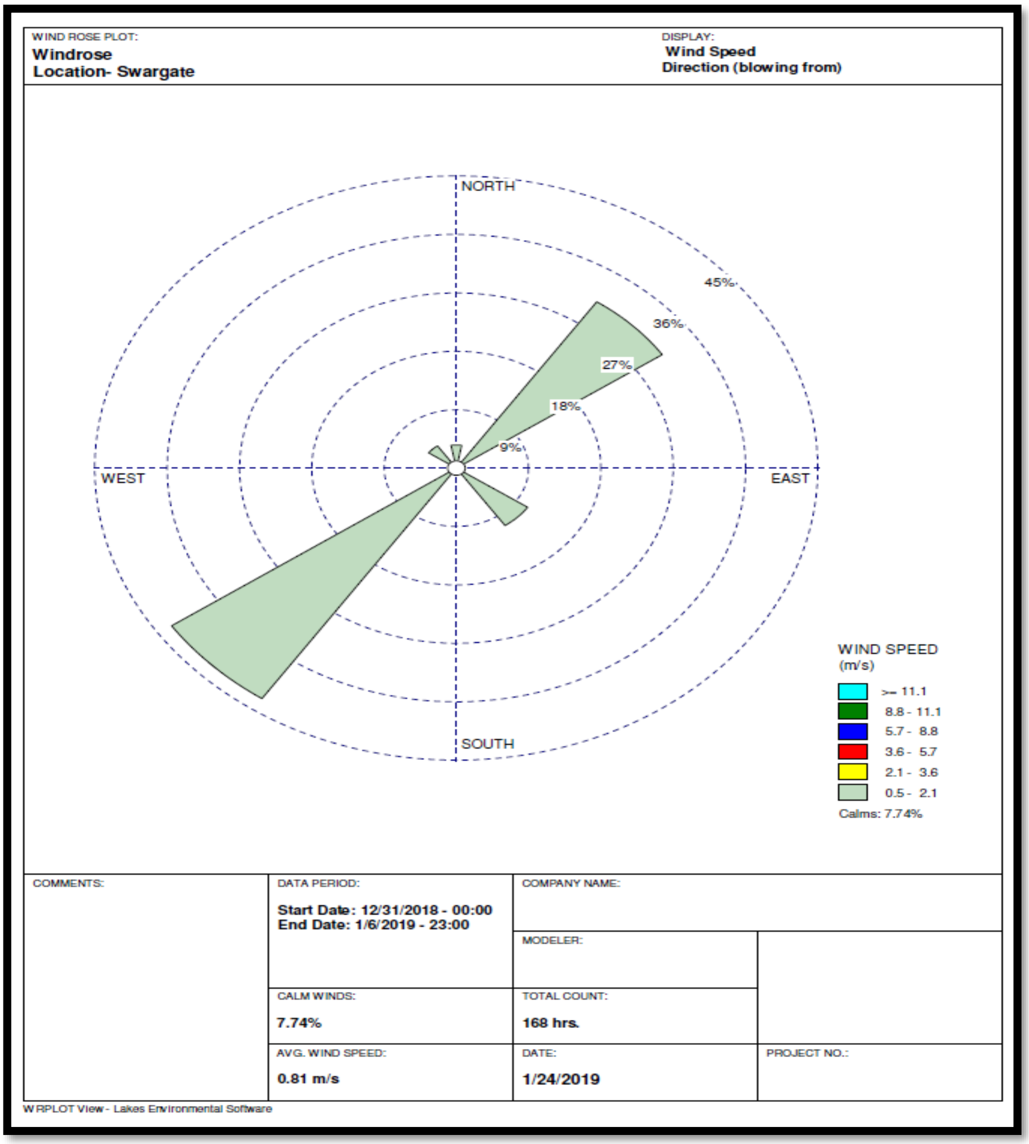


Figure 97. Windrose Diagram of project site

Based on the evaluation of the wind rose, it can be said that the overall predominant wind direction for the district is from the West to South West, with absolutely no wind from the South and considerable percentage of wind from the North direction .The predominant winds from the West and South West direction are responsible for the monsoons as they carry moisture-laden clouds from the Arabian Sea.

14.10.6 Air quality, water quality and noise

Baseline conditions define the characteristics of the existing environment and shape projected future conditions, assuming no project is undertaken. They provide the basis from which project impact comparison are made. Existing ambient air, noise and water quality data on various sections of the project corridors has been collected from secondary sources to establish a baseline database.

14.10.6.1 Air quality monitoring

Ambient air quality refers to the background air quality levels in a region, characterised by concentrations of various pollutants in the atmosphere. In most cases vehicular emissions are the predominant source of air pollution. Existing ambient air quality data on various sections of the project corridors was collected to establish a baseline database. The aim was to identify areas that already have high pollution levels or are expected to experience so, on account of the project, and to design adequate mitigation measures, as applicable.

The activities, which generate modify atmospheric air quality, are transportation (i.e., motor vehicle emissions, which are addressed in this study); industry; domestic and construction. The principal sources of air pollution due to metro projects are machineries used during construction phase and the vehicles that ply over it during the operation phase. The monitoring locations should be selected based on the sensitivity of the receptors to vehicular traffic and to obtain baseline concentrations of the various representative land uses along the corridors. The baseline data of air environment need to be monitored for the below mentioned parameters:

- Particulate Matter (PM_{10});
- Particulate Matter ($PM_{2.5}$);
- Sulphur oxide (SOx);
- Oxides of Nitrogen (NOx); and
- Carbon monoxides(CO);

Dispersal of pollutants depends upon factors like prevailing wind direction and other weather conditions, height of the source, and characteristics of plantation and presence of other sinks along the project corridor.

Primary data collected from project corridor has been examined to establish the baseline scenario for the project corridor. The sources of air pollution in the region are identified as industries, vehicular traffic, dust arising from roads etc.

Ambient air quality data within vicinity of the Project Corridor has been Monitored & analysed by MoEF & NABL accredited, Shreeji Aqua Treatment Pvt. Ltd. laboratory. Site specific ambient air quality is given below:

Table 107 : : Ambient Air Quality Monitoring Results

Sr. No.	Location	Concentration µg/m³				mg/m³
		$PM_{2.5}$	PM_{10}	SO_2	NO_x	CO
1	Swargate	56.0	97.0	28.0	30.0	0.069
2	Katraj	58.0	94.0	24.0	28.0	0.063
	CPCB Standards	**60**	**100**	**80**	**80**	**04**

The ambient air quality levels with respect to PM2.5, PM10, Sulphur dioxide, Nitrogen oxides (NOx) and Carbon monoxide (CO) ranges from 56.0 µg/m3 to 58.0 µg/m3, 94.0 to 97.0 µg/m3, 24.0 µg/m3 to 28.0 µg/m3, 28.0 to 30.0 µg/m3 and 0.063 to 0.069 mg/m3 respectively in the project corridor. All the ambient air quality parameters are within the National Ambient Air Quality Standards (NAAQS).

14.10.6.2 Noise Quality Monitoring

Along the proposed project construction proposals, there is significant industrial activity and significant vehicular traffic contributing to ambient noise levels. Therefore, the ambient noise levels may be higher than the noise quality standards. Project development results in increase in noise levels due to movement and operation of machinery, heavy vehicles, loading and unloading of construction materials, apart from high noise levels at the asphalt plants (90 - 100 dB(A). These activities are intermittent and localised.

During the operation phase, noise will be generated from Metro Rail movement in three ways, namely from the vehicle body parts, from the Wheel-Track system (also known as the rolling noise) and from the driver behaviour, such as use of horns.

To assess background noise levels in the study area, primary data from project corridor has been collected. Description of the noise monitoring stations and the Leq values at each station are given in the following tables.

The day noise level monitored during 6 A.M. to 10 P.M. and night levels 10 P.M. to 6 A.M. reviewed from existing data of Pune District & within vicinity of the Project Corridor, collected by MoEF & NABL accredited, Shreeji Aqua Treatment Pvt. Ltd. laboratory. The major source of noise identified in the study area has been predominantly the vehicular movement and the construction activities.

In the vicinity of the Project Corridor, Ambient Noise Monitoring night time Leq (Ln) varies from 57.27 to 60.48 dB (A) and the daytime Leq (Ld) varies from 78.37 to 80.15 dB (A) within the study area. Ambient noise level is very high as per the standards prescribed by CPCB for Silence, Residential, Commercial & Industrial Area. The major source of noise identified in the study area has been predominantly the vehicular movement and the construction activities.

Table 108 : : Ambient Noise Quality Monitoring Results

S. No.	Test Parameters	Results		Units	Requirement (as per CPCB Guidelines Limits in dB (A) Leq		
		Swargate	Katraj		**Category of Area/ Zone**	**Day Time**	**Night Time**
1.	**Equivalent Noise Level** (6.0 AM TO 10.0 PM)	80.15	78.37	dB(A)	Industrial Area	75	70
2.	**Equivalent Noise Level** (10.0 PM TO 6.0 AM)	57.27	60.48	dB(A)	Commercial Area	65	55
					Residential Area	55	45
					Silence Zone	50	40

14.10.6.3 Water Resources & Quality

Water environment consists of water resources and its quality. Its study is important from the point of view to assess the adequacy of water resources for the needs of the project in its various stages of the project cycle and also to assess the impact of the project on water environment.

The Pune district has three major drainage systems namely:

- The Bhima Ghod River System in northern, north-eastern and eastern part of which Bhima River has a total length of about 355 km and Ghod river has a drainage of about 196 km.
- Mula-Mutha River System covering the central part and having total length of 242 km in the district.
- Nira River system covering south, south-east and eastern part and has total length of about 231 km in the district.

The Mutha River flows from western side to eastern side towards Daund. Mula River, which is coming from Western side of Pune City, meets the Mutha river near Sangamwadi and then the combined rivers flow towards Solapur side. Width of Mutha River bed is 200 meters (660 feet). The northwestern outskirts of Pune's urban area serve as the crossway for two other rivers, namely Pavana and Indrayani. The Bhima River also flows from the northwestern part about 8-9 km away from the main city. Most of the talukas in Pune district are flood prone. The rivers likely to cause flooding are:

- River Bhima (Tal. Shirur, Daund, Indapur and Haveli);
- River Mula (Pune city);
- River Mutha (Tal.Punecity and Mulshi);
- River Indrayani (Tal. Khed, Haveli and Maval);
- River Ghod (Tal. Ambegaon);
- River Mina and Pushpavati (talJunnar);
- River Nira (Tal. IndapurandPurandar);
- River Pavana (Tal. Haveli).

Figure 98. River map of Pune District

Prime source of ground water in the district are Dug wells and tube wells. Ground water Bearing Formations in Pune district are: Weathered, fractured, jointed and vesicular Basalts. The depth to water level in the district shows wide variation:

- Pre-Monsoon Depth to Water Level (May-2011): 0.40 to 20.10 mbgl
- Post-Monsoon Depth to Water Level (Nov.2011): 0.09 to 14.65 mbgl
- Pre-Monsoon Water Level Trend (2002-11): Rise- Negligible to 0.75 m/yr : Fall- Negligible to 0.56 m/yr
- Post-Monsoon Water Level Trend (2002-11): Rise- Negligible to 0.63 m/yr : Fall- Negligible to 0.27 m/yr

Baseline information on the quality of surface and ground water sources along the alignment of proposed project is required before predictions can be made of the future quality. The proposed project may contaminate the surface/ground water during the construction, operation as well as maintenance phases. A plan for monitoring and mitigation will, therefore, be required to avoid the pollution or deterioration of the water sources.

14.10.6.3.1 Ground Water

Ground water of the area may be impacted due to leaching of contaminants from stored raw materials at site & sewage generated due to labour activity, excess draft of ground water. Run-off from project site may contains high quantity of suspended solids due to presence of sediments from excavated area & other pollutants due to presence of contaminants like oil, paints etc. This run-off on reaching surface water body will degrade the surface water quality which in turn may impact aquatic flora & fauna. Ground water Quality of Pune City & along the project corridor is given in below mentioned tables.

Table 109 : Physico-chemical Characteristics Ground Water Monitoring

Sr. No	Parameters	units	Khadki station	Kunbisahkari Bank (durbankar)	Shivaji nagar	Ashoka mall	Bharat petrol pump (karve road)	Agricultural college	water Desirable Limit
1.	Colour	Hazen	C/L	C/L	C/L	C/L	C/L	C/L	5
2.	Odour	-	U/O	U/O	U/O	U/O	U/O	OU/	U/O
3.	Turbidity	NTU	1	1	1	1	1	1	5
4.	pH	--	7.65	8.05	7.25	7.35	7.46	7.92	6.5-8.5
5.	Conductivity	us/cm	1072	170	420	795	660	692	-
6.	Total Dissolve Solids	mg/l	697	104	265	511	424	450	500
7	Alkalinity as CaCO3	mg/l	328	40	116	256	216	232	200
8.	Total Hardness as	mg/l	368	88	160	256	216	216	300

Sr. No	Parameters	units	Khadki station	Kunbisahkari Bank (durbankar)	Shivaji nagar	Ashoka mall	Bharat petrol pump (karve road)	Agricultural college	water Desirable Limit
9	Calcium as Ca	mg/l	115	16	58	96	74	74	75
10	Magnesium as Mg	mg/l	20	12	4	4	8	8	30
11	Bicarbonate	mg/l	400	49	142	312	264	283	
12	Chloride as Cl	mg/l	65	11	22	31	26	37	250
13	Sulphate as SO4	mg/l	80	15	34	56	45	40	200
14	Nitrate as NO3	mg/l	17	2	6	12	8	8.5	45
15	Fluorides as F	mg/l	1.2	0.6	0.85	0.85	0.75	0.6 5	1
16	Phenolic compound as C6H5OH	mg/l	BDL	BDL	BDL	BDL	BDL	BD L	0.001
17	Cyanide	mg/l	BDL	BDL	BDL	BDL	BDL	BD L	0.05
18	Aluminium	mg/l	BDL	BDL	BDL	BDL	BDL	BD L	0.03
19	Arsenic	mg/l	BDL	BDL	BDL	BDL	BDL	BD L	0.05
20	Cadmium	mg/l	BDL	BDL	BDL	BDL	BDL	BD L	0.01
21	Chromium as Cr+6	mg/l	BDL	BDL	BDL	BDL	BDL	BD L	0.05
22	Iron	mg/l	0.7	0.1	0.16	0.17	0.2	0.1 5	0.3
23	Copper	mg/l	BDL	BDL	BDL	BDL	BDL	BD L	0.05
24	Lead	mg/l	BDL	BDL	BDL	BDL	BDL	BD L	0.05
25	Manganese	mg/l	BDL	BDL	BDL	BDL	BDL	BD L	0.1
26	Mercury	mg/l	BDL	BDL	BDL	BDL	BDL	BD L	0.001
27	Zinc	mg/l	1	BDL	0.5	1	0.6	0.7	5

Source: Detail project report of Pune Metro 2009

The quality of the well water was inferred in comparison with the National Standards of Drinking Water Quality (IS: 10500). All the well water samples were colourless, odourless and with agreeable taste. One sample had high turbidity and the samples showed well-balanced pH. The chemical characteristics such as total hardness, chlorides, dissolved solids, sulphates and nitrates were within limits. Among the metals analysed iron, copper, zinc, chromium, magnesium, cadmium, selenium, mercury and arsenic were not detected or were within stipulated limit.

Table 110 : Physico-chemical & Biological Characteristics Ground Water along the project corridor

Sr. No.	Parameters	Unit	Reference Method	Result	Acceptable limits of IS 10500:2012 Standard	Permissible limits of IS 10500:2012 Standard
1	Temperature	°C	IS 3025 (Part9):1984	25	NS	NR
2	pH	--	APHA 4500 H+B	8.29	6.5-8.5	NR
3	Colour	Hazen	Observation Method	1.0	5.0	15.0
4	Conductivity	µs/cm	APHA 2510-B	700.0	NS	NS
5	Turbidity	NTU	APHA-2130-B	0.2	1.0	5.0
6	Total Suspended Solids (TSS)	mg/lit	APHA 2540-D	12.0	NS	NS
7	Total Dissolved Solids (TDS)	mg/lit	APHA 2540-C	440.0	500.0	200.0
8	Dissolved Oxygen (DO)	mg/lit	IS 3025 (Part 38):1989	7.65	NS	>5.0
9	Oil & Grease	mg/lit	IS 3025(Part 39):1991	<2.0	NS	NS
10	Total Hardness	mg/lit	APHA-2340-C	298.0	200.0	600.0
11	Calcium	mg/lit	APHA-3500-Ca-B	69.73	75.0	200.0
12	Sodium	mg/lit	APHA 3120,3500-Na	45.20	NS	NS
13	Magnesium	mg/lit	APHA-3500-Mg-B	30.13	30.0	100.0
14	Alkalinity	mg/lit	IS 3025 (Part 23):1986	195.0	200.0	60.0
15	Nitrate	mg/lit	APHA-4500-NO2-N-B	1.1	45.0	NR
16	Ammonical Nitrogen	mg/lit	APHA-4500-NH3-C	0.7	0.5	NR
17	Phosphate	mg/lit	APHA-4500-P-D	1.4	NS	NS
18	Sulphate	mg/lit	APHA 4500- SO42--E	22.7	200.0	400.0
19	Chloride	mg/lit	APHA 4500-Cl$^-$-B	36.26	250.0	1000.0
20	Fluoride	mg/lit	APHA-4500-F-D	BDL	1.0	1.5
21	Phenol	mg/lit	APHA-5530-D	BDL	0.001	0.002

Sr. No.	Parameters	Unit	Reference Method	Result	Acceptable limits of IS 10500:2012 Standard	Permissible limits of IS 10500:2012 Standard
22	Lead	mg/lit	APHA-3120,3500-Pb	0.03	0.01	NR
23	Iron	mg/lit	APHA-3120,3500-Fe	BDL	0.3	NR
24	Arsenic	mg/lit	APHA-3120,3500-As	BDL	0.01	0.05
25	Zinc	mg/lit	APHA-3120,3500-Zn	<0.01	5.0	15.0
26	Cadmium	mg/lit	APHA-3120,3500-Cd	<0.01	0.003	NR
27	Manganese	mg/lit	APHA-3120,3500-Mn	<0.01	0.1	0.3
28	Chromium	mg/lit	APHA-3120,3500-Cr	0.03	0.05	NR
29	Copper	mg/lit	APHA-3120,3500-Cu	0.01	0.05	1.5
30	Faecal Coliform	Per 100	IS 1622:1981	Absent	Absent	Absent
31	Total Coliform	Per 100	IS 1622:1981	Nil	Nil	Nil

The water quality in the impact zone was assessed through physico-chemical and bacteriological analysis of ground samples. The results have been compared with the drinking water quality standards specified in IS: 10500. The ground water quality largely meets the drinking water standards. All the analysed parameters are within desirable limit except Total Hardness & Magnesium that marginally exceeds the desirable limit but well within permissible limit.

14.10.6.3.2 SURFACE WATER

The source of surface water of Pune is the Mula and Mutha river. Secondary data of surface water quality of the Pune City is given below Table 111.

Table 111: Physico-chemical Characteristics Surface Water Monitoring

S. No.	Parameters	Unit	Vitthalwadi (Mutha river)	GarwareBridge (Mula river)	Sangam Bridge (Mutha river)	Bund Garden (Mula Mutha)	Acceptable limits of IS - 10500:2012
1	Colour	Hazan	Brownish	Light darkish	Light darkish	Light greyish	5
2	Odour	-	Objectionable	Objectionable	Objectionable	Objectionable	U/O

S. No.	Parameters	Unit	Vitthalwadi (Mutha river)	GarwareBridge (Mula river)	Sangam Bridge (Mutha river)	Bund Garden (Mula Mutha)	Acceptable limits of IS - 10500:2012
3	Turbidity	NTU	26	32	30	28	5
4	pH	--	7.50	7.35	7.30	7.40	6.5-8.5
5	Conductivity	uS/cm	550	640	690	460	-
6	Total Dissolve Solids sum	mg/l	360	448	476	325	
7	Alkalinity as CaCO3	mg/l	140	165	173	115	200
8	Total Hardness as CaCo3	mg/l	162	188	195	113	300
9	Calcium as Ca	mg/l	35	52	60	27	75
10	Magnesium as Mg	mg/l	18	14	11	11	30
11	Sodium	mg/l	29.0	45.0	52.0	21.0	_
12	Potassium	mg/l	8.0	11.0	9.0	11.0	_
13	Bicarbonate	mg/l	171	201	211	140	_
14	Chloride as Cl	mg/l	43	67	58	35	250
15	Sulphate as SO4	mg/l	35	42	47	23	200
16	Nitrate as NO3	mg/l	3.5	11.4	14	3	45
17	Fluorides as F	mg/l	0.2	0.4	0.5	0.3	1
18	Phenolic compound as C6H5OH	mg/l	BDL	BDL	BDL	BDL	0.001
19	Cyanide	mg/l	BDL	BDL	BDL	BDL	0.0 5
20	Aluminium	mg/l	BDL	BDL	BDL	BDL	0.0 3
21	Arsenic	mg/l	BDL	BDL	BDL	BDL	0.0 5
22	Cadmium	mg/l	BDL	BDL	BDL	BDL	0.01
23	Chromium as Cr+6	mg/l	BDL	0.02	0.035	BDL	0.05
24	Iron	mg/l	0.25	0.6	0.48	0.05	0.3
25	Copper	mg/l	BDL	BDL	BDL	0.02	0.05
26	Lead	mg/l	BDL	BDL	BDL	BDL	0.05
27	Manganese	mg/l	BDL	BDL	BDL	BDL	0.1
28	Mercury	mg/l	BDL	BDL	BDL	BDL	0.001
29	Zinc	mg/l	0.4	1.6	1.5	0.8	5
30	DO	mg/l	1.2	0.6	0.5	2.5	_
31	COD	mg/l	21	35	42	16	–
32	BOD	mg/l	12	12	15	5	_

Source: Detail project report of Pune Metro 2009

Katraj lake is near to the project alignment & Physico-chemical & Bacteriological characteristics. Water quality of the lake is given below.

Table 112 : : Physico-chemical & Biologicall Characteristics of Surface Water

Sr. No.	Parameters	Unit	Reference Method	Result	Surface Water Standards as per IS:2296
1	Temperature	°C	IS 3025 (Part 9):1984	25	NS
2	pH	--	APHA 4500 H+B	8.97	8.5
3	Colour	--	Observation Method	Colourless	NS
4	Conductivity	µs/cm	APHA 2510-B	891.0	1000.0
5	Turbidity	NTU	APHA-2130-B	3.3	NS
6	Total Suspended Solids (TSS)	mg/lit	APHA 2540-D	72.0	NS
7	Total Dissolved Solids (TDS)	mg/lit	APHA 2540-C	584.0	NS
8	Dissolved Oxygen (DO)	mg/lit	IS 3025 (Part 38):1989	8.2	4.0
9	Bio-Chemical Oxygen Demand (BOD)@ 270C for 3 days	mg/lit	IS 3025(Part 44):1993	21.0	NS
10	Chemical Oxygen Demand (COD)	mg/lit	APHA 5220-C	59.02	NS
11 12	Oil & Grease	mg/lit	IS 3025(Part 39):1991	<2.0	0.1
13	Total Hardness	mg/lit	APHA-2340-C	344.0	NS
14	Calcium	mg/lit	APHA-3500-Ca-B	84.96	NS
15 16	Sodium	mg/lit	APHA 3120,3500-Na	81.46	NS
17	Magnesium	mg/lit	APHA-3500-Mg-B	62.94	NS
18	Ammonical Nitrogen	mg/lit	APHA-4500-NH3-C	<0.1	NS
19	Phosphate	mg/lit	APHA-4500-P-D	2.4	NS
20	Sulphate	mg/lit	APHA 4500- SO42--E	56.2	NS
21	Chloride	mg/lit	APHA 4500-Cl⁻-B	85.26	NS
22	Fluoride	mg/lit	APHA-4500-F-D	BDL	NS
23	Phenol	mg/lit	APHA-5530-D	BDL	NS
24	Lead	mg/lit	APHA-3120,3500-Pb	0.11	NS
25	Iron	mg/lit	APHA-3120,3500-Fe	7.54	NS
26	Arsenic	mg/lit	APHA-3120,3500-As	0.06	NS
27	Zinc	mg/lit	APHA-3120,3500-Zn	<0.01	NS
28	Cadmium	mg/lit	APHA-3120,3500-Cd	<0.01	NS
29	Manganese	mg/lit	APHA-3120,3500-Mn	<0.01	NS

Sr. No.	Parameters	Unit	Reference Method	Result	Surface Water Standards as per IS:2296
30	Chromium	mg/lit	APHA-3120,3500-Cr	0.08	NS
31	Copper	mg/lit	APHA-3120,3500-Cu	0.03	NS
32	Faecal Coliform	Per 100 ml	IS 1622:1981	80.0	NS
33	Total Coliform	Per 100 ml	IS 1622:1981	>1600.0	NS

The Katraj water quality was assessed through physio-chemical and bacteriological analysis. The results have been compared with the drinking water quality standards specified in IS: 10500 & IS 2296 for various use of water. Parameters like BOD, COD, Faecal Coliform, Coliform etc. exceeds the limits and not suitable for drinking & domestic use.

14.10.7 Ecology & Biodiversity

14.10.7.1 Reserve and protected forests

The proposed corridors do not pass through any reserve/protected forest in their entire lengths. Moreover, no protected areas/environmentally sensitive areas are found in their indirect impact zones as well (10 km radius).

However, the project alignment is running parallel to the Rajiv Gandhi zoological park in Katraj. The **Rajiv Gandhi Zoological Park**, commonly known as the **Rajiv Gandhi Zoo** or **Katraj Zoo**, is located in Katraj, Pune district. It is managed by the Pune Municipal Corporation. The 130-acre (53 ha) zoo is divided into three parts: an animal orphanage, a snake park, and a zoo, and includes the 42-acre (17 ha) Katraj Lake.

Figure 99. Rajiv Gandhi Zoological Park along the Project Alignment

The main tree species in the project area are Madhuca, Erythrina, Terminalia elliptica, Brideliaretusa, Tectonagrandis, Meynalaxiflora, Dalbergiasisoo, Holarrhenapubescens, Grewiatilifolia, Lagerstroemia sp. Eucalyptus, Peltophorum, Bombax ceiba, Butea monosperma, Mangiferaindica, GliricidiaseMetro Authoritym, Cassia fistula, Careyaarborea, Terminalia chebula, Ficus sp. Melia azadirecta Diospyros melanoxylon, HolopteliaXantolis, Acacia chundra, Sterculiaurens, Lannea&Emblica officinalis etc.

Fauna- The wild fauna found in study area are Semnopithecushypoleucos, Macaca radiata, Herpestesedwardsii, Pteropusgiganteus, Funambuluspalmarum

Birds- The Avi Fauna found in study area are Milvus migrans, Accipiter badius, Alcedoatthis, Halcyon smymensi, Ardeolagrayii, Bubulcuscoromandus, Egretta intermedia, Vanellus indicus, Spilopeliachinensis, Streptopelia senegalensis, Corvus culminates, Corvussplendens, Eudynamysscolopaceus, Dicrurusmacrocercus, Meropsorientalis, Cinnyrisasiaticus, Passer domesticus, Phalacrocoraxniger, Pavocristatus, Ploceusphillippinus, Pycnonotuscafer, Pycnonotusjocosus, Turdoidesmalcolmi

Reptiles- Indian Monitor (Varanus bengalensis), Garden Lizard (Calotes versicolor), Common Rat Snake (Ptyasmucosus), Common tree Snake (Dendrelaphistristis), etc.

14.10.7.2 Vegetation Along the Project Stretch

However, significant amounts of vegetation are observed within proposed ROW of metro corridors. 146* trees will be impacted due to proposed project construction. Impacted Tree species along the project stretch are: Almond, Ashok, Bada Neem, Banyan, Berry (Ber Coconut Gulmohar Banyan Jamun, Karanjia, Mango, Neem, Neergudi, Palm, Guava, Papdi, Pipal, Sirish, Umber.

Impacted Trees along the Station 1

Impacted Trees along the Station-2

Impacted Trees along the Station-3

Impacted Trees along the Station 3

Figure 100. Impacted Trees Along the Project Alignment

Table 113 : Summary of Girth Wise Trees Impacted Along the Project Stretch

Side	Girth Size (Cm)						
	0-30	31-60	61-90	91-120	121-150	>150	Total
Right	*34*	*9*	*7*	*5*	*3*	*2*	60
Left	*31*	*17*	*5*	*6*	*16*	*11*	86
Total	65	26	12	11	19	13	**146**

* Approximatey, 146 no. of trees will be impacted due to the project. However, this is a preliminary assessment. Detailed assessment shall be done at later stages.

14.10.8 Seismicity

Pune lies very close to the seismically active zone around Koyna Dam, about 100 km (62 mi) south of the city and has been rated in Zone 3 by the India Meteorological Department. Pune has experienced some moderate and many low-intensity earthquakes in its history. Suitable seismic factor as per the India Meteorological Department (IMD) to be adequate needs to be considered for design purpose for Civil Engineering structures and while finishing civil designs.

14.11 Demographic Profile

14.11.1 Population

The proposed project falls in Pune district of Maharashtra State and it is expected that about 5,057,709 of the State population will benefit. The population percentage of the project influence district is reflected in Table 114 .

Table 114 Affected Population

S. No	State/District	Total Population (2011)
1	Maharashtra	11,23,74,333
2	Pune	94,29,408
3	Pune Metropolitan Region	5,057,709

Source: PCA, Census of India 2011

14.11.2 Population Density

Population density of the project influenced district varies considerably as per the census data of 2011, which clearly indicate that the density of population in Pune district (603 persons/ sq.km.), has increased during 2001-2011. Any significant increase in population density brings in two demographic factors that determines it i.e. natural increase in population and migration. Further, natural increase depends on the fertility and mortality rates. This is evident from the table below Table 115.

Table 115 Population Density

S. No	State/ District	Density/km2	
		2001	2011
1	Maharashtra	315	365
2	Pune	462	603

Source: PCA, Census of India 2011

14.12 Environmental & Social Impacts

Based on the project particulars and existing environmental conditions, potential impacts have been identified that are likely to result from the proposed metro rail project.

The positive environmental impacts typically include reduction in traffic congestion, quick public transport service and safety, less fuel consumption, reduction in air pollution, reduction of noise level etc. Due to the Proposed project possible impacts are identified and assessed based on the activities associated with project location, design, construction & operation phase. This segment identifies and evaluate the harmful impacts on the environment, likely to be consequence of the proposed development. The various potential environmental impacts envisaged from the various project activities are enlisted :

(1) Air Environment

(2) Water Environment

(3) Noise & Vibration

(4) Land Environment

(5) Ecological Impacts

(6) Socio-Economic Impacts

14.12.1 Components of Impact Assessment

The construction and operational phases of the proposed project comprises various activities each of which may have an impact on environmental parameters. Various impacts during the construction and operation phases on the environment have been studied to estimate the impact on the environmental attributes and are discussed in the subsequent section. The probable impacts of each of these activities on various sectors of environment have been mentioned below under three headings:

- Impacts due to project location
- Impacts during construction phase
- Impacts during operational phase

14.12.1.1 Impacts due to project location

Land use changes: the alignment will not have much effect on the land use of the city. The alignment contains only Underground stations. The efforts have been made to keep both the land requirement and change of land use minimum.

Land acquisition impacts: The proposed project requires land. The acquisition of land for the project shall displace people from their home, livelihood base since land is a scarce commodity in Metropolitan areas. Acquisition of the private land may cause social disruption and economic loss for the project affected families/people. 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 minimize any negative impacts. Efforts have been made to keep land requirement (Govt. and private land) to the barest minimum by so choosing the alignments that the acquisition of private property is minimal. Land need to be acquired for the proposed Depot/Station locations however alignment will run underground.

Land is mainly required for station buildings, platforms, entry/exit structures, traffic integration, Depot, power sub-stations, ventilation shafts, administrative buildings, and temporary construction depots and work sites etc. route alignment of rail tracks is proposed underground to minimise the resettlement impacts.

Relocation impacts: the project will involve relocation of shops, commercial-cum-residential buildings and hutments along the proposed corridors. The policy framework and entitlements for the project will be based on national laws: The Land Acquisition Act, 1894 (LAA, amended in 1984) and The National Rehabilitation and Resettlement Policy, 2007 (NRRP); The Maharashtra Project Affected Persons Rehabilitation Act, 1999' as modified up to 2006 and Involuntary Resettlement Policy of the WB/ADB. Compensation shall be paid accordingly, for relocation of shops, commercial-cum-residential buildings and hutments that will be affected due to the proposed project.

Impact on Flora & Fauna: The proposed metro lines are in urban/city area and will not pass through any forests. However, due to the proposed metro construction some trees are likely to be lost. With removal of these trees the process for CO2 conversion will get affected.

The alignment is running parallel to the Rajeev Gandhi Zoological Park; however, the station locations has been proposed away from the park boundary keeping in mind the impact during construction and operation phase. . Key impact to the zoological park is Air and Noise pollution during construction stage, the project alignment is underground hence there will not be major impact during operation stage.

Figure 101. Proposed Station Near Katraj, away from the Zoological Park

Shifting of utilities and drainages: there will be shifting of existing water supply pipelines, electrical lines and sewerage lines.

Impact on Historical and Cultural Monuments, the proposed project will affect residential and commercial structures at some of the portion of alignment. No Archaeological Monuments are directly affected. Utmost care needs be taken so that no significant impact is anticipated on the historical structures due to project activities during construction and operation.

Impact on Local Transport Facilities

The project has been proposed to cater the additional demand of present and future traffic requirement. Hence, no loss of job to the existing transport facilities is anticipated. The drivers of local transport facilities like buses, taxis, autos and rickshaws may be utilized to cater the requirement of transport from stations to work place and vice-versa. Additional employment opportunities are also anticipated due to the proposed project.

14.12.1.2 Impacts during construction phase

The most likely negative impacts related to the construction works are listed below:

- Pressure on local Infrastructure;
- Soil erosion problems;
- Solid waste generation;
- Health risk at construction site;
- Traffic congestion and diversion problems;
- Excavated and construction material disposal problems;
- Water contamination problems;
- Impact on air quality;
- Noise Impact;
- Displacement.

Pressure on local infrastructure: considering the nature and the magnitude of the project, impacts shall be short term and low in magnitude and will be limited to the construction phase only.

Soil erosion/contamination: the vegetation and top soil shall be disturbed during the construction stage due to excavation and movement of vehicles and equipment. Run off from unprotected excavated areas, and underground construction can result in excessive soil erosion. The spillage of oil from machinery or cement residual from concrete mixer plants might contaminate the soil if not properly collected and disposed off.

Construction solid waste generation: problems could arise from dumping of construction spoils (concrete, bricks) waste materials (from contractor camps) etc. causing surface and ground water pollution. However, it is proposed to have mix concrete directly from batching plant for use at site. Batching plants will be located away from the site. The other construction materials such as steel, bricks, etc. will be housed in a fenced stored yard. The balance material from these yards will be removed for use/disposal.

Health risk at construction site: at the project site, direct exposure to dust generation is likely to cause health-related impact especially dust-related diseases. This would be minimized by providing suitable respiratory personal protective equipments (PPE) such as nose masks with suitable filters etc.

Dust mitigation plan has to be adopted for the local population. Health risks include disease hazards due to lack of sanitation facilities (water supply and human waste disposal) and insect vector disease hazards of local workers and disease hazards to the local population. Mitigation measures should include proper water supply, sanitation, drainage, health care and human waste disposal facilities. In addition to these, efforts need to be made to avoid water spills, adopt disease control measures and employment of local labour. Problems could arise due to difference in customs of imported workers and local residents. These risks could be reduced by providing adequate facilities in worker's camps and by employment of preferably local labour.

Traffic congestion and diversion problems: most of the roads of the project area are broad with traffic signals in proper places but some areas have congested stretches where traffic movement is very slow. Hence, traffic congestion during the construction phase may be a major issue.

Water contamination problems: within the vicinity of project site no water body is present, however Katraj Lake in the zoological park is the only water body falling parallel to the project alignment. Since all construction-related activities will primarily be confined to the enclosed corridor, no major impacts are anticipated. The mitigation measure will include Prevention of dumping of construction spoil and debris in the lake, Movement of machinery, workforce shall be restricted around the water body and no waste from construction camps shall be disposed into it.

Figure 102. : Katraj Lake along the Project Alignment

Impact on air quality: potential impacts on the air quality during the construction stage will be due to the fugitive dust and the exhaust gases generated in and around the construction site. The principal sources of air pollution due to project is plants and machineries used during construction phase. Such impacts will be low to moderate and spatially restricted along the immediate corridor of impact.

Impact on noise quality: due to the various construction activities, there will be short-term noise impacts in the immediate vicinity of the project corridor. The impact will be felt more in the congested areas where utmost care has to be taken to reduce noise generation by using acoustic enclosures. The utmost care shall be taken at the Katraj station along the zoological park.

Social impact: as local labour will be hired from the vicinity of the project site and shall be utilized for the construction purpose and all the activities shall be confined to the project site only, no adverse social impacts are envisaged due to the proposed project.

14.12.1.3 Impacts during operation phase

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:

- Impact on land environment;
- Noise pollution;
- Air Pollution;
- Water supply and sanitation at stations;
- Safety.

Noise pollution: 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. Airborne noise is radiated from at-grade and elevated structures, while ground-borne noise and vibration are of primary concern in underground operations. Underground metros are not known to generate audible sound at the ground level. since the metro has underground alignment, noise pollution will not be the major issue .

Vibration emanates from rail - wheel interaction and the same 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.

Air pollution: metro operation will cause no air pollution in the city and reduce congestion on the roads there by contributing to improvement in the overall pollution levels in the city.

Water supply and sanitation: the metro's operation will require substantial groundwater. The Client shall install rainwater harvesting facilities at the stations in compliance to the Mandatory Roof Top Rain Harvesting regulations. All stations shall employ a cooling water re-circulation system for air conditioning. Recycled water shall be used for facility cleaning and landscape irrigation. All toilets will be equipped with low-flow fixtures.

Safety: during operation, accidents related to train operation like collision, derailment, fire, power outages, or operation stoppage may occur. In the unlikely event of simultaneous tripping of all the input power sources or grid failure, the power supply to stations as well as to trains will be interrupted. A standby silent type DG set at underground stations shall be installed. To provide a high level of safety with trains running at close headway ensuring continuous safe train separation, eliminate accidents continuous speed monitoring and automatic application of brake in case of disregard of signal / warning by the driver, and provides safety and enforces speed limit on section having permanent and temporary speed restrictions .

14.12.2 Beneficial impacts of the proposed project

Positive impacts have been listed under the following headings:

- Employment opportunity
- Impact on Land Environment
- Traffic flow Improvement/ Less air pollution;
- Quick service and safety
- Less fuel consumption and carbon dioxide reduction.
- Reduction in air pollution

14.12.2.1 Employment opportunities

The project is expected to generate employment in the secondary and tertiary sectors during the construction and operation phases. Thus, the project would provide substantial direct employment; besides, more people would be indirectly employed in allied activities and trades.

14.12.2.2 Impact on land environment

There would be increased scope for commercial, industrial and residential development along the project corridor.

14.12.2.3 Less air pollution

Introduction of Mass Rapid Transport System will reduce the traffic load on the roads. Many vehicle owners and users of auto-rickshaws will shift to metro rail as it will be a faster and convenient mode of transport. Thus, reduction of traffic will lead to reduction of automobile emission and consequently air pollution.

14.12.2.4 Quick service and safety

The metro rail system would be more efficient and faster as compared to the traditional modes of travel. In addition, reduction of congestion will make the roads safer and will reduce the incidence of accidents.

14.12.2.5 Less fuel consumption

On implementation of the project, it is estimated that both petrol and diesel consumption will get reduced. The saving will be due to two factors namely Reduction in vehicles and decongestion on roads.

14.12.3 Summary of impacts and mitigation measures

A summary of the potential environmental impacts during construction and operation phases along with recommended mitigation measures is presented in a matrix format in following Table 116.

Table 116: Summary of environmental impacts and mitigation measures

Area	Impacts	Mitigation measures
	Construction phase	
Topography & geology	• Change in existing profile of the land-use • Disturbance on geological setting due to quarrying	• The overall topography of the area is not going to alter due to the proposed alignment's • . No new quarry will be proposed for the Project requirements only existing, live, licensed quarries will be used as sources of aggregates. It will be ensured the aggregates procured during construction stage will be from the authorized or licensed suppliers
Water use	• Impact on the local water sources due to use of construction water	• Maximum rainwater harvesting and minimum use of existing water sources for construction will be ensured to minimize likely impacts on other users

Area	Impacts	Mitigation measures
	Construction phase	
Water Quality	• Increase of sediment load in the run off from construction sites • Water pollution due to sewage from construction camps	• Sediment traps will be provided to reduce sediment load in construction wastewater • Proper sanitation facilities will be provided in construction camps.
Air Quality	• Deterioration of air quality due to fugitive dusts emission from construction activities and vehicular movement along unpaved roads • Deterioration of air quality due to gaseous emissions from construction equipment & vehicular traffic. • Deterioration of air quality due to emission from asphalt and hot mix plants	• Construction materials will be stored in enclosed spaces to prevent fugitive emissions • Truck carrying soil, sand and stone will be duly covered to avoid spilling • Adequate dust suppression measures will be undertaken to control fugitive dust • Low emission construction equipment & vehicles will be used
Noise level	• Increase in noise level due to operation of construction equipment & vehicular traffic	• Protective gears such as ear plugs etc. will be provided to construction personnel exposed to high noise levels as preventive measure • Low noise construction equipment will be used • Construction activities carried out near residential areas will be scheduled to the day time only so that minimum disturbances are caused to people • The contractor will ensure that noise from construction activities does not result to exceedances of relevant limits prescribed in the Indian Ambient Air Quality Standards for Commercial Area and Silence Zone.

Area	Impacts	Mitigation measures
	Construction phase	
		• local residents and shop owners should be informed of the nature and duration of intended activities prior to commencement and kept updated as to changes in the management and mitigation plan equipment compounds will be located off-site • noise barriers will be installed at critical work areas particularly around the Zoological Park • enclose especially noisy activities if above the noise limits • employ transportable noise screens between noise sources and identified noise sensitive areas for the duration of noisy construction activities • maximize the possibility of scheduling noisy activities at the same time to minimize the duration of exposure
Floral & fauna	• Loss of trees due to construction of proposed metro corridor	• Preferential plantation of flowering trees with less timber & fruit value will be carried out • Cooking fuel will be provided to construction workers to avoid cutting /felling of trees for fuel wood • Compensatory afforestation cost for compensatory plantation will be provided
Rehabilitation & Resettlement	• Loss of private structures	• Some of the residential/commercial structures will be impacted. Proper Rehabilitation and

Area	Impacts	Mitigation measures
	Construction phase	
		Resettlement measures will be adopted
Employment & trading opportunities	• loss of source of livelihood for the PAP's losing commercial structures. • The construction will improve the job opportunities	• Most of the construction labourers will be recruited from local areas to alleviate social tension of migration • Some of the construction materials like stone chips & sand will be procured locally
	Operation Phase	
Land-use & Encroachment	• Change of land use by squatter/ encroachment within the ROW and induced development outside the ROW	• Planning agencies and Collector/ Revenue Officer will be made involved for controlled development and prohibiting squatter/ encroachment within ROW
Drainag e	• ·Filthy environment due to improper maintenance of drainage	• Drainage system will be properly maintained
Air quality	• The proposed project will provide a reduced vehicular emission load atmosphere	
Noise level	• Noise pollution due to operation phase of proposed metro rail corridors	• Regular monitoring of noise level at specified locations will be conducted
Access	• The proposed corridors will help to increase the accessibility of the project site	•

14.12.4 Impact Matrix

A matrix is a grid-like table that is used to identify the interaction between project activities, which are displayed along one axis, and environmental characteristics, which are displayed along the other axis. Using the table, environment-activity interactions can be noted in the appropriate cells or intersecting points in the grid. Impact matrix summarizing environmental parameters impact and nature of impact for the project is given in Table 117.

Table 117 : Potential Environmental Impacts of Project

Environmental Parameters Impact	Nature of Potential Impacts during Construction and Operation Phases									
	Local	Regional	Short Term	Long Term	Reversible	Irreversible	Negative	Positive	Significant	Insignificant
Topography		No Impact								
Drainage	√						√			√
Soil	√			√		√	√ (construction)	√ (operation)	√	
Water Resources	√			√			√			√
Water Quality	√			√			√		√	
Land Use	√			√		√	√ (construction)	√ (operation)		√
Ambient Air Quality	√		√				√		√	
Noise & Vibration	√		√				√			√
Flora	√			√			√ (construction)	√ (operation)	√	
Fauna	√			√			√ (construction)	√ (operation)	√	
Employment	√			√		√		√	√	
Aesthetic	√		√ (construction)	√ (operation)				√	√	

14.12.5 Environmental Assessment Checklist

Based on the environmental screening, a checklist has been prepared (see table below) to assess the Environmental & Social Sensitivity of Project:

Table 118: Environmental Assessment Checklist for Environmental & Social Sensitivity of Project

Screening Questions	Yes	No	Remarks
Project siting **Is the project adjacent to or within any of the following environmentally sensitive areas?**			
Cultural heritage site		√	No cultural heritage site in proximity of project.
Protected area		√	No forest is in the vicinity of the project. No wildlife-protected area is located close to the alignment and nearby (assessment made up to 10 Km) area.
Wetland		√	No designated Wetland
Mangrove		√	No mangrove area is located in the project site
Estuarine		√	Not applicable
Buffer zone of protected area		√	No protected area or its buffer Zone
Special area for protecting biodiversity		√	No special biodiversity area is located within the ROW
Potential environmental impacts *Will the Project cause…*			
Encroachment on historical/cultural areas, disfiguration of landscape by		√	No encroachment on historical or cultural areas.

Screening Questions	Yes	No	Remarks
road embankments, cuts, fills, and quarries?			The topography of project is passing through plain terrain and rolling terrain at some of the location. Minor impacts on landscape by embankments to improve profile. Cuts and fills are not ruled out. Opening of New Quarries is not envisaged. Only operational and licensed quarry will be used for sourcing materials for the project Proper environmental management plan will be adopted during construction to sustain the quarries.
Encroachment on precious ecology (e.g. sensitive or protected areas)?		√	There is no National Parks, Wild Life Sanctuaries or any other similar eco-sensitive areas in the project area. Only cutting of small number of trees is involved. Attempts have been made to minimise the cutting of trees.
Deterioration of surface water quality due to silt run off and sanitary wastes from worker-based camps and chemicals used in construction?		√	Adequate sanitary facilities and drainage in the workers camps will help to avoid this possibility. As the construction activity in this project will not contain any harmful ingredients, no impact on surface water quality is anticipated.
Increased local air pollution due to rock crushing, cutting and filling works, and chemicals from asphalt processing?	√		Localised air pollution level is likely to increase for a short duration during the construction period due to construction vehicle movement and asphalt processing.

Screening Questions	Yes	No	Remarks
			The asphalt mixing plant (hot mix plant) to be located away from habitat areas with adequately high stack for effective dispersion of likely emissions. Dust separation measures like spraying of water on unpaved vehicle movement areas are proposed to minimise the dust generation.
Risks and vulnerabilities related to occupational health and safety due to physical, chemical, biological, and radiological hazards during project construction and operation?	√		Workers may get exposed to dust and noise during construction activities. However, the exposure levels are likely to be short and insignificant. Workers will be provided requisite PPEs to minimise such exposure and associated harmful occupational health effects. As such, no occupational health hazard is anticipated during operation phase.
Noise and vibration due to civil works?	√		Suitable mitigation measures such as use of Personal Protective Equipments will be taken to minimize the adverse effects.
Dislocation or involuntary resettlement of people?	√		The project-affected persons are expected to be very less as the metro corridor will generally follow underground alignment. However, at stations and cross-over location, there will be need for small land acquisition. This aspect will be addressed as per Govt. rules and ADB‟s Social Safeguard Policies (SPS-09) separately.
Other social concerns relating to inconveniences in living conditions in the project areas that may trigger cases of upper		√	Appropriate mitigation measures to curb the air pollution within permissible levels will keep a check on this problem.

Screening Questions	Yes	No	Remarks
respiratory problems and stress?			Deterioration in ambient air quality will be localised and temporarily during construction activity. The project area is largely located in open areas.
Hazardous driving conditions where construction interferes with pre-existing roads?		√	To minimize the construction interference, suitable traffic management plan will be designed and implemented by the contractor.
Poor sanitation and solid waste disposal in construction camps and work sites, and possible transmission of communicable diseases from workers to local population?		√	Provisions for sanitation, health care and solid waste disposal facilities such as disposal of sewage in soak pit, first aid facility will be done to avoid such possibility. Awareness plan for workers will be prepared to educate them about communicable diseases.
Creation of temporary breeding habitats for mosquito vectors of disease?		√	No such condition is anticipated.
Dislocation and compulsory resettlement of people living in right-of-way?	√		Proper resettlement action plan will be proposed.
Accident risks associated with increased vehicular traffic leading to loss of life?		√	Adequate safety measures will be adopted to avoid accidents during construction and operation stages. Measures, like signage, speed control; crash barriers will be taken close to sensitive locations such as schools, temple or hospitals.
Increased noise and air pollution resulting from traffic volume?		√	Increase in noise and air pollution is expected during construction phase but is likely to be confined within few meters of either side of the project alignment.

Screening Questions	Yes	No	Remarks
			Adequate mitigation measures will be adopted as per the prescribed Environmental Management Plan to minimise the same. During operation stage, metro will provide a comfortable travel and provide pollution free alternate mode for commuters.
Increased risk of water pollution from oil, grease and fuel spills, and other materials from vehicles using the road?	√		This possibility is minimal but cannot be ruled out. Controlled construction activities and proper drainage system will reduce this possibility.
Large population influx during project construction and operation that causes increased burden on social infrastructure and services (such as water supply and sanitation systems)?		√	Most of the workers will be hired locally. The small construction camps are unlikely to cause any significant burden on social infrastructure and services.
Social conflicts if workers from other regions or countries are hired?		√	Most of the workers will be hired locally.
Risks to community health and safety due to the transport, storage, and use and/or disposal of materials such as explosives, fuel and other chemicals during construction and operation?		√	The construction material (aggregate from approved quarries, borrow earth, bitumen) will be sourced from nearby and approved sources. No explosive or chemicals are likely to be used. Bitumen waste if any generated during construction and garbage from stations will either be recycled or disposed of in controlled manner.
Community safety risks due to both accidental and natural causes, especially where the		√	No such impacts are anticipated. Adequate awareness will be created amongst people and workers through information disclosure,

Screening Questions	Yes	No	Remarks
structural elements or components of the project are accessible to members of the affected community or where their failure could result in injury to the community throughout project construction, operation and decommissioning.			safety signage and public consultation about safety aspects.

Table 119 : Environmental Assessment Checklist for Climate Change and Disaster Risk of Project

Climate Change and Disaster Risk	Yes	No	Remarks
Is the Project area subject to hazards such as earthquakes, floods, landslides, tropical cyclone winds, storm surges, tsunami or volcanic eruptions and climate changes?		√	As per BIS categorization project area falls in Zone III indicating Moderate- low earthquake hazard risk. The area is not subject to natural hazards like tropical cyclone winds, storm surges, tsunami or volcanic eruptions and climate changes.
Could changes in temperature, precipitation, or extreme events patterns over the Project lifespan affect technical or financial sustainability (e.g. increased erosion or landslides could increase maintenance costs, permafrost melting, or increased soil moisture content could affect sub-grade).		√	The project design was based on projects already in operation in other cities with similar climatic conditions. The project area is not subject to erosion or landslide etc. Technical or financial sustainability of the project is unlikely to be affected due to any extreme event pattern.
Are there any demographic or socio-economic aspects of the Project area that are already vulnerable (e.g., high incidence		√	No such condition exists or anticipated.

Climate Change and Disaster Risk	Yes	No	Remarks
of marginalized populations, rural-urban migrants, illegal settlements, ethnic minorities, women or children)?			
Could the Project potentially increase the climate or disaster vulnerability of the surrounding area (e.g., by encouraging settlement in areas that will be more affected by floods in the future, or encouraging settlement in earthquake zones)?		√	No such condition is anticipated.

No significant Social and Environmental impact has been found due to the proposed project in the project influence area.

14.13 Environmental Management Plan

The main purpose of the Environmental Management Plan (EMP) is to delineate all the measures to be undertaken during various phases of the project to offset or mitigate the adverse environmental Impacts (if any) to acceptable level to protect the environment especially the community likely to be affected by the proposed project. The EMP should necessarily cover all phases of project cycles i.e. planning and design, construction and operation. The potential Impacts on the environment due to the proposed project were Identified based on the nature of activities undertaken during its construction and those envisaged to occur during Its operation in the light of present status of the environment and legal compliance required. The mitigation measures required to be taken already taken during various stages of the project have been described below. The Environment Management measures shall be implemented during the various stages of the project – Pre-construction stage, Construction Stage and Operation Stage.

A description of the various management measures suggested during different stages of construction is provided in Table 120.

14.13.1 EMP Matrix

14.13.1.1 Pre-Construction Stage

Pre-construction activities by Metro Authorities

Prior to Contractor mobilization, the Metro Authority will ensure that an encumbrance free Corridor of Impact is handed over to enable the start of construction. Clearance involves the following activities:

- Removal and felling of trees,
- Relocation of common property resources and utilities that will be impacted.
- Formal arrangements for maintenance of enhancement sites. This includes plantation of trees and barricades along the project site.

Pre-construction activities by Contractor

Pre-construction stage involves mobilisation of the Contractor and the activities undertaken by the Contractor pertaining to the planning of logistics and site preparation necessary for commencing construction activities. The activities include:

- Joint field verification of EMP by the Environment Specialist of the Supervision Consultant and Contractor.
- Identification and selection of material sources (quarry and borrow material, water, sand etc).
- Procurement of construction equipment / machinery such as crushers, plants and other construction equipment and machinery.
- Selection, design and layout of construction areas, plants, labour camps etc.
- Apply for and obtain all the necessary clearances/ NOCs/ consents from the agencies concerned.
- Planning traffic diversions and detours including arrangements for temporary land acquisition.

14.13.1.2 Construction Stage

Construction activities by the Contractor

Construction stage is the most crucial stage in terms of activities that require careful management to avoid environmental impacts.

There are several other environmental issues that have been addressed as part of good engineering practices, the costs for which have been accounted for in the Engineering Costs. They include providing drainage, provision of cross-drainage structures etc.

Construction activities by the Metro Authority/Supervision Consultant

The Metro Authorities /Supervision Consultant shall be involved in the smooth execution of the project and assisting the EPC Contractor during this phase. Their work shall include but not limited to:

- Monitoring and guiding the EPC Contractor on adopting good environmental and engineering practices.
- Arranging training to the EPC Contractor and other stakeholders according to the needs arising.

14.13.1.3 Operation Stage

The operation stage involves the following activities by Metro Authority:

- Monitoring of environmental conditions through approved monitoring agency.
- Monitoring of operational performance of the various mitigation/enhancement measures carried out.

Table 120 : Environmental Management Plan (EMP)

Environmental parameters / Issues	Mitigation measures	Parameters for Monitoring	Responsibility of Implementation
Pre-Construction/ Design Phase			
Energy conservation/ natural ventilation	Energy conservation through provision of energy efficient fittings, maximize use of natural light.	Periodic energy auditing, electricity usage bills	DPR/ Design Consultant Environmental Management Cell/ Unit
Water Conservation	Reduce water requirements through water efficient plumbing fittings, by making provision for rain water harvesting, Recycle and reuse of waste water to the maximum extent possible, using alternative sources of water e.g.	Water consumption estimates and its compliance/status during construction /operation phase	DPR/ Design Consultant or Design unit of Metro Authority
Reduction in incremental air pollution through traffic management	Designing proper traffic management plan around the proposed project to facilitate smooth flow of traffic, removal of encroachments /unauthorized hawkers on footpaths/roads to increase the carrying capacity of the roads.	Air Pollution monitoring	DPR/ Design Consultant or Design Unit of Metro Authority in Consultation with SPCB and Traffic Police
Environmental Enhancement	Development of Green belt as a part of Station building land scaping	DPR/ Land Scaping plan	DPR/ Design Consultant or Design unit of Metro Authority in consultation with Environmental
Fire Management	Providing Firefighting facilities as per National Building Code (2004) provisions, Periodic maintenance /checking of the fire & educate the	DPR/ Work contracts included in the Tender documents	DPR/ Design Consultant or Design unit of Metro Authority
Inclusion of environmental management related clauses in work contract	Inclusion of various environmental related aspect (viz., disposal/ management of spoils during construction phase, monitoring of environmental parameters during pre-construction /construction/Operation Phase) of project, appointment of	DPR/ Work Contractor	DPR/ Design Consultant or Design unit of Metro Authority in consultation with Environmental Management Cell/ Unit of Metro Authority
Construction Phase			
Air Emissions	All equipment's will be operated within specified design parameters	Random check of equipment log & Manuals	Engineering unit at the Project site
	Vehicle trips to be minimized to the extent possible	Vehicle Logs	Contractor/CivilEngg unit at the Project site

Environmental parameters / Issues	Mitigation measures	Parameters for Monitoring	Responsibility of Implementation
	Any dry, dusty materials stored in Sealed containers or prevented from blowing	Absence of stockpiles or open containers of dusty containers of dusty	Contractor/Civil Engg unit at the Project site/ Environmental
	Compaction of soil during various construction activities	Construction logs	Contractor/Civil Engg unit at the Project site
	Ambient Air Quality Monitoring within construction zone to be monitored	The Ambient Air Quality will conform to the standards for SPM, SO2, and NOx, CO a	Contractor/ Environmental Management Cell/ Unit of Metro Authority
Noise Pollution	List of all noise generating machinery onsite along with age to be prepared. Equipment to be maintained in good working order	Equipment logs, noise reading	Contractor/ Environmental Management Cell of Metro Authority
	Night working to be minimized	Working hours records	Contractor/Civil Engg. unit at the Project site
	Generation of vehicular noise	Maintenance records of vehicles	
	Implement good working practices (equipment selection and siting) to minimize Noise and also reduce its impacts on human health (ear muffs, safe	Site working practices records, noise reading	DPR/ Design Consultant / Civil Engg. unit of Metro Authority
	No machinery running when not required	Log books/ physical supervision	Contractor/Civil Engg unit at the Project site
	Acoustic mufflers/ enclosures to be provided in large engines	Mufflers/ enclosures in place	Contractor/ Environment Management Cell/ Unit of Metro Authority
	Noise to be monitored in ambient atmosphere within the premises	Noise reading	as per PCC requirement or half yearly, whichever is lesser
	The noise level not to exceed the permissible limit both during day and night times	Noise level monitoring	Contractor/ Environmental Management Cell/ Unit of
	All equipment operated within specified design parameters	Random checks of equipment logs/ manuals	Contractor/CivilEngg unit at the Project site

Environmental parameters / Issues	Mitigation measures	Parameters for Monitoring	Responsibility of Implementation
	Vehicle trips to be minimized to the extent possible	Vehicle logs	Contractor/Civil Engg unit at the Project site
Soil Erosion	Minimize area of site clearance to the extent possible, Compensatory plantations as apart of land scaping to compensate the loss of trees/vegetation, development of green belt, avoid providing concrete flooring outside the Station	Physical inspection /supervision	Contractor/CivilEngg unit at the Project site in consultation with Environmental Management Cell/ Unit of Metro Authority
Surface Runoff	Covering the spoils to prevent the wash out during rainy seasons, provision of green belt to minimize surface run off	Physical inspection /supervision	Contractor/Civil Engg unit of Metro Authority at the Project site
Disposal/ Recycle of Construction Waste	Providing sufficient no. of garbage bins, segregate biodegradable and non-biodegradable wastes and dispose off them accordingly including disposal of spoils/waste generated during construction phase at the pre - designated site by the contractor, reuse of construction waste at the construction	Log books of disposal trucks, Physical inspection /supervision	Contractor/Civil Engg unit of Metro Authority at the Project site
Non - Routine Events and Accidental Release	Preparation/ inclusion of emergency preparedness plan in the work contract to avoid/manage emergencies	DPR/Work Contract	Contractor/Civil Engg unit at the Project site
Workers Safety/ Health Hazard	First aid facilities at the work/construction site, provision of safe drinking water and sanitation facilities for construction workers, safety/health related issues for construction workers to be included in the civil/electrical work	DPR/Work Contract	Contractor/CivilEngg unit of Metro Authority at the Project site
Environmental Management Cell/ Unit	Setting up of Environmental Management cell/ Unit to be set up to ensure implementation and	DPR/Work Contract	Environmental Management Cell/ Unit of Metro Authority
Operation Phase			
Air Emissions	Stack emissions from DG sets to be optimized and monitored, periodic	Air pollution monitoring	Environmental Management Cell/ Unit of
	Air quality monitoring at the project site as per the Post Project Monitoring (PPM) details, Incentives/encouragement to the Staff to use public transport instead of private vehicles		Metro Authority

Environmental parameters / Issues	Mitigation measures	Parameters for Monitoring	Responsibility of Implementation
Noise Pollution (DG sets and Vehicles)	Noise generated from operation of DG sets to be optimized and monitored, Dg sets to generate less than 75dB(A) Leq at 0.5m from the source, DG sets to be provided at basement with proper acoustic enclosures /mufflers, Chimney height of 8m above the roof top, no-horn zone inside the Station building complex	Noise Pollution monitoring	Environmental Management Cell/ Unit of Metro Authority
Wastewater Discharge	All the wastewater generated in the station building complex to be collected through the internal sewer line and ultimately discharging it to municipal; sewage line to be taken to sewage treatment plan, Separate lines for surface run off arid its disposal into drainage system	Physical inspection as a part of periodic maintenance	Contractor/Civil Engg and Environmental Management Cell/ Unit of Metro Authority
Solid Waste Management	Provision of adequate no. of bins in the Station building, segregation and collection of bio- Degradable (kitchen wastes) and non-biodegradable wastepaper and computer stationery), Disposal of solid wastes as a part of maintenance and included in the work contract	Physical inspection as a part of periodic maintenance	Contractor/Building Maintenance unit of METRO AUTHORITY
Indoor Air Pollution (Inside Station building and Parking lots)	Indoor air pollutants (viz., CO, VOC, RSPM to be reduced by providing proper ventilation and to be monitored periodically as per the stipulated PPM, declaring whole Station building as "No Smoking Zone"	Indoor Air Pollution Monitoring	Environmental Management Cell/ Unit of METRO AUTHORITY
Energy Uses	Energy usage for AC's and other electrical appliances to be minimized, conduct energy auditing of the Station building annually, use of solar energy for different usages	Energy usage quantity, bills trends over a period of time	Energy Auditors, maintenance section of the Station building
Emergency Preparedness including Fire Management	Fire protection and safety measures to take care of fire and explosion hazards, mock drills to check the emergency preparedness in case of fire, earthquake etc.	Mock drills/ safety auditing by the consultant	Maintenance section of the Station building (METRO AUTHORITY)

Environmental parameters / Issues	Mitigation measures	Parameters for Monitoring	Responsibility of Implementation
Environmental Management Cell/ Unit	Setting up of Environmental Management Cell/ Unit to be set up to ensure implementation and monitoring of environmental safeguards	DPR	Environmental Management Cell/ Unit of METRO AUTHORITY

Table 121 : Environmental Monitoring Plan

Environmental Component	Project Stage	Monitoring						Institutional Responsibility	
		Parameters	Special Guidance	Standards	Location	Frequency	Duration	Implementation	Supervision
Air	Construction Stage	PM_{10}, $PM_{2.5}$, SO_2, NO_x, CO, HC (non-methane)	High volume sampler to be located 50 m from the plant in the downwind direction. Use method specified by CPCB for analysis	The Air (Prevention and Control of Pollution) Rules, CPCB, 1994	Plant Site	Once in year for three seasons (except monsoons)	Continuous 24 hours- Weekly twice for two non-consecutive day.	Contractor through approved monitoring agency	Engineer, Metro Authority
	Construction Stage	PM_{10}, $PM_{2.5}$, SO_2, NO_x, CO,	High volume Sampler to be located 40 m from the earthworks site downwind direction. Use method specified by CPCB for analysis	The Air (Prevention and Control of Pollution) Rules, CPCB, 1994	Stretch of the project where construction is in progress at the site At 4 Station Locations	Once in year for three seasons (except monsoons)	Continuous 24 hours/ Weekly twice for two non-consecutive day.	Contractor through approved monitoring agency	Engineer, Metro Authority

Environmental Component	Project Stage	Monitoring						Institutional Responsibility	
		Parameters	Special Guidance	Standards	Location	Frequency	Duration	Implementation	Supervision
	Operation Stage	PM_{10}, $PM_{2.5}$, SO_2, NO_X, CO, HC	High Volume Sampler to be located at 15m from edge of the pavement	The Air (Prevention and Control of Pollution) Rules, CPCB, 1994	At 4 station locations.	Once in year for three seasons (except monsoons)	Continuous 24 hours/or for 1 full working day.	Contractor through approved monitoring agency	Engineer, Metro Authority
Water Quality	Construction Stage	pH, BOD, COD, TDS, TSS, DO, total coliform, conductivity Oil & Grease and Pb	Grab sample collected from source and analyse as per Standard Methods for Examination of Water and Wastewater	Water quality standards by CPCB	At 2 locations as per requirement.	Once in year for three seasons (except monsoons)	-	Contractor through approved monitoring agency	Engineer, Metro Authority

Environmental Component	Project Stage	Monitoring						Institutional Responsibility	
		Parameters	Special Guidance	Standards	Location	Frequency	Duration	Implementation	Supervision
	Operation Stage	pH, TDS, TSS, DO, Temp, Pb, Oil and Grease	Grab sample collected from source and analyse as per Standard Methods for Examination of Water and Wastewater	Water quality standards by CPCB	At 2 locations as per requirement.	Once in a year	-	Metro Authority	Metro Authority
Noise Levels	Construction Stage	Noise levels on dB (A) scale	Free field at 1 m from the equipment whose noise levels are being determined.	Noise standards by CPCB	Plant Site	Once in year for three seasons (except monsoons)	Continuous over 24 hours	Contractor through approved monitoring agency	Engineer, Metro Authority

Environmental Component	Project Stage	Monitoring						Institutional Responsibility	
		Parameters	Special Guidance	Standards	Location	Frequency	Duration	Implementation	Supervision
		Noise levels on dB (A) scale	Equivalent Noise levels using an integrated noise level meter kept at a distance of 9m & 15m from edge of Pavement	Noise standards by CPCB	Stretch of the project where construction is in progress at the site At 4 Locations	Once in year for three seasons (except monsoons)	Continuous over 24 hours	Contractor through approved monitoring agency	Engineer, METRO AUTHORITY
	Operation Stage	Noise levels on dB (A) scale	Equivalent Noise levels using an integrated noise level meter kept at a distance of 9 m and 15 m from edge of Pavement	Noise standards by CPCB	At 4 station locations	Once a year	Continuous over 24 hours	Contractor through approved monitoring agency	Engineer, Metro Authority

Environmental Component	Project Stage	Monitoring						Institutional Responsibility	
		Parameters	Special Guidance	Standards	Location	Frequency	Duration	Implementation	Supervision
Soil Quality	Construction Stage	Monitoring of heavy metals	Contamination standards given by EPA	As per IRC code of practice	At Selected 2 locations	Once in year for three seasons (except monsoons)	One-time sample	Contractor through approved monitoring agency	Engineer, Metro Authority

14.14 Environmental Budget

Mitigation measures proposed in the EMP will be implemented by the Contractor. The budgetary provisions for the implementation of the environmental management plan of the Project are presented in Table 122.

Table 122: Environmental Management Cost Construction & Operation Phase

Environmental Aspect	Frequency of monitoring	No. of sampling locations	Total Samples	Rate per sample (Rs.)	Total Cost (Rs.)
Construction Phase					
Air Pollution Monitoring	Quarterly	5	30	10,000	300000
Noise Pollution Monitoring	Quarterly	5	30	4,000	120000
Ground Water Quality Monitoring	Quarterly	2	6	10,000	60000
Surface Water Quality Monitoring	Quarterly	2	6	10000	60000
Soil Monitoring	Quarterly	2	6	8000	48000
Waste Management					1000000
Water Conservation Rain Water Harvesting			3	500000	1500000
Training & Education to Workers for Environment Conservation & Awareness					1000000
Dust Suppression & Air & Noise Pollution Control Measure					1000000
Green Cover/Afforestation & Maintenance					1500000
Tentative Tree Cutting Cost for 146* no. of trees					41642

Environmental Aspect	Frequency of monitoring	No. of sampling locations	Total Samples	Rate per sample (Rs.)	Total Cost (Rs.)
Tentative Tree Plantation Cost (However the cost shall be as per the availability of the land and as per the discussion with concern forest department)			90	150000	13500000
Sub Total (A)					**28229641**
Operation Phase					
Air Pollution Monitoring	Quarterly	4	24	10,000	240000
Noise Pollution Monitoring	Quarterly	4	24	4,000	96000
Ground Water Quality Monitoring	Yearly	2	2	10,000	20000
Surface Water Quality Monitoring	Yearly	2	2	10000	20000
Soil Monitoring	Yearly	2	2	8000	16000
Maintenance Cost for Plantation					1000000
Training & Education to Workers for Environment Conservation & Awareness					1000000
Maintenance cost for Environment Safeguard					1000000
Sub Total (B)					**3392000**
Total Cost (A)+(B)					31621641
Contingency @5%					1581082
Total Environmental Mitigation Measures Cost (Rs.)					**33202723**

* Refer Exhibit 1 for Tree Inventory

14.15 Conclusion & Recommendation:

The preliminary environmental studies along the project corridor based on the secondary baseline data and field survey has revealed some of the environmental issues along the project corridor as well as potential adverse impacts due to the project. The negative impacts due to location of proposed corridor IA include: Project Affected People (PAPs), Change of Land use, Loss of trees/forest and Utility/Drainage Problems. The impacts due to construction include: Soil erosion, pollution and health risk at construction site, traffic diversion and risk to existing buildings, excavated soil disposal problems, dust generation, increased water demand, impact due to supply of construction material. Anticipated Impacts due to operation are noise pollution, water supply and sanitation at stations, traffic congestion issues and impact due to depots.

Mitigation measures and management plan for Compensatory Afforestation, Construction Material, Housekeeping, Air Pollution Control, Noise and vibration Control are suggested for early consideration in designing and decision of most appropriate alignment.

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.

Social Impact Assessment

This section deals with the Social Impact Assessment and the Short Resettlement Action Plan as a part of the Detailed Project Report.

Social impact assessment aims to identify likely impacts on the local communities and other existing settlements, congested and built up areas including community property resources (CPRs) and any other impacts on the population within project corridor etc., so that the basic information could be provided to the engineering design team.

The objective of this study is to minimize the adverse impacts on the targeted population, if any, with the best possible engineering solutions and the most appropriate cost, with complete coordination between the engineering, social and environmental teams during the design process.

At this stage, social impact assessment of the project area has been carried out and steps have been taken to minimize adverse impacts at the design stage itself to make the project people friendly and economically viable. Wherever avoidance/ reduction of the adverse social impact is not possible, the affected population has been compensated, resettled and rehabilitated properly by adopting adequate mitigation measures, with an objective of improving the living conditions of the project affected people (PAPs).

The following key steps were taken, while preparing social impact assessment report and, thereafter, short resettlement action plan for the project including options for mitigation measures at the time of project implementation:

- Avoid/ reduce the adverse social impacts at the initial design stage, especially while finalizing the alignments;
- Mitigate the unavoidable adverse impacts at planning, designing and implementation phase; and

- Provide compensation to project affected persons (PAPs) and common properties at replacement costs by adopting appropriate rehabilitation and resettlement measures in the light of Government of India policies RFCTLARR Act, 2013, ADB Safeguard Policy Statement, 2009 (SPS) on the Involuntary Resettlement guidelines and concerned State Government rules and regulations.

14.16 Social Impact Assessment

14.16.1 Scope & Objectives of the Project

The Social Impact Assessment process generally begins with screening at the time of project identification where steps are taken from the beginning and plans/ designs/ alignments are finalized in such a way that to the extent possible adverse impacts are avoided at the designing stage itself and make these projects people friendly. These steps are:

- Avoiding the adverse social impact at the designing stage especially while finalising the alignments and station locations.
- Mitigating the adverse impacts at designing stage and construction /operation phase.
- Compensating the affected people/common properties and rehabilitation and resettlement measures.

The overall objective of conducting social impact assessment is to provide input of social concerns to be detailed in design and to avoid or minimize the adverse social impacts with the best possible engineering solutions at the most optimal cost with complete co-ordination between the engineering, environmental and social teams during the entire design process.

In brief, keeping in mind the scope and objectives of the study, the following main tasks has been considered for accomplishment:

- To highlight the need for a proposed metro project;
- To describe the proposed project and alternatives;
- To evaluate the potential impacts of proposed metro project options on the valued ecosystem components within the project study area;
- To consult the local people, officials and experts on options and impacts in order to establish institutional capacity;
- To encourage the public participation during consultation;
- To select the preferred project option and suggest mitigation plan.

14.16.2 Approach and Methodology

The social impact assessment at this stage is based on 'Social Survey', conducted within the corridor.

The social survey of the affected properties has been carried out by using a questionnaire format, conducted within the corridor in the light of up-to-date project design.

The approach and methodology involve the following:

- To understand the settlement pattern and the physical features along the project corridor to identify the critical sections of the metro stretch and to develop an understanding of socio-economic profile.
- A social survey was carried out, administering a questionnaire for collection of information on affected population, properties/structures, likely impact on land, type of ownership and social groups etc.
- Documentation of the PAP's perception regarding the adverse impacts that may be caused due to the project.
- Developing a database with estimates of different categories of PAPs irrespective of their legal holdings.
- Analysis of census and socio-economic data collected for the purpose of social impact assessment and short resettlement action plan.

14.16.3 Project Benefits and Beneficiaries

The proposed metro project is expected to bring positive benefits for the users and act as a development stimulant for the country in terms of overall socio-economic development in the region as discussed in the subsequent paragraph.

14.16.4 Direct Project Benefits

Major benefits that are likely to accrue from the project include:

- Stimulus for further development in the region along with increase in employment opportunities;
- Improved metro network benefitting the local people including businessmen, traders, merchant, tourists and short distance motorists;
- Reduction in travel time, distance as well as transportation cost will be reduced;
- Boost for socio-economic and tourism development along the project;
- Vulnerable and poor people's income will be increased and;
- Facilitate the provision of extension and social services by the government, NGOs and other voluntary institutions;

14.16.5 Indirect Project Benefits

As quantified above, the most direct beneficiaries of this project are users, i.e., the population living along project, as well as passengers travelling in private and public transport etc. There will be benefit from reduced transportation costs and travel times between the connected regions, and much improved travelling comfort. However, the communities located along the project corridor will also get economic benefit indirectly mainly because of two reasons;

- During the construction period a large number of skilled and unskilled workers will be employed by private contractors, resulting in important income generation. Unskilled workers will be recruited from the area for physical works, resulting in direct income generation for this group in the area of the project.
- Private contractors and consultants will get benefit from the contracts that will arise from project execution and from the subsequent operation. Both women and men are expected

to benefit from the improved mobility, safety and access to markets and services along the project corridor. However, in terms of safety benefits women and children will be benefitted from the increased safety related measures generated by the project at the time of travelling, since they tend to constitute the majority of commuters in the proposed metro project, in order to access social services, markets and shopping stores.

14.16.6 Social and Resettlement Impacts

The present exercise will explore the impact on the population as well as on the properties, reported in this section as follows:

This report will assess the social impacts and land acquisition requirement for the project section Corridor-2A i.e. Swargate to Katraj which traverses through the Sahakar Nagar, Maharshi Nagar, Walvekar Nagar, Bibvewadi, Padmawati Nagar, Balaji Nagar, Mangawadi, Dhankawadi & Katraj in Pune District. Total length of the main line from Swargate to Katraj is 5.464 km which is completely underground. 3 Stations have been proposed in Phase 2 A, all of which are underground stations.

The present report has described the impact on the land and structures at the proposed underground station locations, entry exit and at proposed cross over. The track alignment is proposed as underground keeping in mind to minimise the resettlement impact.

As per findings of the census survey of affected land and non-land assets, the project impacts can be broadly classified as (i) impacts on private structures (ii) impacts on livelihoods due to loss of private properties and (iii) loss of common property resources (iv) impact on Govt./Pvt. Land.

From the analysis of impacts, it is noted that altogether 52 structures including 46 private, 5 Govt and 1 religious structures will be affected due to the project. The details of project impacts are presented in the following table:

Table 123 : Summary of Project Impacts

S. No.	Impacts	Number
1	Total land acquisition including Govt. and Pvt. Land (in hectare)	2.63
2	Total no. affected Structures	52
3	Total no. affected Private Structures (7 Households)	46
4	Total no. Tenants	21
5	Total no. Employees	205
6	Total no. Govt. Properties	5
7	Total no. Religious Properties	1
8	Fully Displaced Structures	46
9	Losing Commercial (TH) Fully displaced	43

Source: Census Survey, Systra Faridabad, 2018

14.16.7 Scope of Land Acquisition

The scope of land acquisition is quite significant in the project because of limited availability of RoW. According to the latest Land Acquisition Plan (LAP), prepared as a part of Detailed Design Report, **1.94 hectares** of land including private land and govt. land will be acquired for the main line and additional **0.29 Ha** of defence land will be acquired for stabling lines proposed at Nigdi. Thus, total of **2.63 Ha** of area will acquired for the project.

Census survey of affected structure owners is carried out to identify the persons who would be affected by the project and to make an inventory of their assets that would be lost to the project, which would be the basis of calculation of compensation.

At this juncture, the land ownership details have been identified for the private landowners. However, the further details can be assessed during the joint verification process. Here, the social composition of affected persons has been analysed, considering the data collected from the structure owners.

The major findings and magnitude of impacts are discussed in the following sections.

14.16.8 Ownership of Land Being Acquired for the Project

The land acquisition for the project section has been calculated considering the proposed ROW. The land, which has to be acquired, includes private as well as government land are documented in Table 124.

Table 124 : Land Acquisition details

S. NO	Station	Name of Station	Side	Survey No.	Area of Acquisition (SQM)	Area of Acquisition (HECTARE)	ASR (Per sqm)	Multiple	Acquisition cost as per ASR	Land Cost (In Crores)	Type of Land	REMARKS	IMPACT
1	Station 01 (Market Yard, Gul Tekdi)	**Lift**	Right	47	40.00	0.0040	0	2	0	0.00	Govt		Footpath/Road
		Entry 02	Left	612	217.45	0.0217	32270	2	14033900.3	1.40	Pvt		Parking Area
			Left	612	114.00	0.0114	0	2	0	0.00	Govt		Road
		Stair Case	Left	611	98.00	0.0098	0	2	0	0.00	Govt		Footpath & Road
		Ancillary	Left	611	1074.00	0.1074	209870	2	450800760	45.08	Pvt	T.K Shah & Brothers	T.K Shah & Brothers
		Entry 03	Right	41	67.00	0.0067	0	2	0	0.00	Govt		Road
			Right	41	275.40	0.0275	0	2	0	0.00	Govt		Footpath
		Station Box	Median of the Road	NA	3765.12	0.3765	0	2	0	0.00	Govt		Road
		Total			**5650.97**	**0.5651**			**464834660.3**	**46.48**			
2	Station 02 (Padmavati)	**Entry 01**	Right	14	162.00	0.0162	0	2	0	0.00	Govt		Footpath
			Right	16	162.00	0.0162	0	2	0	0.00	Govt	Dhananjay Ramchandra Deshpande/ Mangalamurti Sahakari Housing Society Limited	Road
		Lift 01	Right	14	40.00	0.0040	14660	2	1172800	0.12	Pvt	Dhananjay Ramchandra Deshpande/ Mangalamurti	Pvt Land

												Sahakari Housing Society Limited	
		Lift 02	Left	17	39.00	0.0039	0	2	0	0.00	Govt		Footpath
		Stair Case	Left	17	99.00	0.0099	0	2	0	0.00	Govt		Footpath
		Entry 04	Left	17	324.00	0.0324	0	2	0	0.00	Govt		Footpath
		Ancillary	Left	19	1421.00	0.1421	26220	2	74517240	7.45	Pvt		Private
		Station Box	Left	17	1816.45	0.1816	0	2	0	0.00	Govt		Nala/Drainage
			Left	17	1633.23	0.1633	117280	2	383091367	38.31	Pvt		Fruniture Market
			Left	19	315.83	0.0316	26220	2	16562177.64	1.66	Pvt		Open Land
		Total			**6012.52**	**0.6013**			**475343584.7**	**47.53**			
3		**Vent Shaft**	Left		**357.00**	0.0357	26220	2	18721080	1.87	Pvt		
					357.00	**0.0357**			**18721080**	**1.87**			
4	**Station 03 (Katraj)**	**Entry 02**	Left	6	324.00	0.0324	0	2	0	0.00	Govt		Footpath
		Lift 01	Left	1	35.00	0.0035	0	2	0	0.00	Govt		Footpath
		Stair Case	Right	NA	77.33	0.0077	0	2	0	0.00	Govt		Footpath
		Ancillary	Right	84	816.30	0.0816	26220	2	42806929.32	4.28	Pvt		Isuzu
		Entry 03	Right	NA	167.00	0.0167	0	2	0	0.00	Govt		Footpath
		Station Box	Right	84	3765.12	0.3765	**0**	2	0	0.00	Govt		Road
		Cross Over	Right	7 & 6	125.69	0.0126	26180	2	6580971.32	0.66	Pvt		Bharti Vidhyapath Hostel
			Right	7 & 6	111.12	0.0111	0	2	0	0.00	Govt		Pune District Cooperative Milk

													Production Union
			Right	7 & 6	1908.70	0.1909	0	2	0	0.00	Govt		Footpath & Road
		Total			**7330.25**	**0.7330**			**49387900.64**	**4.93879006**			
5		**Depot/ stabling lines**			2926.754	0.29	17660	1	51686475.64	5.17			**Defense**
6	**RSS**				4000	0.4	**0**	**0**	**0**	**0**			**Government**
Grand Total					26277.47	2.63			**1059973701**	**106**			
Contingency@5%									**52998685.06**	**5.3**			
Total Land Cost with Contingency@5%									**1112972386**	**111.3**			

14.16.9 Land Required for Stabling Lines

A vacant defence land near Nigdi station has been identified for Depot location. Area identified the at elevated stabling lines proposed is 2926.74 sqm.

Table 125 : Land Requirement and cost for Stabling Lines proposed

Area of Acquisition (SQM)	ASR (INR Per sqm)	Land Cost (In Cr.	Contingency@5%	Total Land Cost with Contingency@5%	OWNERSHIP
2926.74	17660	5.17	0.26	5.43	Defence Land

14.16.10 Land Required for Receiving sub station

The details of land required for RSS is given in table below:

Corridor	Location	Land Area	Ownership
2A (Swargate to Katraj)	Near Existing Swargate station	4000 sqm	Government

Table 126 : Land Required for RSS

14.16.11 Impacted Properties

The properties to be affected by the proposed project include shops, or any other structure. It has been attempted to get the details of various structures that are located within the proposed RoW of the project.

The census survey, within proposed Right of Way, has been carried out to enumerate the properties falling within proposed ROW. The finding of the survey revealed that there are significant numbers of structures, i.e., a total of 52 structures are going to be affected within the proposed right of the way. Structures include the private properties, government properties and religious properties. The following sections deals with the details of the affected structures along the project. The number of properties and its distance from the existing centreline is depicted in Table 127.

Table 127 : Properties to be Affected

S. No	Properties to be Affected	Left	Right	Total
1	Private, Government and Religious Properties	48	4	**52**

Source: Census Survey, Systra Faridabad, 2018

The properties falling within the corridor of impact as per its type of ownership have been documented in Table 128

Table 128 : Ownership of Properties to be affected

S. No	Type of Properties	Left	Right	Total	%
1	Private	42	4	46	88.46
2	Government	4	1	5	9.62
3	Religious	1	0	1	1.92

Total	**47**	**5**	**52**	100

Source: Census Survey, Systra Faridabad, 2018

Saibaba Nagar Station Ch. 19.565

Saibaba Nagar Station Ch. 19.565

Saibaba Nagar Station Ch. 19.565

Figure 103. Temples affected due to proposed alignment

The impact on religious structures is generally considered as an area of concern due to its association with the religious sentiments of the people. It was observed during socio-economic survey that religious properties are falling under proposed station boxes and cannot be avoided as there is limited space available for station boxes. There is no other option available to propose station boxes to avoid impact on religious properties. The details of type of construction of the structures are summarized in Table 129

Table 129 : Type of Construction of Private Structures

S. No	Type of Construction (Private Properties)	Left	Right	Total	%
1	Semi-Pucca	42	0	42	91.30
2	Pucca	0	4	4	8.70
Total		**42**	**4**	**46**	**100**

Source: Census Survey, Systra Faridabad, 2018

The total number of private properties will be affected due to the project is 46 in number. These private properties are used for commercial purpose. It was revealed during social survey that most of the structures along the project are commercial structures as shown in Table 130

Table 130 : Type of Private Properties to be Affected

S. No	Type of Private Properties	Left	Right	Total	%
1	Commercial	41	1	42	91.30
2	Godown	1	0	1	2.17
3	Boundary Wall	0	2	2	4.35
4	Under Construction	0	1	1	2.17
Total		**42**	**4**	**46**	**100**

Source: Census Survey, Systra Faridabad, 2018

Data collected through field survey shows that there are 6 government properties are to be affected due to the proposed project. The details of such properties are summarized in the Table 130.

Table 131 : Type of Government & Religious Properties to be Affected

S. No	Type of Government & Religious Properties	Left	Right	Total	%
1	Boundary Wall (City Pride)	1	0	1	16.66
2	Boundary Wall (Society)	1	0	1	16.66
3	Boundary Wall	1	0	1	16.66
4	Boundary Wall & Tin Shed (Society)	0	1	1	16.66
5	Temple	1	0	1	16.66
6	Toilet	1	0	1	16.66
Total		**5**	**1**	**6**	**100**

Source: Census Survey, Systra Faridabad, 2018

14.16.12 Legal Status of the Ownership of the Properties/ Structures

Due to loss of structures many people will be losing their properties/ livelihoods and will be economically affected. As per the census survey of structures, 47 households will be losing their properties/ livelihood due to loss of structures under titleholders' category and 21 Tenants, 205 employees under non-titleholder' category. The details of the affected households are shown in Table 132.

Table 132 : : Entitlement of Properties

S. No	Category of Affected Households	Description	Number of PAPs		Total
			Left	Right	
1	Title Holder	Structures	42	5	47
2	Tenant	Structures	21	0	21
3	Employees	Structures	205	0	205
Total			**268**	**5**	**273**

Source: Census Survey, Systra Faridabad, 2018

14.16.13 Social profile of the PAPs along the Project

The purpose of our census survey was to create a broad database of the affected properties as well as the project-affected persons (PAPs) in order to understand the social profile of the project-affected area. It helps to appraise the positive as well as negative change in the life style of the communities in the project influence area due to implementation of the project as an external intervention. Based on the primary data collected during census survey, an assessment of the social profile of the affected population of structures only has been outlined in the following paragraphs and tables.

14.16.13.1 Total Affected Households

Due to loss of structures many people will be losing their properties/ livelihoods and will be adversely affected. The data reveals that as many as total **273** households are getting affected due to the proposed project. The details for the same are shown in Table 133.

Table 133 : Number of Affected Households

S. No	Type of Impacts	Category of PAHs	Number of PAPs		
			Left	Right	Total
1	Structure Only	Owner (TH)	42	5	47
2		Tenant (NTH)	21	0	21
3		Employees (NTH)	205	0	205
Total			**268**	**5**	**273**

Source: Census Survey, Systra Faridabad, 2018

14.16.13.2 Religious Category of PAHs along the Project

Social customs and tradition play a major role in determining the socio-economic development as well as occupational pattern in the influence area, keeping this in mind a social analysis has been conducted taking into account the religious profile of the PAHs within the corridor of impact. In the project, majority of the PAHs belong to Hindu population (82.98%) followed by Muslim population (17.02%). Table 134 delineates the religious cluster of the affected households.

Table 134 : Religious Categories of PAHs along the Project

S. No	Religious Group	Left	Right	Total	%
1	Hindu	37	2	39	82.98
2	Muslim	5	3	8	17.02
Total		**42**	**5**	**47**	**100**

Source: Census Survey, Systra Faridabad, 2018

14.16.13.3 Social Category of PAHs along the Project

In many places, especially in rural India, the social category plays a dominant role in determining the accessibility to resources. People from Schedule Tribe or Schedule caste are deprived of their rights. Such sections of the society need special concern while rehabilitating them.

At this stage, the socio-economic profile of structures owner has been updated, who are losing their property due to the project. Here, the social composition of affected persons has been analyzed, considering the data collected from the structure's owners.

The analysis of collected data indicates that majority of PAH's belongs to OBC category (44.68%) followed by General category (31.91%) and (14.89%) are SC category. Data was collected regarding social classification of PAHs and the same has been presented in Table 135

Table 135 : Social Stratification of PAHs along the Project

S. No	Social Category	Left	Right	Total	%
1	SC	7	0	7	14.89
1	OBC	21	0	21	44.68
2	General	14	1	15	31.91
4	NA	0	4	4	8.51
Total		**42**	**5**	**47**	**100**

Source: Census Survey, Systra Faridabad, 2018

14.16.13.4 Type of family of PAHs along the Project

The analysis of collected data indicates that majority of PAH's lives in Joint Family (82.98%) followed by Nuclear Family (6.38%). Data was collected regarding type of family has been presented in Table 136.

Table 136 : Type of family of PAHs along the Project

S. No	Type of Family	Left	Right	Total	%
1	Joint	39	0	39	82.98
2	Nuclear	3	0	3	6.38
3	NA	0	5	5	10.64
Total		**42**	**5**	**47**	**100.00**

Source: Census Survey Systra Faridabad, 2018

14.16.13.5 Occupation Pattern in the family along the Project

The project is dominated by families which are involved in commercial activities. Table 137 gives the detail explanation.

Table 137 : Occupation Pattern of PAHs along the Project

S. No	Occupation Pattern	Left	Right	Total	%
1	Business	41	1	42	91.49

2	NA	1	4	5	8.51
Total		**42**	**5**	**47**	**100**

Source: Census Survey, Systra Faridabad, 2018

14.16.14 Applicable Resettlement Policy and Regulations

The Social Assessment describes the approach to be followed in minimizing and mitigating negative social and economic impacts caused by the project. In addition, social assessment identifies categories of expected project impacts, including loss of property and assets, loss of livelihood, and other social and economic impacts on roadside communities. All people and households adversely affected by the project would be enumerated and supported as per the Entitlement Matrix which is under preparation. The outcomes of consultation with community with regards to relocation of religious and community structures, if any constructed encroaching on Government lands would be duly documented. Over the years, R&R policies have been developed at international, national and organizational levels. The Acts and Policies relevant to the SIA are:

- Asian Development Bank's Safeguard Policy Statement (SPS), 2009
- The notifications of Department of Revenue and Forest, Maharashtra Government for Resettlement and Rehabilitation dated 13/08/2014, 27/08/ 2014 (2 Nos.)
- Order of CBDT, Ministry of Finance, Govt. Of India dated 25/10/2016
- The Right to Fair Compensation and Transparency in Land Acquisition, Rehabilitation and Resettlement Act, 2013 (No. 30 of 2013)

The following section deals with these policies with a comparison and subsequently deals with the entitlements and eligibility for compensation and other resettlement entitlements.

14.16.15 ADB's Safeguard Policy Statement (SPS), 2009 on Involuntary Resettlement

Objectives: To avoid involuntary resettlement wherever possible; to minimize involuntary resettlement by exploring project and design alternatives; to enhance, or at least restore, the livelihoods of all displaced persons in real terms relative to pre-project levels; and to improve the standards of living of the displaced poor and other vulnerable groups.

Scope and Triggers: The involuntary resettlement safeguards cover physical displacement (relocation, loss of residential land, or loss of shelter) and economic displacement (loss of land, assets, access to assets, income sources, or means of livelihoods) as a result of (i) involuntary acquisition of land, or (ii) involuntary restrictions on land use or on access to legally designated parks and protected areas. It covers them whether such losses and involuntary restrictions are full or partial, permanent or temporary.

Policy Principles:

- Screen the project early on to identify past, present, and future involuntary resettlement impacts and risks. Determine the scope of resettlement planning through a survey and/or census of displaced persons, including a gender analysis, specifically related to resettlement impacts and risks.

- Carry out meaningful consultations with affected persons, host communities, and concerned non-government organizations. Inform all displaced persons of their entitlements and resettlement options. Ensure their participation in planning, implementation, and monitoring and evaluation of resettlement programs. Pay particular attention to the needs of vulnerable groups, especially those below the poverty line, the landless, the elderly, women and children, and indigenous Peoples, and those without legal title to land, and ensure their participation in consultations. Establish a grievance redress mechanism to receive and facilitate resolution of the affected persons' concerns. Support the social and cultural institutions of displaced persons and their host population. Where involuntary resettlement impacts and risks are highly complex and sensitive, compensation and resettlement decisions should be preceded by a social preparation phase.

- Improve, or at least restore, the livelihoods of all displaced persons through (i) land-based resettlement strategies when affected livelihoods are land based where possible or cash compensation at replacement value for land when the loss of land does not undermine livelihoods, (ii) prompt replacement of assets with access to assets of equal or higher value, (iii) prompt compensation at full replacement cost for assets that cannot be restored, and (iv) additional revenues and services through benefit sharing schemes where possible.

- Provide physically and economically displaced persons with needed assistance, including the following: (i) if there is relocation, secured tenure to relocation land, better housing at resettlement sites with comparable access to employment and production opportunities, integration of resettled persons economically and socially into their host communities, and extension of project benefits to host communities; (ii) transitional support and development assistance, such as land development, credit facilities, training, or employment opportunities; and (iii) civic infrastructure and community services, as required.

- Improve the standards of living of the displaced poor and other vulnerable groups, including women, to at least national minimum standards. In rural areas provide them with legal and affordable access to land and resources, and in urban areas provide them with appropriate income sources and legal and affordable access to adequate housing.

- Develop procedures in a transparent, consistent, and equitable manner if land acquisition is through negotiated settlement to ensure that those people who enter into negotiated settlements will maintain the same or better income and livelihood status.

- Ensure that displaced persons without titles to land or any recognizable legal rights to land are eligible for resettlement assistance and compensation for loss of non-land assets.

- Prepare a resettlement plan elaborating on displaced persons' entitlements, the income and livelihood restoration strategy, institutional arrangements, monitoring and reporting framework, budget, and time-bound implementation schedule.

- Disclose a draft resettlement plan, including documentation of the consultation process in a timely manner, before project appraisal, in an accessible place and a form and language(s) understandable to affected persons and other stakeholders. Disclose the final resettlement plan and its updates to affected persons and other stakeholders.

- Conceive and execute involuntary resettlement as part of a development project or program. Include the full costs of resettlement in the presentation of project's costs and benefits. For a project with significant involuntary resettlement impacts, consider implementing the involuntary resettlement component of the project as a stand-alone operation.

- Pay compensation and provide other resettlement entitlements before physical or economic displacement. Implement the resettlement plan under close supervision throughout project implementation.

- Monitor and assess resettlement outcomes, their impacts on the standards of living of displaced persons, and whether the objectives of the resettlement plan have been achieved by taking into account the baseline conditions and the results of resettlement monitoring. Disclose monitoring reports.

Involuntary Resettlement Categorization

A proposed project is assigned to one of the following categories depending on the significance of the probable involuntary resettlement impacts:

- Category A: A proposed project is classified as category A if it is likely to have significant involuntary resettlement impacts. A resettlement plan, including assessment of social impacts, is required.

- Category B: A proposed project is classified as category B if it includes involuntary resettlement impacts that are not deemed significant. A resettlement plan, including assessment of social impacts, is required.

- Category C: A proposed project is classified as category C if it has no involuntary resettlement impacts. No further action is required.

- A project's involuntary resettlement category is determined by the category of its most sensitive component in terms of involuntary resettlement impacts. The involuntary resettlement impacts of an ADB-supported project are considered significant if 200 or more persons will experience major impacts, which are defined as (i) being physically displaced from housing, or (ii) losing 10% or more of their productive assets (income generating). The level of detail and comprehensiveness of the resettlement plan are commensurate with the significance of the potential impacts and risks.

The Mumbai Metro 7 project falls in "Category B" based on Asian Development Bank's Safeguard Policy Statement (SPS), 2009 since the project is likely to have involuntary resettlement impacts with more than 200 persons will be physically displaced from housing or will lose 10% or more of their productive assets (income generating).

14.16.16 MAHARASHTRA NOTIFICATION ON RESETTLEMENT AND REHABILITATION

Revenue and Forest Department of Maharashtra Government has issued Notification No. LQN. 12/2013/C.R. 190/A-2 on 27th August 2014 for Resettlement and Rehabilitation of PAPs for projects in the state of Maharashtra as per Section 108 of the Right to Fair Compensation and Transparency in Land Acquisition, Rehabilitation and Resettlement Act, 2013 to provide higher compensation. The details of the notification are given in the following paragraphs:

Part-1. Land Valuation:

1. The market value of land to be acquired will be determined by ready reckoner value fixed under the Maharashtra Stamp Act (59 of 1958) and the Maharashtra Stamp (Determination of True Market Value of Property) Rules, 1995.
2. The multiplication factor by which market value of the land is multiplied will be 2 in case of rural areas and 1 for urban areas. (This factor should be at least 10% higher than the state approved multiplier.)
3. Compensation of the land to be acquired in rural area: (market value x 2) *plus* value of assets attached to land or building) *Plus (*100% solatium) = Land Compensation Price;

   Compensation of the land to be acquired in urban area: (market value x 1) *plus* value of assets attached to land or building) *plus* (100% solatium) = Land Compensation.
4. In case the land is acquired for urbanization purpose 20% of the developed land will be reserved and offered to the landowner at price equal to cost of acquisition and cost of development. The net land reserved and offered will be excluding the land required for infrastructure development by recovering the cost of acquisition and cost of development gross land i.e. 20%. The land required for infrastructure development and cost of the same as per norms prescribed by Public Works Department or Irrigation Department or Rural Development Department or Municipal Corporations or City and Industrial Development Corporation of Maharashtra (CIDCO) or Mumbai Metropolitan Region Development Authority (MMRDA) or Maharashtra Industrial Development Corporation (MIDC). The actual area required for development of infrastructural facilities will be taken into consideration at the time of calculation of land to be allotted.

The net land to be reserved or offered to land owner will be:—

20% of the gross land-land required for infrastructural development as per norms prescribed by Public Works Department or Irrigation Department or Rural Development Department or Municipal Corporations or City and Industrial Development Corporation of Maharashtra (CIDCO) or Mumbai Metropolitan Region Development Authority (MMRDA) or Maharashtra

Industrial Development Corporation (MIDC) norms-recovery of cost of acquisition as per Right to Fair Compensation and Transparency in Land Acquisition. Rehabilitation and Resettlement Act, 2013 and cost of development as per norms prescribed by Public Works Department or Irrigation Department or Rural Development Department or Municipal Corporations or City and Industrial Development Corporation of Maharashtra (CIDCO) or Mumbai Metropolitan Region Development Authority (MMRDA) or Maharashtra Industrial Development Corporation (MIDC) for gross 20% land.

Explanation.— As per the City and Industrial Development Corporation of Maharashtra (CIDCO) norms, the area required for infrastructure development considered is 30%., then the net land to be reserved or offered to land owner will be : 20% of the gross land-7% area required for infrastructure development=14% of the land acquired-(recovery of cost of acquisition and cost of development as per City and Industrial Development Corporation of Maharashtra (CIDCO) norms for gross 20% land.

The acquiring body may also give monetary value equivalent of the net developed land in lieu of actually providing the land to the displaced persons or his family.

Part-2. Rehabilitation and Resettlement components:

- If a house is lost in rural area, a constructed house shall be provided as per the specifications of *Indira AawasYojana* or Rs. 1.65 lacs in lieu of house.

  Explanation. - In case *of Indira Aawas Yojana,* a house of 25 sq.mt. will be provided. Considering the low specifications, the construction cost will be minimum Rs. 600 per sq. ft. which gives Rs. 1,61,400 excluding the cost of the developed land.
- If a house is lost in urban area, a constructed house shall be provided of 50 sq.mt. plinth area as per Public Works Department norms or Rs. 5.5 lacs in lieu of house.

  Explanation, —Considering the construction cost of Rs. 1000 per sq. Ft., the cost of house will bs Rs. 5,38,000 excluding the cost of the developed land.
- Onetime payment of Rs. 5 lacs to each affected family to those who have eligible candidate for employment.
- Subsistence allowance to the affected displaced families of Rs. 3000 per month for a year after displacement date. For the families belonging to Scheduled Castes or Scheduled Tribes such families will get additional Rs. 50,000.
- Transportation cost of Rs. 50,000 per affected displaced families.
- Those families having cattle shed or petty shops will get Rs. 25,000 one-time financial assistance.
- One-time grant for artisans, small traders of Rs. 50,000.
- One-time resettlement allowance of Rs. 50,000 after shifting of house.
- Stamp duty and registration charges will be borne by Requiring Body for the first transaction of the rehabilitated person only.
- The Requiring Body will provide the infrastructure in Rehabilitation and Resettlement area, which includes the roads, drainage, *Panchayatghar,* post office, *Samajmandir* and other facilities as mentioned in the THIRD SCHEDULE of the Right to Fair Compensation

and Transparency in Land Acquisition. Rehabilitation and Resettlement Act, 2013. However, if the Requiring Body monetize the amenities as per family costs of constructing these amenities as per cost norms developed by Public Works Department or Rehabilitation Department or Irrigation Department or Rural Development Department or Urban Development Department or Municipal Corporations or City and Industrial Development Corporation of Maharashtra (CIDCO) or Mumbai Metropolitan Region Development Authority (MMRDA) or Maharashtra Industrial Development Corporation (MIDC). In such an eventuality, the Requiring Body shall offer 10% plus the total per family cost of all the amenities to be provided under the THIRD SCHEDULE of the said Act.

- All monetary value fixed above shall be entitled to be increased by 5% on the 1st January of each year unless the rate of inflation index is less than 5 % for that year.
- Above package will be applicable if the affected person accepts the same through a written consent.

[*Note:* - The explanations provided above are only the supportive information on the basis of City and Industrial Development Corporation of Maharashtra (CIDCO) practice and shall not be included part of the Guidelines]

It may be seen that the Government of Maharashtra has further prescribed entitlements for families affected due to acquisition of land, which are currently applicable.

The Revenue and Forest Dept., Govt. of Maharashtra, vide Notification dated 27/08/2014, has prescribed rules for various matters under Section 109 of the RFCTLARR Act

14.16.17 The Right to Fair Compensation and Transparency in Land Acquisition, Rehabilitation and Resettlement Act, 2013 (No. 30 Of 2013)

The Right to Fair Compensation and Transparency in Land Acquisition, Rehabilitation and Resettlement (RFCTLARR) Act, 2013 is effective from January 1, 2014 after receiving the assent of the President of Republic of India, repealing the Land Acquisition Act, 1894. The new Act extends to the whole of India except the state of Jammu and Kashmir. The aim of the new act is to minimize displacement and promote, as far as possible, non-displacing or least displacing alternatives and also aims to ensure adequate compensation including rehabilitation package and expeditious implementation of the rehabilitation process with the active participation of those affected. The Act also recognizes the need for protecting the weaker sections of the society especially members of the scheduled castes and scheduled tribes.

The aims and objectives of the Act include: (i) to ensure, in consultation with institutions of local self-government and Gram Sabhas established under the Constitution of India, a humane, participative, informed and transparent process for land acquisition for industrialization, development of essential infrastructural facilities and urbanization with the least disturbance to the owners of the land and other affected families; (ii) provide just and fair compensation to the affected families whose land has been acquired or proposed to be acquired or are affected by such acquisition; (iii) make adequate provisions for such affected persons for their rehabilitation and resettlement; (iv) ensure that the cumulative outcome of compulsory acquisition should be that affected persons become partners in development leading to an improvement in their post-acquisition social and economic status and for matters connected therewith or incidental thereto.

The key features of the new land acquisition act are as follows: Schedule I outlines the proposed minimum compensation based on a multiple of market value. Schedule II and III outline the resettlement and rehabilitation (R&R) entitlements to land owners and livelihood losers, which shall be in addition to the minimum compensation per Schedule I. The Schedules IV lists out other land acquisition acts, which will be repealed with 1 year after LAAR is effective.

The salient provisions of the RTFCTLARR Act relevant to the Metro project are as follows:

- The Act (Section 105) specifies that the provision of the Act shall not apply to the enactments relating to land acquisition specified in the Fourth schedule of the Act which includes Metro Railways (Construction of Works) Act, 1978. However, as stipulated in Sub Section (3) of Section 105 and as subsequently notified by the GoI, the compensation for acquisition of private land and rehabilitation and resettlement benefits specified under the new LARR Act remain applicable even for such activities taken up under the Metro Railways Act.
- Preparation of Social Impact Assessment study including assessment of public purpose through a process of public consultation and disclosure for land acquisition proposals covered under the Act.
- Transparent procedures to be followed in the acquisition of land from preliminary notification to award and possession and preparation and implementation of rehabilitation and resettlement schemes for those affected by acquisition of land for public purpose.
- Procedure and methodology for determination of market value for compensation to be provided to legal title holders.
- Infrastructural facilities to be provided in resettlement areas and special provision for Scheduled Castes and Tribes.
- Institutional mechanism for implementing the provision of the Act, monitoring of R&R and grievance redressal.
- Procedure for payment of compensation.
- Temporary possession of land.
- The owners of land and structures (including those having certain legal rights) proposed to be acquired and, in urban areas, those who are staying on or whose livelihood is dependent on such land for a period of 3 years prior to acquisition of land are entitled for certain compensation and benefits under the Act.
- For legal title holders in urban areas, the compensation for land is equivalent to market value of land, value of assets attached to the land or buildings and 100% solatium on value of land.
- For houses lost as a result of acquisition of land in urban areas, a constructed house of not less than 50 sq.m. plinth area (if required in multi-storied building) is to be provided for a family. Alternatively, if so desired by the PAP, a one-time financial

assistance of not less than Rs. 1.5 lakhs are to be given for construction of a house. However, the location of house in terms of the distance from lost house is not prescribed.

- In addition, the affected family is to be provided (i) training and skill development for job to one family member in the project or one-time payment of Rs. 5 lakhs or annuity policies that pay Rs. 2,000 per month per family for 20 years indexed to CPI (ii) monthly subsistence allowance of Rs. 3,000 per month for a period of one year (iii) one-time financial assistance of Rs. 50,000 towards transportation cost for shifting (iv) one-time resettlement allowance of Rs. 50,000.
- Each petty shop owner / small trader / self-employed person and family owning non-agricultural land, or commercial, industrial or institutional structure is to be provided one-time financial assistance of minimum Rs. 25,000 for construction of shop.
- The stamp duty and registration charges for the land and house to be provided to the PAPs shall be borne by the acquiring body.

It may be seen that while elaborate provisions for compensation and R&R benefits are made for those affected due to the acquisition of land for the project, the Act does not prescribe any benefits for occupants of structures located on public (Government) land and affected by the project. Further, the Act does not envisage any resettlement benefit for occupants / owners of structures used for other than residential purposes and affected by the project.

The Central Board of Direct Taxes vide Order dated 25/10/2016 has clarified that the compensation received in respect of award or agreement, which has been exempted from levy of income tax vide Section 96 of the RFCTLARR Act shall also not be taxable under the provisions of Income Tax Act, 1961.

14.16.18 Community Consultation and Stakeholder Analysis

Extensive public consultations were carried out with various stakeholders at various locations throughout the length of the project corridor. The consultations were undertaken with PAPs, in selected area. The locations, number of people that participated and the consultation methods are summarized in Table 138

Table 138 : Summary of Consultation Sessions

Date	State	District	Tehsil	Village	No. of person	Type of Consultation
27/11/2018	Maharashtra	Pune	Haveli	Katraj Chowk	13	Consultation
27/11/2018	Maharashtra	Pune	Haveli	Near City Pride Cinema	4	Consultation
01/01/2019	Maharashtra	Pune	Haveli	Dhanakwadi (Near Furniture Market)	40	Consultation

**Source: Public consultation during social assessment.*

The purpose of public participation and consultation for this resettlement planning study was to create awareness on the project and involve those persons in the study who are to be affected positively or negatively and involve also other stakeholders by giving them opportunities to express their views and concerns about expected and perceived impacts and about the most suitable ways for mitigating negative effects and enhancing positive project effects.

The consultations intended to create a sense of commitment towards implementing the social safeguard plan for the project. With due consideration of vulnerable PAPs including SC, PH, Aged (60+) and WHH, consultations were carried out through various methods including individual interviews, consultation meetings, and informal and formal group discussions.

A list of participants' location/place wise is provided in this report. The photographs of public consultations are shown in following figure.

Figure 104. A view of people's participation during census survey and public consultation along the project road corridor near City Pride Cinema & Katraj Chowk (Top), Furniture Market, Dhanakwadi (Bottom)

14.16.19 Issues Raised and Responses

Various topics were covered in the consultations with villagers, project affected people, community leaders and village sarpanches. The issues raised, and the responses given are summarized in table below.

Table 139:Issues raised and responses

Issues raised	Reponses
Land acquisition minimization	People were informed that within the broader corridor alignment, several alternatives were studied taking into consideration of social and environmental impacts, including the land acquisition. The option selected is with the least land acquisition impacts.
Provision of new bypass construction	The PAPs suggestions will be discussed with the design Engineers and accordingly incorporated if technically feasible.
Resettlement impacts mitigation measures	A resettlement action plan will be prepared in line with relevant LARR Act, 2013.
Underpasses at schools and hospitals	The exact location of underpasses will be discussed with the design engineer. The final location will select by taking into account people's concerns and needs, as much as technically viable.
Wayside amenities and public facilities including toilets and drinking water	The locations of road side amenities and public services such as rest areas, service areas, bus shelter, urinals and drinking water facilities will be incorporated in the project design.
Road safety measures	Adequate road safety measures will be incorporated in the project design. If needed, additional road safety measures can be added during construction, taking into account local people's concerns.
Pedestrian pathways	The design includes pedestrian pathways for crossing the highway at populated locations. Local people's suggestions can still be incorporated in the project, if technically feasible.
Resettlement assistance package	Compensation will be paid to the eligible PAPs and assistance will be given for relocation and livelihood rehabilitation as set to be forth in the LARR Act, 2013.

Issues raised	Reponses
Compensation should be computed at current market price of land and structures	Compensation rate of lost assets will be determined based on the prevailing market value in the project area.
Avoidance of the demolition of religious properties	PAPs suggestions will be incorporated in the project design if technically feasible. However, relocation of religious structures will be done at proper place after consensus with the local communities.
Income and employment generation schemes should be launched all along the project influence area	Contractors typically hire most unskilled workers locally for construction activities and maintenance work. Other different options will be provided to PAPs for income restoration, such as land-for-land compensation, cash for land, and combination of land and cash for land. These measures would help the PAPs to restore or enhance their income and livelihood.
Special signage near schools, college and road turnings and crossings	The signage near the prominent locations has been incorporated in the road design. Additional signs can be added as needed.
During construction local people should be preferred for employment by the contractor	Contractors typically give priority to local people when hiring workers, both during construction and operational phases.

*Source: Public consultation during social assessment

14.16.20 Definitions and Eligibility Criteria for Various Categories of Displaced Persons

The definitions provided below are as per Chapter 1 Section 3 of the Right to Fair Compensation and Transparency in Land Acquisition, Rehabilitation and Resettlement Act, 2013 (RFCTLARR).

Table 158: Issues raised and responses

Administrator	An officer appointed for the purpose of rehabilitation and resettlement of affected families under sub-section 1 of section 43 of the RFCTLARR Act 2013
Affected Area	Such area as may be notified by the Appropriate Government for the purposes of land acquisition Includes:

Affected Family	A family whose land or other immovable property has been acquired; A family which does not own any land, but a member or members of such family may be agricultural labourers, tenants including any form of tenancy or holding of usufruct right, share-croppers or artisans who may be working in the affected area for three years prior to the acquisition of the land, whose primary source of livelihood stand affected by the acquisition of land' The Scheduled Tribes and other traditional forest dwellers who have lost any of their forest rights recognized under the Scheduled Tribes and other Traditional Forest Dwellers (Recognition of Forest Rights) Act, 2006 due to acquisition of land; Family whose primary source of livelihood for three years prior to the acquisition of the land is dependent on forests or water bodies and includes gatherers of forest produce, hunters, fisher folk and boatmen and such livelihood are affected due to acquisition of land; A member of the family who has been assigned land by the State Government or the Central Government under any of its schemes and such land is under acquisition; A family residing on any land in the urban areas for preceding three years or more prior to the acquisition of the land or whose primary source of livelihood or three years prior to the acquisition of the land is affected by the acquisition of such land.
Appropriate Government	Means: In relation to acquisition of land situated within the territory of a State, the State Government; In relation to acquisition of land for public purpose in more than one State, the Central Government, in consultation with the concerned State Governments or Union territories; Provided that in respect of a public purpose in a District for an area not exceeding such as may be notified by the Appropriate Government, the Collector of such District shall be deemed to be the Appropriate Government
Collector	Means the Collector of a revenue district, and includes Deputy Commissioner And any officer specially designated by the Appropriate Government to perform the function of a Collector under the RFCTLARRA 2013

Commissioner	Means the Commissioner for Rehabilitation and Resettlement appointed under sub-section (1) of section 44 of the RFCTLARRA 2013
Cost of Acquisition	Includes: Amount of compensation which includes solatium, any enhanced compensation ordered by the Land Acquisition and Rehabilitation and Resettlement Authority or the Court and interest payable thereon and any other amount determined as payable to the affected families by such Authority or Court; Demurrage to be paid for damages caused to the land and standing corps in the process of acquisition Cost of acquisition of land and building for settlement of displaced or adversely affected families; Cost of development of infrastructure and amenities at the resettlement areas; Cost of rehabilitation and resettlement as determined in accordance with the provisions of the RFCTLARR Act 2013 Administrative cost for (a) acquisition of land, including both in the project site and out of the project area lands, not exceeding such percentage of the cost of compensation as may be specified by the Appropriate Government; and (b) rehabilitation and resettlement of owners of the land and other affected families whose land has been acquired or proposed to be acquired or other families affected by such acquisition; Cost of undertaking Social Impact Assessment Study
Displaced Family	Means any family, who on account of acquisition of land has to be relocated and resettled form an affected area to the resettlement area
Family	Includes a person, his or her spouse, minor children, minor brothers and minor sisters depended on him: provided that widows, divorces and women deserted by families shall be considered separate families
Holding of Land	Means the total land held by a person as an owner, occupant or tenant or Otherwise
Land	Includes benefits to arise out of land, and things attached to the ear or permanently fastened to anything attached to the earth
Landless	Means such persons or class of persons who may be: Considered or specified as such under any State law for the time being in force; or In a case of landless not being specified as above, as may be specified by the Appropriate Government

Land Owner	Includes any person: Whose name is recorded as the owner of the land or building or part thereof, in the records of the authority concerned; or Any person who is granted forest rights under the Scheduled Tribes and Other Traditional Forest Dwellers (Recognition of Forest Rights) Act, 2006 or under any other law for the time being in force; or Who is entitled to be granted Patta rights on the land under any law of the State including assigned lands; or? Any person who has been declared as such by an order of the court or Authority
Marginal Farmer	means a cultivator with an un-irrigated land holding up to one hectare or irrigated land holding up to one-half hectare;
Small Farmer	means a cultivator with an un-irrigated land holding up to two hectares or with an irrigated land holding up to one hectare, but more than the holding of a marginal farmer.
Local Authority	Includes a town planning authority (by whatever name called) set up under any law for the time being in force, a Panchayat as defined in article 243 and a Municipality as defined in article 243P of the Constitution
Market Value	Means the value of land determined in accordance with section 26 of the RFCTLARRA 2013
Person Interested	Means: All persons claiming an interest in compensation to be made on account of the acquisition of land under the RFCTLARRA 2013 The Scheduled Tribe and other traditional forest dwellers, who have lost any forest rights recognized under the Scheduled Tribes and Other Traditional Forest Dwellers (Recognition of Forest Rights) Act, 2006; A person interested in an easement affecting the land; Persons having tenancy rights under the relevant State laws including share-croppers by whatever name they may be called; and Any person whose primary source of livelihood is likely to be adversely affected;
Person	Means: All persons claiming an interest in compensation to be made on account of the acquisition of land under the RFCTLARRA 2013 The Scheduled Tribe and other traditional forest dwellers, who have lost any forest rights recognized under the Scheduled Tribes and Other Traditional Forest Dwellers (Recognition of Forest Rights) Act, 2006;

Interested	A person interested in an easement affecting the land; Persons having tenancy rights under the relevant State laws including share-croppers by whatever name they may be called; and Any person whose primary source of livelihood is likely to be adversely affected;
Resettlement Area	Means an area where the affected families who have been displaced as a result of land acquisition are resettled by the Appropriate Government
Scheduled Areas	Means the Scheduled Areas as defined in section 2 of the Provision of the Panchayats (Extension to the Scheduled Areas) Act, 1996.
Vulnerable Persons	Persons who are physically challenged, widows, persons above sixty years of age, below-poverty line households and woman-headed household.

14.18.1 The Entitlement Matrix

An Entitlement Matrix has been developed, based on the RFCTLARR Act 2013, that summarizes the types of losses and the corresponding nature and scope of entitlements; and is in compliance with National/State Laws. The following entitlement matrix presents the entitlements corresponding to the tenure of the DPs and the same has been approved and endorsed by Government of Maharashtra.

Table 159: Entitlement Matrix

Sl. No.	Impact Category	Entitlements		Implementation Guidelines
PART I. TITLE HOLDERS – Compensation for Loss of Private Property				
1	Loss of Land (agricultural, homestead, commercial or otherwise)	1.1	**Compensation for Land** a. Land will be acquired by the competent authority in accordance with the provisions of RFCTLARR Act, 2013. b. Replacement cost for land will be, higher of (i) market value as per Indian Stamp Act, 1899 for the registration of sale deed or agreements to sell, in the area where land is situated; or (ii) average sale price for similar type of land, situated in the nearest village or nearest vicinity area, ascertained from the highest 50% of sale deeds of the preceding 3 years; or (iii) consented amount paid for PPPs or private companies. c. Plus 100% solatium and 12% interest on the market value of land from date of commencing till the date of the award or the date of taking possession. d. In case of severance of land, house, factory or other building, as per Section 94 (1) of the RTFCTLARR Act, 2013, the whole land and/or structure shall be acquired, if the owner so desires. e. Stamp duty and registration fee	

Sl. No.	Impact Category	Entitlements		Implementation Guidelines
2	Loss of Structure (house, shop, building or immovable property or assets attached to the land)	2.1	a. The market value of structures and other immovable properties will be determined by PWD on the basis of relevant PWD Schedule of Rates (SR) as on date without depreciation with 100% solatium or replacement cost, whichever is higher.	1-month notice will be provided before demolition of the structure.
			b. Lump-sum of Rs.25, 000 to all families who lose cattle shed, or replacement cost of structure, whichever is higher.	
			c. Loss of other properties such as irrigation wells will be compensated at scheduled rates of (PWD) with 100% solatium, or replacement cost of asset, whichever is higher.	
			d. Replacement cost of bore well, opens well and hand pumps, plus 100% solatium. Wells and hand pumps must be operational to be eligible.	
			e. Owners have right to salvage materials of the affected structures.	
			f. In case of impact to crops, three months (90 days) advance notification for the harvesting of standing crops (or) lump sum equal to the market value of the yield of the standing crop lost determined by the Agricultural /Horticulture Department.	
			g. In case of impact to timber trees, Compensation based on timber value at market	

Sl. No.	Impact Category	Entitlements		Implementation Guidelines
			price or as valued by the Forest Department with 100% solatium whichever is higher. For other perennial trees as valued by the Horticultural Department with 100% solatium or replacement cost whichever is higher.	
PART II. REHABILITATION AND RESETTLEMENT - Both Land Owners; and Families, whose Livelihood is primarily dependent on Land Acquired				
3	Land Owners losing land or structures	3.1	Each affected family will be given a one-time Resettlement Allowance of Rs 50,000.	
		3.2	One-time lump sum payment (in lieu of employment or annuity) of Rs 5,00,000 for Affected Family whose land or other immovable property has been acquired and to those whose livelihood is fully dependent on the acquired land.	Affected Family whose land or other immovable property has been acquired and to those whose livelihood is fully dependent on the acquired land.
		3.3	All affected families, if physically displaced from residence or commercial place due to acquisition, the following payments will be applicable: • Rs 36,000 subsistence grant for all physically displaced families; • Additional Benefits to Vulnerable families Rs. 50,000 • Rs 50,000 for transportation; • Rs 150,000 in rural areas and Rs 200,000 in urban	a. Vulnerable Families are those belonging to SC /ST category or those who are eligible to BPL Antyodaya Anna Yojana Scheme, Vulnerable Families are those belonging to SC /ST category or those are eligible to BPL Antyodaya Anna Yojana Scheme, those headed by woman, elderly (above 60 years of age), or disabled and squatters who are landless.[13] b. Maha Metro will be responsible for identifying

[13] "Landless" means such person or class of person considered as such under any state law for the time being in force.

Sl. No.	Impact Category	Entitlements		Implementation Guidelines
			areas as house construction grant; • Rs 25,000 for each affected family of an artisan or self-employed.	and acquiring land and assist affected family in house construction.
4	Families whose livelihood is primarily dependent on the private land or structures to be acquired (users of private land or structures such as workers, share-croppers, artisans, tenants etc.) Workers shall be of full-time employment either in businesses or agriculture that are affected due to acquisition. In case of seasonal employed workers, these are not eligible for benefits.	4.1	Each affected family will be given a one-time Resettlement Allowance of Rs 50,000.	-
		4.2	All affected families, if physically displaced from residence or commercial place due to acquisition, the following payments will be applicable: • Rs 86,000 subsistence grant for vulnerable families; and Rs 36,000 subsistence grant for all other families; • Rs 50,000 for transportation; • Rs 150,000 in rural areas and Rs 200,000 in urban areas as house construction grant; • Rs 25,000 for each affected family of an artisan or self-employed.	a. Vulnerable Families are those belonging to SC /ST category or those are eligible to BPL Antyodaya Anna Yojana Scheme, those headed by woman, elderly (above 60 years of age), or disabled and squatters who are landless b. PIU will be responsible for identifying and acquiring land and support affected family in house construction
PART III. UNFORESEEN IMPACTS				
Unforeseen impacts encountered during implementation will be addressed in accordance with the principles of RFCTLARR Act 2013				

TOTAL R & R COST

The R&R budget for the proposed project worked out approximately for **Corridor 2A** is **Rs. 156.82 Crores,** which includes the cost of land and structure, relocation or enhancement of religious and government structures and R & R Assistance given to affected people. The details of the tentative budget are given in Table 142.

Table 160 : R&R COST

Sl. No.	Item	Eligibility	Quantity (Sqm.)	Unit Rate (Rs)	Amount (cr.)	Compensation (Factors to be multiplied) (Urban= 1* MV)	100% Solatium of column 6	Total (In Crores)
1	2		3	4	5	6	7	8
A	**Compensation for Land**							
1	Cost of land including contingency	-	**19350.73**	As per ASR	**1059973701**			**111.3**
Sub Total (A)								**111.3**
B	**Compensation for Structure**							
1	Pucca	-	2641.94	40067.34	105855488	No factor Applicable	105855488	211710976
Sub-total (B)								**21.17**
C	**R&R Assistance**							
1	Annuity allowance, losing primary source of Income	Land and structure Owner (Fully Displaced)	46	500000	23000000			2.30
2	Substance Assistance for displaced family	Losing Commercial Structures (Fully Displaced) 46 TH, 21 Tenants & 205 Employees	272	36000	9792000			0.98
3	Transportation cost for displaced family	Losing Residential and Commercial Structures (Fully Displaced) 46 TH & 21 Tenants	67	50000	3350000			0.34
4	Resettlement Allowance	TH Losing Residential and Commercial Structures (Fully Displaced)	273	50000	13650000			1.37
Sub Total C								**4.98**
D	**Administrative and other Costs**							
1	NGO (RAP Implementation)	1500000						0.15
Sub-total (D)								**0.15**
Total R&R Cost (B+C+D)								26.3
Contingency @ 5%								1.31
Cost of Dismantling & Restoration of BRTS								**17.91**
GRAND TOTAL								**156.82**

*** construction cost has been taken from government evaluation site (igrsmaharashtra.com)**

Exhibit 1 – Details of Tress along the Alignment

Project Name:-Pune Metro Project (Swargate-Katraj Section)										
District: Pune						Division: Pune Forest Division				
Forest Range: Pune						Road Side (LHS/RHS): RHS				
Sr.No.	**Kilometer**	**Tree No.**	**Distance from Centre of Road (m)**	**Species Name**	**Girth Size (m)**	**Girth Size (cm)**	**Condition 1.- Green 2.- Dry**	**Condition 1- Fit 2- Unfit 3- Sound**	**Height (m)**	**Remarks**
1	STATION 01	1		KARANJIA	0.5	50	1	1	2.2	CUT
2		2		KARANJIA	0.7	70	1	1	0.1	CUT
3		3		KARANJIA	0.4	40	1	1	2	CUT
4		4		KARANJIA	0.3	30	1	1	1.2	CUT
5		5		UMBER	0.5	50	1	1	2.1	CUT
6		6		KARANJIA	0.1	10	1	1	2.1	CUT
7		1		GULMOHAR	3	300	1	1	1.7	TRIM
8		1		IMLY	1.25	125	1	1	2	CUT
9		2		IMLY	2	200	1	1	1.25	CUT
10		3		IMLY	1	100	1	1	1.25	CUT

11		4		IMLY	0.5	50	1	1	1.25	CUT
12		5		IMLY	0.75	75	1	1	1.25	CUT
13		6		UMBER	1	100	1	1	1.7	CUT
14	STATION 02	1		UMBER	0.6	60	1	1	0.9	CUT
15		2		PEEPAL	0.8	80	1	1	1	CUT
16		1		SAFEDA	1	100	1	1	6	CUT
17		2		KARANJIA	0.8	80	1	1	0.5	CUT
18	STATION 03	1		RUBBER	0.25	25	1	1	1.1	TRIM
19		2		NEEM	0.25	25	1	1	0.7	TRIM
20		3		PEEPAL	0.25	25	1	1	0.5	TRIM
21		4		SILVER	1.25	125	1	1	0.5	TRIM
22		5		NA	0.9	90	1	1	2	CUT
23		1		UMBER	0.5	50	1	1	2	CUT
24		2		NILGIRI	0.25	25	1	1	1	CUT
25		3		NILGIRI	0.25	25	1	1	1	CUT
26		4		PEEPAL	1.2	120	1	1	3	CUT
27		5		JAMUN	0.25	25	1	1	3.5	CUT
28		6		BAIR	0.25	25	1	1	3	CUT

29		7		BADA NEEM	0.25	25	1	1	2.5	CUT
30		8		SUBABAD	0.25	25	1	1	2.5	CUT
31		9		BADA NEEM	0.5	50	1	1	2	CUT
32		10		SESAM	0.4	40	1	1	1.5	CUT
33		11		NEEM	0.3	30	1	1	2	CUT
34		12		BAIR	0.25	25	1	1	1.2	CUT
35		13		PAPDI	0.25	25	1	1	2	CUT
36		14		PAPDI	0.25	25	1	1	2.5	CUT
37		15		NEEM	0.25	25	1	1	2	CUT
38		16		NEEM	0.25	25	1	1	2	CUT
39		17		NEEM	0.25	25	1	1	2	CUT
40		18		SAGWAN	0.5	50	1	1	2.5	CUT
41		19		WAD	0.75	75	1	1	1.8	CUT
42		20		SILVER	0.3	30	1	1	1.7	CUT
43		21		PAPDI	0.25	25	1	1	1.55	CUT
44		22		PAPDI	0.25	25	1	1	1.35	CUT
45		23		PEEPAL	0.3	30	1	1	6	CUT
46		24		AMLA	0.25	25	1	1	4.5	CUT
47		25		JAMUN	0.25	25	1	1	1.25	CUT
48		26		WAD	0.25	25	1	1	3	CUT
49		27		NEEM	0.1	10	1	1	3	CUT

50		28		PAPDI	0.1	10	1	1	2	CUT
51		29		PAPDI	0.1	10	1	1	1	CUT
52		30		VAD	0.1	10	1	1	2	CUT
53		31		BADAM	1	100	1	1	1.5	CUT
54		32		BADAM	1.5	150	1	1	1.2	CUT
55		33		SILVER	0.75	75	1	1	10	CUT
56		34		SILVER	0.25	25	1	1	8	CUT
57		35		NEEM	0.25	25	1	1	3	CUT
58		36		PEEPAL	0.25	25	1	1	12	CUT
59		37		ASHOK	0.3	30	1	1	8	CUT
60		38		SAFEDA	0.3	30	1	1	10	CUT

Project Name:- Pune Metro Project (Swargate-Katraj Section)

District: Pune		**Division: Pune Forest Division**
Forest Range: Pune		**Road Side (LHS/RHS): LHS**

Sr.No.	Kilometer	Tree No.	Distance from Centre of Road (m)	Species Name	Girth Size (m)	Girth Size (cm)	Condition 1.- Green 2.- Dry	Condition 1- Fit 2- Unfit 3- Sound	Height	Remarks
1		1		SIRISH	2.1	210	1	1	1.25	CUT

2	STATION 01	2		PEEPAL	1.5	150	1	1	2.1	CUT
3		3		SIRISH	1.6	160	1	1	4	CUT
4		4		SIRISH	2.15	215	1	1	2.3	TRIM
5		1		SIRISH	1.5	150	1	1	2	CUT
6		1		GULMOHAR	1.5	150	1	1	0.1	TRIM
7		2		SIRISH	1.5	150	1	1	0.1	TRIM
8		3		SIRISH	1.3	130	1	1	3.5	TRIM
9		4		SIRISH	1.67	167	1	1	2	TRIM
10		5		SIRISH	2.3	230	1	1	0.5	TRIM
11		1		SIRISH	1.2	120	1	1	1.8	CUT
12		2		BADAM	0.05	5	1	1	0.5	CUT
13		3		MANGO	0.04	4	1	1	0.2	CUT
14		4		COCONUT	0.02	2	1	1	0.02	CUT
15		5		MANGO	0.02	2	1	1	0.09	CUT
16		6		MANGO	0.02	2	1	1	0.02	CUT
17		7		UMBER	0.1	10	1	1	0.5	CUT
18		8		ASHOK	0.2	20	1	1	2	CUT
19		9		ASHOK	0.2	20	1	1	2	CUT

20		10		ASHOK	0.3	30	1	1	6	CUT
21		11		GULMOHAR	0.3	30	1	1	4	CUT
22		12		GULMOHAR	0.6	60	1	1	3	CUT
23		13		GULMOHAR	0.5	50	1	1	2	CUT
24		14		GULMOHAR	0.4	40	1	1	4	CUT
25		15		GULMOHAR	1	100	1	1	3	CUT
26		16		GULMOHAR	1.5	150	1	1	5	CUT
27		17		GULMOHAR	1.5	150	1	1	5	CUT
28		18		GULMOHAR	1.5	150	1	1	6	CUT
29		19		GULMOHAR	1.5	150	1	1	6	CUT
30		20		UMBER	0.5	50	1	1	1	CUT
31		21		UMBER	0.4	40	1	1	1	CUT
32		22		UMBER	0.4	40	1	1	1	CUT
33		23		UMBER	0.4	40	1	1	1	CUT
34		24		UMBER	0.4	40	1	1	1	CUT
35		25		UMBER	0.4	40	1	1	1	CUT
36		1		SIRISH	1.5	150	1	1	1	TRIM
37		1		WAD	4	400	1	1	1.5	CUT

38		2		WAD	1.5	150	1	1	1.7	CUT
39		3		KADU NEEM	0.5	50	1	1	2	CUT
40		4		KADU NEEM	0.5	50	1	1	3	CUT
41		5		KADU NEEM	0.5	50	1	1	1.25	CUT
42	STATION 02	1		KARANJIA	0.15	15	1	1	0.2	CUT
43		2		KARANJIA	0.2	20	1	1	0.2	CUT
44		3		NA	0.3	30	2	2	2	CUT
45		4		PALM	0.3	30	1	1	10	CUT
46		5		ASHOK	0.3	30	1	1	3	CUT
47		6		ASHOK	0.3	30	1	1	3.5	CUT
48		7		IMLY	1	100	1	1	2	CUT
49		8		PALM	0.5	50	1	1	10	CUT
50		9		ASHOK	0.3	30	1	1	5	CUT
51		1		PEEPAL	0.15	15	1	1	3	TRIM
52		2		UMBER	0.75	75	1	1	1.5	TRIM
53		3		ALMOND	0.75	75	1	1	3	TRIM
54		4		ALMOND	0.75	75	1	1	3	TRIM
55		5		NEEM	1.1	110	1	1	2	CUT

56		6		SIRISH	1.25	125	1	1	1.5	CUT
57		7		SIRISH	0.8	80	1	1	1.5	CUT
58		8		GULMOHAR	0.9	90	1	1	2	CUT
59		9		GULMOHAR	1.7	170	1	1	1.5	CUT
60		10		SIRISH	1.35	135	1	1	0.9	CUT
61		11		SIRISH	1.4	140	1	1	1.6	CUT
62		12		SIRISH	1.5	150	1	1	3	CUT
63		13		GULMOHAR	1	100	1	1	3	CUT
64		1		SUBABAD	2	200	1	1	1.6	CUT
65		2		BADA NEEM	1.8	180	1	1	1.25	CUT
66		1		BANYAN	3.5	350	1	1	0.1	CUT
67		2		NA	1	100	1	1	1	CUT
68		3		PEEPAL	0.3	30	1	1	1.2	CUT
69		4		PAPADI	0.5	50	1	1	1.6	CUT
70		5		BADAM	0.35	35	1	1	2	CUT
71		6		BADAM	0.25	25	1	1	2.5	CUT
72		7		BADAM	0.25	25	1	1	3	CUT
73		8		BADAM	0.25	25	1	1	3.5	CUT

74		9		SIRISH	2.5	250	1	1	1	CUT
75		10		SIRISH	1.5	150	1	1	0.9	CUT
76	STATION 03	1		SUBABAD	0.25	25	1	1	1.5	TRIM
77		2		SUBABAD	0.25	25	1	1	2.25	TRIM
78		3		SUBABAD	0.25	25	1	1	3.25	TRIM
79		4		SIRISH	0.1	10	1	1	1.25	TRIM
80		5		NEEM	0.17	17	1	1	3	TRIM
81		6		SIRISH	0.25	25	1	1	3	TRIM
82		1		WAD	0.5	50	1	1	2	TRIM
83		2		WAD	0.25	25	1	1	2	TRIM
84		3		SUBABAD	0.25	25	1	1	2.25	TRIM
85		4		SUBABAD	0.15	15	1	1	1.1	TRIM
86		1		SUBABAD	0.5	50	1	1	1.1	TRIM

15. DISASTER MANAGEMENT MEASURES

15.1 Introduction

“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 in substantial 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”.* As per world health organisation (WHO):

“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.”

A disaster is a tragic event, be it natural or manmade, which brings sudden and immense agony to humanity and disrupts normal life. It causes large scale human suffering due to loss of life, loss of livelihood, damages to property and persons and also brings untold hardships. It may also cause destruction to infrastructure, buildings, communication channels essential services, etc.

15.2 Need for Disaster Management Measures

The effect of any disaster spread over in operational area of Pune Metro is likely to be substantial as Pune Metro will deal with thousands of passengers daily in underground tunnels, viaducts and stations. Disaster brings about sudden and immense misery to humanity and disrupts normal human life in its established social and economic patterns. It has the potential to cause large scale human suffering due to loss of life, loss of livelihood, damage to property, injury and hardship. It may also cause destruction or damage to infrastructure, buildings and communication channels of Metro. Therefore, there is an urgent need to provide for an efficient disaster management plan.

15.3 Objectives

The main objectives of this Disaster Management Measures are as follows:

- Save life and alleviate suffering.
- Provide help to stranded passengers and arrange their prompt evacuation.
- Instil a sense of security amongst all concerned by providing accurate information.
- Protect Metro Rail property.

- Expedite restoration of train operation.
- Lay down the actions required to be taken by staff in the event of a disaster in Pune Metro in order to ensure handling of crisis situation in 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.

15.4 List of serious Incidents Requiring use of Provisions of the Disaster Management Measures

Metro specific disasters can be classified into two broad categories e.g.: Man-made and Natural.

A. Man-made Disasters.

1. Terrorist attack
2. Bomb threat/ Bomb blast
3. Hostage
4. Release of Chemical or biological gas in trains, stations or tunnels
5. Fire in metro buildings, underground/ elevated infrastructures, power stations, train depots etc.
6. Train accident and train collision/derailment of a passenger carrying train
7. Sabotage
8. Stampede

B. Natural Disasters.

1. Earthquakes
2. Floods
3. Cyclone

15.5 Authorities to be contacted in case of disaster - Provisions under Disaster Management Authority

A. The National Disasters Management Authority (NDMA)

Establishment of National Disaster Management Authority:-

(1) 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.

(2) 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:-

(a) The Prime Minister of India, who shall be the Chairperson of the National Authority, ex officio;

(b) Other members, not exceeding nine, to be nominated by the Chairperson of the National Authority.

(3) The Chairperson of the National Authority may designate one of the members nominated under clause (b) of sub-section (2) to be the Vice- Chairperson of the National Authority.

(4) The term of office and conditions of service of members of the National Authority shall be such as may be prescribed.

B. State Disasters Management Authority (SDMA)

Establishment of State Disaster Management Authority:-

(1) 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.

(2) 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:-

(a) The Chief Minister of the State, who shall be Chairperson, ex officio;

(b) Other members, not exceeding eight, to be nominated by the Chairperson of the State Authority;

(c) The Chairperson of the State Executive Committee, ex officio.

(3) The Chairperson of the State Authority may designate one of the members nominated under clause (b) of sub-section (2) to be the Vice- Chairperson of the State Authority.

(4) The Chairperson of the State Executive Committee shall be the Chief Executive Officer of the State Authority, the Chief Minister shall be the Chairperson of the Authority established under this section.

(5) The term of office and conditions of service of members of the State Authority shall be such as may be prescribed.

C. Command & Control at 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:-

(1) National Crisis Management Committee (NCMC) under the chairmanship of Cabinet Secretary

(2) Crisis Management Group (CMG) under the chairmanship of Union Home Secretary.

(3) State Level Committee under the chairmanship of Chief Secretary.

(4) District Level Committee under the Chairmanship of District Magistrate.

All agencies of the Government at the National, State and district levels will function in accordance with the guidelines and directions given by these committees.

D. 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:-

(a) Prepare a disaster management plan setting out the following, namely:-

(i) Provisions for prevention and mitigation measures as provided for in the District Plan and as is assigned to the department or agency concerned;

(ii) Provisions for taking measures relating to capacity-building and preparedness as laid down in the District Plan;

(iii)The response plans and procedures, in the event of, any threatening disaster situation or disaster;

(b) 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;

(c) Regularly review and update the plan; and

(d) Submit a copy of its disaster management plan, and of any amendment thereto, to the District Authority.

15.6 Provisions at Metro Stations/ Other installations

To prevent emergency situations and to handle effectively in case 'one arises' there needs to be following provisions for an effective system which can timely detect the threats and help suppress the same.

i) Fire detection and suppression system
ii) Smoke management
iii) Environmental control system (ECS)
iv) Tunnel ventilation system
v) Track-way exhaust system (TES)
vi) Station power supply system
vii) DG sets & UPS
viii) Lighting system
ix) Station area lights
x) Tunnel lighting
xi) Tunnel lighting control
xii) Seepage system
xiii) Water supply and drainage system
xiv) Sewage system
xv) Any other system deemed necessary

The above list is suggestive not exhaustive. Actual provisioning has to be done based on site conditions and other external and internal factors.

Certain measures are suggested in the following sections which need to be selected/ tailored according to local conditions, regulations and O&M practices for safety and effectiveness.

15.6.1 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 non-smoking 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.

15.6.1.1 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 electricity supply if necessary
- Prevent the fire from spreading
- Seek assistance of Fire services.

15.6.1.2 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.

15.6.1.3 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.

Cut off power 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.

15.6.1.4 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.

Appropriate O&M procedures should be in place taking into account past experience of other metro systems to handle fire incidents.

15.6.1.5 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 endeavour 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.

15.6.2 Measures in Case of Collision of Trains or derailment

Collision of Metro trains is a rare occurrence, particularly at high speeds as signalling system provides protection from such incidents. Only in case signalling system is disabled, train collision is possible at low speed, except in case of wrong side failure or poor design/ maintenance.

Appropriate O&M procedures should be in place taking into account past experience of other metro systems to avert collision scenario and to handle the event of a train collision if it happens.

15.6.2.1 Medical Assistance

Provisions for Medical assistance and procedures for O&M staff to handle injured and casualties in case of collision or derailment shall be in place. External medical help in case of such incidents shall be planned in advance and called for immediately when required.

15.6.3 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 well-being 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.

15.6.3.1 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.

Appropriate O&M procedures shall be in place to handle bomb threat or suspicion, bomb detection and rescue operation and medical assistance in case bomb explosion takes place. A coordinated effort along with bomb squad may be required to neutralise further threat and for restoration to normal operation.

15.6.3.2 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.

15.6.4 Appropriate O&M procedures and training of O&M staff

Appropriate O&M procedures and training of O&M staff shall be carried out to detect and act to neutralise the effects of such attack. Passenger awareness measures shall be taken to help them in case they are caught in such scenario and cooperate with O&M staff. Measures in Case of Natural Calamities

Traction Power supply shall be switched off in a manner which does not shut down station supplies unless it unsafe for occupants.

In the event of a significant earthquake, train should be stopped until earthquake is confirmed subsided.

Passenger evacuation shall be done following appropriate operating procedures for such scenario.

15.7 Preparedness for Disaster Management

Being a technological complex system worked by new set of staff, with a learning curve to improve and stabilize with time, intensive mock drills for the staff concerned is very essential to train them to become fully conversant with the action required to be taken 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:

a. Fire Drill
b. Rescue of a disabled train
c. Detrainment of passengers between stations
d. Passenger evacuation from station
e. Drill for use of rescue & relief train.

Hot line telephone communication with state disaster management

15.8 Security measures in metro

15.8.1 Introduction

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.

15.8.2 Three pillars of security

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;
- 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 must be qualified, trained, well equipped and motivated. The staff members should be skilful, 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.

15.8.3 Different phases of security

There are three different phases associated with the security system in metro. These phases are as under:

- **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 must be given in controlling unused, damaged properties which could otherwise prove to be a breeding ground for more serious crimes.

- **Preparedness**

Plans must be prepared to respond to incidents and to mitigate the impacts. Staff must be accordingly trained to carry out the exercises. The results of the risk assessment will give basis for such plans.

- **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.

15.8.4 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 Pune Metro.

15.8.5 Proposed provisions for security system

For providing an efficient security system in metro station areas the following provisions are suggested:

- 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.
- 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.
- 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.
- 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.
- Bomb Detection Equipment's with modified vehicle as per requirement of security agency.
- Bomb Blanket at least one per station and depot.
- Wireless sets (Static and Handheld) as per requirement of security agency.
- Dragon light at least one per metro station
- Mobile phones, land lines and EPBX phone connections for senior security officers and control room etc.
- 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.
- Bullet proof Morcha one per security check point (i.e. AFC array) and entry gate of metro train depot administration.

- Bullet proof jackets and helmets for Quick Response Team (QRTs) and riot control equipment's 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.
- Furniture to security agency for each 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.
- Ladies frisking booth - 1 per security check point (AFC) Wooden Ramp - 1 per DFMD for security check points.
- Wall mounted/ pedestal fan at security check point, ladies frisking booth and bullet proof morcha, as per requirement.
- Physical barriers for anti-scaling at Ramp area, low height of viaduct by providing iron grill of appropriate height & design/concertina wire.
- Adequate number of ropes. Queue managers, cordoning tapes, dragon search lights for contingency.
- Iron grill at station entrance staircases, proper segregation of paid and unpaid areas by providing appropriate design grills etc.

Proper design of emergency staircase and fireman entry to prevent unauthorized entry.

16. DETAILED PROJECT COST ESTIMATE

16.1 Introduction

16.1.1 Preliminary cost estimates of Pune MRT have been prepared covering civil, electrical, signalling and telecommunications works, rolling stock, etc. at July 2021 price level and escalated @5% PA.

16.1.2 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 to main line and maintenance depot related to alignment including traction power supply, signalling, viaduct, ballastless track have been estimated at rate per route Km. Cost of station structures, telecommunication other electrical services at these stations including Lifts & Escalators and Automatic Fare Collection (AFC) installations at all stations have been assessed in terms of each station as a unit. Similarly, rolling stock costs have been estimated in terms of number of units required. In remaining items, viz. Land, utility diversions, rehabilitation, EIA, R&R etc. the costs are assessed on the basis of each item, taken as an independent entity.

16.1.3 In order to arrive at realistic cost of various items, costs of the project have been derived from similar executed project in similar scenario in India. Rates are also adopted based on Report for Benchmarking for cost estimation of Metro Rail Projects issued by MoHUA, GoI in February, 2019.

Capital Cost Estimate of Swargate - Katraj (July '21 Price Level)

S. No	Item	Unit	Rate	Quantity	Amount (in INR Cr)
1	**Alignment & Formation**				
1.1	Underground Section - Twin Tunnel	R. Km.	210.00	5.01	1,052.10
1.2	Viaduct for Stabling Line/Depot	R. Km.	41.81	0.9	37.63
	Sub Total - Alignment & formation				**1,089.73**
2	**Station Buildings including Architectural Finishes, Lifts & Escalators**				
2.1	Station Building - Cut & Cover	Each	190.00	3	570.00
2.2	E&M tunnel ventilation incl. Lifts & Escalators	Each	56.50	3	169.51
2.3	Ventilation Shaft between Station 2 & Station 3	Each	50.00	1	50.00
	Sub- total Station Building				**789.51**
3	**Stabling Lines**				

3.1	Civil works, OHE, Signaling, Telecom, etc.,	LS	11.72	1	11.72
	Sub-total Depot				**11.72**
4	**Permanent Way**				
4.1	Ballastless track for Main Line	R.Km	7.46	5.464	40.75
4.2	Ballastless track for Depot/Stabling Line	T.Km	7.46	0.9	6.71
	Sub-total Permanent Way				**47.47**
5	**Traction & power supply incl. OHE, ASS etc. Excl. lifts & Escalators**				
5.1	Underground Section	R. Km.	13.00	5.464	71.01
5.2	HT Cabling 132 KV - Single core	KM	1.69	15	25.42
5.3	RSS	Each	50.85	1	50.85
	Sub-total Traction and Power Supply				**147.28**
6	**Signalling and Telecom**				
6.1	**Signalling**				
a	Main Line	R.Km	4.97	5.46	27.17
b	On Board Equipment	Per train	1.92	14.00	26.90
	Sub-total Signalling				**54.06**
6.2	**Telecommunication**				
a	Station	Per station	5.09	3.00	15.26
	Sub-total Telecom				**15.26**
7	**Enviornment Cost**				
7.1	Environmental Cost				3.32
	Sub-total Enviornment				**3.32**
8	**Misc. utilities etc**				
8.1	Civil works	R. Km.	3.39	5.464	18.52
8.2	Electrical Works	R. Km.	3.39	5.464	18.52
	Sub-total Misc				**37.05**
9	**Security**				
9.1	Civil works	Per Station	0.42	3.00	1.25
	Sub-total Security				**1.25**
10	**AFC**	Per Station	3.96	0.00	0.00
	Sub-total AFC				**0.00**
11	Platform Screen Doors (PSD)	Per Station	3.39	3.00	10.17

12	Multimodal Integration and Last mile connectivity	Per station	3.39	3.00	10.17
13	Rolling Stock	Per coach	9.04	18.00	162.73
14	**Total Cost at July '21 price level (Excluding Land, R&R, General Charges, Contingencies, Central & State Taxes)**				**2379.72**
15	General Charges @ 5%				118.99
16	Contingencies @ 3 % on Sr. No.14 i.e. on basic cost				71.39
17	**Total Cost at July '21 price levels incl. General Charges and Contingencies (Excluding Land, R&R, Central & State Taxes)**				**2570.10**
18	Central and State Taxes @ July '21 Price Level				376.96
19	**Total Cost incl. General Charges, Contingencies, Central and state Taxes @ July '21 Price Levels (Excl. Land and R&R)**				**2947.05**
20	Land				111.30
21	R&R				45.52
22	**Total Cost incl. General Charges, Contingencies, Central and state Taxes @ July '21 Price Levels (Incl. Land and R&R)**				**3103.87**
23	Escalation at 5 % per annum on the above (S. No: 22)				512.44
24	**Total Completion Cost incl. Land and R&R Costs**				**3616.31**
25	Interest During Construction (IDC)				30.29
26	**Total Completion cost including IDC**				**3646.60**
27	PPP component (AFC) incl. escalation & taxes				17.26
28	**Total Completion Cost**				**3663.86**

Note: July '21 Price Level is considered and the prices are escalated till the completion period to arrive at the completion cost.

16.2 Civil Engineering Works

16.2.1 Land

i) Land requirements have been kept to the barest minimum & worked out on area basis. For underground alignment, no land acquisition is proposed, except small areas for locating entry/exit structures, traffic integration, station box etc. at stations. For Each station, temporary land acquisition is required for the purpose of construction using cut and cover method.

ii) Total land requirement has been worked out to **2.63 Ha**, which comprises **1.94 Ha** of private and government land for main alignment and station locations, **0.29 Ha** of defence land shall be acquired for stabling lines proposed in Nigdi and additional government owned land of **0.4 Ha** shall also be needed for RSS proposal.

iii) Cost of land has been worked out based on the rates published by department of registration and stamps, Government of Maharashtra. For private land and structures, the cost of acquisition is taken as 2 times the published rates.

iv) The total cost of land acquisition for Swargate to Katraj alignment works out to INR **111.30 Cr.**

16.2.2 Alignment

Alignment has been proposed to be completely underground, proposed to be constructed using TBM. Cost of twin tunnel is taken as 210 Cr./km.

16.2.3 Station Building

The cost includes general services at the stations but excludes the cost of tunnel, lifts & escalators, which have been considered separately under, respective items. The cost of stations has been worked out based on the basis of earlier constructed stations in same rock starta like Mumbai Metro Line 3 and the same was discussed for ongoing stations in Pune Metro Phase 1. Out of 3 stations proposed, 2 are located under the ROW. During construction full traffic decking will be required. Secant pile will also add on to the extra cost on outside wall to retain Earth. Thus, average cost of each station is taken as 190 Cr.

16.2.4 Permanent Way

For underground stations, ballastless track has been planned. Rates are adopted based on Report for Benchmarking for cost estimation of Metro Rail Projects issued by MoHUA, GoI in February 2019.

16.3 Utility Diversion

The provision of utility diversion has been taken as 6 Cr. per running km as per ministry guidelines, 2019 for the alignment length.

16.4 Environmental Impact Assessment

Cost provision for environmental impacts has been made to cover various protection works, additional compensatory measures, compensation for loss of 146[14] trees, compensatory afforestation and fencing, monitoring of water quality, air/noise pollution during construction, establishment of Environmental Division. The total cost works out to **3.32 Cr**.

16.5 Rehabilitation and Resettlement

Private structure:

Efforts has been made to keep the acquisition of private land to the minimum. Provision towards compensation of rehabilitation of properties on private land, likely to be affected has been assessed after site inspection. Total of 52 structures will be affected.

[14] Approximatey, 146 no. of trees will be impacted due to the project. However, this is a preliminary assessment. Detailed assessment shall be done at later stages.

R&R assistance has been worked out including annuity allowance, loosing primary source of income, substance assistance for displaced family, transportation cost and resettlement allowance. Administrative and other cost for implementation of RAP is also considered. Provision amount based on compensation rates works out to ~**27.61 Cr.**

BRT along the alignment:

With regard to the first point, cost of breaking and restoration of the BRT has been considered @2.4 Cr/km duly escalated from 2Cr./km, which was the rate for breaking Delhi BRTS in 2016. Breaking of BRT corridor of 5.8km from Moolchand to Ambedkar Nagar cost ~12 Cr.

Table 140 : Basis of BRT dismantling cost

Corridor	Length	Cost of Breaking @FY 15 price levels	Per km Cost of breaking @ FY 15 price levels	Per km Cost of breaking @ July 21 price levels
Delhi BRT (Moolchand to Ambedkar Nagar)	5.8km	~12 Cr	~2Cr/km	2.4 Cr/km

Cost of construction of BRT is taken as 20 Cr. per running km based on 12th Five Year Plan and First-hand interactions with PMPML. The total cost of dismantling and restoration works out to **Rs 17.91 Cr.** for affected length of ~0.8 km.

16.6 Traction and Power supply

Provisions have been made to cover the following sub heads, some of which is existing from Phase 1:

- ROCS
- Auxiliary sub-stations (ASS) are envisaged to be provided at each station (1 ASS for Underground station) for stepping down 33 kV supply to 415 V for auxiliary applications.
- 25kV switchgear along the line.
- SCADA augmentation
- Miscellaneous items e.g. Illumination, lifting, T&P and C&M for traction part etc.
- RSS proposed near Swargate station.

The rate has been worked out in line with benchmarking of cost issued by GOI, 2019.

HT cabling cost has been considered based on actual length of 15km (2.5km X 6runs) @ Rs 1.69 Cr. Per km and GIS type RSS is considered based on the cost Benchmarking issued by MOHUA, 2019.

16.7 Rolling Stock

The rate has been worked out in line with benchmarking of cost issued by GOI, 2019.

16.8 Depot

Elevated Stabling lines have been proposed near Nigdi station of corridor 1A. Total cost of which works out to Rs 11.72 Cr without land. Cost of land acquisition out to Rs 5.43 Cr.

16.9 Taxes and Duties

The details of taxes and duties are detailed as below,

TAXES & DUTIES

S. No	Description	Total cost (Cr.)	Imported Materials (%)	Indigenous Materials (%)	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 GST (Taxes & Duties) (Cr.)
1	Alignment & Formation											
1.1	Underground Section - Twin Tunnel	1,052.10	20	80	10.84	19.91	19.91	50.66	50.50	50.50	101.00	151.66
1.2	Viaduct for Stabling Line/Depot	37.63	10	90	0.19	0.36	0.36	0.91	2.03	2.03	4.06	4.97
2	Station Buildings including Architectural Finishes, Lifts & Escalators											
2.1	Station Building - Cut & Cover	570.00	20	80	5.87	10.79	10.79	27.45	27.36	27.36	54.72	82.17
2.2	E&M tunnel ventilation incl. Lifts & Escalators	169.51	40	60	3.49	6.42	6.42	16.33	6.10	6.10	12.20	28.53
2.3	Ventilation Shaft between Station 2 & Station 3	50.00	20	80	0.52	0.95	0.95	2.41	2.40	2.40	4.80	7.21
3	Stabling Lines											
3.1	Civil works, OHE, Signaling, Telecom, etc.,	11.72	10	90	0.06	0.11	0.11	0.28	0.63	0.63	1.27	1.55
4	Permanent Way											

4.1	Ballastless track for Main Line	40.75	20	80	0.42	0.77	0.77	1.96	1.96	1.96	3.91	5.87
4.2	Ballastless track for Depot/Stabling Line	6.71	20	80	0.07	0.13	0.13	0.32	0.32	0.32	0.64	0.97
5	Traction & power supply incl. OHE, ASS etc. Excl. lifts & Escalators											
5.1	Underground Section	71.01	40	60	1.46	2.69	2.69	6.84	2.56	2.56	5.11	11.95
5.2	HT Cabling 132 KV - Single core	25.42	40	60	0.52	0.96	0.96	2.45	0.92	0.92	1.83	4.28
5.3	RSS	50.85	40	60	1.05	1.92	1.92	4.90	1.83	1.83	3.66	8.56
6	Signalling and Telecom											
6.1	Signalling											
a	Main Line including OCC	27.17	50	50	0.70	1.29	1.29	3.27	0.82	0.82	1.63	4.90
b	On Board Equipment	26.90	50	50	0.69	1.27	1.27	3.24	0.81	0.81	1.61	4.85
6.2	Telecommunication											
a	Station	15.26	50	50	0.39	0.72	0.72	1.84	0.46	0.46	0.92	2.75
7	Enviornment & R & R incl. Hutments etc.											
7.1	Environmental Cost	3.32	0	100	0.00	0.00	0.00	0.00	0.20	0.20	0.40	0.40
8	Misc. utilities etc											
8.1	Civil works	18.52	0	100	0.00	0.00	0.00	0.00	1.11	1.11	2.22	2.22
8.2	Electrical Works	18.52	0	100	0.00	0.00	0.00	0.00	1.11	1.11	2.22	2.22

9	Platform Screen Doors (PSD)	10.17	40	60	0.21	0.38	0.38	0.98	0.37	0.37	0.73	1.71
10	Security											
10.1	Civil works	1.25	0	100	0.00	0.00	0.00	0.00	0.08	0.08	0.15	0.15
11	Multimodal Integration and Last mile connectivity	10.17	0	100	0.00	0.00	0.00	0.00	0.61	0.61	1.22	1.22
12	Rolling Stock	162.73	40	60	3.35	6.16	6.16	15.67	5.86	5.86	11.72	27.39
13	General Charges	118.99	0	100	0.00	0.00	0.00	0.00	10.71	10.71	21.42	21.42
	TOTAL	**2,498.70**			**29.84**	**54.83**	**54.83**	**139.50**	**118.73**	**118.73**	**237.46**	**376.96**
											Total Central GST & Basic Custom Duty	**203.40**
											Total State GST	**173.56**
											Total Taxes & Duties	**376.96**
											Total Taxes & Duties (incl. Escalation)	**440.32**

COMPONENT WISE ESCALATION FOR SWARGATE - KATRAJ EXTN. LINE (RS. IN CRORE)

Yr	Year	Cost Distribution	Land Distribution	Cost at July '21 Price Level					Escalation Factor	Completion Cost				
				Component Cost incl. GC and contingency without Taxes, Land, R&R	Central Taxes	State Taxes	Land and R&R	Total Cost		Completion Cost incl. GC and contingency without Taxes, Land, R&R	Central Taxes with escalation	State Taxes with escalation	Land and R&R	Total Completion Cost
	2021-22								1.000					
Y1	2022-23	10.0%	20%	257.01	20.34	17.36	31.36	326.07	1.050	269.86	21.36	18.22	32.93	342.37
Y2	2023-24	20.0%	50%	514.02	40.68	34.71	78.41	667.82	1.103	566.71	44.85	38.27	86.45	736.27
Y3	2024-25	30.0%	30%	771.03	61.02	52.07	47.05	931.16	1.158	892.56	70.64	60.27	54.46	1077.94
Y4	2025-26	25.0%		642.52	50.85	43.39		736.76	1.216	780.99	61.81	52.74	0.00	895.54
Y5	2026-27	15.0%		385.51	30.51	26.03		442.06	1.276	492.02	38.94	33.23	0.00	564.19
Total		**100%**		**2570.10**	**203.40**	**173.56**	**156.82**	**3103.87**		**3002.15**	**237.59**	**202.74**	**173.84**	**3616.31**

17. TRANSIT ORIENTED DEVELOPMENT PLAN

17.1 TRANSIT ORIENTED DEVELOPMENT

Transit Oriented Development is essentially development, macro or micro that is focused around a transit node and facilitates complete ease of access to the transit facility thereby inducing people to prefer to walk and use public transportation over personal modes of transport. It could be located within a quarter- to half-mile radius of a transit station that offers a mix of housing, offices, shopping, and transportation choices within a neighbourhood or business district. The primary goals of TOD are to:

1. Reduce/discourage private vehicle dependency and induce public transport use – through design, policy measures & enforcement.
2. Provide easy public transport access to the maximum number of people within walking distance /through densification and enhanced connectivity.

The above goals can be addressed by two steps. Firstly, by getting more people close to the station, which can be done through densification and modifying mix of uses around the station. Following this, second step would be to facilitate the existing and proposed population to access the stations by addition and improvement of transport infrastructure. To achieve this paradigm shift, TODs offer attractive alternatives to the use of personal modes – pleasurable walking experiences, very easily accessible and comfortable mass transportation with easy, convenient and comfortable intermodal transfers for last mile connectivity and other low cost, comfortable, non- motorized transportation options. Figure below shows some of the transit-oriented development facilities.

Figure 105. **Figure 109 : Transit Oriented Development Facilities - Pedestrian Crossing, Segregated Lanes, Lane Markings, Bike Lanes**

Source: The NACTO Urban Street Design Guide

17.1.1 TOD - OBJECTIVES

- Increase 'location efficiency' to provide multi-modal transportation
- Boost transit ridership and minimize vehicular traffic.
- Provide a rich mix of housing, shopping, and transportation choices.
- Generate revenue for the public and private sectors.
- Provide value for both new and existing residents.
- Pedestrian and NMT friendly environment

- Manage parking, bus and vehicular traffic, parking for PT/IPT and NMT modes has been prioritized at-grade and on-street, within the station vicinity area.
- Design for pedestrian safety, comfort and convenience on all street's connectivity.
- Design infrastructure to ensure rapid and comfortable transfers.

17.2 National TOD Policy

17.2.1 Elements of TOD Policy

- The "TOD influence zones" shall be plotted at each Station area level by drawing the travel distance from the Centre of the Station in following manner:
  Intense TOD Zone - 300m buffer from transit stop/ station
  Standard TOD Zone – 800m buffer from transit stop/ station
- The types of planned and unplanned development within the Zone 1 Standard TOD and Zone 2 Intense TOD influence zones may be categorized into three broad categories: Redevelopment, Greenfield and brownfield development.
- Redevelopment/ Infill: Infill Sites are empty sites within Existing Urban Area which may have opened for development.
  Redevelopment sites could be any of the following:
  i. Low density areas with gross density less than 250 du/ha
  ii. Shopping/ Commercial centres
  iii. Industrial areas/ clusters
  iv. Resettlement Colonies
  v. Unauthorized colonies
  vi. Urban Villages
  vii. JJ clusters
- Redevelopment projects with FAR above 1.5 to be located only within Intense TOD zone. For commercial development, at least 50% of total street frontage length to be active frontage.
- FAR below 3 is not desirable (Within 800m influence zone)
- Non-Permissible Uses for all new projects within TOD Intense Zone as per above policy:
  i. Car-sales showrooms
  ii. Banquet halls
  iii. Automobile-repair/ services/ vehicular servicing shops
  iv. LPG Godowns
  v. Electric Substation 220 KV (Check Buffer requirement/restriction)
  vi. Bus Depot (permitted only if clubbed with terminal and in the form of mixed-use development site)
  vii. Cremation ground
  viii. Stand-alone Multi Level Parking without on-site mixed use.
  ix. Open ground parking lot (if provided shall be counted as FAR consumption)
  x. Any trade or activity involving any kind of obnoxious, hazardous, inflammable, non-compatible and polluting substance or process shall not be permitted.

17.3 Need of Detailed TOD Study

TOD proposal will increase 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. The transit corridor will have 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.

To make the Transit system successful and to absorb the development potential created due to transit system, pre-requisite is for the population to shift from private mode of travel to the mass transit. Such condition can be satisfied if more population and trip attracting activities are concentrated in the vicinity of transit line. Thus, by bringing people close to the transit system, they are facilitated to shift to public mode of travel. Such development can be encouraged by proposing high density residential, commercial and mixed-use development close to the transit system. Thus, by integrating land use and transport planning, planned sustainable urban growth centres can be promoted, having walkable and liveable communes with high density mixed land-use.

Along with this, TOD creates additional value to land, property and businesses, with better accessibility and more efficient use of land with higher density, leading to agglomeration benefits. VCF mechanisms gives opportunity to capture the value of these benefits from the beneficiaries. In TOD influence area, premium levy can be charged on incremental FAR proposed. Thus, this amount shall be used to fund Metro. Thus, in order to identify TOD potential in the study area, station wise detailed assessment is done. For easy execution of the TOD proposal, provision of legislative proposal shall be made in the implementation plan.

17.1 TOD Proposal for Pune Metro Corridor 2A: Swargate to Katraj

17.1.1 Integrating Land use and Transportation and Using Land as a resource: Approach for TOD Implementation

17.1.1.1 Influence area demarcation

The area in the immediate vicinity of the transit station or transit line, i.e. within a walking distance, having high density compact development with mixed land use to support all basic needs of the residents is called the influence zone of a transit station/ corridor. Influence zone is established along the transit corridor. It has been identified as a delineated zone (around 500m) on either side of the transit corridor within 10 - 12 minutes walking distance. This area of influence is demarcated as planning area for TOD implementation.

17.1.1.2 Densification

Densification is promoted in the influence area by providing higher Floor Area Ratio (FAR)/ Floor Space Index (FSI) and higher population & job density as compared to the area around and beyond the influence areas. Density and FAR is not kept consistent across the influence area. To ensure sustainable development, the minimum FAR proposed is 2 and maximum goes upto 4 , depending on the accessibility of the locality. This will promote higher concentration of people within the walking distances of transit station, thereby increasing the ridership of the public transport and resulting in increased fare revenue, pollution and congestion reduction.

17.1.1.3 Mixed use development

Mixed land use is stipulated for development/ redevelopment in the TOD zone as it would reduce the need for travel by providing most of the activities such as shopping, entertainment and public amenities. within the walking distance of the residents. It would also link origins and destinations, i.e. residences with work places or activity nodes. This would ensure better utilization of transit fleet by distributing loads in both directions, rather than creating unidirectional peak hour flows. To promote such development, 200m buffer from the transit station is reserved for mix of high grade commercial and Residential development, which will be used for mix of uses. Existing commercial development within the influence zone of 200m are also permitted to be developed with FAR 4. High grade Commercial development is proposed along the existing arterial road i.e. Pune Satara Road, to minimise the requirement of Road Widening. Existing arterial road with ROW of 51m can easily serve the high-density commercial development with FAR 3 to 4. This commercial corridor will have an 'active frontage' which will provide for pedestrian safety. This will satisfy the TOD principle which says, 'At least 50% of total street frontage length needs to be active frontage'. Following the commercial belt, high density residential development is envisaged. Existing residential areas and areas under Public Semi-Public uses are left untouched.

17.1.2 Inventory (within 500 M either side) & Overall Activity Pattern

Land use distribution in the influence zone reflects that a small chunk of land i.e. is reserved under industrial use, which comprises to be low density development. This 2.25% of industrial land has potential for re-development under TOD principals as no rehabilitation will be involved. Along with this, 0.38% of land is commercial land, which can be densified with the provision of high FAR. Slum pockets present in the study areas can also be redeveloped into high density residential development.

Land Use	% breakup
Residential	54.12
Commercial	0.38
Industrial	2.25
PSP	7.41
Recreational Green	3.12
Forest	5.51
Water body	4.77
Utilities	1.55
Roads	20.88

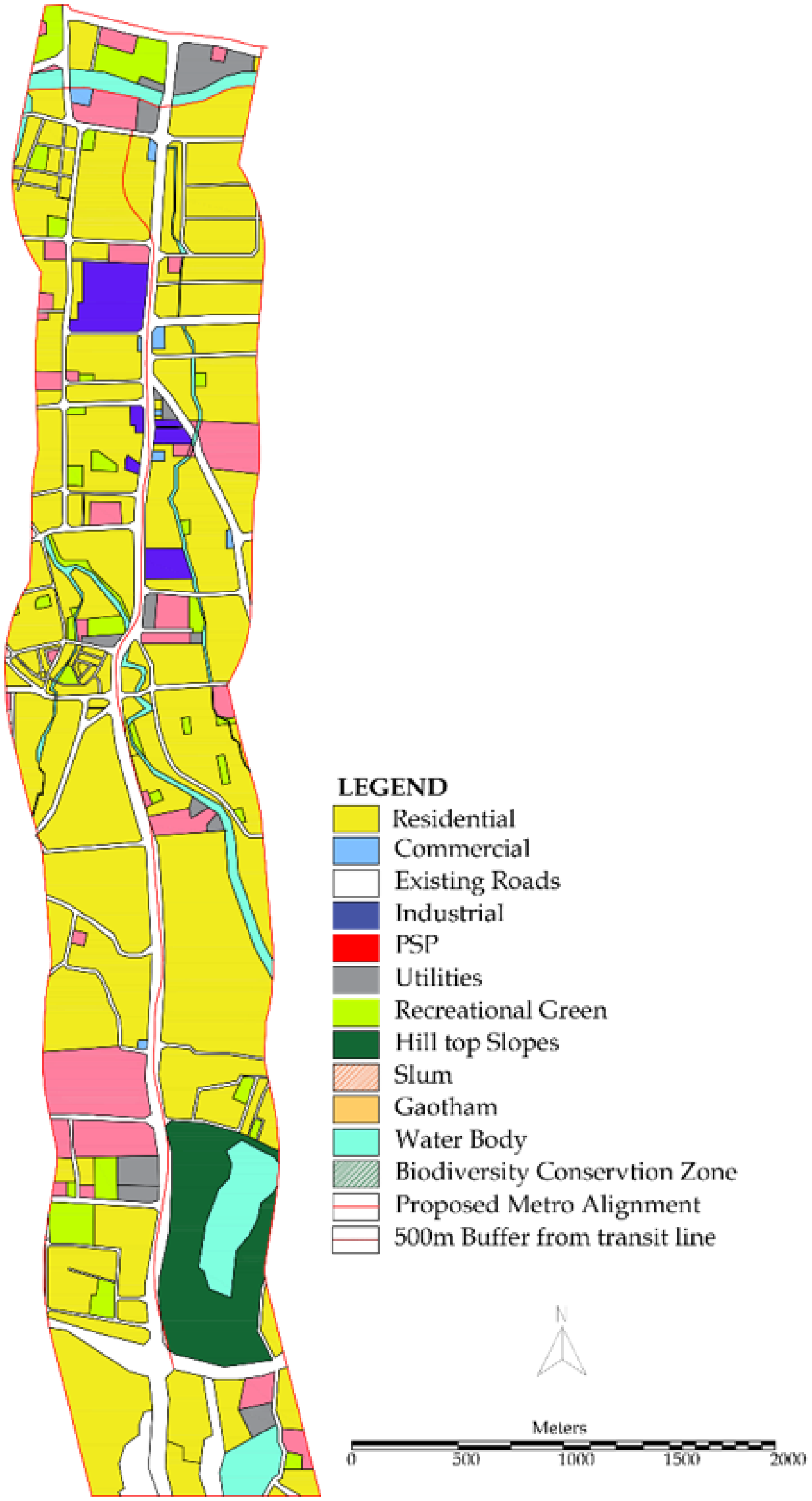
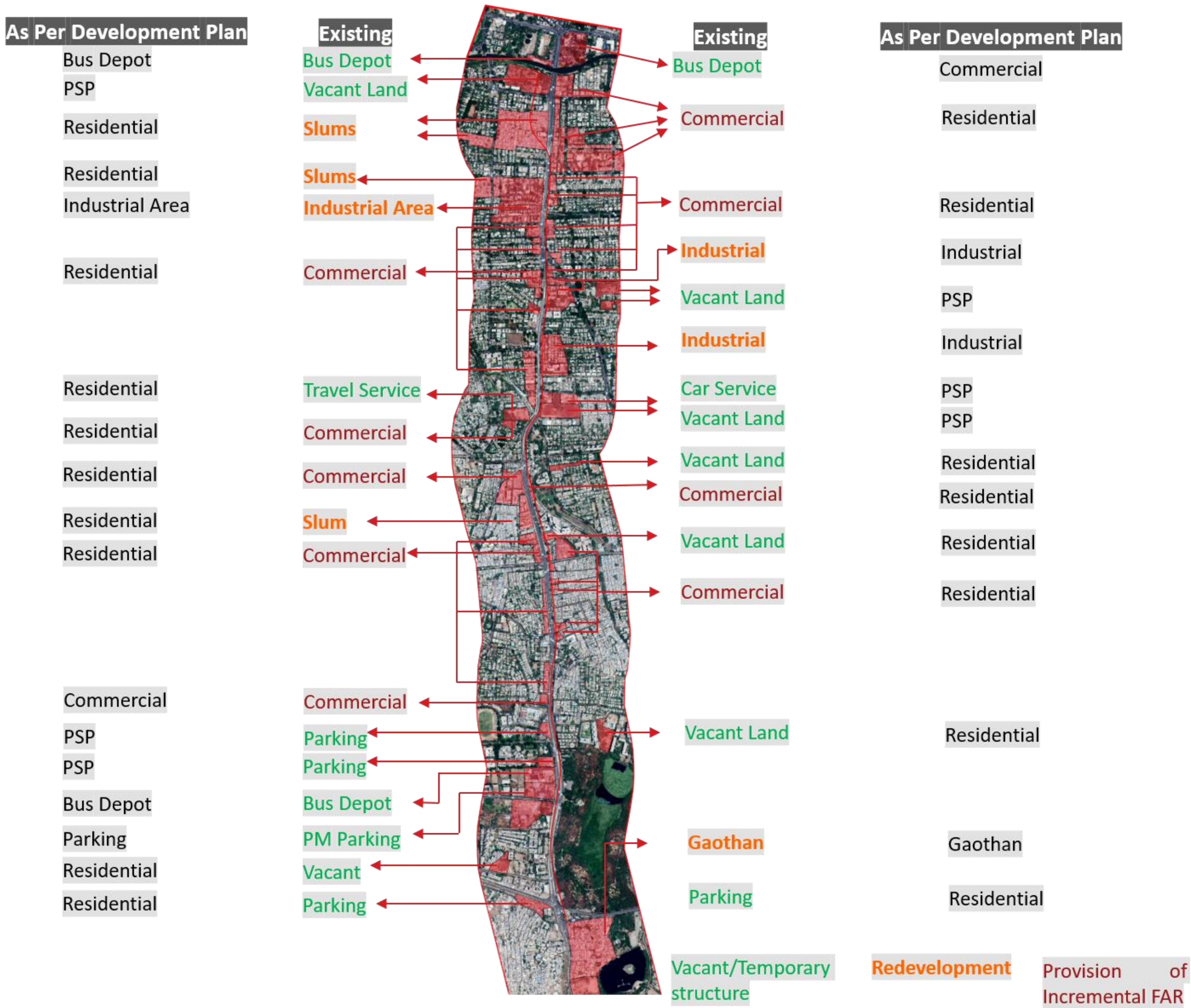


Figure 110 : Land use distribution of TOD zone

17.1.3 Inventory (within 500m either side)



Inventory of land parcels with potential for redevelopment and densification has been identified. Such parcels are mostly vacant land, Surplus government land, Bus Depots, Open parking spaces and existing low-grade commercial spaces. Locations and areas of such spaces are listed down along the identified corridor. As per the inventory, 10.7 million sqft of space is identified with potential of densification, summary of which is given below:

Table 141 : summary of Potential land available for application of TOD Policy

Land Type	Area (Mn sft)
Vacant Plot	2.26
Low Rise Commercial Development	1.37
slum Redevelopment	2.13
Industrial Redevelopment	1.25
Government Land	3.38

17.1.4 Assessment of Development Potential

Higher FSI is promoted in the influence area, which is not consistent throughout the area. FAR Proposed varies with plot size and width of access road. FAR is Proposed as per TOD guidelines stipulated in DCR Rules of PMC, 2017, clause 24.8.3 (Exhibit 1 at the end of the chapter).

Maximum permissible FSI shall be determined by satisfaction of both the criteria's i.e. Minimum road width as well as plot area, as shown in the table below:

Plot area (sqm)	ROAD WIDTH					
	Less than 9m	9m to up to 12m	12m to up to 18m	18m to up to 24m	24m to up to 30m	30m and above
Below 1000	Basic FSI	2	2	2	2	2
1000 to below 2000	Basic FSI	2	2.5	2.5	2.5	2.5
2000 to below3	Basic FSI	2	2.5	3	3	3
3000 to below 4000	Basic FSI	2	2.5	3	3.5	3.5
4000 or above	Basic FSI	2	2.5	3	3.5	4

Existing commercial space (low grade), vacant plots, Parking areas/Bus Depots, Slums, Industrial areas identified in the inventory are densified and thus development potential is identified. Considering the proposal of high FAR (as per DCR Rules), total of 38.22 Million Square Feet of high grade commercial and high dense residential potential can be achieved, summary of which is given below

Table 142 : Summary of development potential in TOD influence zone

	Vacant Plot (mn. Sft)	Slum Redevelopment (mn. Sft)	Government Plot (mn. Sft)	Industrial Redevelopment (mn. Sft)	TOTAL (mn. Sft)
Station 1 (Near Market Yard, Gultekdi)	4.52	7.11	7.91	3.90	23.44
Station 2 (Padamavati)	5.69	0.00	1.03	1.12	7.84
Station 3 (Near Katraj)	0.47	0.73	0.15	0.00	1.35
Market Yard	0.00	0.00	5.58	0.00	5.58
TOTAL	10.68	7.84	14.67	5.02	38.21

To ascertain mixed use development along with the required street network, the minimum plot area in the influence zone is defined. In order to avail high FAR provision under TOD Policy, smaller plot owners are assumed to amalgamate plots for development. Thus, wherever required, smaller vacant plots are assumed to be amalgamated and will thus be developed with potentially high FAR.

In order to depict application of TOD Policy within the influence area along Metro corridor from swargate to Katraj, redevelopment of industrial areas and slum redevelopment proposals are made. Industrial area considered for redevelopment here are Parvati Industrial area and Bibvewadi Industrial area. Following slum pockets are identified and proposed to be redeveloped : Parvati Darshan slum, shiv Darshan Slum, Shelke Basti slum, Slum Near Central Govt. Health Scheme, Sambhaaji Nagar Slum and anna Bhai Sathe jhopadpatti complex. Rest vacant plots are proposed to be developed with high FAR as per TOD Norms.

Influence area is divided into 6 sites and thus redevelopment Proposal is given:

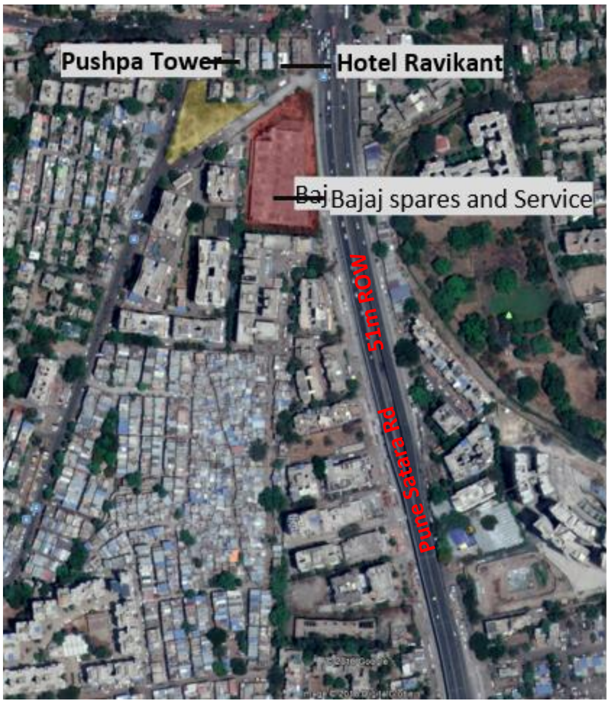
Site is divided into 6 sites and thus redevelopment Proposal is given:

17.1.4.1 Site 1 of 6

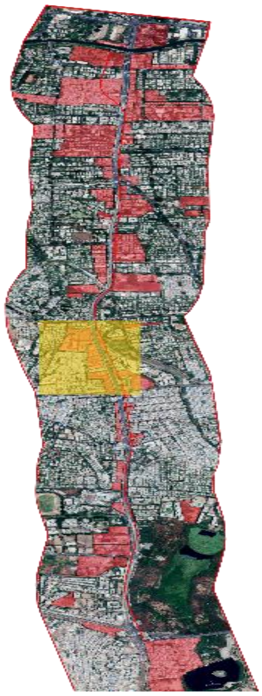
KEY MAP

Redevelopment of Ice Factory has potential to generate 1825646 sqft of commercial developable space. Similarly, Redevelopment of existing low-grade commercial space of SBI Bank has potential to generate 248705 sqft of commercial developable space. PMC Bus depot and parking space of 476221.2 sqft shall be used to generate revenue in form of property development of government land parcel. This land parcel shall be leased out to a private developer on 50 Year lease and thus shall generate 213 Cr.

17.1.4.2 Site 2 of 6



KEY MAP



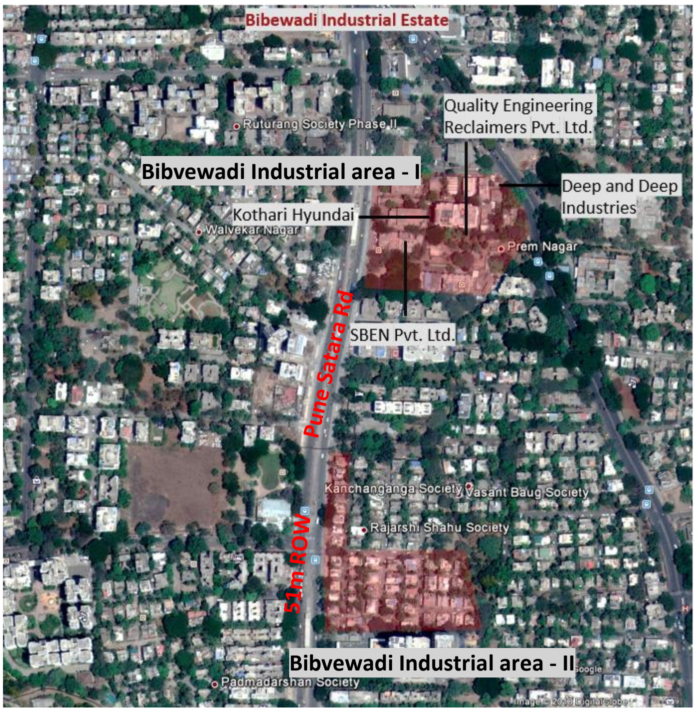
Redevelopment of a low-grade commercial space shall generate 226816.14 sqft of commercial developable space. Vacant Plot of 27733.82 sqft when developed with the proposed FAR of 2.5, shall generate 83201.45 sqft of residential developable space.

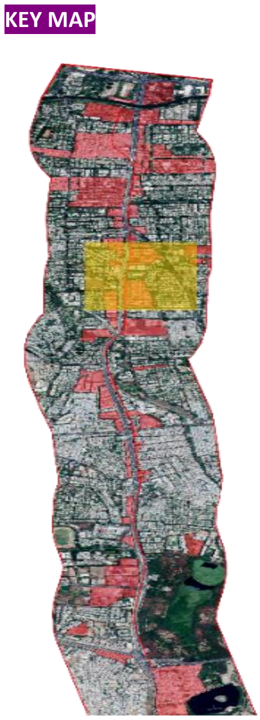
17.1.4.3 Site 3 of 6

KEY MAP

Existing Industrial area are proposed to be converted to high grade commercial or residential areas. Parvati Industrial area covers 811773 sqft of area. This conversion shall provide 3247094 sqft of developable space.

17.1.4.4 Site 4 of 6





Redevelopment of Bibewadi Industrial area shall generate 656983 sqft of high grade commercial or residential space. As abutting road has ROW 51m, FAR 4 can be proposed after amalgamation of Plots.

17.1.4.5 Site 5 of 6

Redevelopment of buildings, the entitlement of rehabilitation of area of an existing tenement is provided as per DCR Rules of PMC, 2017, clause 24.4. While redevelopment tenement size provided shall be equal to the carpet area of existing tenement plus 35% thereof. This additional carpet area will be dependent on plot size, as defined in the table below:

Area of Plot under Redevelopment	Additional entitlement (as % of carpet area of existing tenement)
Up to 4000sqm	Nil
4000sqm to 2 Ha	155
2Ha to 5 Ha	25%
5Ha to 10 Ha	35%
Above 10Ha	45%

After rehabilitation of existing tenements, 3. 82 sqft of developable space can be generated.

KEY MAP

Redevelopment of slum pockets shall generate 3.819 sqft of developable space Under

17.1.4.6 Site 6 of 6

KEY MAP

Similarly, with Redevelopment of Sambhaji Nagar vasti, 144101 sqft of developable space shall be generated.

Other vacant Plots generate 16.26 million sqft of developable potential as per prescribed FSI.

Summary of development Potential of vacant space is given in the table below:

Sr. No.	Notes	Ground Coverage(Sqft)	Abutting ROW DP	Proposed FAR	Development Potential (sqft)
1		456411.6	60	4	1825646.4
2		64750.4579	15	2.5	161876.1
3		50736.0689	15	2.5	126840.2
4	Plot Area 4458.6315	22237.3864	15	2.5	55593.5
5		125171.451	15	2.5	312928.6
6		85760.4142	60	4	343041.7
7		40947.0822	60	3.5	143314.8
8		90726.5709	60	4	362906.3
9	Plot size to be checked	27733.818	24	3	83201.5
10	Plot amalgamation	89139.5415	15	2.5	222848.9
11	24874.9513 is within TOD Zone(More than 50%)	493068.054	60	4	1972272.2
12	Plot size to be checked	58068.8068	60	4	232275.2
13	Plot amalgamation, Garages etc	116258.163	20	3.5	406903.6
14		22630.0869	60	3	67890.3
15	Plot amalgamation	68834.9898	18	3	206505.0
16	Plot amalgamation	332634.261	18	3	997902.8
17		330479.202	60	4	1321916.8
18		84774.7305	20	3	254324.2
19		19138.1184	10	2	38276.2
20		28337.3908	10	2	56674.8
21		49277.7596	10	2	98555.5
22	Plot amalgamation	16376.8347	10	2	32753.7
23		29127.3351	8	2	58254.7
24		39372.5594	12	2.5	98431.4
25	Plot amalgamation	21765.9965	60	4	87064.0
26		18493.6342	60	4	73974.5

KEY MAP

Summary of slum re-development Potential is summarised in the following table:

	Ground Coverage (Sqft)	Abutting ROW DP	Proposed FAR	Basic Tenement size (sqft)	Additional Tenement Size	Basic +Additional Tenement: Carpet area	Built-up area to be provided	Development Potential (Million sqft)
Slum 1 (Parvati Darshan Poorgrahst)	1003540	60	4	923256.7	35%	1246396.59	1780567	2.233
Slum 1 (Parvati Darshan Poorgrahst)	229613.5	24	3.5	211244.5	15%	242931.135	347044.5	0.456
Slum 2 (Shivdarshan Poorgrahst Vasahat)	74951.17	24	3.5	68955.1	15%	79298.3346	113283.3	0.149
Slum 2 (Shivdarshan Poorgrahst Vasahat)	420467.9	24	3.5	386830.5	15%	444855.053	635507.2	0.836
Slum 3 (anna Bhai Sathe)	72464.58	24	3.5	66667.4	15%	76667.528	109525	0.144
Slum 4 (Sambhaaji Nagar Slum)	208589.4	24	3.5	191902.2	15%	220687.558	315267.9	0.4147
Slum (Near Central Govt. Health Scheme)	122226.7	15	2.5	112448.6	15%	129315.89	184737	0.120
TOTAL								4.3 55

Slum redevelopment shall provide 2.01 million sqft of potential for high grade commercial/ residential potential. Along with this, 1.96 million sqft of area is provided for slum resettlement.

Summary of slum re-development Potential is summarised in the table below:

	Area(Sqft)	Abutting ROW DP	Proposed FAR	% Deduction for amenities	Effective Development Potential (sqft)
Parvati Industrial area	811773.6	60	4	25%	2435321
Bibewadi Industrial area	164245.9	60	4	25%	492737.7
Bibewadi Industrial area- II	280118.3	60	4	25%	840355

Redevelopment of industrial land will provide 5.02 million sqft of potential for high grade commercial/ residential potential. Industrial Plots are assumed to be amalgamated by an external actor , and thus shall be developed as per TOD Policy.

17.1.4.7 *Land Value Assessment & Revenue Potential*

Evidence from around the world demonstrates that well-conceived infrastructure investment generates benefits that exceed costs. This is a result of the indirect benefits offered by the investment. In other words, large scale public infrastructure investment leads to an increment in land and property valuation. Value capture refers to the recovery of a share of this increment. The appreciation usually occurs due to regulatory changes such as higher permissible densities and change in land use, investments in public goods infrastructure that increases quality of housing, jobs access and transportation, or social benefits and emergence of an important commercial, cultural, institutional, or residential developments in the neighbourhood. Land/ property owners in the proximity then become indirect beneficiaries of the appreciation in value without any effort. This appreciation is also in business opportunities. Value Capture Financing (VCF) is the mechanism of capturing the increment due to the appreciation in value. This fee levied, wherein a share of increased property value is levied as a charge is called as Premium levy.

TOD creates additional value to land, property and businesses, with better accessibility and more efficient use of land with higher density, leading to agglomeration benefits. VCF mechanisms gives opportunity to capture the value of these benefits from the beneficiaries. In TOD influence area, premium levy can be charged on incremental FAR provided. 50% of the value of incrementable developable space is charged as premium levy. This revenue generated through premium charge will be deposited in a separate amount by the municipality. This account will be ‘ Pune Infrastructure Development Fund’. This amount will thus be used for developing new infrastructure. Thus, this amount shall be used to fund Metro.

Total premium collection area is 12.011 Million sqft from vacant land and 3.64 mn sqft from industrial redevelopment and 2.01 mn sqft from slum re-development. Case wise summary of premium collection area is given below:

a. Vacant Lands

Sr. No.	Basic FAR	Proposed FAR	Incremental FAR	Development Potential (sqft)	Premium Potential (sqft)	ASR (sqft)	Premium Levy (Cr)
1	1.1	4	2.9	1825646.4	1323593.6	2432.2	161.0
2	1.1	2.5	1.4	161876.1	90650.6	2432.2	11.0
3	1.1	2.5	1.4	126840.2	71030.5	2432.2	8.6
4	1.1	2.5	1.4	55593.5	31132.3	2432.2	3.8
5	1.1	2.5	1.4	312928.6	175240.0	2432.2	21.3
6	1.1	4	2.9	343041.7	248705.2	2122.8	26.4
7	1.1	3.5	2.4	143314.8	98273.0	2122.8	10.4
8	1.5	4	2.5	362906.3	226816.4	3300.8	37.4
9	1.1	3	1.9	83201.5	52694.3	3300.8	8.7
10	1.1	2.5	1.4	222848.9	124795.4	3494.1	21.8
11	1.1	4	2.9	1972272.2	1429897.4	2432.2	173.9
12	1.1	4	2.9	232275.2	168399.5	1881.3	15.8
13	1.1	3.5	2.4	406903.6	279019.6	3152.2	44.0
14	1.1	3	1.9	67890.3	42997.2	3152.2	6.8
15	1.1	3	1.9	206505.0	130786.5	3279.5	21.4
16	1.1	3	1.9	997902.8	632005.1	2378.3	75.2
17	1.1	4	2.9	1321916.8	958389.7	3279.5	157.2
18	1.5	3	1.5	254324.2	127162.1	3279.5	20.9
19	1.1	2	0.9	38276.2	17224.3	2378.3	2.0
20	1.1	2	0.9	56674.8	25503.7	2378.3	3.0
21	1.1	2	0.9	98555.5	44350.0	2378.3	5.3
22	1.1	2	0.9	32753.7	14739.2	2378.3	1.8
23	1.1	2	0.9	58254.7	26214.6	2378.3	3.1
24	1.1	2.5	1.4	98431.4	55121.6	2378.3	6.6
25	1.5	4	2.5	87064.0	54415.0	2941.3	8.0
26	1.1	4	2.9	73974.5	53631.5	2941.3	7.9
Total							**1621.3**

Application of TOD Policy on vacant plots shall generate Rs. 1621.3 Crore as Premium levy.

a. Industrial Area

	Proposed FAR	Basic FAR	Incremental FAR	Development Potential (sqft)	% Area reserved for Amenities	Effective Premium Potential	ASR (sqft)	Premium Levy (cr)
Parvati Industrial area	4	1.1	2.9	3247094	25%	1765608	2613.3	230.708
Bibvewadi Industrial area	4	1.1	2.9	656983.6	25%	357234.8	2667.2	47.641
Bibvewadi Industrial area-II	4	1.1	2.9	1120473	25%	609257.3	2667.2	81.252
TOTAL								**359.601**

Application of TOD Policy through redevelopment of industrial areas shall generate Rs. 359.601 Crore as Premium levy.

b. Slum Redevelopment

	Basic FAR	Proposed FAR	Development Potential (sqft)	Built-Up area to be provided	Premium Potential from developer	ASR (sqft)	Premium Levy
Slum 1 (Parvati Darshan Poorgrahst)	1.1	4	4014159.70	1780567	1129699.23	3494.087	197.36
Slum 1 (Parvati Darshan Poorgrahst)	1.1	3.5	803647.42	347044.5	204028.04	3494.087	35.64
Slum 2 (Shivdarshan Poorgrahst Vasahat)	1.1	3.5	262329.08	113283.3	66599.47	3494.087	11.63
Slum 2 (Shivdarshan Poorgrahst Vasahat)	1.1	3.5	1471637.70	635507.2	373615.77	3494.087	65.27
Slum 3 (anna Bhai Sathe)	1.1	3.5	253626.04	109525	64389.96	193.3342	0.62
Slum 4 (Shankar Maharaj Vasahat)	1.1	3.5	730062.81	315267.9	185346.56	3494.087	32.38
Slum (Near Central Govt. Health Scheme)	1.1	2.5	305566.85	184737	0	0	
							340.91

Slum redevelopment shall generate Rs 340.91 though premium levy.

Thus, Revenue from Premium Levy over the development period (30 Years) will be Rs 2321.805 Crore. Per year revenue generated will be Rs. 77 crores. This amount will be shared with Maha Metro through Pune Infrastructure development fund. TOD revenue is expected to start from at least 7 years after commencement of the Project. Thus, Revenue generated through TOD in year FY 38 works out to 126.8 Cr. Per year premium earned by Maha Metro by application of TOD Policy is summarized in the table given below:

Table 143 : Per year premium earned by Maha Metro

Escalation from price levels at 2018-2019	2.5%
	Revenue from premium Levy
2037-38	127
2038-39	130
2039-40	133
2040-41	137
2041-42	140
2042-43	143
2043-44	147
2044-45	151
2045-46	155
2046-47	158
2047-48	162
2048-49	166

Escalation from price levels at 2018-2019	2.5%
	Revenue from premium Levy
2049-50	171
2050-51	383
2051-52	392
2052-53	402
2053-54	412
2054-55	422
2055-56	433
2056-57	444

17.1.5 PPP Potential

Property Development in Government Identified Land

One of the best ways to realize upfront revenues for the project is by giving the land to a private developer on lease for 50 years. Property with clear title of land with government under PMC has been proposed for the said development. The land area is approximately 51.73 acre. An FSI of 4, 3 and 3.5 is assumed for the proposed development, depending on the accessibility of the plot.

Another property considered for property development is Market yard which lies under the clear title of APMC. APMC runs one of the oldest wholesale markets in Pune. It comprises:

- Grain Market
- Vegetable and Flower Market

APMC has leased out plots on a 99-year lease to wholesale grain traders. However, the flower and vegetable market present an opportunity for re-location. Thus, this 32 Acre of land has been proposed for said development. An FSI of 4 is assumed for the proposed development, due on the accessibility of the plot. Thus, in order to realise the upfront revenue for the project, this parcel of land has been proposed to be leased out to a private developer on lease for 50 years. The value of clear ownership of the Market yard works out to 507 Crores.

The full value of clear ownership of the PMC and APMC owned land works out to 812 Crores.

Table 144 : Land Value

		Ground Coverage (Sqft)	Abutting ROW DP	Proposed FAR	Development Potential (sqft)	Capital Lease Inflow (Cr)
B1	PMPML Depot	476221.2	60	4	1904885.0	173
A2	Vacant Govt. Land	1414298	60	4	5657192	515
A1	PMPML	44250.41	60	4	177001.7	16
F1	Travel service	102365.9	60	4	409463.6	42
C1	Vacant/ PSP	121967.9	24	3.5	426887.7	45
D1	Parking/	22600.16	20	3	67800.5	7

		Ground Coverage (Sqft)	Abutting ROW DP	Proposed FAR	Development Potential (sqft)	Capital Lease Inflow (Cr)
E1	Travel Service (Katraj)	37025.96	60	4	148103.9	14
	TOTAL					812

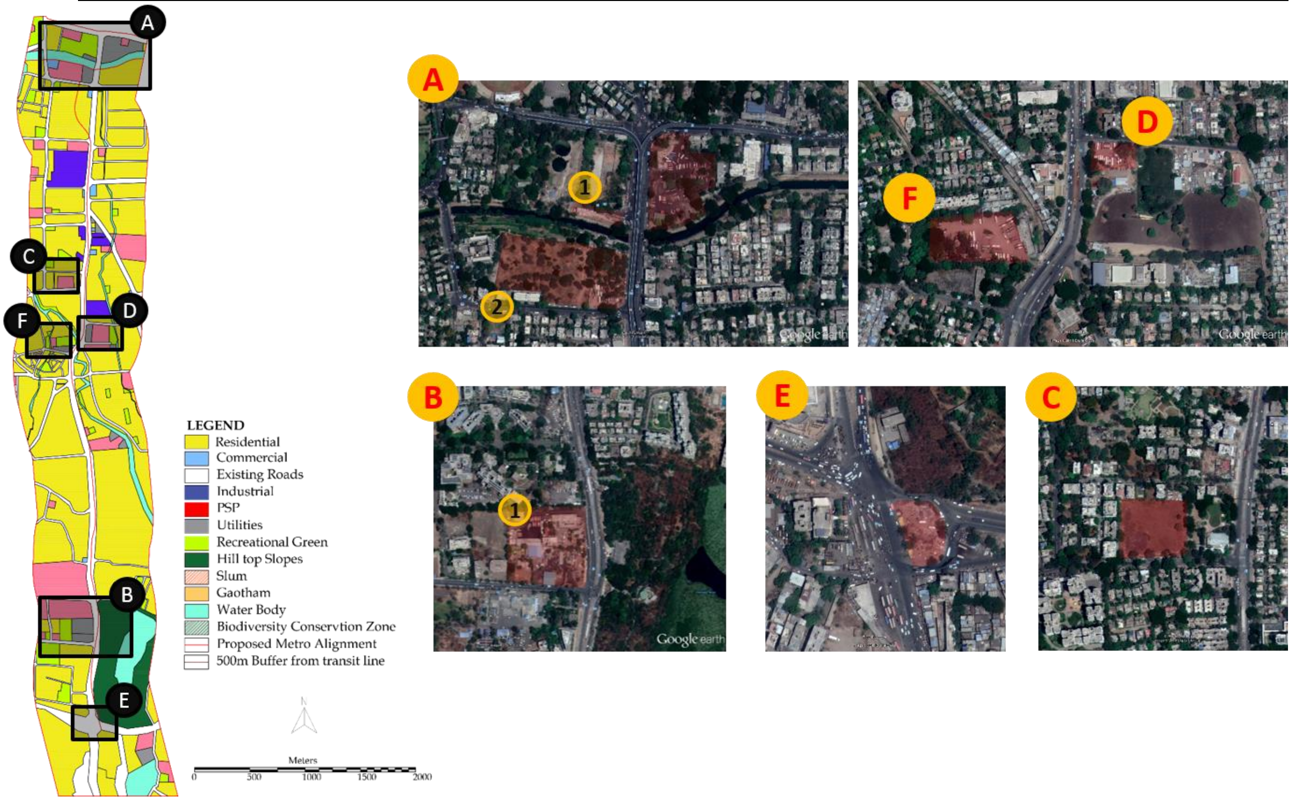


Figure 106. Location of Government Land Parcels considered for Property development

Assumptions made for inflows from asset monetization are:

- Lease Rental in the Area = 40 INR/Sqft/ Month
- Cap Rate = 10%
- Construction Cost = Rs 3500/sqft

From an accounting treatment perspective, this is treated as other equity in the balance sheet and not as Other Income. The other equity can be treated as deferred revenue year on year. However, in this model, the other equity item is not phased out.

17.2 Impact Assessment of TOD Proposal

Population growth is bound to happen with TOD. Increases residential FAR implies densification of the area. Average Population density proposed will be 180 PPH for areas which are proposed to be developed with FAR 2 and 225 PPH for areas which are proposed to be developed with FAR 2.5, 270 for areas which are proposed to be developed with FAR 3, 310 PPH for areas which are proposed to be developed with FAR 3.5 and 360 PPH for areas which are proposed to be developed with FAR 4. Thus, average Projected population after 30 years will be 69745 Persons. This Projected Population was then compared with the population projected in the comprehensive mobility Plan of Pune, 2018. Pune average density in 2011 is 30.4 DU/Ha and is projected to be 40.1 DU/Ha in 2031 and 51.3 DU/Ha in 2031 in CMP. This density is thus projected to year 2051 through curve fitting method. Population density thus came out to be 71.99 DU/Ha. Correlation factor for such curve is coming out to be 0.99, depicting the reliability of the relation. This projected density is applicable for very low-rise development with the basic FAR of 1. Population density is thus calculated for proposed residential FAR 4, 3.5, 3, 2.5 and 2 each. Projected population in such a case will be 55943 persons. This population as per the methodology adopted in CMP is comparable 69745 persons as per methodology used in this report.

Demand for infrastructure will increase with this incremental population, thus cost of development of the area will increase. Cost of development will comprise of two components i.e. Infrastructure Provision and Road Widening, which are discussed in detail in next section.

17.3 Implementation Mechanism

Land use structure of the influence zone is proposed, wherein high-density residential development and high-grade commercial development is encouraged. Industrial uses are replaced with high grade commercial development / dense residential. Existing slums are proposed to be redeveloped. For effective implementation of TOD Policy, Plots with good accessibility are proposed to be developed with high FSI. Minimum ROW required to propose incremental FSI is 9m. Plot size is also considered while proposing high FSI.

Apart from Road widening, Other utilities and infrastructure will also have to be proposed to provide for increment population. In case of Industrial to Residential conversion, land must be reserved for amenities and public services in order develop the plot with high FAR as per DCPR Rule Clause M 6.4. Area will be reserved for public amenities based on plot size in following manner:

Plot Size	% Area Reserved
< 2Ha	5%
2-5Ha	20%
>5Ha	25%

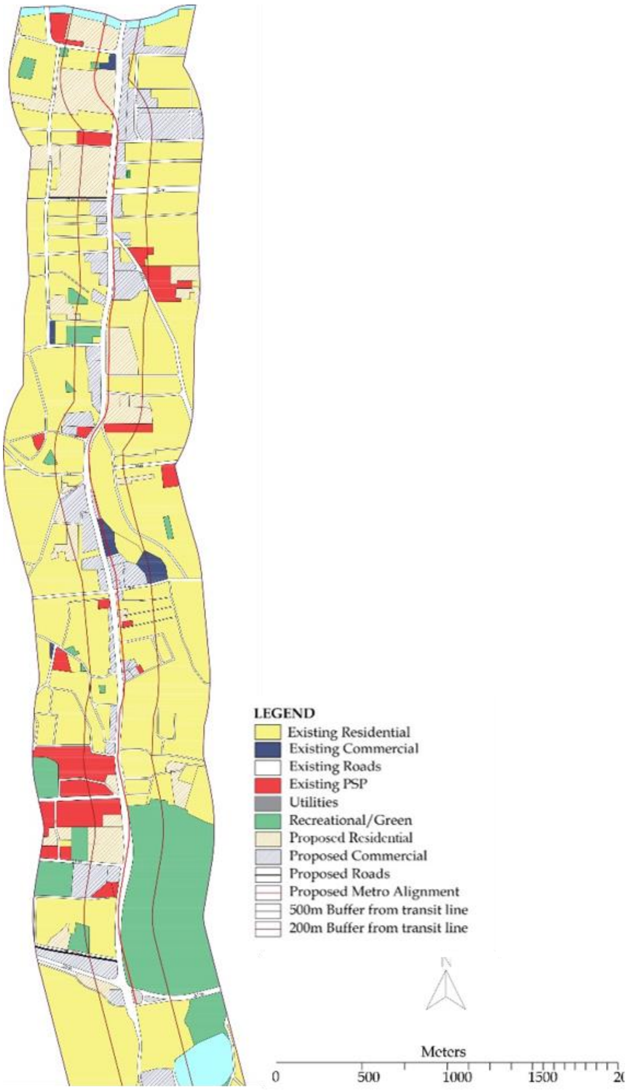


Figure 107. Proposed development pattern for TOD influence area over 30 years

Infrastructure cost is assumed to be Rs. 50INR/sqft of developable area proposed. Thus, total cost for infrastructure provision shall be Rs 191 crore.

Thus, at the expense of Rs 191 Cr, Premium Levy over the development period (30 Years) of Rs. 2321.8 crores shall be earned. Therefore, Share of Premium levy for the finance of Maha metro shall be 97 Cr from the year of operation i.e. FY 2027-28.

Table 145 : Summary of TOD Proposal

Total Development Potential Available based on additional FSI	88.22 Million sft
Total Premium Amount to be collected (@FY 19 price levels)	2321.8 Cr.
TOD Implementation Cost (@FY 19 price levels)	191 Cr.
Net TOD Revenue (@FY 19 price levels)	2130.8 Cr.

EXHIBIT 1 – TOD – Development Control Rules, Pune Municipal Corporation, 2017

24.8 TRANSIT ORIENTED DEVELOPMENT (TOD)

24.8.1 Definitions

(i) **TOD zone** :- It is the area along/around the proposed MRTS/Metro corridor as will be delineated by Pune Municipal Corporation with approval of the State Government.

(ii) **Base permissible FSI** :- It is the FSI that is otherwise permissible on any land with respect to zone shown as per the sanctioned development plan and the relevant provision of the Principal DCR excluding the TDR and the premium FSI, redevelopment incentive FSI that can be received.

(iii) **Gross plot area** :- Gross Plot Area means total area of land after deducting area under reservation or deemed reservation like amenity space if any, area under D.P. Road and Road widening.

(iv) **Principal DCPR** : - Principal DCPR means these DC Regulations excluding the provisions regarding TOD zone.

24.8.2 Date of coming into force :- The date of coming into force of these regulations shall be the date as notified by the Government.

24.8.3 Maximum Permissible FSI :- The maximum permissible total FSI in TOD zone shall be 4.00 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 below-

Sr. No.	Road width in m.	Min .Plot Area in sq.m.	Maximum Permissible FSI
1	2	3	4
1	9 m. and up to 12 m.	Below 1000	2.00
2	12 m. and up to 18 m.	1000 or above	2.50
3	18 m. and up to 24 m.	2000 or above	3.00
4	24 m. and up to 30 m.	3000 or above	3.50
5	30 m. and above	4000 or above	4.00

Explanation:-

1) The maximum permissible FSI as per the above Table shall be determined by satisfaction of both the criteria's viz. Minimum Road width as well as plot area, simultaneously. However in case, both these criteria's are not satisfied simultaneously, the maximum permissible FSI

shall be the minimum of that permissible against each of these two criteria's, as illustrated below ;

Illustrations: -

Utilization of FSI

Plot Area in sqm	Road width					
	Less than 9mt.	9 m. and up to 12 m	12 m. and up to 18 m	18 m. and up to 24 m.	24 m. and up to 30 m.	30 m. and above
Below 1000	Principal DCPR	2	2	2	2	2
1000 to below 2000	Principal DCPR	2	2.5	2.5	2.5	2.5
2000 to below 3000	Principal DCPR	2	2.5	3.0	3.0	3.0
3000 to below 4000	Principal DCPR	2	2.5	3.0	3.5	3.5
4000 or above	Principal DCPR	2	2.5	3.0	3.5	4.0

24.8.3.1 **Premium to be Paid -** Additional FSI over and above base permissible FSI of respective land use zones as per principal DCPR, may be permitted on the payment of premium equivalent as would be decided by Government from time to time.

24.8.3.2 **Integrated Mobility Plan**:- There shall be an Integrated Mobility Plan envisaging inter-linkages between different modes of mass transport, parking management, traffic management and pedestrianisation.

24.8.3.3 The maximum permissible FSI as given in Table under regulation 24.8.3 shall be calculated on the gross plot area.

24.8.3.4 In case of plot / plots falling partly within the TOD zone, the FSI permissible shall be as follows, provided that the total area of the plot (plot falling within TOD zone plus plot falling outside TOD zone) shall be as prescribed in the table in regulation no. 24.8.3 :-

(i) Where 50% or more area of such plot / plots falls within TOD zone, these regulations including FSI shall apply to the total area of such plot / plots.

(ii) Where less than 50% area of such plot / plots falls within TOD zone, these regulations including FSI shall be applicable to the part of plot / plots falling within TOD zone, whereas for the part of plot / plots falling outside TOD zone, these regulations except provisions regarding FSI shall be applicable. The FSI permissible for the part falling outside TOD zone shall be as per Principal Development Control Regulations.

Notwithstanding anything contained in any other provision of this DCPR the Parking, Double height terraces up to 20% and 15% balconies not enclosed, Stair cases, Lift wells with machine rooms, Refuge areas, Voids, Service Floor & Entrance lobbies of the building in TOD zone shall be free of FSI.

Notwithstanding anything contained in any other provisions of these regulations, TDR shall not be allowed to be received on the plots within TOD zone, irrespective of its location in congested area / non congested area as per the Development Plan of Pune.

24.8.4 Tenement Size

For any development or redevelopment within TOD zone, size of tenement shall be minimum 25 sqm and maximum 120 sqm of built-up area and out of total proposed tenements, the tenements equivalent to at least 50% of total FSI shall be of a size equal to or less than 60 sqm. These tenements shall not be allowed to be clubbed/amalgamated in any case.

24.8.5 Permissible mixed use in TOD zone:

Mixed use in the form of residential and commercial may be permissible on the residential plot in TOD zone fronting on the road width of 12 mt. and above. And mix use on plot / plots in commercial zone in Pune Municipal Corporation shall be permissible as per the principal DCPR and the maximum permissible FSI under these regulations shall be allowed on the payment of premium.

24.8.6 Other provisions regarding marginal open spaces shall be governed by the proposed height of structure, as given in the provisions 24.8.7 below and should conform to the Maharashtra Fire Prevention and Life Safety Measures Act, 2006 (Maharashtra Act no. III of 2007) as amended from time to time. No building permission shall be issued without NOC of the Fire Officer. Other regulations regarding room sizes, apertures for light and ventilation shall be as per the principal DCPR in force.

24.8.7 Marginal Spaces

Sr. No.	Building Height	Side and Rear Margins	Remark
a	15.0 mt and below	H/2-4	Minimum 3.0 mt. for Residential minimum 4.5 mt. for Commercial and Minimum 6.0 m. for Special Buildings.
b	Above 15.0 mt. and upto 24.0 mt.	H/4	
c	24.0 mt and above	H/5 subject to Maximum 12.0 mt.	

Note- However if Developer / Owner provides more than 12.00 mt. side and rear margins, it shall be permissible.

24.8.7.1 No projections shall be allowed in marginal spaces so that minimum 6 mt. marginal spaces remain free from all encumbrances for the movement of fire tenders. In case if ramp is necessary from accessibility, such ramp may be allowed after living 6 mt. clear margin,

24.8.7.2 For calculation of marginal distances the height of the parking floors (Maximum two floors above the Ground Level) shall not be taken in account, However height of such parking floors will be counted towards the total height of the building for deciding the building as high rise building and for civil Aviation purpose.

24.8.7.3 Car lift / mechanical parking shall be permissible, as per Principal DCPR as amended from time to time.

24.8.8 Parking

Parking in the TOD zone shall be provided as per the table given below.

Sr. No.	Occupancy	One parking space for every	Transit Oriented Development Influence Zone		
			Car	Scooter / Motorcycle	Cycle
1	Residential	**For 4 units** having carpet area From 25 and upto 40 sq.mt.	0	1	2
		For 2 units above 40 and upto 60 sq.mt.	**1**	1	2
		For every unit above 60 and upto 80 sq.mt.	1	2	2
		For every unit above 80 sq.mt	1	1	1
2	Govt. & Semi Govt. Private business buildings	100 sq.mt carpet area or fraction thereof	1	2	2

Note: i) Parking spaces for differently – abled persons shall be provided as per Indian Road Congress Code No. IRC 103:2012 in each new construction / development / re-development in the TOD zone.

ii) No on street parking shall be permissible, unless specifically allowed in the integrated mobility plan report.

24.8.8.1 Incentive for providing Public Parking in the area falling within the radius of 200 mt. from the Metro/MRTS Station.

If the owner / developer of the plot falling within the radius of 200 mt. from the Metro Station/MRTS, is willing to provide Public Parking space over and above the parking spaces required as per the table given in regulation No.24.8.8 of these regulations, the same shall be allowed and in that case the premium to be paid by such developer / owner as per regulation No.24.8.3.1 shall be reduced by the amount equal to the premium worked out for 25% of the area earmarked for such additional Public Parking space, subject to following conditions:-

a) Such parking area shall be in the built-up form and shall be handed over to Planning Authority free of cost before granting the Occupation Certificate to the project. The Planning Authority should enter into an agreement with owner / developer for such parking space at the time of granting Commencement Certificate to the project. Such Public Parking area shall be clearly shown on the proposed building plan / layout and a condition to above effect shall be incorporated in the Commencement Certificate.

b) The parking area shall have independent access from major road adjacent to the plot and with proper entry and exits.

c) The parking area to be made available at individual site shall be at minimum 100 sq.mt. at one place either at Ground floor / Stilt floor or first floor.

d) The maximum parking area that can be provided shall be decided by the Commissioner, Nashik Municipal Corporation , as the case may be, on considering the location of such site and the parking requirement.

e) A board showing the location of such public parking space should be displayed at suitable places by the Planning Authority.

f) Area covered under such parking shall not be counted towards FSI consumption.

g) Concerned land owner / developer / society / public company shall not be allowed to operate the public parking.

h) The proposed development shall be further subject to such conditions as may be decided by the Municipal Commissioner.

24.8.9 In case of metro rail, development or redevelopment, proposed by the Authority / individual applicant / any other Planning Authority, from the edge of the Metro Rail, within 20 mt. distance from the Metro Rail, on its either side, the concerned Planning Authority i.e. Pune Municipal Corporation before granting such permission for development / redevelopment shall seek prior NOC from the concerned Metro Railway Authority as required under the Metro Railways (Construction of Works) Act, 1978 from the point of view of safety of the Metro Railway and such other related matters.

24.8.10 In case of any conflict between these Regulations and any other Regulation/s of the DCR, these Regulations shall prevail for the TOD zone.

24.8.11 No Compound wall / fencing shall be permissible on the boundary of plot fronting on road and 50% front marginal distance (subject to minimum of 3.0 mt.) shall be kept accessible and to be used as foot paths, for pedestrians. However, it shall be permissible for the applicant to construct / erect fencing, on the boundary, after leaving the space for pedestrians as specified above.

However for the plots situated on 9mt. and 12mt. wide Roads having 100% residential use therefore above rule shall not be made applicable.

24.8.12 Large wholesale stores, car dealer showrooms, warehouses/storages, auto service centres, Garages etc. shall not be permissible in TOD zone.

24.8.13 Provision of Inclusive housing shall not be applicable in TOD zone.

24.8.14 For Gunthewari development regularized under the provisions of Maharashtra Gunthewari Development Act, 2001 and falling in TOD zone, seeking provisions for redevelopment, these regulations shall apply.

24.8.15 The width of passage shall be minimum 1.5 mt. for residential use & 2.0 mt. for commercial use.

18. FINANCIAL ANALYSIS AND NON-FARE BOX REVENUE ASSESSMENT

18.1 Introduction

The chapter seeks to examine the financial viability of the proposal to add to the existing metro network planned for Pune city. Based on the optimum routes discussed with Maha Metro and covered in the previous chapters, the existing metro line is proposed to be extended from PCMC to Nigdi on one end and Swargate to Katraj on the other. Chakan is an industrial suburb of Pune – having emerged as a major automobile hub. A new line connecting Chakan to Nashik Phata is also proposed.

This chapter evaluates the financial feasibility of this extended line from Swargate to Katraj. The proposed extension would be constructed at an approximate cost of **INR 3134.16 Crores** at July 2021 prices. This includes all central and state taxes. The total cost completion cost (excl. PPP components) works out to **INR 3,646.60Crores.**

Table 146 : Project Cost Details

Sr. No	Swargate to Katraj Corridor	July '21 Price Level (INR Cr.)	Compeltion Cost (INR Cr.)
1	**Without Land, R&R and taxes (Excl. PPP Comonent)**	**2600.39**	**3032.44**
2	**With Land, R&R and taxes (Excl. PPP Comonent)**	**3134.16**	**3,646.60**

Construction period start is assumed in November 2022 and period of construction is assumed as 4.5 years. Start of operations is assumed April 2028.

The total investment of **INR 3616.31 Crores** (Total Project completion cost: Rs **3,646.60** Cr minus IDC: Rs **30.29** Cr) is broken down by year is presented in the table below.

Table 147 : Project Cost Phasing

(RS. IN CRORE)

Yr	Year	Cost Distribution	Land Distribution	Cost at July '21 Price Level					Escalation Factor	Completion Cost				
				Component Cost incl. GC and contingency without Taxes, Land, R&R	Central Taxes	State Taxes	Land and R&R	Total Cost		Completion Cost incl. GC and contingency without Taxes, Land, R&R	Central Taxes with escalation	State Taxes with escalation	Land and R&R	Total Completion Cost
	2021-22								1.000					
Y1	2022-23	10.0%	20%	257.01	20.34	17.36	31.36	326.07	1.050	269.86	21.36	18.22	32.93	342.37
Y2	2023-24	20.0%	50%	514.02	40.68	34.71	78.41	667.82	1.103	566.71	44.85	38.27	86.45	736.27
Y3	2024-25	30.0%	30%	771.03	61.02	52.07	47.05	931.16	1.158	892.56	70.64	60.27	54.46	1077.94
Y4	2025-26	25.0%		642.52	50.85	43.39		736.76	1.216	780.99	61.81	52.74	0.00	895.54
Y5	2026-27	15.0%		385.51	30.51	26.03		442.06	1.276	492.02	38.94	33.23	0.00	564.19
Total		**100%**		**2570.10**	**203.40**	**173.56**	**156.82**	**3103.87**		**3002.15**	**237.59**	**202.74**	**173.84**	**3616.31**

18.1.1 Investment towards Rolling Stock

Total investment provided in the FIRR calculation towards requirement of additional rolling stock duly escalated @ 5% per annum to cater increased ridership is placed in table as follows:

Financial Year	No.of cars – Nigdi Katraj Corridor	Incremental Cars	Investment at escalated levels
FY 37	132	24	Rs 451.07 Cr
FY 47	150	18	Rs 551.06 Cr

18.1.2 O&M Costs

Energy Charges – Energy consumption figures for traction and auxiliary power over a 30-year period has been detailed below

Description	Traction		Auxilliary		Units
	Value (year 2026-2027)	Value (year 2056 - 2057)	Value (year 2026-2027)	Value (year 2056 - 2057)	
Load	1.14	1.24	9.88	9.88	MVA
Energy usage (annual)	6.78	7.35	29.20	35.04	million Units

Grid electricity charges are taken as 5.60 INR per KWH. 80% is assumed to be drawn from the grid and 20% from solar as per RESCO model. Solar charges are taken as 4 INR/KWH.

18.1.3 Employee Costs

The O&M staff is assumed to be provided @ 32 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 Pune metro phase 2A corridors is Rs. 8.94 Lakhs in the year 2018. The escalation factor used for staff costs is 7.5 % per annum to provide for growth in salaries.

18.1.4 Maintenance Costs

Maintenance costs have been arrived at basis the table below. Escalation of 5% has been assumed to arrive at 2023-24 costs.

Table 148 : Per unit cost of repairs and Maintenance of DMRC (2010 prices)

Unit Cost of Repairs and Maintainance of DMRC (2010 Prices)		
	2010 Prices	
Maintenance Cost	1.45	Cr/ km/ year
Length of Main Alignment	5.464	Km

Summary of O & M expenditure is as follows:

Table 149 : Year wise summary of Operation and Maintenance expenses

Financial Year	Energy Expense (Cr.)	Employee benefit expense (Cr.)	O & M Expenditure (Cr.)
FY 28	28	37	14
FY 29	29	40	14
FY 30	29	44	15
FY 31	30	48	16
FY 32	31	52	16
FY 33	31	57	17
FY 34	32	62	18
FY 35	33	68	19
FY 36	33	74	20
FY 37	34	80	21
FY 38	35	88	22
FY 39	36	95	23
FY 40	37	104	24
FY 41	38	113	26
FY 42	39	124	27
FY 43	41	135	28
FY 44	42	147	30
FY 45	43	160	31
FY 46	45	175	33
FY 47	46	190	34
FY 48	48	207	36
FY 49	49	226	38
FY 50	50	246	40
FY 51	51	269	42
FY 52	52	293	44
FY 53	53	319	46
FY 54	54	348	48
FY 55	55	379	51
FY 56	56	413	53
FY 57	57	450	56

Salvage value is considered as 0 for ease of calculation.

18.1.5 Replacement Cost

The replacement cost is provided for meeting the cost on account of replacement of equipment due to wear and tear. With the nature of equipment proposed to be provided, it is expected that only 50% of signalling and telecom and 25% of electrical works would require replacement after 15 years.

18.2 Revenue

The revenue streams for the project are detailed as under:

1.1 Fare Box Revenue

1.2 Non-Fare Box Revenue

1.2.1 Premium levy from property development along the development corridor

1.2.2 Sharing of Cess on stamp duty with PMC

1.2.3 Property Development on available Government Land

1.2.4 Advertising Revenue

1.2.5 ATMs/ Kiosks on Stations

18.2.1 Fare Box Revenue

The incremental trips per day on the Nigdi Swargate corridor and the trip length distribution is detailed in the following tables:

Table 150 : Projected Metro Ridership – Nigdi - Katraj

Year	Without Extension (PCMC-Swargate)	With Extension (Nigdi-Katraj)
2027	540000	668000
2037	677000	888000
2047	773000	1028000
2051	788000	1050000
2053	795000	1061000
2057	803000	1072000

Table 151 : Projected Metro Ridership – Nigdi - Swargate

Year	Without Extension (PCMC-Swargate)	With Extension (Nigdi-Swargate)
2023	466000	495000
2031	613000	651000
2033	634000	677000
2041	720000	782000
2043	738000	802000
2051	788000	858000
2053	795000	867000

Table 152 : *Average Trip length for incremental corridor*

Year	Without extension (Nigdi – Swargate)	With Extension (Nigdi – Katraj)
2027	7.90	8.09
2037	8.11	8.35
2047	8.28	8.63
2057	8.39	8.83

The fare box revenue has been calculated based on ridership in the full Nigdi-Katraj corridor, subtracting the farebox from Nigdi-Swargate Corridor.

The fare structure has been taken in accordance with Government Resolution No.PMR-3313/C.R.29/UD-7 and letter dated 29th October 2013 (refer Exhibit 1 at the end of chapter) vide which sanction was accorded to Sanction to the revised proposal of Pimpri- Chinchwad to Swargate and Vanaz to Ramwadi Metro Rail corridor of Pune Mahanagar Metro Rail Project. The letter also accorded in principal sanction to implement commuter fares as tabulated below as the Pune Mahanagar Metro Rail Project is proposed to be implemented under the provisions of Metro Railway Act enacted by the Government of India. The fares at 2018-2019 prices are detailed in Table 153:

Table 153 : Fare structure

Sr. No.	Distance in K.M.	Fare (Rs.) @ 2018-2019 Prices
1	0-2	13
2	2-4	17
3	4-6	20
4	6-9	25
5	9-12	27
6	12-15	30
7	15-18	32
8	18-21	35
9	21-24	37
10	24-27	38
11	27-30	42
12	More than 30 K.M.	45

The average incremental trip length is between 7 to 9 kms for the corridor – Nigdi to Katraj. Hence, the applicable fare slab is 6 to 9.

The above table is at 2019 price levels.

Table 154 : Fare structure Matrix

Distance (Km)	Fare as per table above	Fare @ start of project 2027-28	Fare Revision – FY 30
6 to 9	25	46	53

18.2.2 Non-Fare Box Revenue

>90% of non-fare box revenue for the extension would come in the form of revenue support from PMC – classified as Other Income in the Profit and Loss Statement. The IRR without non-operational non fare box revenue i.e. TOD works out to 6.5 %. This would be realized with a combination of:

- Share of premium levy on property development
- Share of cess on property registrations

The following section analyses and presents findings to make this practically realizable.

18.2.2.1 Premium levy from property development along the development corridor

TOD policy envisages extensive development for a width of 500 meters on either side of the transit corridor. This development potential has been analysed by an in-depth study of existing land use of plots along development corridor. Post this, a rigorous methodology was followed with a plot wise analysis to arrive at the true development potential of the development corridor. An assessment of associated costs that will have to be borne by the municipality in order to realize this development potential was also taken out. While this is covered in detail in the application of TOD policy chapter given below is a summary of the methodology followed:

- The area was divided into development zones based on distance from the station and distance from the transit line
- The individual plot end use was assessed.
- The width of the access road to the plot was assessed.
- Based on the above criterion, FAR of 3/ 4/ 2.5 and residential/ commercial was accorded to the individual plots.

We have fixed the premium on incremental FAR based on prevailing ASR rates. This additional revenue from higher FSI is assumed to be realized over a 30-year period. The same is escalated @2.5%.

Table 155 : Year wise share of Premium with Maha Metro

Year	Revenue to Metro from Premium Levy with Max FAR 4 (Rs. Cr)
FY 35	118
FY 36	121
FY 37	124
FY 38	127
FY 39	130
FY 40	133
FY 41	137
FY 42	140
FY 43	143
FY 44	147
FY 45	151
FY 46	155
FY 47	158
FY 48	162
FY 49	166
FY 50	171
FY 51	175
FY 52	179
FY 53	184
FY 54	188

FY 55	193
FY 56	198
FY 57	203
FY 58	208
FY 59	213
FY 60	218
FY 61	224
FY 62	229
FY 63	235
FY 64	241

18.2.2.2 Sharing of Cess on stamp duty with PMC

FY 19 – 1% cess collection on stamp duty in PMC stood at 258 Crores. 25% share per year from the same is proposed to be given as revenue support to the extension from Swargate to Katraj over a 30-year period and assumed to be escalated at 2.5%.

Table 156 : Year wise share of cess on stamp duty with Maha Metro

Year	Revenue to Metro from Cess on Stamp Duty (Rs. Cr)
FY 35	95.9
FY 36	98.3
FY 37	100.8
FY 38	103.3
FY 39	105.9
FY 40	108.5
FY 41	111.2
FY 42	114.0
FY 43	116.9
FY 44	119.8
FY 45	122.8
FY 46	125.9
FY 47	129.0
FY 48	132.2
FY 49	135.5
FY 50	138.9
FY 51	142.4
FY 52	146.0
FY 53	149.6
FY 54	153.3
FY 55	157.2
FY 56	161.1
FY 57	165.1
FY 58	169.3

FY 59	173.5
FY 60	177.8
FY 61	182.3
FY 62	186.8
FY 63	191.5
FY 64	196.3

At FY 35 Price levels, the cess and Premium sharing with Maha Metro would translate into an annual revenue grant of 213.7 Crores.

18.2.2.3 Property Development in Government Identified Land

Property with clear title of land with government under PMC has been proposed for the said development. The total land area is approximately 39.32 acre. An FSI of 4 is assumed for the proposed development.

One of the best ways to realize upfront revenues for the project is by giving the land to a private developer on lease for 50 years. The full value of clear ownership of the land works out to 1319 Crores.

Table 157 : Land value

Land Plots	Ground Coverage(Sft)	Proposed FAR	Capital Lease Inflow (Cr.)
PMPML Depot	476221	4	173
Vacant Govt. Land	1414298	4	515
PMPML	44250	4	16
Parking/Travel service	114366	4	42
Vacant/PSP	141968	3.5	45
Parking/Travel Service	24600	3	7
Govt. Land (Katraj)	38026	4	14
Market Yard	1393914	4	507
TOTAL			1319 Crore

This amount is expected to be realized in FY 28 when the metro becomes operational so that the developer does not price the construction risk of the project into his quote and maximum possible value is realized.

From an accounting treatment perspective, this is treated as other equity in the balance sheet and not as Other Income. The other equity can be treated as deferred revenue year on year. However, in this model, the other equity item is not phased out.

18.2.2.4 Advertising Revenues

The following sources of advertising revenues are evaluated in the said report:

Station boards – Based on typical station alignment - 120 Sqm of advertising space is identified per station. Occupancy rate from start of operation has been identified as below with occupancy rates remaining constant at 85% FY 37 onwards:

Table 158 : Year wise occupancy rate of station boards on stations

2027-28	2028-29	2029-30	2030-31	2031-32	2032-33	2033-34	2034-35	2035-36	2036-37
50%	60%	60%	60%	60%	60%	70%	70%	80%	85%

Train Wrapping and In Train Advertising – From DMRC norms, only 10% of the trains are wrapped. Based on the same, the number of trains with wrapping and in-train advertising has been capped at 1 as only 8 incremental trains are proposed.

18.2.2.5 ATMs/ Kiosks on Stations

There are 3 stations along the alignment. From the typical layout of the station, space for 2 ATMs/ kiosks have been identified.

Lease rental of 40 INR/ square feet / month is currently assumed. Escalation in standard commercial development of 15% every 3 years is incorporated as 5% per year. 85% occupancy is targeted only from the 10th year of operation. The occupancy rate from start of project in FY 28 is detailed below with occupancy rates remaining constant at 85% FY 37 onwards:

Table 159 :Year wise occupancy rate of ATM/Kiosk on stations

2027-28	2028-29	2029-30	2030-31	2031-32	2032-33	2033-34	2034-35	2035-36	2036-37
50%	60%	60%	60%	60%	60%	70%	70%	80%	85%

Table 160 : Summary of Non farebox revenue

(In INR Crore)

Financial Year	Revenue Fare Box (Cr.)	REVENUE NON-FARE BOX			Total Income (Cr.)
			OTHER INCOME (Cr.)		
		Inflow from Advertising, train wrapping etc (Cr.)	Premium Levy on Development	LBT share of Registration	
FY 28	167	6			173
FY 29	179	6			185
FY 30	228	6			234
FY 31	235	6			241
FY 32	296	6			302
FY 33	310	6			316
FY 34	390	6			396
FY 35	396	6	118	96	616
FY 36	491	6	121	98	716
FY 37	511	6	124	101	742
FY 38	631	6	127	103	867
FY 39	626	6	130	106	868

Financial Year	Revenue Fare Box (Cr.)	REVENUE NON-FARE BOX			Total Income (Cr.)
		Inflow from Advertising, train wrapping etc (Cr.)	OTHER INCOME (Cr.)		
			Premium Levy on Development	LBT share of Registration	
FY 40	757	6	133	109	1005
FY 41	769	6	137	111	1023
FY 42	924	6	140	114	1184
FY 43	919	6	143	117	1185
FY 44	1110	6	147	120	1383
FY 45	1132	6	151	123	1412
FY 46	1360	7	155	126	1648
FY 47	1359	7	158	129	1653
FY 48	1626	7	162	132	1927
FY 49	1637	7	166	136	1946
FY 50	1930	7	171	139	2247
FY 51	1910	7	383	312	2612
FY 52	2247	7	392	319	2965
FY 53	2263	7	402	327	2999
FY 54	2657	7	412	336	3412
FY 55	2626	7	422	344	3399
FY 56	3074	7	433	353	3867
FY 57	3083	7	444	361	3895

18.3 Financial Internal Rate of Return

The **financial internal rate of return** at completion cost basis with farebox and non-fare box revenue with additional revenue sources (Other Income) from improved FSI along the development corridor (TOD) and cess from stamp duty works out to **14.45 %.**

The profit and loss statement and cash flow statement are attached in the exhibit at the end of chapter.

Additionally, there is a monetary grant from PMC generated by granting a 50-year capital lease on PMC owned land. From an accounting treatment perspective, monetary grant is treated as other equity in the balance sheet and not as Other Income. The other equity can be treated as deferred revenue year on year and phased out from the balance sheet. However, in this model, the other equity item is not phased out.

Also, Salvage value is considered as zero for ease of calculation

18.4 FIRR Sensitivity

While calculating impact of FIRR with various Capex scenarios, revised depreciation calculations and tax impact have not been affected due to small effect.

Table 161 : Capital Cost sensitivity analysis

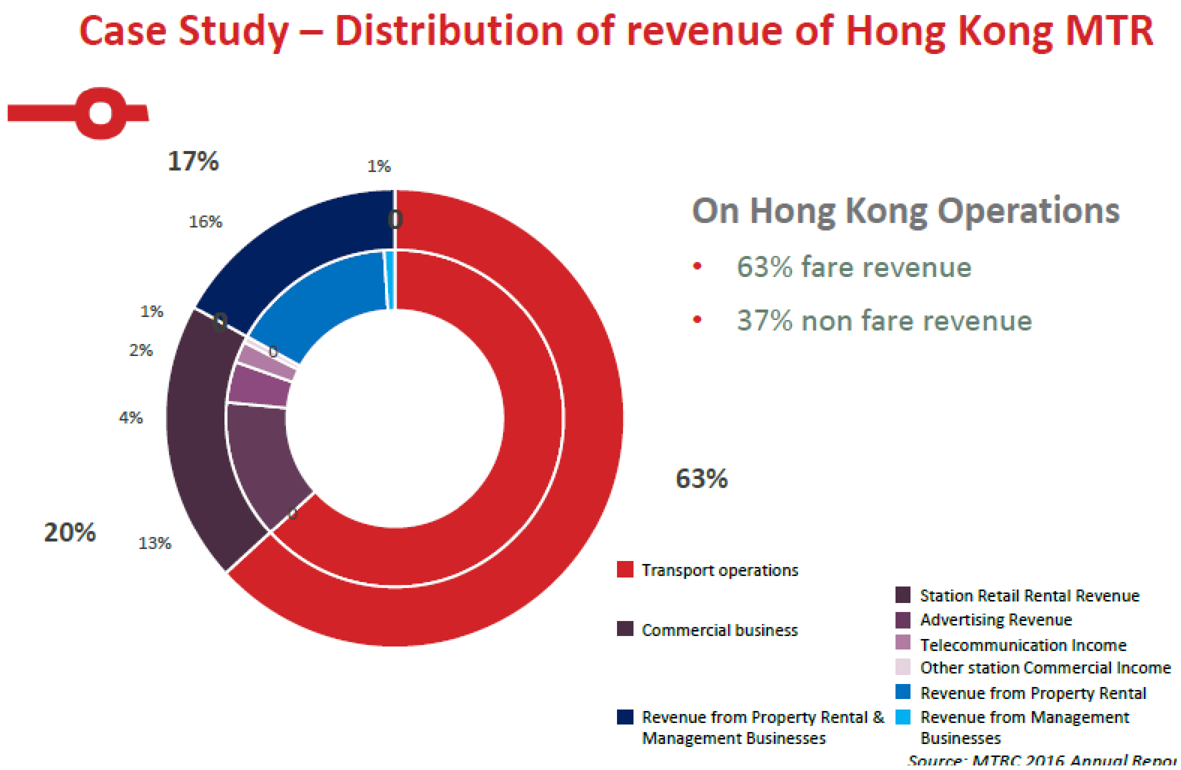
Capital cost sensitivity			
10% increase in capital cost	20% increase in capital cost	10% decrease in capital cost	20% decrease in capital cost
13.46%	12.60%	15.61%	17.01%
O & M Cost			
10% increase in O & M Cost		10% decrease in O & M Cost	
14.25%		14.64%	
Property Development			
With PD		Without PD	
14.45%		12.25%	

18.5 Funding Options

18.5.1 Funding Objectives

The objective of the exercise is not just financial closure but to achieve financial closure while ensuring availability of lowest cost of funds while procuring and creating sustainable systems to achieve optimal project costs. It, being a public utility service, analysis of life cycle costs – low maintenance cost and longer life spans; must be done to ensure optimal project costs. Fares must be set which minimize dependence on subsidies. Returns must accrue to both direct and indirect beneficiaries. Additionally, one must draw on experience of metro projects the world over with regard to funding patterns. Experience from successful metro projects Singapore, Hong Kong suggests between 60% to 100% government capital contribution as metro projects typically yield high economic benefits reflected in the substantially better economic IRRs of the project.

Hong Kong has one of the highest non fare box revenue collections in the world at 37% and yet 66% of the capital contribution comes from the government. This underlines the fact that government funding is required despite exploring non fare box revenue sources well.



18.6 Financing Options

The operational metro services in India have adopted a similar capital structure. This DMRC/ BMRC/ CMRL pattern of financing is discussed in detail below. Another method of financing is through a public private partnership. **However, PPP mode will present several challenges the most major being:**

- **Access to low cost fund – 0.6% interest rate from multilateral funding agencies.**
- **Mode of sharing of monetary and non-monetary grants by PMC will have the lowest cost in case the asset is owned by a GoI and state controlled SPV structure**
- **This is an extension of an existing asset. The rolling stock however being added is for the entire section and not just the extended portion. Therefore, there will be sharing of both capital revenue which will prove challenging of the extended portion is hived off to a private party.**

18.6.1 DMRC/BMRC/CMRL pattern of Financing

A special purpose vehicle is set up for project implementation and subsequent operation and maintenance. Equity contributions are made by:

- Government of India
- State Government
- Pune Municipal Corporation

Typically, Government of India makes up to 20% equity contributions at the maximum. The project cost taken for equity contribution excludes cost of land acquisition and R&R. A portion of the above will be in the form of subordinated debt which would include taxes, land etc. 20% is funded by state Government again in the form of equity or grants. Balance 60% constitutes loans from multilateral funding agencies.

18.6.1.1 *Multilateral funded loan @ 0.6% per annum*

Table 162 : Loan terms

S.n.	Parameter	Value
1	Annual Interest rate for loan	0.6%
2	Front end fee	Management fee = 0.25% Commitment Fee= 0.25% p.a. on undisbursed portion
3	Repayment Period	15 Years
4	Moratorium Period	5 Years
5	Payment Schedule	Bi-annual

Table 163 : Project Capital Structure – SPV Model Loan @ 0.6%

Particulars	Amount (Rs. Cr)	Percentage
Grant by GoI	300.21	10.0%
Grant by PMC	450.32	15.0%
Grant by GoM	450.32	15.0%
Soft Loan from bilateral/multilateral funding agencies	1801.29	60.0%
Project Cost Eligible for Grant	**3002.15**	**100.0%**
SD for State Taxes, Central Taxes & Duties by GoM	440.32	
Contribution for Land, R&R, IDC, etc. by PMC	204.13	
Total	**3646.60**	
PPP Component	17.26	
Total Cost including PPP Component	**3663.86**	

18.7 Conclusion and Recommendation

- FIRR for the project is 14.45%
- SPV model with loan funded at 0.6% per annum is proposed for implememtation of the project due to highest Equity IRR among all the options studied.

EXHIBIT- 1 - Government Resolution No.PMR-3313/C.R.29/UD-7 and letter dated 29th October 2013

Sanction to the revised proposal of Pimpri- Chinchwad to Swargate and Vanaz to Ramwadi Metro Rail corridor of Pune Mahanagar Metro Rail Project.

Government of Maharashtra

Urban Development Department

Government Resolution No.PMR-3313/C.R.29/UD-7

Mantralaya, Mumbai-400032

Date: 29th October 2013.

Ref:- Government Resolution No. PMR-3313/C.R.29/UD-7 Mantralaya, Mumbai-400032 ,dated 11 Sept,2013

PREAMBLE:

Keeping in view the traffic and transportation problems arising out of ever-increasing population and rapid increase in number of vehicles, it has become necessary to strengthen the Public Transport systems in Pune Metropolitan Region. Pune Metro Railway Project is one of the several proposals contemplated to address this traffic problem engulfing Pune and Pimpri-Chinchwad. Pune Municipal Corporation and Pimpri Chinchwad Municipal Corporation jointly appointed Delhi Metro Rail Corporation to prepare a Detailed Project Report for examining the feasibility of planning and implementation of Pune Metro Railway Project.

In the Detailed Project Report of Pune Metro Project prepared by Delhi Metro Rail Corporation (DMRC) various Metro Rail Corridors have been proposed. Phase 1 of the Project includes two corridors viz. Corridor 1- Pimpri Chinchwad to Swargate and Corridor2 – Vanaz to Ramwadi. After giving due consideration to technical issues, feasibility of implementation and financial viability, the General Body of Pune Municipal Corporation has accorded approval to Corridor 2 – Vanaz to Ramwadi, which entirely traverses through their jurisdiction, vide Resolution no. 90 dated 23/06/2010. Similarly, for Corridor 1- Pimpri Chinchwad to Swargate, the General Bodies of Pune Municipal Corporation and Pimpri Chinchwad Municipal Corporation have accorded approval vide Resolution no.577 of PMC General Body-51 dated 24/12/2012 and Resolution no.133 of PCMC General Body-8 dated 20/9/2012 respectively.

Vide the Government Resolution referred to above the Government of Maharashtra had accorded sanction to 'Corridor 2 Vanaz to Ramwadi' elevated Metro Project. But due to elapse of time leading to increase in cost a revised proposal for Corridor 2 Vanaz to Ramwadi along with a proposal for Corridor 1- Pimpri Chinchwad to Swargate is now submitted to the Government of Maharashtra seeking its sanction for the same. Pune

Mahanagar Metro Railway proposal under Phase 1 comprises of Corridor-1 (Pimpri Chinchwad to Swargate - Length 16.59 km) and Corridor- 2 (Vanaz to Ramwadi- Length 14.52km). Corridor – 1 Pimpri Chinchwad to Swargate is estimated to cost Rs.5618 Crore at January 2013 prices with a completion cost estimated at Rs 6960 Crore. Corridor- 2 Vanaz to Ramwadi is estimated to cost Rs.2663 Crore at January 2013 prices with a completion cost estimated at Rs 3223 Crore. The subject of granting sanction to the proposal of Corridor-1 and revised proposal of Corridor-2 of Pune Metro Railway Project has been under the consideration of Government of Maharashtra. After considering all the relevant aspects of the proposal, the Government of Maharashtra has taken following decision.

GOVERNMENT RESOLUTION

[I] Sanction is hereby accorded to the proposal of Corridor no 1-Pimpri Chinchwad to Swargate and revised proposal of Corridor no 2- Vanaz to Ramwadi which form Pune Mahanagar Metro Rail Project Phase 1.

1. Sanction is hereby accorded to Corridor no.1 Pimpri Chinchwad to Swargate, partly elevated and partly underground as per details attached at Annexure 1, which forms a part of Pune Mahanagar Metro Rail Project Phase 1.

2. Vide the above referred Government Resolution the Government of Maharashtra had accorded sanction to 'Corridor 2 Vanaz to Ramwadi' elevated Metro Project Sanction is now accorded to the revised proposal of Corridor 2 Vanaz to Ramwadi (as per details attached at Annexure 2), which forms a part of Pune Mahanagar Metro Rail Project Phase 1, incorporating the updated capital expenditure based on January 2013 prices and revised time line for implementation.

3. Sanction is hereby accorded to submit the proposal of Pune Mahanagar Metro Rail Project Phase 1 comprising of the above referred two corridors to the Government of India for seeking its approval.

4. Sanction is hereby accorded for the establishment of 'Pune Mahanagar Metro Rail Corporation Limited' a Special Purpose Vehicle Company (SPV) for implementation of the project comprising of the two corridors. Since in comparison to 20% equity participation of the Government of India the equity participation of Government of Maharashtra and the Local Bodies being 30%, sanction is hereby accorded to appoint six directors nominated by the Government of Maharashtra and the two Municipal Corporations on the Board of the proposed Company. Government of India needs to be requested to keep this in view. Accordingly following shall be the list of Directors :

   1) Principal Secretary (UD-1) Urban Development Dept., Govt. of Maharashtra.

2) Principal Secretary (Finance) Finance Dept., Govt. of Maharashtra.
3) Principal Secretary (UD-2) Urban Development Dept., Govt. of Maharashtra.
4) Municipal Commissioner, Pune Municipal Corporation
5) Municipal Commissioner, Pimpri Chinchwad Municipal Corporation.
6) Principal Secretary (Industries) Industries, Energy & Labour Dept., Govt. of Maharashtra.
7) Nominated Officers from Govt. of India – 5

5. Sanction is hereby accorded to vest the 'Pune Mahanagar Rail Corporation Limited' with similar authority as is available to Delhi Metro rail Corporation (DMRC) for Implementation of the Project. Sanction is hereby accorded to appoint Pune Municipal Corporation and Pimpri Chinchwad Municipal Corporation as the Executing Agencies, until the formation of Pune Mahanagar Metro Rail Corporation Limited.

6. Sanction is hereby accorded to authorize Pune Municipal Corporation and the proposed Pune Mahanagar Metro Rail Corporation to enter into correspondence with the Government of India and the Ministry of Railways in connection with the implementation of the project and obtaining funds to the tune of 20% which is the equity participation of the Government of India. Sanction is hereby accorded to authorize the Municipal Commissioner of Pune Municipal Corporation for entering into correspondence with the Government of India until the SPV Company is established.

7. Sanction is hereby accorded to the proposed Financial Structure for the project implementation which is as follows :
    - Pune Mahanagar Metro Rail Project Phase 1 – Corridor 2 Vanaz to Ramwadi – Pune Municipal Corporation 10% Share, Govt of Maharashtra 20% Share, Govt. of India 20 % Share, Balance 50 % to be raised through borrowing or other sources.
    - Pune Mahanagar Metro Rail Project Phase 1 – Corridor 1 Pimpri Chinchwad to Swargate – Pune Municipal Corporation and Pimpri Chinchwad Municipal Corporation 10% Share, Govt of Maharashtra 20% Share, Govt. of India 20 % Share, Balance 50 % to be raised through borrowing or other sources.

8. The 10 % share of the total capital cost of Corridor no. 2 Pimpri Chinchwad to Swargate, which forms a part of Pune Mahanagar Metro Rail Project – Phase 1, shall be shared by Pune Municipal Corporation and Pimpri Chinchwad Municipal Corporation in proportion of the expenditure which will be incurred over the length falling in the jurisdiction of each of the Corporations (Pro rata basis). Pune Municipal Corporation and Pimpri Chinchwad Municipal Corporations are directed to deposit their respective

shares for Corridor no. 1 and Corridor no. 2 with the 'Pune Mahanagar Metro Rail Corporation Limited'.

9. Sanctions is hereby accorded to deposit 20% share of the State Government in the capital expenditure of the project with the 'Pune Mahanagar Metro Rail Corporation Limited'. The 20% share of the State Government shall also include the cost of State Government Land, assessed at prevalent rates, required to be acquired for the Project.

10. Sanction is hereby accorded to raise funds for implementation of the Project through various sources of revenue listed in Annexure 3 attached herewith.

11. In principal sanction is hereby accorded to implement commuter fare rates as tabulated below as the Pune Mahanagar Metro Rail Project is proposed to be implemented under the provisions of Metro Railway Act enacted by the Government of India.

Sr.No.	Distance in K.m.	Revised Rate as per Year 2009(Rs.)	Rate for Pune Metro for the Year 2018-2019(Rs.)
1	0-2	8	13
2	2-4	10	17
3	4-6	12	20
4	6-9	15	25
5	9-12	16	27
6	12-15	18	30
7	15-18	19	32
8	18-21	21	35
9	21-24	22	37
10	24-27	23	38
11	27-30	25	42
12	More than 30 K.m.	27	45

Sanction is hereby accorded to periodic revision of fares by the Fare Regulation Committee to be established as per the provisions of the Metro Railway Act.

12 Sanction is hereby accorded to declare this Project as Essential Public Project and Important Public Transport Project.

[II] In principal sanction is hereby accorded to extension of Pune Metro Project Corridor no. 1 from Pimpri to Nigdi and Swargate to Katraj (a Length of approximately 15 km). Sanction is hereby accorded to include these extensions as Phase 2 and prepare a Detailed Project Report for the same and forward it to the Government of India as a standalone proposal.

This Govt. Resolution is being forwarded after giving due considerations to the Govt. of Maharashtra's Planning Department's demy-official reference No.155/1444 dtd.13/08/2013 and Finance Department's demy-official reference No.470/ Expenditure dtd.14/08/2013

In the Name & Orders from Governor of Maharashtra.

(S.K.Salimath)
Deputy Secretary, Govt. Of Maharashtra

To,

The Secretary, Governor, Govt. of Maharashtra,

Principal Secretary of Chief Minister, Mantralaya, Mumbai 400 032

The Secretary of Vice Chief Minister, Mantralaya, Mumbai 400 032

Private Secretary of State Minister(Navi), Mantralaya, Mumbai 400 032.

Chief Secretary, Govt. of Maharashtra, Mantralaya, Mumbai 400 032

Upper Chief Secretary(Revenue)Revenue & Forest Department, Mantralaya, Mumbai 400 032

Upper Chief Secretary, Home Department, Mantralaya, Mumbai 400 032

Principal Secretary (Navi -1), Nagar Development Department, Mantralaya, Mumbai 400 032

Principal Secretary (Finance) Finance Department, Mantralaya, Mumbai 400 032

Principal Secretary ,Planning Department, Mantralaya, Mumbai 400 032

Principal Secretary(Transport),Home Department, Mantralaya, Mumbai 400 032

Principal Secretary(Navi 2),Nagar Development Department, Mantralaya, Mumbai 400 032

Secretary (Special Project),General Administration Department, Mantralaya, Mumbai 400 032

EXHIBIT – PROJECT IRR

Sr No	Year	Revenue Fare Box	Revenue Non Fare Box	Other Income		PD	Total Income	O&M Expenses					With PD	Without PD	Capital Expenditure				O&M Cost	
			Inflow from Advertising, train wrapping etc	Premium levy on development	LBT share of Registration			Energy Expense	Employee Benefit Expense	Maintenance Expenditure	Total Expenses	Capital Expenditure	Net Cash Outflow	Net Cash Outflow	10% increase	20% increase	10% decrease	20% decrease	10% increase	10% decrease
1	2022-2023											341.92	-341.92	-341.92	-376.11	-410.30	-307.73	-273.54	-341.92	-341.92
2	2023-2024											736.72	-736.72	-736.72	-810.40	-884.07	-663.05	-589.38	-736.72	-736.72
3	2024-2025											1077.94	-1077.94	-1077.94	-1185.73	-1293.53	-970.15	-862.35	-1077.94	-1077.94
4	2025-2026											895.54	-895.54	-895.54	-985.09	-1074.65	-805.99	-716.43	-895.54	-895.54
5	2026-2027											564.19	-564.19	-564.19	-620.61	-677.03	-507.77	-451.35	-564.19	-564.19
6	2027-2028	160.00	6.13	96.65	78.72	1319.00	1660.51	28.20	37.00	13.60	78.80	0.00	1581.71	262.71	1581.71	1581.71	1581.71	1581.71	1573.83	1589.59
7	2028-2029	172.00	6.16	99.07	80.69		357.92	29.00	40.49	14.28	83.77	0.00	274.15	274.15	274.15	274.15	274.15	274.15	265.77	282.53
8	2029-2030	219.00	6.17	101.55	82.71		409.43	29.00	44.13	15.00	88.13	0.00	321.29	321.29	321.29	321.29	321.29	321.29	312.48	330.11
9	2030-2031	225.00	6.18	104.09	84.78		420.04	30.00	48.11	15.75	93.85	0.00	326.19	326.19	326.19	326.19	326.19	326.19	316.80	335.57
10	2031-2032	284.00	6.19	106.69	86.90		483.77	31.00	52.44	16.53	99.97	0.00	383.80	383.80	383.80	383.80	383.80	383.80	373.80	393.80
11	2032-2033	298.00	6.19	109.35	89.07		502.62	31.00	57.16	17.36	105.52	0.00	397.10	397.10	397.10	397.10	397.10	397.10	386.55	407.65
12	2033-2034	374.00	6.24	112.09	91.30		583.62	32.00	62.30	18.23	112.53	0.00	471.09	471.09	471.09	471.09	471.09	471.09	459.84	482.35
13	2034-2035	380.00	6.25	114.89	93.58		594.72	33.00	67.91	19.14	120.05	0.00	474.67	474.67	474.67	474.67	474.67	474.67	462.67	486.67
14	2035-2036	471.00	6.29	117.76	95.92		690.98	34.00	74.02	20.10	128.12	0.00	562.86	562.86	562.86	562.86	562.86	562.86	550.05	575.67
15	2036-2037	491.00	6.33	120.71	98.32		716.35	35.00	80.68	21.10	136.78	451.07	128.50	128.50	83.39	38.29	173.61	218.71	114.82	142.18

16	2037-2038	605.00	6.34	123.73	100.77		835.84	36.00	87.94	22.16	146.10	0.00	689.74	689.74	689.74	689.74	689.74	689.74	675.13	704.35
17	2038-2039	601.00	6.36	126.82	103.29		837.47	37.00	95.86	23.27	156.12	0.00	681.35	681.35	681.35	681.35	681.35	681.35	665.74	696.96
18	2039-2040	727.00	6.38	129.99	105.88		969.24	38.00	104.48	24.43	166.91	64.23	738.10	738.10	731.68	725.26	744.53	750.95	721.41	754.79
19	2040-2041	738.00	6.40	133.24	108.52		986.16	39.00	113.89	25.65	178.54	236.04	571.58	571.58	547.98	524.38	595.19	618.79	553.73	589.44
20	2041-2042	887.00	6.42	136.57	111.24		1141.22	41.00	124.14	26.93	192.07	35.41	913.75	913.75	910.21	906.66	917.29	920.83	894.54	932.95
21	2042-2043	882.00	6.44	139.98	114.02		1142.44	42.00	135.31	28.28	205.59	0.00	936.85	936.85	936.85	936.85	936.85	936.85	916.29	957.41
22	2043-2044	1066.00	6.46	143.48	116.87		1332.81	43.00	147.49	29.69	220.18	0.00	1112.63	1112.63	1112.63	1112.63	1112.63	1112.63	1090.61	1134.64
23	2044-2045	1087.00	6.48	147.07	119.79		1360.34	45.00	160.76	31.18	236.94	0.00	1123.40	1123.40	1123.40	1123.40	1123.40	1123.40	1099.71	1147.09
24	2045-2046	1306.00	6.50	150.75	122.78		1586.03	46.00	175.23	32.74	253.97	0.00	1332.07	1332.07	1332.07	1332.07	1332.07	1332.07	1306.67	1357.46
25	2046-2047	1305.00	6.53	154.52	125.85		1591.90	48.00	191.00	34.37	273.37	551.06	767.46	767.46	712.36	657.25	822.57	877.68	740.13	794.80
26	2047-2048	1561.00	6.55	158.38	129.00		1854.93	49.00	208.19	36.09	293.28	0.00	1561.65	1561.65	1561.65	1561.65	1561.65	1561.65	1532.32	1590.98
27	2048-2049	1571.00	6.58	162.34	132.22		1872.14	50.00	226.93	37.90	314.82	0.00	1557.32	1557.32	1557.32	1557.32	1557.32	1557.32	1525.84	1588.80
28	2049-2050	1853.00	6.61	166.40	135.53		2161.53	51.00	247.35	39.79	338.14	0.00	1823.39	1823.39	1823.39	1823.39	1823.39	1823.39	1789.58	1857.21
29	2050-2051	1834.00	6.64	170.56	138.92		2150.11	52.00	269.61	41.78	363.39	0.00	1786.72	1786.72	1786.72	1786.72	1786.72	1786.72	1750.38	1823.06
30	2051-2052	2157.00	6.67	174.82	142.39		2480.88	53.00	293.88	43.87	390.75	0.00	2090.13	2090.13	2090.13	2090.13	2090.13	2090.13	2051.06	2129.21
31	2052-2053	2177.00	6.70	179.19	145.95		2508.84	54.00	320.33	46.06	420.39	0.00	2088.46	2088.46	2088.46	2088.46	2088.46	2088.46	2046.42	2130.49
32	2053-2054	2550.00	6.74	183.67	149.60		2890.01	55.00	349.15	48.37	452.52	0.00	2437.49	2437.49	2437.49	2437.49	2437.49	2437.49	2392.23	2482.74
33	204-2055	2521.00	6.77	188.26	153.34		2869.38	56.00	380.58	50.79	487.36	0.00	2382.01	2382.01	2382.01	2382.01	2382.01	2382.01	2333.28	2430.75
34	2055-2056	2951.00	6.81	192.97	157.17		3307.95	57.00	414.83	53.32	525.16	0.00	2782.80	2782.80	2782.80	2782.80	2782.80	2782.80	2730.28	2835.31
35	2056-2057	2960.00	6.85	197.79	161.10		3325.75	68.69	452.17	55.99	576.84	0.00	2748.91	2748.91	2748.91	2748.91	2748.91	2748.91	2691.22	2806.59
		34413.00	193.34	4243.37	3456.22		43624.93	1272.89	5063.33	903.75	7239.97	4954.11	31430.85	30111.85	30935.44	30440.03	31926.26	32421.68	30706.86	32154.85
													14.45%	**12.25%**	**13.46%**	**12.60%**	**15.61%**	**17.01%**	**14.25%**	**14.64%**

19. ECONOMIC ANALYSIS

19.1 Introduction

1. The current service delivery is not commensurate with the existing traffic scenario in urban areas in general. Pune City urban transport service is one such area which require more attention. Based on Comprehensive Mobility Plan Study (CMP), 2018 findings, a metro rail transport system is proposed to tackle the growing intra-urban transport demand in Pune City.

2. As a public transport system, Metro Rail Transport System (MRTS) proposed in Pune will supplement the growing intra-city travel demand, especially in the selected heavy traffic corridors. Spending public money in the construction of MRTS lines has been defended as a socially desirable public investment which produces several types of benefits such as:

- Passenger time savings,
- Increase in comfort,
- Generation of new trips,
- Reduction in congestion and delays in roads,
- Reduction in accidents, reduction in environmental externalities,
- Wider economic benefits including the development of the less developed regions

3. Many factors influence the market shares between the other modes of public transport and MRTS. According to the literature, travel time is the most important one. The MRTS has a clear advantage over the traditional bus services and the fast growing costly IPT modes. Other factors that contribute to the relative position of MRTS are ticket prices, frequency of the service, the integration of networks, accessibility , reliability and punctuality of the services and government policy.

4. The findings of this Feasibility Study will determine this intra-urban transport service through MRTS to improve accessibility so that residents of Pune City will have better access to economic and social activities.

19.2 Scope and Objectives

1. The objective of this feasibility study (FS) to evaluate the potential for the identified MRTS services in Pune City and to assess strategically the overall need and potential for development.
2. The scope of the study is divided into two stages, further divided into several phases:
3. Stage 1
    a. Phase 0 – Inception
    b. Phase 1 – Transport demand assessment
    c. Phase 2 – Corridor definition and Techno-economic feasibility
4. Stage 2
    a. Phase 3 – Detailed Project Report

5. Based on the identified study area, following three corridors were identified for further detailed investigations. As part of the Phase 2, the present section assessed the economic feasibility for the identified MRTS corridors and to provide recommendations for project implementation. The key success will hinge on the selection of the most viable route, the introduction of reliable systems, sufficient budget allocation and of course smooth land acquisition.

6. However, considering the traffic data availability, the above three corridors were reduced to two corridors in the initial draft feasibility report, by integrating (i) Nigdi-Katraj Section and (ii) PCMC-Nigdi Section, as these two sections are extension of the on-going Swargate – PCMC corridor. Subsequently, considering the comments of the client, Corridor 1A (PCMC-Nigdi Section) is considered separately for economic analysis. Thus, the present report had considered Corridor 2A (Swargate to Katraj Section) for the study include:

Corridor 2A:	Swargate - Katraj	Km	5.464

7. The objective of the economic analysis in the FS is to identify and quantify the benefits and costs associated with the investment proposal in order to select the optimum solution along with the economic viability in terms of its likely investment return potential. This is carried out in order to assess the economic feasibility and prioritize the identified transport investment proposal and assist the governments in Maharashtra State in making the right decision.

19.3 Approach and Methodology for the Analysis

1. The economic analysis contained in this chapter has been undertaken in accordance with the available guidelines including '*Appraisal Guidelines for Metro Rail Projects Proposals*' (2017) and '*Metro Rail Policy 2017*' by the Ministry of Housing & Urban Affairs, Govt. of India; and '*Manual on Economic Evaluation of Highway Projects in India*' IRC-SP30, 2009 by the Indian Roads Congress, '*Guidelines for the Economic Analysis of Projects, and Framework for the Economic and Financial Appraisal of Urban Development Sector Projects'1994* by Asian Development Bank (ADB). Economic analysis involves comparing 'with project' and 'without project' alternatives. By comparing the above alternatives, the net agency costs and net user costs and finally net project benefits associated with the project during its analysis period were calculated for the proposed improvement options separately in order to arrive at their internal rate of return (IRR) and net present value (NPV) both for economic and financial analysis.

19.3.1 Methodology for Economic Analysis

1. In accordance with the guidelines, economic feasibility analysis was carried out for 30 years analysis period for Life Cycle Cost Analysis (LCCA):

- Base Year (July 2021)

- Construction period (2022 - 2027)
- Project opening for traffic (2027)
- Project operating period (2027 - 2057)
- End of the analysis period (2057)

2. Thus, a period of 30 years of operation is considered for the evaluation. All the cost was at 2021 (Base Year) level and also the results including NPV, IRR were estimated for the base year level.

3. Considering the component wise opportunity cost (estimated for Maharashtra State conditions), the financial cost was converted into economic cost in accordance with the available guidelines from international funding agencies like Asian Development Bank (ADB).

4. The conventional economic model like HDM (which is used for highway improvement project analysis) may not be relevant for most of the rapid urban transport projects etc. Hence appropriate excel based models are developed, to quantify the relevant project benefits; life cycle costing; project net benefits and finally economic feasibility criteria like EIRR and ENPV.

5. Updated inputs available from the guidelines explained above, available secondary sources and the input data from the Comprehensive Mobility Plan (2018) with suitable updates pertaining to the unit rates of VOC and travel time for different vehicle categories etc were used for the excel based models developed for this study.

6. The cost – benefit analysis was carried out by using the discounted cash flow (DCF) technique to obtain the economic internal rate of return (EIRR) and economic net present value (ENPV) for the proposed investments and the likely quantified project benefits linked with the project during the project analysis period

7. *Economic Opportunity Cost of Capital (EOCC)*: Given the complexity of estimating country-specific economic opportunity cost of capital (EOCC), a discount rate of 14% in constant economic prices is used. The EIRR must be compared with the EOCC, for interpretation purpose of project feasibility.

19.4 Estimation of Economic Project Cost of MRTS

19.4.1 Capital Cost

For economic analysis, only the cost estimates of the MRTS (excluding the cost of property development[15]) estimated in the cost section is adopted. Adding the preoperative expenses, physical contingency, applicable taxes, price contingency etc, the total financial cost for all the proposed three corridors were estimated for the base year (2018).

[15] Property development being a commercial activity, it is not considered for economic analysis.

The economic costs of capital works and annual operation and maintenance are calculated from the financial cost estimates on the following basis:

(i) Price contingencies are excluded but physical contingencies are included because they represent real consumption of resources;

(ii) Import duties and taxes are excluded because they represent transfer payments. For this the shadow exchange rate factor (SERF) worked out below (1.03)[16] was used;

(iii) The existence of unemployment and under-employment for unskilled workers within the Indian economy means that the opportunity cost of unskilled labour can be lower than its wage rate – a conversion factor (SWRF) of 0.81[17] of the market wage rate for construction labour is used to estimate the shadow wage rate;

(iv) The market wage rate for skilled labour and the acquisition cost of land are considered to represent opportunity costs, as both factors are in demand;

(v) Land cost is excluded for estimation of economic cost;

(vi) All costs are valued using the domestic price numeraire, to enable an easier comparison with the information used to measure benefits (e.g. a significant component of benefit is the savings in resources, which would be used in the without project situation).

Table 164 : Details of project cost

Details	Total
Length Km	**5.464**
Project Cost Rs Million	31,074.52
Project Cost Rs Million/Km	5,687.14
Economic Cost Rs Million	26,665.31
Economic Cost Rs Million/Km	4,880.18

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Shadow Exchange Rate Factor (SERF)						INR in Billion
Details	2015-16	2014-15	2013-14	2012-13	2011-12	Average
Exports (INR Billion)	17,146	18,963	18,942	16,353	14,660	17,213
Imports (INR Billion)	24,880	27,371	27,142	26,732	23,455	25,916
Customs Duties (INR Billion)	2,083	1,887	1,231	1,155	1,056	1,482
Shadow Conversion Factor (SCF)	0.953	0.961	0.974	0.974	0.973	0.967
Shadow Exchange Rate Factor (SERF)	**1.05**	**1.04**	**1.03**	**1.03**	**1.03**	**1.03**

Source: Hand Book of Statistics on Indian Economy, 2015-16, 2014-15 & 2013-14, Reserve Bank of India

Note: Calculation Method based on ERD Technical Note Series No. 11, February 2004, 'Shadow Exchange Rate for Project Economic Analys

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Shadow Wage-rate Factor (Y)	
Unskilled labor cost (Rs. per day)* (L)	400
Minimum Wages in Maharastra w.e.f January 1, 2018 (Rs. per day	495
Shadow Wage-rate Factor (Y); Y = L/M	0.81

*Wages practiced in Maharastra state in the construction industry in 2018.

** Minimum Wage in Maharastra w.e.f January 1, 2018 to March 31, 2018; https://www.labourlawreporter.com/wp-content/uploads/2017/04/Minimum-wages-maharashtra-01-01-18-a.pdf

Note: Calculated using the 'Guidelines for the Economic Analysis of Projects, 1997, ADB

19.4.2 Capital Replacement

25% of electrical and mechanical equipments, 50% of signalling and telecommunication equipment need replacement in 15 years, rolling stock will be added in 20 years.

Table 165 : Estimated Replacement Cost Rs Million

Year	Total
2037	4,510.69
2040	642.27
2041	2,360.36
2042	354.05
2047	5,510.58

Source: Financial Model

19.4.3 O&M Cost

Annual operating costs of this investment proposal at constant prices has been broken down into different items of this investment proposal and used for analysis purposes. This annual operation and maintenance (O&M) for the proposed project include staff cost, maintenance cost and power charges as estimated in the financial analysis chapter, is considered for analysis.

Table 166 : Maintenance Cost

1. Staff cost @ 32 persons/km & @Rs 0.9 million/year - Rs Million	370
2. Maintenance cost @15 million/km	136
3. Power charges	282
Total	**788**

Source: Financial Model

19.5 Economic Benefits of MRTS

Proposed MRTS is expected to divert passengers from the existing modes like car, bus, two wheelers and auto with better comfort and improved speed. These improvements will benefit the users in terms of better speed with service quality and reduced travel time. In addition, the proposed MRTS will reduce the carbon emission from the diverted traffic and also will reduce stress on the existing road corridors. Reduction in the congestion on the existing road corridors will result in reduction of road accidents. Accordingly, the economic benefits considered in the present analysis for the subprojects in transport component in this investment proposal include:

i) Value of Travel Time Savings
   a. For the diverted passengers by using the proposed HSR system;
   b. For the non-diverted passengers in the form of reduced congestion due to the diverted HSR traffic
ii) Value of vehicle operating cost (VOC) savings
   a. For the diverted passengers by using the proposed HSR system;
   b. For the non-diverted passengers in the form of reduced congestion due to the diverted HSR traffic

iii) Savings in Reduction of Accidents
iv) Pollution Reduction Benefits in terms of reduction in carbon emission from the vehicles due to the diversion to MRTS
v) Reduced Road Infrastructure Costs
  a. Reduction in annual maintenance cost
  b. Reduction in the road capacity improvement cost

Above project economic benefits are estimated on annual basis for the selected alignment corridors proposed in the technical section. Projected MRTS traffic for the selected option, in terms of daily passengers and passenger km, upon which the benefits are estimated is presented below in Table 167. Average trip length by MRTS is estimated to be 7.7km. Considering the assigned traffic to MRTS, its trip length, the modes from which these MRTS trips were diverted etc., the travel scenario under (i) without project and (ii) with project scenario including distribution by different modes were developed. This was used as the inputs for estimating all the project benefits discussed above.

Table 167 : Projected MRTS Daily Traffic Diverted from Different Modes

Year	Corridor2A – Swargate - Katraj	
	No. of daily passengers	Daily Passenger km (Million)
2021	95,000	0.77
2022	101,300	0.82
2023	107,600	0.88
2024	113,900	0.93
2025	120,200	0.98
2026	126,500	1.04
2027	132,800	1.10
2028	139,100	1.15
2029	145,400	1.21
2030	151,700	1.26
2031	158,000	1.32
2032	160,900	1.35
2033	163,800	1.38
2034	166,700	1.41
2035	169,600	1.44
2036	172,500	1.46
2037	175,400	1.49
2038	178,300	1.52
2039	181,200	1.55
2040	184,100	1.58
2041	187,000	1.61
2042	188,250	1.63
2043	189,500	1.65
2044	190,750	1.66

Year	Corridor2A – Swargate - Katraj	
	No. of daily passengers	Daily Passenger km (Million)
2045	192,000	1.68
2046	193,000	1.69
2047	194,000	1.71
2048	194,750	1.69
2049	195,500	1.67
2050	196,250	1.65
2051	197,000	1.64

8. Additional assumptions followed for estimating the project benefits are given below.

Table 168 : Details of Road User Cost adopted for the Study

Vehicle Category	VOC (Rs. / Vehicle Km)	
	2008 [1,3]	2018 [2]
Car - New Technology (Maruti 800)	4.07	6.95
Bus	16.37	27.96
TW	1.40	2.39
Auto rickshaw	3.98	6.80
Share-Auto	4.49	7.67
Taxi	4.70	8.03
2-Axle Truck	14.77	25.23
LCV	10.96	18.72
Goods Tempo	4.61	7.87
Goods Auto	3.59	6.13

1 Approach for Economic and Operation Assessment for Identified Urban Roads and Transportation Sub-projects, Working Paper No. : WP-05, Comprehensive Transportation Study for Chennai Metropolitan Area, May 2008

2. Escalated to 2018 with 5.5% annual growth based on inflation.

3. Includes fuel cost

Table 169 : Vehicle Category wise Passenger Travel Time (2018) - Urban Condition

Vehicle Type	Time value (Rs / Hour), 2018		
	Work	Non work	Combined
Bus	81.99	24.60	59.03
Mini Bus	81.33	24.40	58.56
TW	94.88	28.46	68.31
Car - Old Tech	142.31	42.69	102.47
Car - New Tech	213.47	64.04	153.70

Note:

1. Approach for Economic and Operation Assessment for Identified Urban Roads and Transportation Sub-projects, Working Paper No.: WP-05, Comprehensive Transportation Study for Chennai Metropolitan Area, May 2008

2. Escalated to 2018 with 10% annual growth.

Table 170 : Assumptions for Carbon Emission Estimation

Treatment cost of CO2 Rs/Ton	500

Source: Appraisal Guidelines for Metro Rail Projects Proposals, 2017, MOH&UA, GOI

Carbon (CO_2) Emission - Ton /litre	0.0023

Source: *GHG Analysis Road Improvement, Guidance Note, World Bank Group, February 2016*)

Table 171 : Unit Cost of Accidents

Details	Rs. 2004	Rs. 2018
Cost of Fatal Accident	437342	9,01,194
Cost of person injury	64256	1,32,407
Cost of damage to vehicles	29,911	61,636

Source: Appraisal Guidelines for Metro Rail Projects Proposals, 2017, MOH&UA, GOI
Note: 2004 costs are updated using average 5.5% inflation rate

Table 172 : Estimation of Savings in Road Stress Reduction

Reduction in Maint. Cost Rs Million/Year

Major impacted roads length - Km	5.85
Average annual maintenance Rs Million/Km	0.93
Total annual maintenance Rs Million	5.46
Reduction in Maint. Cost Rs Million/Year	**0.55**

Reduction in Widening Cost Rs Million/Year

Major impacted roads length - Km	5.85
Average widening cost Rs Million/Km	15.00
Total widening cost Rs Million	87.75
Reduction in widening Cost Rs Million/Year	**2.93**

19.6 Economic Analysis – EIRR & NPV for 30 Years

As part of the economic feasibility analysis, the feasibility parameters developed are shown in Table 173. A more detailed economic feasibility analysis is given in Table 173.

- Economic Internal Rate of Return (EIRR)
- Economic Net Present Value (ENPV)

Table 173 : Economic Cost-Benefit Analysis

Details	Present Value (Rs. Crore) a/, b/

Costs	
Capital costs	1805.68
O&M costs	353.12
Total costs	2158.80
Benefits	
Savings in Travel Time Cost	2730.89
Savings in VOC	494.84
Savings in Reduction of Accidents	1.01
Pollution Reduction Benefits	6.00
Reduced Road Infrastructure Costs	1.26
Total benefits	3233.99
Economic Return Measures	
Net present value (Rs. Crore)	1080.4
EIRR (%)	19.80 %

Note: Discounted at 14% EOCC

19.7 Sensitivity Analysis

Sensitivity analysis was carried out to their economic feasibility results for the following scenarios is presented in Table 174:

- Capital cost increase by 15%
- O&M costs increased by 15%
- Target beneficiaries reduced by 15%
- Delay in accrual of benefit by 1 year

Table 174 : Results of Sensitivity Analysis

Details	EIRR (%)	ENPV @14% (Rs Crore)	MIRR (%)	SV	Benefit - Cost Ratio (2021 Price)	Benefit - Cost Ratio (Current Price)
Main Evaluation (Base Case)	19.80%	10,804	13.56%		1.58	4.44
15% Capital Cost Overrun	17.95%	8,103	13.09%	60.0%	1.41	4.13
15% O&M Cost Overrun	19.54%	10,274	13.50%	305.9%	1.54	4.13
15% Decrease in Project Benefits	17.38%	5,953	12.94%	33.4%	1.34	3.78
One Year Delay in Implementation	19.78%	9,388	13.54%		1.58	4.38

SV = Switching Value; MIRR = Modified Internal Rate of Return; ENPV = Economic Net Present Value; EIRR = Economic Internal Rate of Return

Note:

1. Calculated as the percentage change in a variable required for EIRR to reduce to 14%.
2. Discounted at 14% of EOCC.
3. MIRR, is the internal rate of return of an investment that is modified to account for the difference between re-investment rate and investment return.

19.8 Outcome on Economic Viability

1. The evaluation has indicated that the proposed MRTS extension in Pune City in Corridor 2A, among the three corridors, with a length of 5.464 km**,** considered under the investment proposals is found to be economically viable, with the calculated EIRR value exceeding the economic opportunity cost of capital. With the EIRR of 19.80% and ENPV of Rs. 1080.40 Crore @ 14% discount rates, the proposed MRTS is found to be economically viable. In most of the sensitivity analysis scenarios, EIRRs were found to be greater than the minimum required rate. This has identified the areas of risk which need to be focussed during implementation.
2. Furthermore, for this investment proposed, the calculated EIRR value is considered minimum estimates of economic return, as there are a number of economic benefits like travel comfort, tourism benefits, employment generation and environment improvement that have not been quantified.

Exhibit - Economic IRR

Appendix I: Economic Cost-Benefit Analysis of MRTS Compo **Swargate - Katraj Section of Pune MRTS**

Base Case *(Rs.in Million)* Rs Million

Year	Economic Cost: Capital Cost	Economic Cost: O&M Cost	Economic Cost: Total	Economic Project Benefits: VOC Savings	Time savings	Savings in Reduction of Accidents	Pollution Reduction Benefits	Reduced Road Infrstructure Costs	Total	Net Benefit	Base Case	15% Construction Cost (15% Cost Increase Scenario)	15% O&M Cost (15% O&M Cost Increase Scenario)	15% Net Benefits (15% Benefits Reduction Scenario)	One year Delay	Combined Effect (Worst Scenario)
2,022	2,235	-	2,235.2	-	-	-	-	-	-	(2,235)	-2235	-2,570.50	(2,235)	-2,235.22	0	0
2,023	4,470	-	4,470.4	-	-	-	-	-	-	(4,470)	-4470	-5,141.01	(4,470)	-4,470.44	(2,235)	(2,571)
2,024	6,706	-	6,705.7	-	-	-	-	-	-	(6,706)	-6706	-7,711.51	(6,706)	-6,705.66	(4,470)	(5,141)
2,025	5,588	-	5,588.1	-	-	-	-	-	-	(5,588)	-5588	-6,426.26	(5,588)	-5,588.05	(6,706)	(7,712)
2,026	3,353	-	3,352.8	-	-	-	-	-	-	(3,353)	-3353	-3,855.76	(3,353)	-3,352.83	(5,588)	(6,426)
2,027	-	685.6	685.6	842	4,757	2	10	3	5,614	4,929	4929	4,928.93	4,826	4,086.76	(3,353)	(3,856)
2,028	-	706.1	706.1	900	5,072	2	11	3	5,989	5,283	5283	5,282.56	5,177	4,384.26	4,929	3,984
2,029	-	727.3	727.3	959	5,388	2	12	3	6,364	5,637	5637	5,636.57	5,527	4,681.99	5,283	4,278
2,030	-	749.1	749.1	1,018	5,703	2	13	3	6,739	5,990	5990	5,989.94	5,878	4,979.08	5,637	4,573
2,031	-	771.6	771.6	1,078	6,019	2	13	3	7,115	6,344	6344	6,343.67	6,228	5,276.38	5,990	4,867
2,032	-	794.8	794.8	1,138	6,334	2	14	3	7,491	6,697	6697	6,696.72	6,578	5,573.00	6,344	5,161
2,033	-	818.6	818.6	1,198	6,650	2	15	3	7,868	7,049	7049	7,049.07	6,926	5,868.92	6,697	5,454
2,034	-	843.2	843.2	1,259	6,965	2	15	3	8,245	7,402	7402	7,401.71	7,275	6,164.98	7,049	5,746
2,035	-	868.4	868.4	1,321	7,281	2	16	3	8,623	7,755	7755	7,754.62	7,624	6,461.16	7,402	6,039
2,036	-	894.5	894.5	1,383	7,596	3	17	3	9,001	8,107	8107	8,106.76	7,973	6,756.58	7,755	6,331
2,037	3,744	921.3	4,665.2	1,445	7,911	3	17	3	9,379	4,714	4714	4,152.68	4,576	3,307.34	8,107	6,622
2,038	-	949.0	949.0	1,477	8,057	3	18	3	9,557	8,608	8608	8,608.07	8,466	7,174.52	4,714	2,608
2,039	-	977.4	977.4	1,508	8,202	3	18	3	9,734	8,756	8756	8,756.19	8,610	7,296.14	8,608	7,032
2,040	533	1,006.8	1,539.9	1,540	8,347	3	18	3	9,911	8,371	8371	8,291.40	8,220	6,884.68	8,756	7,150
2,041	1,959	1,037.0	2,996.1	1,572	8,492	3	19	3	10,089	7,093	7093	6,798.87	6,937	5,579.41	8,371	6,654
2,042	294	1,068.1	1,361.9	1,604	8,638	3	19	3	10,266	8,904	8904	8,860.36	8,744	7,364.48	7,093	5,130
2,043	-	1,100.1	1,100.1	1,636	8,783	3	19	3	10,444	9,344	9344	9,343.85	9,179	7,777.25	8,904	7,160
2,044	-	1,133.1	1,133.1	1,669	8,928	3	20	3	10,623	9,489	9489	9,489.43	9,319	7,896.05	9,344	7,612
2,045		1,167.1	1,167.1	1,702	9,073	3	20	3	10,801	9,634	9634	9,634.03	9,459	8,013.86	9,489	7,726
2,046		1,202.1	1,202.1	1,735	9,218	3	20	3	10,980	9,778	9778	9,777.61	9,597	8,130.64	9,634	7,839
2,047	4,574	1,238.2	5,812.0	1,768	9,364	3	21	3	11,158	5,346	5346	4,660.28	5,161	3,672.60	9,778	7,950
2,048	-	1,275.3	1,275.3	1,783	9,426	3	21	3	11,236	9,961	9961	9,960.78	9,769	8,275.36	5,346	2,801
2,049	-	1,313.6	1,313.6	1,797	9,489	3	21	3	11,313	9,999	9999	9,999.31	9,802	8,302.37	9,961	8,084
2,050	-	1,353.0	1,353.0	1,812	9,551	3	21	3	11,391	10,038	10038	10,037.70	9,835	8,329.09	9,999	8,105
2,051	-	1,393.6	1,393.6	1,826	9,614	3	21	3	11,468	10,074	10074	10,073.90	9,865	8,353.77	10,038	8,126
2,052	-	1,435.4	1,435.4	1,834	9,664	3	21	M	11,523	10,087	10087	10,087.32	9,872	8,358.91	10,074	8,145
2,053	-	1,478.5	1,478.5	1,841	9,714	4	21	3	11,583	10,105	10105	10,104.53	9,883	8,367.08	10,087	8,144
2,054	-	1,522.8	1,522.8	1,803	9,752	4	21	3	11,583	10,060	10060	10,059.89	9,831	8,322.48	10,105	8,145
2,055	-	1,568.5	1,568.5	1,766	9,789	4	22	3	11,583	10,015	10015	10,014.91	9,780	8,277.40	10,060	8,094
2,056	-	1,615.6	1,615.6	1,727	9,827	4	22	3	11,582	9,967	9967	9,966.57	9,724	8,229.25	10,015	8,042
2,057	-	1,664.0	1,664.0	1,688	9,864	4	22	3	11,581	9,917	9917	9,916.81	9,667	8,179.68	9,967	7,987
									Total	2,33,098	2,33,098	2,28,080	2,27,956	1,87,973	2,23,182	1,69,883
									ENPV	10,804	10,804	8,103	10,274	5,953	9,388	2,317
									EIRR	19.80%	19.80%	17.95%	19.54%	17.38%	19.78%	15.38%
									MIRR	13.56%	13.56%	13.09%	13.50%	12.94%	13.54%	12.37%
									SV			60.0%	305.9%	33.4%		
									B C Ratio	1.58	1.58	1.41	1.54	1.34	1.58	1.17
ENPV @14%	18,056.8	3,531.2	21,588.0	4,948.4	27,308.9	10.1	60.0	12.5	32,339.8							

20. IMPLEMENTATION PLAN

On receipt of the Detailed Project Report, following actions will be required for implementing the Pune Metro Phase 2A:

- Approval to the Detailed Project Report to be taken from Maharashtra State Government (Cabinet approval).
- The DPR to be forwarded to the Ministry of Housing and Urban Affairs (GOI) and Finance Ministry with the request for approving the Metro project and for financial participation through equity contribution in the Pune Metro Corridor 2A.
- Signing of an MOU between Maharashtra State Government, Government of India and PMC 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, operational subsidy, if any, etc.
- The present Special Purpose Vehicle (SPV) a 50:50 jointly owned company of GoI and GoM is responsible for implementation of all metro projects in the state of Maharashtra outside Mumbai Metropolitan region including Pune Metro Rail project phase 1 and the current extension from Swargate to Katraj.
- PMC as a major equity shareholder will form a part of the SPV with a seat in Board of Directors of Maha Metro. The State Government should arrange the funding of subordinated debt required for executing this project and get the whole funding plan approved by the Government of India. The loan portion of the funding will have to be tied up by State Government in consultation with the Government of India.
- An act needs to be passed for collection of 1% cess on property registrations (Earlier covered as LBT) allowing for collection of the cess in PMC and sharing of 25% of this amount with the SPV.
- Implementation of TOD Policy allowing incremental FAR of 4, 500m on either side of alignment, Premium collection for the same and sharing of proceeds with Maha Metro.
- The Government should freeze all developments along the corridors suggested. For any constructions within 50 m. of the proposed alignment, a system of 'No Objection Certificate' should be introduced so that infructuous expenditure at a later stage is avoided.

20.1 Implementation on Delhi Metro Model

Maha Metro has to take action for appointment of General Consultants for project management including preparation of tender documents. Till the General Consultants are in position, Maha Metro should appoint an interim Consultant for all preliminary and enabling jobs such as land acquisition, detailed design of civil structures, utility diversions, etc. The proposed date of commissioning of the corridor with suggested dates of important milestones is given in following table :

Table 175 : Implementation Schedule of the project

S. No	Tasks	Anticipated Timelines
1	Approval of DPR by PMC	Septemeber 2021
2	Approval of DPR by GoM	February 2022
3	Final Approval by GoI	May 2022
4	Packaging & Invitation of Bids	August 2022
5	Commencement of Civil Works	November 2022
6	Commencement of Operation	April 2027

20.2 ORGANISATIONAL SET-UP OF SPV

Maha Metro is the SPV responsible for the implementation of the project, which has already been set up for the implementation of Pune Metro Phase 1 as well as its extension from Swargate to Katraj.

The board comprises of 13 directors of whom, 5 directors are nominees of GoI, five directors are nominees of GoM, and three are functional directors. The chairman is secretary MOHUA – a Nominee of GoI and the Managing director is a nominee of GoM. Since, PMC is a major equity shareholder, the organisational setup of the Maha Metro board would be extended to include a representative of the Pune Municipal Corporation.

The Directors will be Implementing a metro project in a congested metropolis. In sheer size, magnitude and technical complexity there are no parallels to metro projects. Further, these projects are to be carried out in difficult urban environment without dislocating city life, while at the same time preserving the environment. The project involves integration of a number of complex technical systems some of these technologies used in these systems are totally new to the country each one of which is a major project by itself. Interfacing various system contracts is a difficult and highly skilled exercise. Side by side, timely and adequate funds have to be assured for implementation and lands, without encumbrances, have to be taken possession of in time. Clearances from the local authorities have to be taken which includes permission to cut trees, diversion of utilities, management of road traffic, etc., all of which will call for an efficient and competent project implementing agency.

20.3 Contracts

20.3.1 Civil Works

It is proposed to carry out the civil works through following construction contracts:

(a) Tunnel Construction-It is suggested that each contract can be limited to appropriate package lengths.

(b) Station Contracts- It is proposed that each station contract comprises appropriate number of stations.

Architectural finishes, firefighting arrangements and general electrification, will form part of civil contracts.

20.3.2 Systems Contract

- Design, construct and installation for Traction and Power Supply.
- Design, construct and installation of Signal and Telecommunication works.
- Design, construct and installation of lifts.
- Design, construct and installation of escalators.
- Design, construct and commissioning of Automatic Fare Collection System.
- Design and supply of rolling stock.
- Installation of track in Depot and on main line.
- Design and installation of Signages.

20.3.3 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 should be set up. Other members of this Committee should be Secretaries of the concerned Departments of the State Government and Heads of civic bodies who will be connected in one way or the other with the implementation of the project. Commissioner of Pune Urban Development Authority and Municipal Commissioner of PMC should also be the member of this committee. This Committee should meet once a month and sort out all problems brought before it by Maha Metro.

For Delhi Metro also such a High-Power Committee was set up and it proved very useful in smooth implementation of the Delhi Metro rail project.

20.4 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 Urban Development, Ministry of Surface Transport, Ministry of Environment and Forests, Department of Expenditure, Chief Secretary of Delhi Government 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 should be enlarged to include Pune Metro project extension also and the Chief Secretary, Maharashtra should be inducted as a member of this Committee.

20.5 Empowered Group of Ministers (EGOM)

Union Cabinet had set up an Empowered Group of Ministers (EGoM) to take decisions on behalf of the Cabinet on policy matters concerning Delhi Metro project. The Group of Ministers is chaired by the Home Minister. Other members of the GOM are Minister of Urban Development and Poverty Alleviation, Minister of Railways and Minister of Finance and Company Affairs. Chief Minister, Delhi and Lt. Governor, Delhi, are permanent invitees to all meetings of the GOM. The GOM meets whenever any problem requiring decision on behalf of the Union Cabinet is to be taken. It is suggested that the role of this GOM should be enlarged to include Pune Metro Extension. The Chief Minister, Maharashtra should be inducted as a member and should attend the meetings of GOM whenever any issue concerning Pune Metro is to be deliberated upon.

20.6 Concessions from Government

Metro rail projects need very heavy investment. Loans have invariably to be taken to fund a part of the capital cost of the projects. These projects yield low financial internal rate of return. With reasonable fare level, servicing of these loans often poses problems. To make the project financially viable, therefore, the fares need to be substantially increased to socially un-acceptable levels. This results in the ridership coming down significantly, as it is sensitive to increases in the fare level. Thus, the very objective of constructing the metro rail system to provide an affordable mode of mass travel for public is defeated. It, therefore, becomes necessary to keep the initial capital cost of a metro project as low as possible so that the fare level of the metro system can be kept at reasonable level.

Thus, Government should exempt the following: -

- Tax on electricity required for operation and maintenance of the metro system.
- Basic Custom Duty at concessional rate of 5.15%.

20.7 Need for dedicated fund for metro projects

We also strongly recommend that the State Government and PMC start building up funds for the project through dedicated levies as has been done by other State Governments.

To enable the State Governments to provide their share of equity in the Special Purpose Vehicles set up for such projects, it would be necessary to constitute a Special Metro Fund at the State Government level. The State Government should resort to imposition of dedicated levies for raising resources for these Funds. Areas where such dedicated levies are possible via State government and Urban local body are given below:

Annual Grant by PMC:

- An act needs to be passed for collection of 1% cess on property registrations (Earlier covered as LBT) allowing for collection of the cess in PMC and sharing of 25% of this amount with the SPV.
- Implementation of TOD Policy allowing incremental FAR of 4, 500m on either side of alignment, Premium collection for the same and sharing of proceeds with Maha Metro.

21. LIST OF APPROVALS REQUIRED FOR PROJECT IMPLEMENTATION

The details of the comprehensive checklist for approval of large-scale projects

21.1 Project Feasibility / Pre-Sanction Stage

21.1.1 APPROVALS FROM LOCAL BODY

- Land use plan approval
- Approval for change in land use
- NOC for construction / augmentation
- Relaxation in respect of density/ ground coverage/ FAR/ setbacks/ height

21.1.2 APPROVAL FROM AIRPORT AUTHORITY

- No objection certificate (legal document) is required for height clearance
- NOC from coastal zone management authority

21.2 Sanction Stage - Lay Out Plan/ Local Area Plan/ Urban Design Plan

- Local body approvals
- Approval from national monument authority
- Approval from tree authority committee
- Approval from Maharashtra heritage conservation committee
- Approval from railway authority/port
- Approval from road owning agency
- Approval from traffic & coordination dept. (municipal)
- Approval from chief fire officer
- Approval from chief controller of explosives
- Approval is required from the chief inspector of factories, in case of industrial building.
- Environment clearance is required from ministry of environment and forests (MOEF)

21.3 Sanction / Building Permit Stage

- Approval from local body
- Approval from licensing
- Approval is required from the power distributing / supply agency
- Approval / NOC /assurance is required from the water supply agency
- Approval / NOC is required from the storm water & drain department/sewerage department
- Approval is required from the storm water & drain dept. / sewerage dept. for drainage & sewerage connection before start of construction

21.4 Construction Stage

- Permission is required from the central ground water authority
- Intimation to the local authority
- Plinth level notice

21.5 Completion Cum Occupancy Certificate Stage

- MRT Rail / Rail Safety Clearance
- Completion-cum-occupancy certificate from local body
- Approval from the lift inspector
- Approval for handicapped accessibility & amenity

22. RISK ASSESSMENT

Pune MRT Line corridor project is a complex project in a transport infrastructure pristine environment. In order to mitigate most of the risks identified at this stage of the project, it becomes essential the selected contractors demonstrate adequate experience and a General Consultant is introduced in order to control and monitor the performance of the contractor. Possible Risk & Mitigation measures are listed below.

22.1 Before Construction

22.1.1 Land Acquisition – Temporary & Permanent

Land pocket identifications for temporary & permanent works should be accurately assessed during planning and design stages and land should be acquired ahead of the construction activities. Any delay in land acquisition will have immediate impact on the schedule of the project. Local authorities shall be proactive in this as delay in land acquisition affects project time frame & budget adversely.

The General Consultant would work hand in hand with the State Government and Maharashtra Metro Rail Corporation Limited to pass these obstacles standing along the way.

22.1.2 Utility Identification & Relocations

Utility Identification survey shall be done, before start of the construction, through GPRS/ Equivalent survey. Proper & timely shifting of utilities are essential in order to avoid delay in construction.

22.1.3 Energy providers

Utilities may also be directly connected to the existing and newly implemented Pune MRT system. This is particularly true for the energy providers. Power supply design will have to be prepared in collaboration with the local energy providers in order to ensure the power requirement can actually be met by the provider and under which conditions.

Once the power supply scheme has been agreed upon and implemented, the system will require to be highly reliable to ensure continuous operation at the defined time of operation. An audit of the power provider shall be conducted before construction so that adequate measures are taken ahead of operations.

22.1.4 Monitoring of the project

Since Maharashtra Metro Rail Corporation Limited have the required expertise and few experienced manpower to check and monitor the contractors' work, it may be necessary to engage a General Consultants from the very start of the Pune MRT project, who will do this job on behalf of Maharashtra Metro Rail Corporation Limited.

22.2 During Construction

22.2.1 Construction schedule

Planned construction schedule envisages 5 years for construction and commissioning of first approx. 5.464 km which is very challenging, and it is important the contractor in charge has a clear understanding of the works to be accomplished and the construction methods to be followed.

Adequate monitoring of project construction and schedule should also be implemented to identify an issue appearing and avoid any slippage. The nomination of a General Consultant would serve that purpose.

22.2.2 Cost management

Along with schedule risks, project such as MRT project are often exposed to costs risk.

22.2.3 Interface management

While it needs to be anticipated before construction starts, interface management becomes critical during construction if not performed adequately resulting in mistake at site and delay.

22.2.4 Setting up of working site

It is paramount the working site areas are clearly delineated and properly barricaded and guarded to avoid unattended intrusion of non-authorized personnel or vehicle.

When setting up the working areas, traffic management plan shall be implemented to provide adequate traffic diversion and lessen disruptions to the road users.

22.2.5 Concurrent activities with other departmental construction work

In order to avoid conflicting works activities, proper liasoning is required between different Government departments working on the same perimeter.

22.2.6 Safety, Health & Environment

The Contractor is required to comply with all the precautions as required for the safety of the workmen as per the International Labour Organisation (ILO) as far as those are applicable to this contract. The contractor shall supply all necessary safety appliances such as safety goggles, helmets, masks, etc., to the workers and staff. The contractor has to comply with all regulation regarding.

The Contractor shall also ensure they fulfil their contract requirements for minimizing construction noise by developing mitigation measures to tackle the noise problem for at-grade or elevated tracks, e.g. by prescribing noise barriers or noise enclosures, either complete enclosure or partial.

22.2.7 Approvals from statutory bodies

The approval required for such project are listed in Chapter 21. Delay in statutory bodies' approval will create delay in construction timeline.

22.3 During Operation

22.3.1 Security

Security is a relatively new challenge in the context of public transport. It addresses problems caused intentionally. Security problems or threats are caused by people whose actions aim at undermining or disturbing the public transport system and/or to harm passengers or staff. These threats range from daily operational security problems such as disorder or vandalism. Operating MRT stations and running trains also become a soft target in time of any insurgencies or terrorist activities.

22.3.2 Energy providers

In case the energy provider is not found reliable enough, operations of the system are at risk.

23. SAFETY

Ensuring safety along the newly implemented transport corridor is paramount for the success of the project. Given the configuration of the Metro line corridor, the following items shall be implemented.

23.1 Ensuring safety during construction

Construction methods deployed at site shall not endanger the life of workers. It is advised that method used are largely tried and tested and do not present any kind of risk for the safety of workers.

Implementation of the MRT corridor on underground stretch should ideally happen in a non-built area and located at enough distance from any built-up land wherever practicable.

Traffic diversion shall be adequately planned to avoid any conflict between construction related activities and associated traffic flow on one hand and regular road traffic on the other hand.

Implementation of MRT stations shall be planned in coherence with the urban fabric and local development also planned to support safety requirements generated due to new development.

23.2 Ensuring safety during operation

23.2.1.1 Station operations

Facilities required at any station for emergency evacuation as per NFPA 130 Guidelines has been adopted. The stations have been planned in accordance with 'Guidelines for Pedestrian Facilities, and 'National Building Code-2016', for Disabled friendly and other Indian best practices/standards which ensure adequate sizing of station and comfort of passengers. The regulations are tailored to avoid any injury or casualty in case.

Electrical installations shall be confined in "authorized personnel only" area.

Specific safety rules and procedures shall be followed by MRT staff during both operation in station and in depot area.

23.2.1.2 Train operations

However, signalling system ensures the safety of running trains during operations through an efficient train control, ensuring safety in train movements.

Rolling stock running on the system is tailored to ensure safety of the passengers and shall comprises the following characteristics: continuous automatic train protection, fire-proofing, emergency door control, crashworthiness design protecting passengers in case of accident.

23.2.1.3 Passenger awareness

Wide publicity shall be given to all commuters and general public for awareness on safety in Metro systems. General Do's & Don'ts shall be circulated and displayed in station areas for users and workers in the metro system to ensure safety.

Passengers shall be particularly made aware of risks associated with 25KV OHE/ROCS[18] and unauthorized access to track or prohibited areas in stations.

[18] ROCS is recommended for phase 2A whereas OHE is only used as a reference for calculation purpose.

24. CONCLUSION AND RECOMMENDATION

Pune has witnessed enormous growth during the last 10 years. The growth is mainly the result of immigration as the city provided better employment opportunities. Pune and surrounding areas are experiencing tremendous economic growth supported by favourable socio-economic conditions and investment climate. Rapid urbanization in the recent past has put the city's travel infrastructure to stress. Being densely populated area, Pune's traffic needs cannot be met by only road-based system. Road-based, has already come under stress leading to longer travel time, increased air pollution and rise in number of road accidents. However, BRTS has offered some respite in this context, but it may not be sustainable and cater travel demand in longer horizon. With projected increase in the population of the city, strengthening and augmenting of transport infrastructure has assumed urgency. For this purpose, provision of rail-based Metro system in the city has been considered.

Studies have brought out that a Medium Capacity Metro with carrying capacity of about 15,000 to 25,000 PHPDT will be adequate to meet not only the traffic needs for the present but for the future 30 to 40 years also. The extension of a Metro System of PCMC to Swargate in south i.e. from Swargate to Katraj is at an estimated completion cost of INR 3,663.86 Crores (with Central taxes & duties) to be made operational as recommended in implementation chapter.

A detailed Environmental Impact Assessment Study has been carried out for the project. As a part of this Study, comprehensive environmental baseline data was collected, and both positive and negative impacts of the project were assessed in detail. The project has many positive environmental impacts like reduction in traffic congestion, saving in travel time, reduction in air and noise pollution, lesser fuel consumption, lesser road accidents etc, with a few negative impacts (especially during implementation phase of the project) for which Environmental Management Plan has been suggested.

After examining the various options for execution of the extension of Pune Metro Project, it is recommended that the project should get executed through the existing SPV.

The fare structure is as per the Government Resolution No. PMR-3313/C.R.29/UD-7 dated 11 Sept. 2013.

Pune Metro shall get following exemptions:

- Tax on electricity required for operation and maintenance of the metro system.
- Basic Custom duty is taken at concessional rate of 5%

As per the present policy, 50% of the Central Taxes will be paid by GOI as subordinate Debt and balance 50% will be paid by the concerned State Government. Maharashtra State Government may pursue the Central Government to extend the same benefit to Pune Metro.

While the Financial Internal Rate of Return (FIRR) for the project has been assessed as 14.45%, with central taxes with property development of 33.88 Ha land and the Economic Internal Rate of Return (EIRR) works out 19.80 %.

The project has already received in principle approval from Government of Maharashtra in October 2013.

For implementation of the project, an act needs to be passed for collection of 1% cess on property registrations (Earlier covered as LBT) allowing for collection of the cess in PMC and sharing of 25% of this amount with the SPV. Also, implementation of TOD Policy allowing incremental FAR of 4, 500m on either side of alignment needs to be done, premium collection for the same and sharing of proceeds with Maha Metro.

Meanwhile, the State Government should freeze all future developments along the proposed route of extension of Pune Metro to avoid infructuous expenditure.

Land required for PD if the additional PD income is considered. PMC has provided 33.88 Ha of land, which shall be auctioned out to a developer with maximum allowable FAR of 4, for a 50-year capital lease period after implementation of project in order to maximize the benefit. Accordingly, the corridor is recommended for implementation.

25. Checklist

S.No.	Items	Yes/No
	CMP/ Master Plan	
1.	Does the city have a Master Plan for the horizon year?	Yes
2.	Does the city have a Comprehensive Urban Mobility Plan/Integrated Mobility Plan (IMP); and have the recommendations of the same been incorporated in the City Master Plan/Development Plan?	Yes
3.	Has the Comprehensive Urban Mobility Plan been notified as per the State Town and Country Planning Act, if not, will it be notified in next six months?	Yes
	Alternatives Analysis	
4.	Has the Alternatives Analysis Report been prepared as per the framework issued by MoHUA and with justifications for the construction of a Metro Rail?	Yes
	Detailed Project Report	
5.	As part of the DPR, has Techno Economic Feasibility of the Metro System been examined or not?	Yes
6.	Does the proposal include Economic cost and benefit analysis?	Yes
7.	Does the proposal contain the status report on prevailing pre-metro urban transport infrastructure in the city?	Yes
8.	Is the DPR prepared strictly in accordance with the standards and specifications of Metro rail system issued by MoHUA from time to time?	Yes
	Public Transport System	
9.	Does the city have an existing Public Transport System? (please	
	a) Upto 50 buses	
	b) 50 to 100 buses	
	c) 100 to 200 buses	
	d) More than 200 buses	Yes
10.	Does the proposal include a report on how the Metro Rail will integrate with the existing transportation systems/proposed transit system?	Yes
11.	Does the proposal include a status report on the existing status and financial viability or socio- economic benefits of an existing Metro Rail System, if any in the city and the support being extended by the State Government to improve its financial viability?	
12.	Does the proposal contain a report on making a feeder system integrated with the proposed Metro Rail project?	Yes

S.No.	Items	Yes/No
13.	Does the report ensure last mile connectivity/NMT infrastructure?	Yes
	Transit Oriented Development (TOD) and Non-Fare Box Revenue	
14.	Does the proposal contain distinct proposal for development of commercial property at and around stations to supplement fare-box revenue?	Yes
15.	Are the recommendations of the Transit Oriented Development Plan incorporated in the Master Plan?	Yes
16.	Has TOD plan and Value capture financing framework been prepared as per guidelines issued by MoHUA?	Yes
17.	Does the proposal include expanding utility capacity to densify areas around metro station as per notified TOD policy?	Yes
18.	Does the proposal include measures that will be taken for maximization of non-fare box non-property revenue?	Yes
19.	Does the proposal contain a detailed Environmental and Social Impact Analysis?	Yes
	Economic Analysis	
20.	Does the proposal contain measures for optimization of O&M costs?	Yes
21.	Does the proposal contain an Economic Analysis of the project along with the calculated values of EIRR and ENPV as per approved framework of MoHUA?	Yes
	Implementation Framework	
22.	Does the proposal include the exploration of PPP models for implementing the project? Does proposal contain implementation of at least one component of Metro Rail Project through PPP?	Yes
23	Does the proposal include the exploration of PPP models for Operations and/or maintenance of the project?	Yes (For AFC, PPP Mode is recommended)
24	Does the project clearly bring out key performance indicators and robust monitoring mechanism?	Yes

S.No.	Items	Yes/No
25.	Is the methodology devised for integrating fares of all available modes with Metro system planned (including National Common Mobility Card)?	Yes
26.	Does the proposal contain an MOU in between various service providers to provide seamless integration between the various modes?	No, will be developed at later stage
27.	Does the proposal include any monitoring mechanism to monitor the project during construction & implementation?	Yes
28.	In case the project is for a metropolitan region, is there an MOU between the participating states?	Not applicable , participating state is only Maharashtra
29.	Is there an involvement of municipal corporation/city development authority in implementing and/or operating the project?	Yes
	Role of State Government and UMTA	
30.	Has State Government committed in maintaining the financial viability of metro line?	Yes
31.	Has the State Government committed for providing & financing security provision for Metro System?	Yes
32.	Has the State Government firmed up funding of the project, with exploration of various methods?	Yes
33.	Has the State Government committed financial support to the project including O&M to ensure financial sustainability during the project life cycle including the operations stage?	Yes
34.	Has the State Government set up or firmed up the plan for setting up of UMTA for the city?	Yes
35.	Is the UMTA notified?	Yes
36.	If UMTA is not notified, is there a commitment for notifying it within a year?	Not applicable

S.No.	Items	Yes/No
37.	Is there a role, responsibility and involvement (including financial stake) of the city government in the Metro Rail project, both during construction and the operations phase	Yes
38.	Has the State Government committed for enabling policy & regulatory framework required for enhancing non fare box revenue	Yes
39.	Has the State Government devised any option to enable metro rail implementing agencies to issue corporate bonds	No