EXECUTIVE SUMMARY

0.1 INTRODUCTION

Mumbai, the financial capital of India, has witnessed phenomenal growth in population and employment. The trend is expected to continue in the future. The job opportunities it offers have served as a major attraction for immigration from hinterland of Maharashtra as well as from all parts of the Country. Mumbai Metropolitan Region (MMR) is one of the fast growing metropolitan regions in India. It comprises of 7 municipal corporations, 13 municipal councils and 996 villages and extends over an area of 4,355 sq.km. MMR is projected to have population and employment (both in terms of formal and informal) as 34.0 million and 15.3 million respectively in the year 2031.

Four-fold growth of population since 1951 has been largely accommodated in the suburbs while the highest concentration of jobs has remained in the Island City. The physical characteristics of the City are such that the suburbs have been constrained to spread northwards only, and all transport facilities are concentrated within three narrow corridors. Today's major challenge is to provide connectivity and promote growth by providing additional infrastructure which would improve the quality of life of the residents.

A Master Plan for Mumbai Metro was prepared in 2004 which proposed implementation of metro corridors in three phases i.e. Phase 1: 2005-2011, Phase II: 2011- 2016 and Phase III: 2016-2021. MMRDA has carried out DPR studies for all the three Phase I metro corridors during the period 2005-2009 (Line 1: Versova - Andheri - Ghatkopar, Line 2: Mankhurd - Bandra - Charkop and Line III: Colaba - Bandra). In 2010, MMRDA also carried out the DPRs of four lines of Phase II & III. Among these, RITES carried out the DPR for BKC - Kanjur Marg (via Air port) with extension from BKC to Mahim (Total Length - 23.5 km).

Table 0.1: Phasing of Mumbai Metro Master Plan

Sr. No.	Corridor	Length of the Corridor (km)	Capital Cost @ 2003 prices (Rs in Crores)	Peak Hour Peak Direction Flow (PHPDT)	Phasing	Phase wise length (km)	Proposed Period of Implementation
1	Versova – Andheri – Ghatkopar	15.0	1500	31421	I	63.8	2005-2011
2	Colaba (Backbay) – Mahim – Charkop	36.0	5085	43356			
3	Mahim – Mankhurd	12.8	1595	28022			
4	Charkop – Dahisar (East)	7.5	750	19094	II	19.9	2011-2016
5	Ghatkopar – Mulund	12.4	1540	32698			
6	BKC to Kanjurmarg via Airport	19.5	3225	21441	III	62.8	2016-2021
7	Andheri (East) – Dahisar (East)	18.0	1800	25504			
8	Hutatma Chowk – Ghatkopar	21.8	3455	18354			
9	Sewri – Prabhadevi	3.5	875	4446			

To provide multimodal access to the airport passengers at CSIA, (being developed as a world class airport), it has long been considered necessary to provide metro connectivity to/ from major parts of the City. Initially this was contemplated via Line I (Versova – Andheri – Ghatkopar), but the spur line connection was not found feasible.

The National Facilitation Committee (NFC), decided that the metro connectivity to the CSIA be expedited and put in the phase 1, rather than in the phase 3 as per Metro Master Plan. This was decided to be achieved by merging Line 6 of Phase 3, named BKC – Kanjur Marg via Airport with the Line 3 of Phase I, i.e. Colaba – Mahim – Bandra and run through services from Colaba till SEEPZ.

With this background, MMRDA through MMRC commissioned the services of RITES to update both the studies ; viz. the first conducted by DMRC for Colaba – Mahim – Bandra Metro Line (2007) and the second by RITES for Mahim – BKC – Kanjur Marg (2010); and prepare a combined DPR for the running of through services on the fully underground Colaba – Bandra – SEEPZ corridor (**Figure 0.1**)

0.2 RIDERSHIP ESTIMATION

The ridership figures for the Colaba – Bandra – SEEPZ Metro corridor are provided by MMRDA based on the results of its CTS Transport Demand Model.

The proposed Metro Corridor is expected to have a daily ridership of 16.99 Lakh and Max. PHPDT of 42000 by 2031. The daily ridership and PHPD on the corridor are shown in **Table 0.2**.

Table 0.2: PHPDT and Daily Ridership for 2016, 2025 and 2031

Corridor	2016		2025		2031	
	Max. PHPDT	Daily Ridership (in Lakh)	Max. PHPDT	Daily Ridership (in Lakh)	Max. PHPDT	Daily Ridership (in Lakh)
Colaba-Bandra - SEEPZ	25700	10.06	39000	13.87	42000	16.99

0.3 SYSTEM DESIGN

0.3.1 Permanent Way

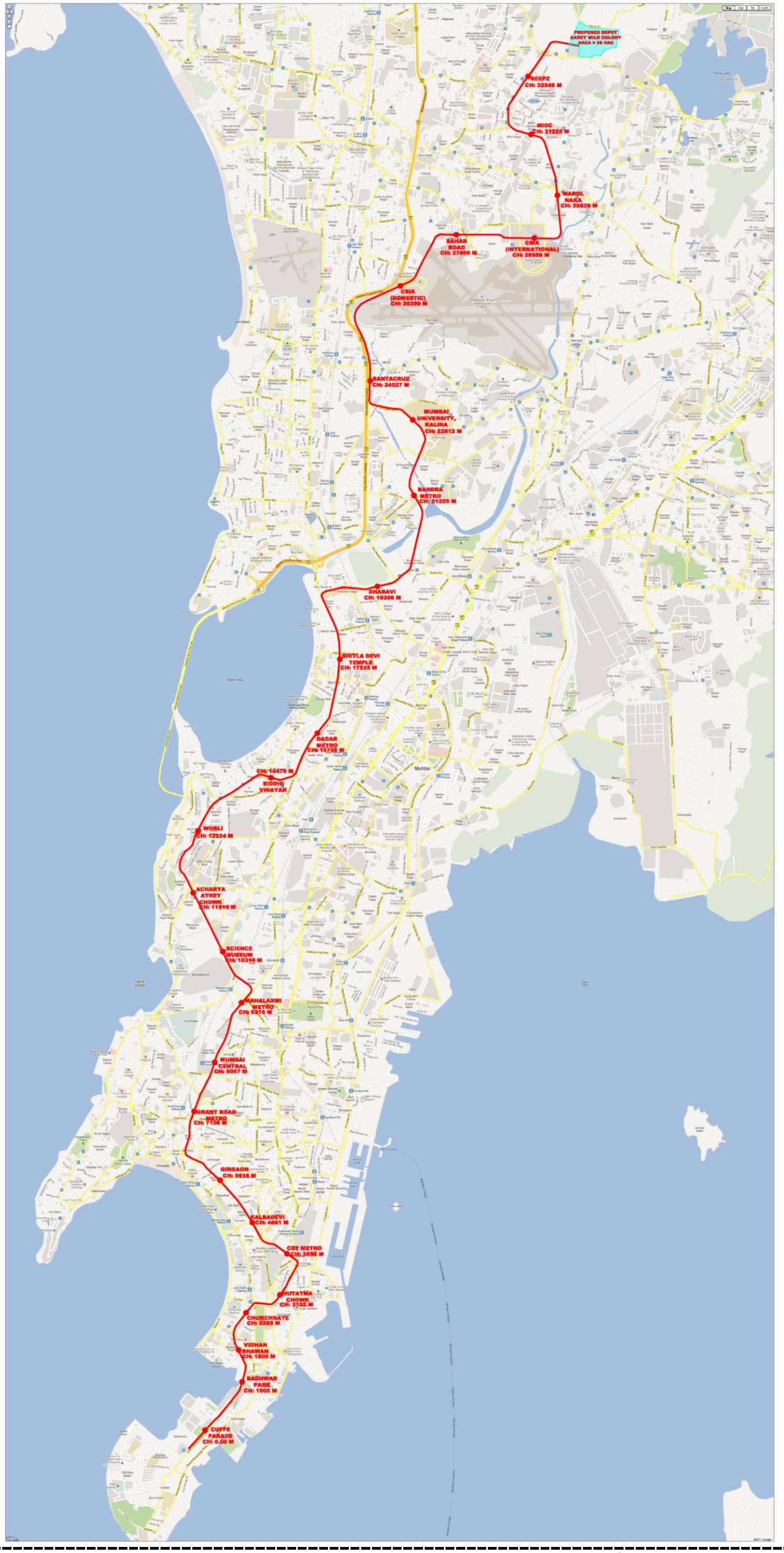
Choice of Gauge

Mumbai Metro Corridors I and II are being implemented with standard gauge and with the objective of uniformity, this corridor is also proposed to be on Standard Gauge(1435mm).

a) 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 is long lasting and requires minimum or no maintenance and at the same time, ensure highest level of safety, reliability and comfort, with minimum noise and vibrations. The ballastless track structure has been proposed keeping the above philosophy in view.

Figure 0.1: Proposed Colaba – Bandra – SEEPZ Metro Corridor



b) Rail Structure Interaction

Rail structure interaction study will determine the need and locations of Rail Expansion Joints (REJ) also. REJ in ballasted track will be for a maximum gap of 120 mm, whereas on ballastless track for a maximum gap of 180 mm.

c) Welding

Flash Butt Welding Technique is to be used for welding of rails. Alumino-Thermit Welding is to be done only for those joints which cannot be welded by Flash Butt Welding Technique, such as joints at destressing locations and approach welds of switches & crossings. For minimising the population of Thermit welds, mobile (rail-cum-road or portable) Flash Butt Welding Plant will have to be deployed.

The track will conform to standards as laid down by Railway Board vide their letter no. 2010/ Proj./Genl/3/3 dated 23/12/2011.

0.3.2 Traction System

Keeping in view the ultimate traffic requirements, uniformity, standardization and other techno-economic considerations, 25kV ac traction system is considered to be the best solution and hence, proposed for adoption. Suitable measures will be required for mitigation of EMI & EMC caused by 25 kV single-phase traction currents.

0.3.3 Signalling and Train Control

Metro carries a 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 'Distance to go' ATP (Automatic Train Protection) and ATS (Automatic Train Supervision) sub-systems.

Signalling & Train Control system on the line is planned for a design headway of 2.5 minutes so as to meet sustained train operation at 3 minutes interval during peak periods.

0.3.4 Telecommunication

The standards proposed to be adopted for telecommunication systems are presented in **Table 0.3.**

Table 0.3 Standards Proposed for Telecommunication Systems

System	Standards
Transmission System	SDH and GE based for the entire telecom network.
Transmission Media	Optical Fibre system as the main bearer for bulk of the telecommunication network,
Telephone Exchange	EPABX of minimum 128 ports is to be provided at all Stations and an Exchange of 256 Ports to be provided at Terminal Station & OCC.
Train Radio System	Digital Train radio (TETRA) communication between motorman of moving cars, stations, maintenance personnel and central control.

System	Standards
Train Destination Indicator System	LED/LCD based boards with adequate visibility to be provided at convenient location at all stations to provide bilingual visual indication of the status of the running trains, and also special messages in emergencies. Provision for display of information for other public transport modes will be made at interchange stations.
Centralized clock system	Accurate display of time through a synchronisation system of slave clocks driven from a master clock at the OCC and sub – master clock in station. This shall also be used for synchronisation other systems.
Passenger Announcement System	Passenger Announcement System covering all platform and concourse areas with local as well as Central Announcement. Provision for announcements for other public transport modes will be made at interchange stations.
Redundancy (Major System)	Redundancy on Radio base station equipment. 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.

0.3.5 Automatic Fare Collection

Ticketing system shall be simple, easy to use/operate and maintain, easy on accounting facilities, capable of issuing single/multiple journey tickets, amenable for quick fare changes and require overall lesser manpower. A computer based automatic fare collection system is proposed.

0.3.6 Rolling Stock

Rolling Stock proposed for Colaba – Bandra – SEEPZ Metro will be similar to Rolling Stock of Line - I of Mumbai Metro. The specifications of the rolling stock and its procurement may be decided on the basis of the project implementation mechanism. The broad features of Rolling Stock which may be followed for the Corridor are presented in **Table 0.4**.

Table 0.4: Broad Features of Rolling Stock

S. No.	Parameter	Colaba – Bandra - SEEPZ Corridor
1	Vehicle dimensions	
	Length (including coupler)	DT-M-T-M-T-M-M-DT : 178360 mm
	Width	3200mm
	Height	DTC : 4118mm over panto in down position TC/MC : 3898mm over AC portion of roof
2	Coach construction	Lightweight stainless steel body
3	Tare Weight	DT (42.0T), T (42.0T), M (42.0T)
4	Axle load	17 T
5	Propulsion system	3 phase drive system with VVVF control
6	Type of traction supply	25KV AC Overhead collection
7	Acceleration/ Deceleration	Maximum 1.1 m/s^2 and 1.3 m/s^2 respectively

0.4 CIVIL ENGINEERING

0.4.1 Alignment Planning

- The consultants developed various alignment options between Colaba - Mahim and presented to MMRC during the course of various discussions/meetings as well as in "Options Report" submitted in Aug'11.
- The corridor is proposed to have double line track, with a capacity to run 8 coach trains.
- The corridor is planned fully underground either on the edge of the existing road or along the median of the road and care has to be taken to cause least disruption to existing services/ traffic movement. Underground structures are planned keeping in view Mumbai's aggressive marine environment and high corrosion proneness - with suitable anti-corrosive treatment to reinforcement/ structural steel, concrete surface in contact with earth as well as exposed to atmosphere.

0.4.2 Engineering Survey

Topographical survey has been carried out along the proposed alignment not less than 80 m wide or built up lines whichever is more as well as 100 m on station areas. The detailed Topographical Survey between Colaba to Mahim has been carried out afresh along the proposed alignment whereas duly updated survey data for Mahim - SEEPZ has been used from line – 6 DPR.

0.4.3 Geometric Design Norms

Horizontal Alignment

As far as possible, the alignment follows the existing roads. On consideration of maximum allowable cant of 125 mm and cant deficiency of 100 mm on Metro tracks, the safe speed on curves of radii of 400 m or more is 80 km/h. However, in the underground section, desirable minimum radius of curve is taken as 300 m for ease of working of Tunnel Boring Machine.

Vertical Alignment

Rail level at stations and in tunneling portion has been kept at least 15 m below the ground level. Since rock has been encountered at shallow depths from the existing ground level, in the range of 2.10 m to 10.0 m, underground tunneling is proposed for construction. The rail level is kept such that, the entire tunnel is encased in the rock and a minimum of 6 m rock cushion is available over the tunnel. This will also avoid the underground utilities (except station areas) and building foundations.

Gradients

The stations are proposed to be on level stretch. Between stations, generally the grades may not be steeper than 3.0%. However, where existing road gradients are steeper than 3%, gradients up to 4% (compensated) are provided in short stretches on the main line.

Design Speed

The maximum sectional speed will be 80 km/h. However, the applied cant and length of transitions will be decided in relation to normal speeds at various locations, as determined by simulation studies of alignment, vertical profile and

station locations. Computerized train simulation studies need to be conducted with proposed gradients at the time of detailed design stage. This is with the objective of keeping down the wear on rails on curves to the minimum.

0.4.4 Alignment Description

The alignment starts from the southern tip of Mumbai City at Colaba/ Cuffe Parade near the WTC junction on Captain Prashant Pethe Marg and moves northwards. After crossing Badhwar Park, it turns left along Jagannath Bhosle Road, moves off the road and runs under the police baracks at Nariman point to connect Vidhan Bhawan and Mantralaya. Further, it aligns along Jamshedji Tata Road to connect with Churchgate Station.

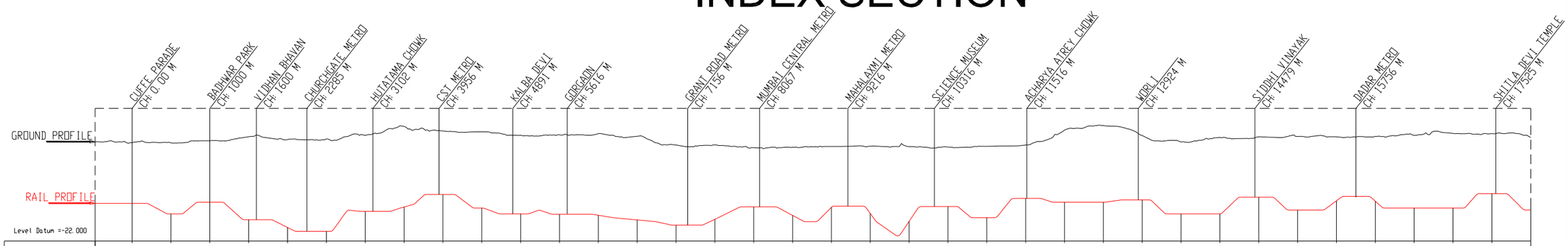
After crossing Oval Maidan along Veer Nariman Road, the alignment further runs along Dr. D.N. Road upto west of CST Rly Station along Mahapalika Marg. Further, the alignment runs along JSS Road, Lamington Road and Dr. Anandrao Nair Marg. After crossing the WR tracks at Mahalaxmi, the alignment runs along Dr. E Moses Marg, Dr. Annie Basant Road, N. Gokhale Road and Lady Jamshedji Road. At Mahim, the alignment turns right along R. Hospital Road, moves along Mahim-Sion Link/ Station Road, crosses Mahim creek (Mithi River) just east of the Sion-Bandra Link Road and further crosses Metro line II (Charkop – Bandra – Mankhurd corridor) at Bandra Metro Station (ITO). The alignment passes through Bandra-Kurla Complex, Bharat Nagar and Valmiki Nagar slums and Kalina University.

Further North, the alignment passes parallel to Santacruz – Chembur Link Road and eastern service road of Western Express Highway. The alignment enters into Mumbai Airport's premises and covers Domestic terminal, Sahar Road and International terminal. The alignment crosses metro line I (Versova – Andheri – Ghatkopar corridor) at Marol Naka. Further, the alignment passes through MIDC and SEEPZ area along Krantiveer Lakhuji Salve Marg with terminal station at SEEPZ opposite the SEEPZ Bus Depot. The alignment terminates north of Jogeshwari – Vikhroli Link Road at Aarey Milk Colony, where depot is located. **The, index section and schematic plan is enclosed as Figures 0.2/1, 0.2/2 & 0.3**.

The total length of the alignment between C/L of Cuffe parade station to SEEPZ station is 32.546 km and the total alignment length is 33.508 km. A total of 27 underground stations have been proposed along the entire length of alignment. 3 underground stations are proposed in Mumbai Airport's premises. List of stations along with their chainage and interstation distance (ISD) is presented in **Table 0.5.**

INDEX SECTION

FIGURE – 0.2/1



CHAINAGE	ELEVATION DIFF.	RAIL LEVELS	GROUNDLEVELS
-425.000	3.538	-12.300	3.538
0.000	-15.644	-12.300	3.344
500.000	-18.301	-15.000	3.302
1000.000	-15.823	-12.000	3.823
1500.000	-21.393	-16.500	4.893
2000.000	-22.651	-18.500	4.151
2500.000	-23.826	-19.500	4.327
3000.000	-19.587	-14.350	5.237
3500.000	-20.755	-13.228	7.528
4000.000	-16.378	-10.000	6.379
4500.000	-19.656	-13.500	6.157
5000.000	-20.281	-15.000	5.282
5500.000	-20.487	-15.100	5.387
6000.000	-21.041	-15.347	5.695
6500.000	-21.564	-16.559	5.005
7000.000	-20.656	-17.900	2.756
7500.000	-19.215	-16.411	2.806
8000.000	-15.260	-13.200	2.060
8500.000	-17.575	-15.388	2.187
9000.000	-15.700	-13.319	2.382
9500.000	-17.337	-14.905	2.434
10000.000	-19.267	-16.919	2.350
10500.000	-15.312	-13.100	2.213
11000.000	-18.408	-16.000	2.408
11500.000	-13.768	-11.000	2.768
12000.000	-18.603	-12.000	6.604
12500.000	-19.778	-12.000	7.778
13000.000	-16.569	-11.400	5.170
13500.000	-18.522	-15.000	3.523
14000.000	-19.705	-15.000	4.706
14500.000	-15.559	-10.700	4.860
15000.000	-18.948	-14.000	4.949
15500.000	-16.463	-11.617	4.846
16000.000	-16.724	-11.735	4.989
16500.000	-18.745	-13.500	5.245
17000.000	-19.248	-13.500	5.748
17500.000	-15.468	-9.800	5.669
18000.000	-18.691	-14.000	4.692

MUMBAI METRO RAIL CORPORATION LTD.			
TITLE	COLABA - BANDRA - SPEEZ MUMBAI METRO CORRIDOR INDEX SECTION		
CONSULTANT	M/s RITES LTD		
PREPARED BY: RAJKISHORE	CHECKED BY : V. K. SHARMA	APPROVED BY : VIVEK GUPTA	DATE: OCT. 2011
SCALE :– NOT TO SCALE	MUMBAI METRO/COLABA-SPEEZ/INDEX SECTION/DRG NO.–1 OF 2		

INDEX SECTION

FIGURE – 0.2/2

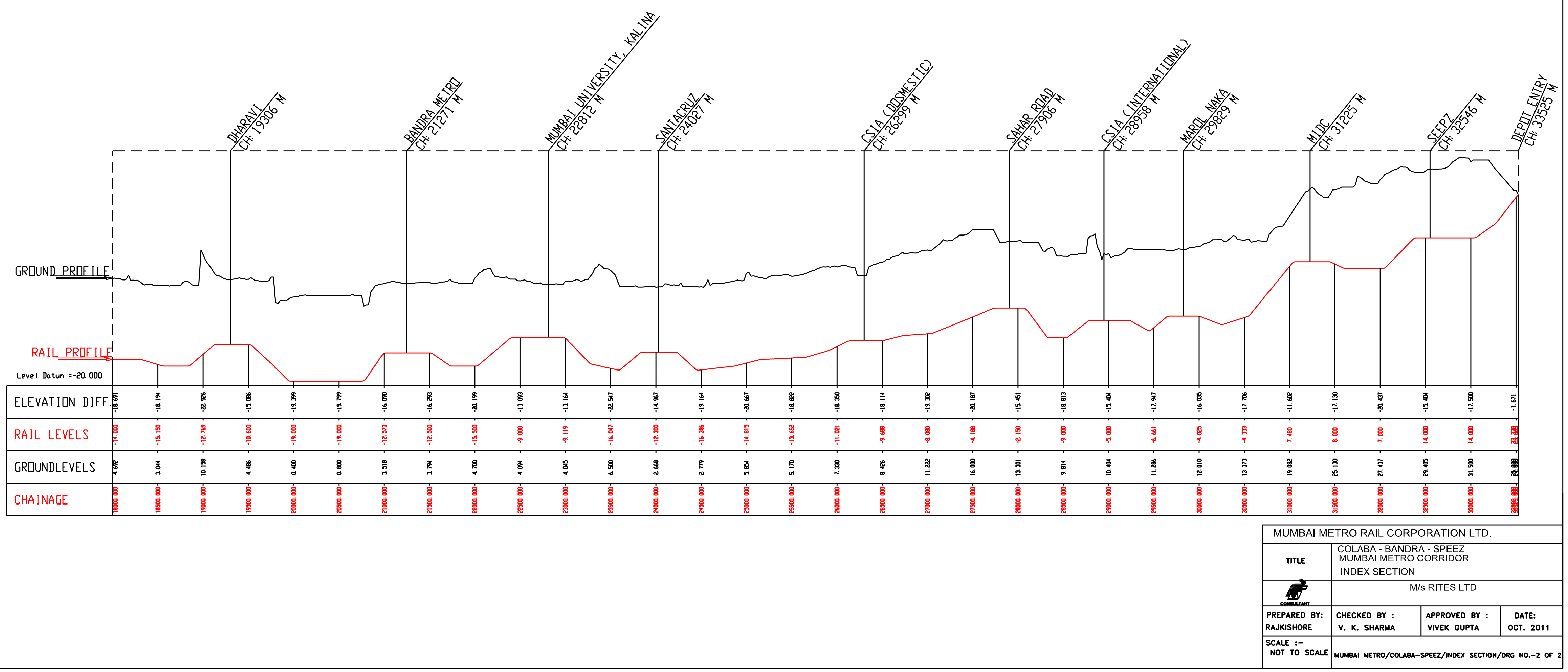
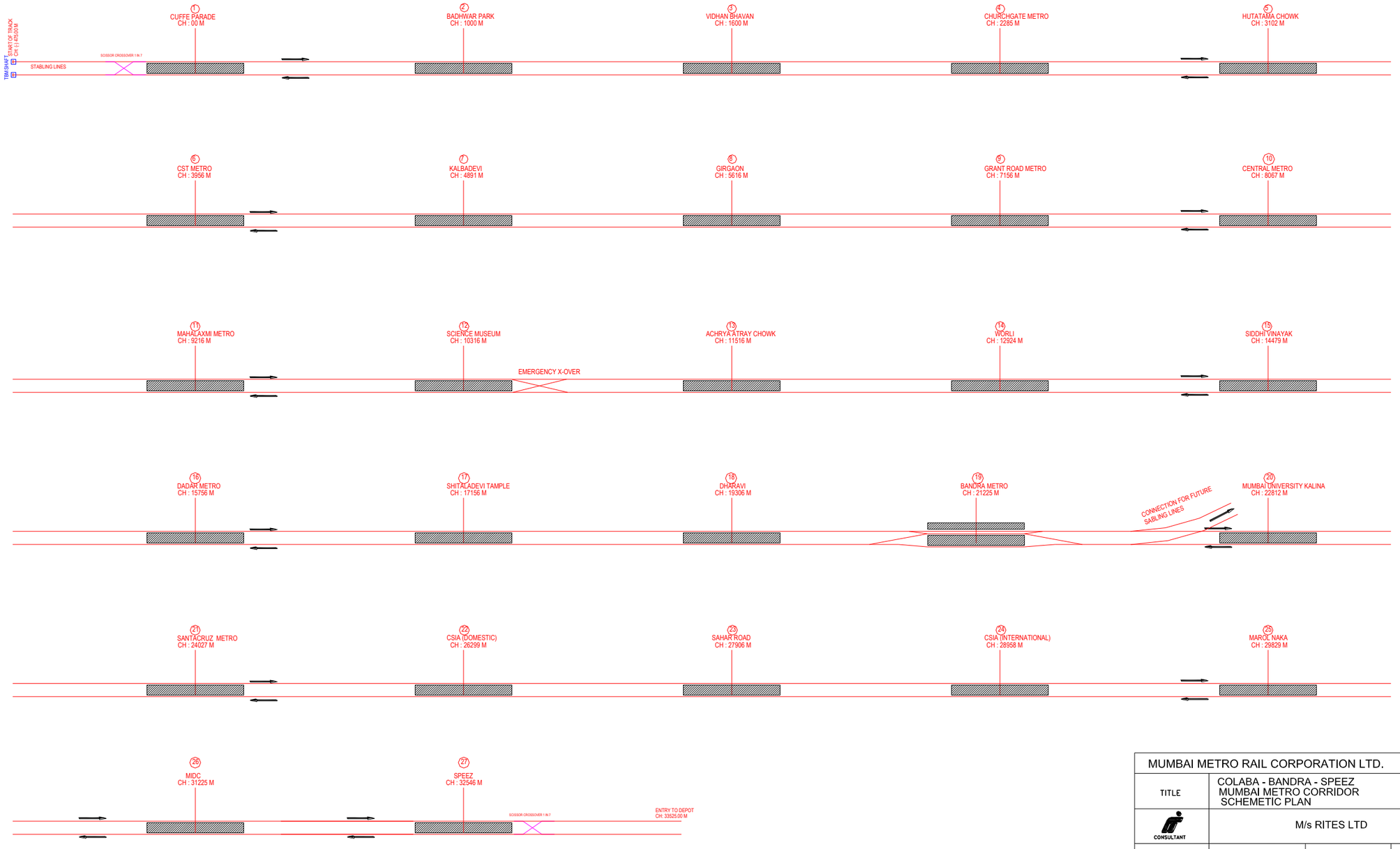


FIGURE – 0.3



MUMBAI METRO RAIL CORPORATION LTD.			
TITLE	COLABA - BANDRA - SPEEZ MUMBAI METRO CORRIDOR SCHEMETIC PLAN		
CONSULTANT	M/s RITES LTD		
PREPARED BY: RAJKISHORE	CHECKED BY : V. K. SHARMA	APPROVED BY : VIVEK GUPTA	DATE: OCT. 2011
SCALE :– NOT TO SCALE	MUMBAI METRO/COLABA–SPEEZ/SCHEMETIC PLAN/DRG NO.–01		

Table 0.5: List of Stations

Sr No.	Station Name	Chainage (M)	INTER STATION DISTANCE (M)	GL/RL (M)	Proposed RL (M)	Level Difference (M)
1	Cuffe Parade	0	-	3.43	-12.30	-15.73
2	Badhwar Park	1000	1000	3.44	-12.00	-15.44
3	Vidhan Bhavan	1600	600	5.14	-16.50	-21.64
4	Churchgate Metro	2285	685	4.00	-19.50	-23.50
5	Hutatma Chowk	3102	817	6.65	-14.35	-21.00
6	CST Metro	3956	854	6.68	-10.00	-16.68
7	Kalbadevi	4891	935	5.15	-15.00	-20.15
8	Girgaon	5616	725	5.50	-15.10	-20.60
9	Grant Road Metro	7156	1540	2.41	-17.90	-20.31
10	Mumbai Central Metro	8067	911	1.95	-13.20	-15.15
11	Mahalakshmi Metro	9216	1149	2.35	-13.00	-15.35
12	Science Museum	10316	1100	2.16	-13.10	-15.26
13	Acharya Atrey Chowk	11516	1200	5.89	-11.00	-16.89
14	Worli	12924	1408	4.52	-11.40	-15.92
15	Siddhi Vinayak	14479	1555	4.70	-10.70	-15.40
16	Dadar Metro	15756	1277	4.85	-10.50	-15.35
17	Shitla Devi Temple	17525	1769	5.71	-9.60	-15.31
18	Dharavi	19306	1781	4.46	-10.60	-15.06
19	Bandra Metro	21271	1965	3.56	-11.60	-15.16
20	Mumbai University, Kalina	22812	1541	3.31	-9.00	-12.31
21	Santacruz	24027	1215	2.74	-12.30	-15.04
22	CSIA (Domestic)	26299	2272	5.35	-9.70	-15.05
23	Sahar Road	27906	1607	13.15	-2.15	-15.30
24	CSIA (International)	28958	1052	10.37	-5.00	-15.37
25	Marol Naka	29829	871	11.35	-5.00	-16.35
26	MIDC	31225	1396	25.72	8.50	-17.22
27	SEEPZ	32546	1321	29.81	14.00	-15.81

Note: Station names are tentative and subject to change

0.4.5 Terminals

i. Cuffe Parade Station (South terminal station)

The Southernmost station on the Metro corridor is Cuffe Parade station. The rail level for Cuffe Parade station is kept 15.00 m (minimum) below the ground level. A passage has also been proposed to provide passenger dispersal facilities to World trade Centre. Reversal facilities have also been planned at Cuffe Parade station with stabling facilities.

ii. ITO Station (Mid Terminal)

ITO station will serve as the Mid Terminal station for the proposed corridor. This station will have one island and one side platform with provision of reversal facilities. Passenger interchange with Metro Line 2 (Charkop – Bandra – Mankhurd) has been planned at this station.

iii. SEEPZ Station (North Terminal station)

Northern Terminal of the corridor will be SEEPZ. Reversal/stabling facility has also been planned at this station. The depot is proposed at Aarey Milk Colony, after the SEEPZ station - north of Jogeshwari – Vikhroli Link Road.

0.4.6 Geo Technical Investigation

Geological site investigation were carried out from Colaba to Mahim for about 18.475 km and Mahim to SEEPZ for about 15.033 Km during preparation of DPR for Colaba – Bandra Metro (line – 3) and Mahim – Kanjur Marg Metro (line – 6). The data available from both the DRR's has been used for finalisation of construction methodology.

0.4.7 Utilities

The proposed metro alignment is passing along major arterial roads which are serving Institutional, commercial and residential areas. A large number of surface and sub-surface utilities viz. sewers, water mains, storm water drains, telephone cables, electric poles, traffic signals, etc. exist along the proposed alignment. Details of the existing utility services along the proposed alignment have been collected from the concerned authorities. The affected portions of the services with reference to the proposed alignment have been identified and temporary diversion and/ or permanent relocation proposals have been indicated.

0.4.8 Archaeological/ Heritage issues

In the Maharashtra region, there are 118 listed Archaeological sites out of which only eight lie in MMR. Out of these eight sites, six are in the Borivili area and beyond. Two sites, i.e. Sion and Parel are in the city limits but lie far from the proposed Corridor . Hence the Corridor does not fall within the purview of the Ancient Monuments and Archaeological Sites and Remains (Monuments and Validation) Act, 2011.

The proposed Corridor is fully underground and does not affect any Listed Heritage Structure so as to seek approval for the execution and operation of Metro Corridor. However, as the Corridor is passing through/along the Heritage Precincts and Hutatma Chowk and CST Metro stations are located in these Precincts, approval of Commissioner, MCGM through MHCC (Maharashtra Heritage Conservation Committee) will have to be obtained. Archaeological sites along corridor are as follows:

1. Worli Fort
2. Dharavi Fort
3. Mahim Fort

0.4.9 Land Requirement

Land is mainly required for;

- MRTS Structure (including Route Alignment), Station Buildings, Platforms, Entry/Exit Structures, Traffic Integration Facilities, Depots, etc.
- Receiving/Traction Sub - Stations
- Radio Towers
- Temporary Construction Depots and work sites for segment casting for underground construction

The abstract of land requirements for different components is given in **Tables 0.6** and **0.7.**

Table 0.6: Summary of Permanent Land Requirement

(Area in m^2)

	Stations		TSS		Depot	Total
	Colaba - Mahim	Mahim - SEEPZ	Colaba - Mahim	Mahim - SEEPZ		
Pvt Land	16200	16060	2000	0	0	**34260**
Govt Land	8268	6688	2000	2000	264070	**283026**
Total	**24468**	**22748**	**4000**	**2000**	**264070**	**317286**

Table 0.7: Summary of Temporary Land Requirement

	Stations		Construction Depot		Total
	Colaba - Mahim	Mahim – SEEPZ	Colaba - Mahim	Mahim - SEEPZ	
Pvt Land	0	627	0	12370	**12997**
Govt Land	5999	12407	40298	69237	**127941**
Total	**5999**	**13034**	**40298**	**81607**	**140938**

0.5 STATION PLANNING AND INTERMODAL INTEGRATION FACILITIES

0.5.1 Stations have been located so as to serve major passenger catchment areas/ destinations and to enable convenient integration with other modes of transport. Stations vary in complexity along the route and have been located by an interactive process influenced by ridership forecasts, interchange requirements with other modes of transport, station spacing, alignment, utilities, road and pedestrian requirements, etc. (**Table 0.8**).

Table 0.8: Station Planning Details

Stations	Development Density	Integration With Other Modes	No. of Entries/ Exits proposed
Cuffe Parade	High	Terminal station, interchange with Colaba bus Depot/Terminal	4
Badhwar Park	High	Inter-modal integration with buses, IPT and private pick/drop	4
Vidhan Bhavan	Medium	Inter-modal integration with buses, IPT and private pick/drop	5
Churchgate Metro	High	Interchange station with existing suburban/ proposed elevated corridor	4*
Hutatma Chowk	High	inter-modal integration with buses, IPT and private pick/drop	4
CST Metro	High	Interchange station with existing suburban corridor	4*
Kalbadevi	High	Inter-Modal integration with buses, IPT and private pick/drop	4
Girgaon	High	Charni road Suburban Railway Station about 400m away	4
Grant Road Metro	High	Grant Road Suburban Railway Station about 600m away	4
Mumbai Central Metro	High	Interchange station with existing suburban/ proposed elevated corridor. Suburban Railway Station about 600m away	4*
Mahalakshmi Metro	High	Interchange station with existing suburban/ proposed elevated corridor and upcoming monorail corridor. Mahalaxmi suburban Railway Station about 400m away	4*
Science Museum	Medium	Inter-modal integration with buses, IPT and private pick/drop	4
Acharya Atrey Chowk	Medium	Inter-modal integration with buses, IPT and private pick/drop	4

Stations	Development Density	Integration With Other Modes	No. of Entries/ Exits proposed
Worli	High	Inter-modal integration with buses, IPT and private pick/drop	4
Siddhi Vinayak	High	Interchange station with proposed MTHL corridor	4*
Dadar Metro	High	Interchange station with existing suburban / proposed elevated corridor Dadar Western Railway Station approximately at a distance of 1000 m	5*
Shitla Devi Temple	High	Mahim Western Railway Station approximately at a distance of 600 m	4*
Dharavi	High	Inter-modal integration with buses, IPT and private pick/drop	5
Bandra Metro	High	Changeover terminal station of Metro Phase I Line II i.e. Charkop-Bandra-Mankhurd,	3*
Mumbai University, Kalina	Low	Inter-modal integration with buses, IPT and private pick/drop	4
Santacruz	High	Suburban Railway Station about 700m away	4
CSIA (Domestic)	Low	Adjacent to Domestic Airport Terminal	4
Sahar Road	Medium	Inter-modal integration with buses, IPT and private pick/drop	4
CSIA (International)	Low	Adjacent to upcoming International Airport Terminal	4
Marol Naka	High	Interchange station with Upcoming Metro Line I (Versova–Andheri-Ghat Kopar Corridor)	3*
MIDC	High	Inter-modal integration with buses, IPT and private pick/drop	4
SEEPZ	Medium	Terminal Station, interchange with SEEPZ Bus Stand	4

* Additional access and traffic dispersal arrangements at interchange stations.

0.5.2 Planning Norms & Standards

The typical size of the proposed underground stations would be nearly 27 m wide and 290 m long. Important criteria that have been applied in Station Planning include:

- Sizing of Station Passenger facilities
- Stipulated Design standards
- Emergency Evacuation
- Passenger circulation, comfort, ease of use, safety and security
- Operational accommodation (Back of House Areas)
- Electrical and mechanical plant and Equipment space requirements
- Platform Screen Doors

Stations are planned assuming a train operation frequency of 2 minutes 30 seconds in 2031. The station layout accommodates the worst case scenario at each station.

The total evacuation time for the movement of all passengers in an emergency from platform level to the landing at the next level does not exceed 4.5 minutes (as per NFPA 130)

Entrances to stations have adequate capacity to satisfy predicted passenger flows and emergency evacuation requirement.

The position of entrances is determined by the juxtaposition of building location of roadways footpaths width, space availability and flow directions of passenger traffic.

The widths of entrances take into account the predicted passenger flows and available space.

All entrances extending to street level are protected against flooding. This protection is done by the provision of a minimum of 3 steps up to a landing (+450 mm minimum).

Minimum Corridor width

- Unidirectional movement: 1.8 m
- Bi-directional movement: 2.0 m
- Where length of the corridor is more than 30 m: 3.0 m
- For staff: 1.2 m

Ramps

- Preferred gradient: 1:20
- Maximum gradient: 1:12
- Minimum width:
  - Unidirectional movement: 1.2 m
  - Bi-directional movement: 1.5 m
- For ramp exceeding 10 m, rest platform: 1.8m long

The most important design consideration is to provide a safe and comfortable environment to passengers during both normal and emergency operation. The space planning requirement for each of the stations with respect to the number of AFC gates, ticket windows, stair width, number of escalators, platform width etc in normal and emergency conditions are based on peak hour passenger traffic. These calculations not only accommodate the normal and delayed operation but also satisfy NFPA 130.

0.5.2 Typical Station Design

Bandra Metro (BKC/ ITO)

The Bandrta Metro station at Bandra Kurla Complex is proposed as a Mid Terminal Station. The BKC station is a major interchange station between the Metro Line II (CBM corridor) and the proposed Colaba – Bandra - SEEPZ corridor. To enable seamless transfer of passengers between one line and another, it is proposed to connect the paid area of the proposed mid terminal station with the paid area of the ITO station of the Charkhop - Bandra - Mankhurd Metro corridor.

The proposed station has a triple platform configuration with ticketing counters at the concourse level on both sides of the station. Auxiliary substations for Power Supply and Traction facilities is placed at the platform level, where as the requirement of System Rooms, Staff facilities, Tunnel Ventilation System and Operations is contained at the Concourse Level. DG set, Fuel Tank, Water Tank and Chiller Plant are placed at the Ground Level.

Island platform is 180 m long and 11.6 m wide, whilst side platform is 180m long and 6.6 m wide. Vertical circulation, in the form of four sets of, adequately sized, stairs and escalators have been provided in the centre of the island platform, and side platform to cater to normal and emergency passenger movement for the projected year 2031.

The Metro Station is also accessible for the disabled with the provision of one lift to connect the ground level to the concourse level (unpaid public area) and another lift to connect the concourse level (paid public area) to the platform level. Separate firemen access stairs and passenger escape stairs have also been provided at each end of the station.

Retail space of about 240 sq mt is proposed at the Concourse level for small kiosks, automatic vending machines, retail shops etc. **Figure 0.4** shows the Concourse Level and Platform Level Plans of the Bandra (BKC) Metro Station.

0.5.3 Inter-modal Integration And Dispersal Facilities

With the increase in passenger traffic dispersing via the road network for the feeder trips, it is vital that adequate traffic dispersal facilities be planned for horizon year traffic and capacity of roads, footpaths/pedestrian facilities, bus stops, IPT stands, Pick / Drop areas to cater to the projected requirements for the proposed metro stations, considering the following objectives:

- To facilitate efficient transfer and dispersal of passengers from/ to the proposed system
- To provide for effective inter-modal interchange of the passengers with the feeder modes including walk, IPT and buses.
- To integrate the proposed system's entry/ exits with those of existing system and upcoming transport infrastructure

This issue become more important for stations involving major interchanges with other existing/proposed/upcoming mass transit modes. The approach followed to achieve these objectives involves the analysis of the present issues, concerns and the potentials in order to facilitate the future traffic demand levels. The same for the typical Bandra Metro station and proposals for achieving the desired efficiency of inter-modal integration and passenger dispersal in view of the overall traffic volume in horizon year is discussed in the **Tables 0.9** and **0.10**.

Table 0.9: Issues, Concerns and Potentials of the Bandra Metro Station Area

Issues	Concerns	Potentials
• Interchange with Charkop-Bandra –Mankhurd Metro Line needs to be suitably addressed	• The immediate surroundings have marshy land wherein the facilities like parking cannot be planned because of Environment concerns and clearances	• Large employment base in the catchment area • Wide footpaths which can accommodate the passenger dispersal • Will cater to the ridership from the proposed Metro Line II i.e. Charkop – Bandra – Mankhurd • Future possibilities of high density as large chunk of land is still vacant which will add to the metro ridership

Table 0.10: Peak hour Passenger Dispersal Demand Levels and Proposed Connectivity & Traffic Circulation at Bandra Metro Station

	Existing Carriagewaywidth	Existing Capacity	Existing Load	Issues	Proposal	Proposed Capacity	Projected Load
Roads							
Bandra Kurla Complex Road	30.5	15250	8960 PCU	• Unorganised pedestrian and vehicular movement near the intersections	• Strengthening of Road shoulder areas for increasing road traffic capacity.	15250	13310 PCU
Bharat Nagar Road	23.5	11750	5235 PCU	• On-street parking of vehicles conflicts the vehicular movement	• Removal of on-street parking of vehicles	11750	7710 PCU
Pedestrian Facilities							
Bandra Kurla Complex Road	6	6000	1210 Persons	• Encroached footpaths by informal activities, slums • Pedestrian – vehicle conflict at the junction	• Widening of footpath in front of station Entry/Exits.	6000	7700 Persons
Bharat Nagar Road	6	6000	1010 Persons	• lack of pedestrian facilities • parking of vehicles on footpath	• Station Entry/ Exits provided across all directions for facilitating convenient access • Strengthening of footpath area, removal of parking • Widening of footpath in front of station Entry/Exits.	6000	7420 Persons
Bus Stops							
		On-Street	1 Buses/ Minutes	• Conflict with the heavy pedestrian volumes and Auto Movements	• Demarcation of designated Bus Bays on main roads, especially near the proposed station entry/exits	Minimum 1 Bus bay to handle a total of at least 2 buses/ minute in peak hour per direction	2 Buses/ Minutes
IPT (Taxi***) Stands/ Pick-Drop Areas***							
		On-Street	• 1 Taxi / minute	• Unorganized Taxi stands and lack of pick/drop areas	• Demarcation of designated Bays and pick-drop zones near station entry/ exits by utilizing Road shoulder areas	Minimum 1 Taxi bay to handle a total of at least 3 Taxi / minute in peak hour per direction	2 Taxi / minute
						Parking	
				• Inadequate formal parking facilities results in unorganized and On-Street Parking leading to congestion	• Planned off-street parking facilities with defined parking bays (about 50) is suggested near the station		

The street level inter-modal integration plan indicating the traffic circulation and proposed road infrastructure / argumentation in the station precinct area is also presented at **Figure 0.5**.

Figure 0.4: Concourse & Plat form Level Plans – Bandra Metro (BKC)

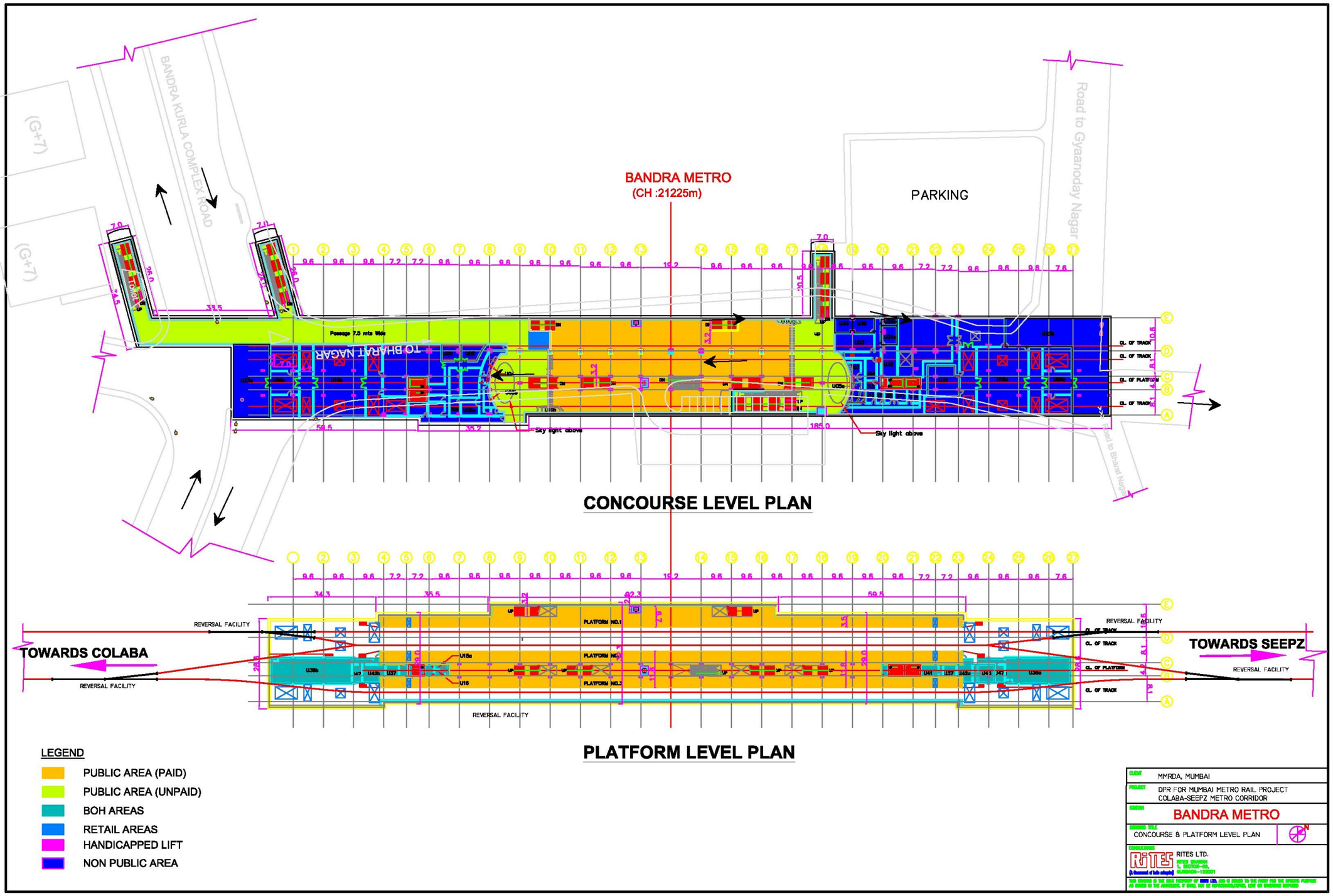
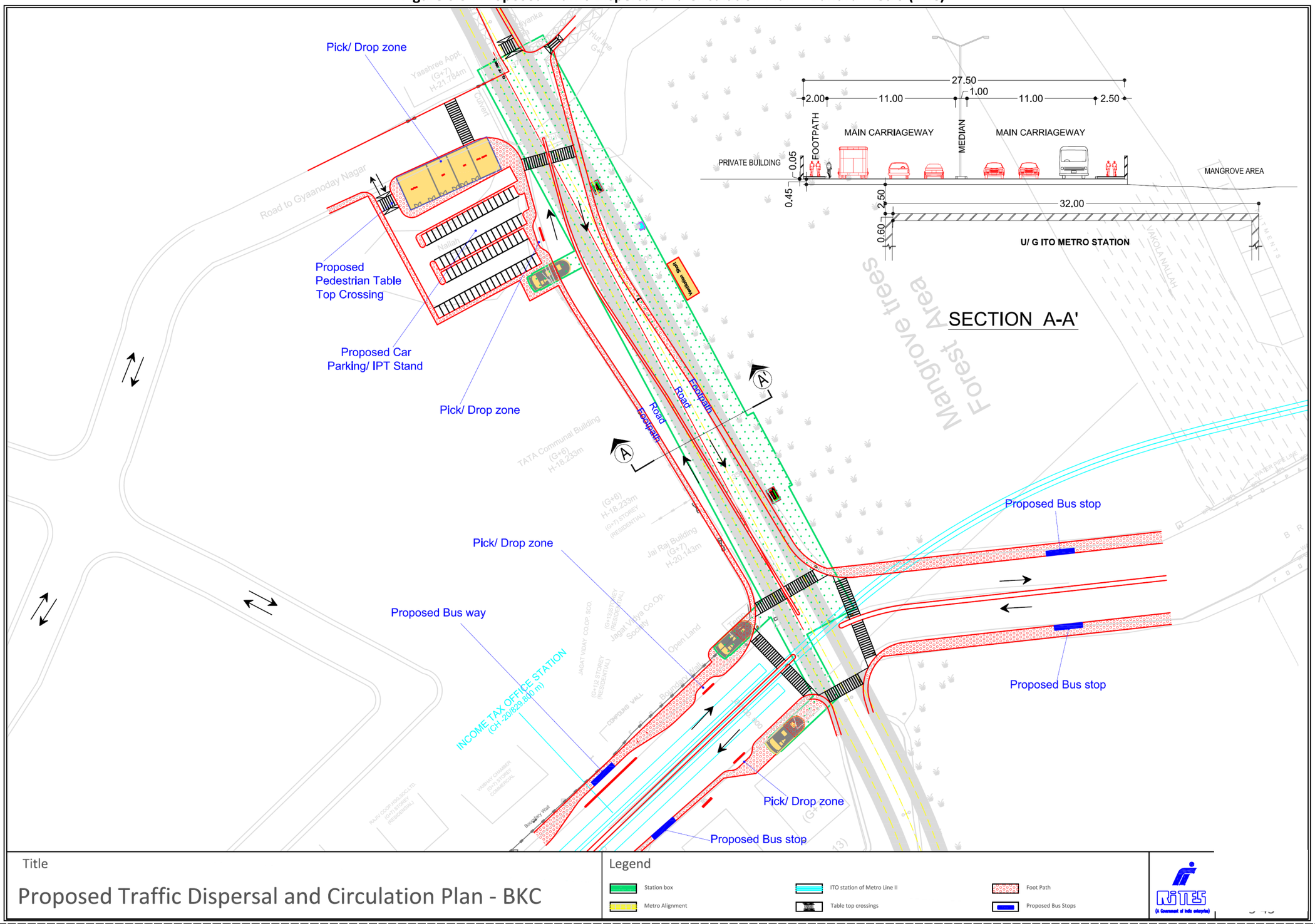


Figure 0.5 : Proposed Traffic Dispersal and Circulation Plan – Bandra Metro (BKC)



0.6 TRAIN OPERATION PLAN

- The salient features of the proposed train operation plan are:

  a) Train operation considers mid-terminal at Bandra.

  b) Running of normal services for 19 hours of the day (5 AM to 12 PM, i.e. midnight) with average station dwell time of 30 seconds,

  c) Airport traffic will be served with a frequency of 20-30 minutes during midnight to 2 AM.

  d) Make up time of 5-10% (on the tangent track) with 8-12% coasting.

  e) Scheduled average speed for Corridor shall be 30 kmph.

Train operation plan with train carrying **capacity @ 6 persons per square meter of standee area** is considered (**Table 0.11**).

Table 0.11: Transport Capacity Provided on the Corridor

Year	Colaba – Bandra			Bandra – SEEPZ		
Section	**2016**	**2025**	**2031**	**2016**	**2025**	**2031**
Cars per train/ Trains Per Hour	6/ 14	6/ 20	6/ 24	6/ 9	6/ 10	6/ 12
Avg. Head way (seconds)	260	180	150	400	360	300
Avg. PHPDT Demand	25000	36000	40000	16000	18000	20000
PHPDT Capacity Available	25088	35840	43008	16128	17920	21504

Selection of Train Length

The peak hour peak direction trips (PHPDT) for Colaba-Bandra section are estimated to be 42000 during the horizon year 2031.

The proposed train operation with 6 car and 150 seconds headway will provide Peak Hour Peak Direction Capacity of **54720** with standee density @ 8 persons /m^2. The capacity provided is more than the peak hour peak direction trips for both the sections and will therefore, ensure comfortable journey for the commuters. With eight car trains the capacity will be in excess of **72000 and can be increased further by improving headway**.

All the systems and infrastructure on the corridor have been provided for 8 car trains having passenger carrying capacity of 3000 (Sitting-386, Standing – 2614 @ 8 persons /m^2). The proposed infrastructure for 8 car rake having capacity of 72000 plus is, therefore, considered adequate. Provision of infrastructure for 9 car rake length will require additional expenditure on longer platforms at each station, in maintenance depot and stabling sidings. Moreover, for the given traffic volume energy requirement for traction will also increase. In view of these techno-economic considerations and requirement to cater to the projected traffic volume, the system design with 8 car trains has advantage over design based on 9 car trains.

- Based on Train formation and headway to meet Peak Hour Peak Direction Traffic Demand in different years, rake requirement has been calculated separately for Colaba – Bandra and Bandra - SEEPZ sections (**Table 0.12**).

Table 0.12: Year Wise Car and Rake Requirement

Time horizon	Section Length		Bare Rake Requirement		Total Bare Rake Reqd.	Maint. Spare	Traffic spare	Total rake Reqd.	Total coach Reqd.
	Colaba-Bandra	Bandra-SEEPZ	Colaba-Bandra	Bandra-SEEPZ					
2016	21.75	11.76	22	8	30	3	2	35	**210**
2025	21.75	11.76	31	9	40	4	3	47	**282**
2031	21.75	11.76	35	11	46	5	4	55	**330**

0.7 MAINTENANCE FACILITIES

The Colaba – Bandra - SEEPZ Corridor would require a dedicated Depot cum workshop facility for the maintenance of the rakes in the inception year 2016. A minor depot for stabling and inspection of about 20 rakes would be required to cater to the maintenance requirement of increased rolling stock holding during the year 2025. Apart from necessary facilities viz. stabling lines, scheduled inspection lines, workshop for overhaul, unscheduled maintenance including major repairs, wheel profiling, heavy interior/under frame/roof cleaning, etc. for the rolling stock operational on the corridor, Depot cum Workshop will also house Operation Control Centre (OCC), Administrative Building, maintenance facilities for Civil – track, buildings, water supply; Electrical – traction, E&M; Signaling & Telecom.; Automatic Fare Collection, etc.

For starting the morning services, some rakes will have to be kept at terminal stations and stabling facilities for the remaining rakes will have to be provided at the depot.

0.8 POWER SUPPLY

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 assumptions:-

a) Specific energy consumption of rolling stock – 70 KWh/1000 GTKM

b) Train operation :

Normal - 6 car at 260 to 150 seconds headway on Colaba-Bandra & 400 to 300 seconds headway on Bandra – SEEPZ section

Designed - 8 car at 2.5 minutes headway on Colaba-Bandra & 5.0 minutes headway on Bandra – SEEPZ section

c) Underground station load – initially 2000kW, which will increase to 2500kW in the year 2031 (Designed load – 3000kW)

d) Depot auxiliary load - initially 2000kW, which will increase to 2500 KW in the year 2031 (Designed load – 3000kW)

e) Power factor of load – 0.9 & Transmission losses @5%

Keeping in view the above norms, designed load and power requirement projected for the year 2016, 2021 and 2031 are summarized in **Table 0.13.**

Table 0.13: Power Demand Estimation (MVA) for Colaba – Bandra – SEEPZ

Year	2016	2025	2031	Designed Load
Traction	24.13	32.49	37.71	55.88
Auxiliary	49.00	65.33	81.67	98.00
Total	**73.13**	**97.82**	**119.38**	**153.88**
Total Traction	**24.13**	**32.49**	**37.71**	**55.88**
Total Auxiliary	**65.33**	**73.50**	**81.67**	**98.00**
G.TOTAL(A+B+C)	**89.46**	**105.99**	**119.38**	**153.88**

Sources of Power Supply

The high voltage power supply network of Mumbai city was studied in detail. The City has 220kV, 100kV, 33/22kV and 11kV network to cater to various types of demand in vicinity of the proposed corridor. Discussions were held with M/s Tata Power Company Ltd. (Licensee of the area) to finalize the Input Power Supply sources and Supply Voltage.

M/s Tata Power Company Ltd. indicated during discussions that their 33kV and 100kV network is highly reliable and stable to meet 33kV and 25kV power requirements of the proposed corridor. Keeping in view the reliability requirements and considering the complete corridor of 33.508 km length with all underground stations, three Receiving Sub-stations are proposed to avail power supply for traction as well as auxiliary services.

Table 0.14: Sources of Power Supply

Corridor	Grid sub-station (with Input voltage)	Location of RSS of Metro Authority	Approx. length of 100 kV cables
Colaba – Bandra – SEEPZ	Receiving Sub Station of Tata Power (100 kV)	Colaba (100/ 33/ 25 kV)	2 km. 100kV (Double Circuit cables).
	Mahalakshmi Receiving Sub Station of Tata Power (100 kV)	Race Course (100/ 33/25 kV)	1 km. 100kV (Double Circuit cables).
	Dharavi Receiving Sub Station of Tata Power (100 kV)	Dharavi (100/ 33/ 25 kV)	1 km. 100kV (Double Circuit cables).

0.9 ENVIRONMENT IMPACT ASSESSMENT

0.9.1 Water Environment (Water Quality)

To ascertain the water quality, representative water samples from six locations were collected for the analysis of physical and chemical parameters.

Surface water collected from Mithi River has high dissolved solids, high hardness, high chloride content, etc. - hence requires treatment for any use. Out of four

ground water samples, three are almost within permissible limit which may be used after filtration followed by disinfection.

0.9.2 Air Environment

In order to establish the base line data, Ambient Air Quality Monitoring (AAQM) has been carried out by setting up ambient air quality monitoring stations through High Volume Sampler (HVS) at five locations, i.e. Churchgate, Grant Road, Mahim (Nr. Bus Depot), Mumbai University, Sahar Road (Nr.IOC) and SEEPZ for the parameters like RSPM, SPM, SO_2, NOx, CO and HC. The results so obtained are reported in **Table 0.15**. The SPM and RSPM level has been observed on higher side as compared with National Ambient Air Quality (NAAQ) standards while parameters like SO_2, NOx and CO are within the permissible limits.

Table 0.15: Air Quality at Project Site

S.No.	Location	RSPM µg/m³	SPM µg/m³	SO_2 µg/m³	NOx µg/m³	CO mg/m³
1	Churchgate	196	351	33	50	2.19
	Permissible limit	60	100	80	80	4.00
2	Grant Road	161	235	29	38.5	2.65
	Permissible limit	60	100	80	80	4.00
3	Mahim	120	321	10.3	29.0	1.05
	Permissible limit	60	100	80	80	4.00
4	Mumbai University[2]	86	236	7.0	18	1.00
	Permissible limit	60	100	80	80	4.00
5	Sahar Road(Nr.IOC)[3]	130	338	15	41.3	1.20
	Permissible limit	60	100	80	80	4.00
6	SEEPZ	140	363	16	55	1.27
	Permissible limit	60	100	80	80	4.00

0.9.3 Noise Level Quality

Noise levels were measured at six locations, i.e. World Trade Centre, Churchgate, Mahim, Mumbai University, Sahar Road (Nr. IOC) and SEEPZ along the project alignment. It is observed that the noise level at World Trade Centre, Churchgate, Mahim and Mumbai University are beyond permissible limits while noise level at Sahar Road and SEEPZ are within permissible limits. Predominant source of noise is the vehicular movement.

0.9.4 Social and Economic Assessment

A sample Socio-Economic Survey (SES) was undertaken for the proposed corridor to assess the socio-economic conditions of project-affected families/people and to examine the impacts of the proposed corridor on these conditions. On the basis of alignment drawings and field visits it was noted that approximately 1520 families would be affected as the dwellings of these families are touching the proposed metro corridor.

During the social survey, it was observed that approximately 57% families are squatters, which need relocation/compensation. The social survey in these affected areas was conducted by using random sampling method. More than 10 % (152 families) of total affected families from major locations along the alignment which represent the whole stretch of proposed corridor were randomly

selected for analysing their socio-economic conditions. The primary data for the study was collected through interviews with the project-affected people by using structured household questionnaire.

0.9.5 Checklist of Impacts

A typical checklist identifying anticipated environmental impacts is presented in **Table 0.16.**

Table 0.16: Evaluation of Environmental Impacts

Proposed activity	Potential impact	Nature of potential impact	Rating of impact		
		Beneficial or adverse	Direct or indirect	Significance of impact	Magnitude of impact
Construction of Metro Rail Corridor	Demand/ Supply Infrastructure Employment	Beneficial Beneficial Beneficial	Direct Indirect Direct	Medium Medium Medium	Medium Medium Low
Raw Materials Consumption	Stone	Adverse	Indirect	Medium	Low
Water consumption	Surface Water Ground Water	Adverse Adverse	Direct Direct	Medium Low	Low Low
Transportation of materials	Ambient noise Public health and safety	Adverse Adverse	Direct Indirect	Low High	Low Low
Atmospheric emission	Ambient air quality, Ambient odor	Adverse Adverse	Direct Direct	Medium Medium	Low Low
Waste water discharge	Land/Water	Adverse	Direct	Low	Insignificant
Solid Waste disposal	Ground water Soil quality	Adverse Adverse	Indirect Indirect	Medium Low	Insignificant Insignificant
Noise generation	Ambient noise	Adverse	Direct	Low	Inignificant
Vibration	Public health	Adverse	Direct	Medium	Insignificant
Construction spoils disposal	Land Water	Adverse Adverse	Direct Direct	Low Medium	Low Low

Note: (Impact) High – Irreversible; Medium – Mitigated through measures; Low – Mitigation required

0.10 COST ESTIMATES

0.10.1 Capital Cost Estimates

The cost estimate has been prepared covering civil, electrical, signaling and telecommunications works, rolling stock, traffic integration facilities, security at stations, environmental protection, rehabilitation, etc. at September, 2011 price level.

The rates are taken as per DPRs of DMRC Phase – III Corridors, which was at Jan ’2011 price level. These rates have been enhanced by 10% to arrive at Sept’2011 price level and also due to difficult working conditions and different subsoil conditions of Mumbai.

The element of central and state taxes and duties (including customs duty, excise duty,VAT), octroi and insurance has been excluded for working out the base project cost. However, these details are tabulated separately for use in financial appraisal of project. The rates of the taxes, duties, octroi and insurance have been adopted as per the Mahim – Kanjur Marg Metro DPR.

Base capital cost of project at September, 2011 price level, works out to be **Rs. 150551 Million** excluding land cost and **Rs. 166416 Million** including land cost. Central and state taxes and duties (customs, Excise and VAT) have been worked out to **Rs. 25467 Million**. The component towards octroi and insurance has been worked out as **Rs. 2951.50 Million.** The abstract capital cost estimate is presented in **Table 0.17.**

Table 0.17: Abstract of Cost Estimate

Sr. No	Item	Amount (Rs Cr)
1	Underground alignment and formation (tunnel by TBM)	4,241
2	Station Building (11 NATM and 16 cut and cover)	5,947
3	Aarey Milk Colony Depot	244
4	P-Way (Track work)	244
5	Traction & power supply incl. OHE, ASS etc.	564
6	Signalling and Telecommunication	615
7	R & R incl. hutments etc.	91
8	Misc. Utilities, road works, other civil works such as signages environmental protection and traffic management	217
9	Rolling Stock	1,764
10	***Total of all items except Land***	***13,927***
11	General Charges incl. design charges @ 5% on all items except land	692
12	***Total of all items including General Charges***	***14,619***
13	Contingencies at 3 % on all items except land	436
14	**Total excluding land**	**15,055**
15	Land (Private)	485
16	Land (Government)	1,056
17	Contingencies at 3 % on land	46
18	***Total land cost***	***1,586***
19	**Total including pvt & govt. land and excluding taxes**	**16,641**
19	Central taxes	2,043
20	State taxes	504
21	Octoroi & insurance	295
22	***Total taxes***	***2,842***
	Total including taxes and excluding land	**17,897**
	Total including taxes and private land	**18,396**
	Total including pvt & govt land and taxes	**19,483**

0.10.2 O&M Estimate

The total Operation and Maintenance cost in the years 2016-17, 2025-26 and 2031-32 is estimated at about Rs. 4407 Million, Rs. 8152 Million and Rs. 12407 Million respectively (**Table 0.18**).

Table 0.18: Operation and Maintenance Costs

(Rs. in Million)

Year	Staff Cost (A)	Maintenance Expenses (B)	Energy Charges (C.)	Total (A+B+C+D)	Total O&M Cost
2016-2017	1,505.75	1,333.45	1567.80	4,407.00	4,407
2025-2026	3,270.34	2,316.42	2565.50	8,152.25	8,152
2031-2032	5,484.68	3,271.87	3650.70	12,407.25	12,407

0.11 ECONOMIC ANALYSIS

The economic appraisal has been carried out within the broad framework of Social Cost – Benefit Analysis Technique. It is based on the incremental costs and benefits and involves comparison of project costs and benefits in economic terms under the "with" and "without" project scenario. In the analysis, the cost and benefit streams arising under the above project scenarios have been estimated in terms of market prices and economic values have been computed by converting the former using appropriate shadow prices. This has been done to iron out distortions due to externalities and anomalies arising in real world pricing systems.

The annual streams of project costs and benefit have been compared over the analysis period of 44 years to estimate the net cost/ benefit and to calculate the economic viability of the project in terms of EIRR. The Economic Internal Rate of Return (EIRR) for the project has then been arrived using Discounted Cash Flow technique to the net benefit stream at economic prices.

The EIRR works out to **17.93 %**.

A sensitivity analysis of the EIRR with 10% cost overrun and 10% reduction in traffic materialization (separately) has been carried out. The EIRRs under these scenarios are given in **Table 0.19.**

Table 0.19: EIRRs - Sensitivity Analysis

Sensitivity Parameter	EIRR (%)
Basic EIRR	17.93
With increase in cost by 10%	17.06
With reduction in traffic materialization by 10%	17.59
With 10% reduction in traffic and increase in cost by 10%	16.73
With increase in cost by 20%	16.07

It can be seen that 10% increase in cost affects economic viability more than it does in case of reduction in traffic for the project. Accordingly, it is recommended that controls should be exercised to keep the construction cost under check.

0.12 FINANCIAL ANALYSIS

0.12.1 The basic Project cost of the metro corridor at September 2011 prices is estimated at Rs 150551 Million. The cost of land is estimated at Rs.15,865 Million. Of the total land cost,

Rs 4,985 Million is cost of private land and the cost of government land has been estimated at Rs 10,880 Million. The total cost of project including land, is estimated at Rs 166,416 Million.

The Central and State taxes and duties (Customs, Excise and VAT) amount to Rs 25,467Million. Of the total taxes and duties, Rs 20,432 Million are central taxes (Customs and Excise duty) and Rs 5,035 Million are state taxes (Value Added Tax). The component towards Octroi and insurance works out to be Rs. 2121 Million and Rs. 831 Million respectively.

For the purpose of financial analysis, only cost of private land being a cash payout has been added to the project. The government land is expected to be available on transfer basis. Further, JICA is expected to part fund the project through soft loan. The completion cost including IDC works out to Rs 217,523 Million

The revenue streams have been worked out based on MMRDA fare as well as DMRC fares (**Table 0.20**).The fare sensitivity of DMRC fares on the expected Metro ridership has not been considered in this comparison.

Table 0.20: Total Revenue Collection (Rs in Millions)

Source of Revenue	2017-2018		2030-2031		2035-2035	
	MMRDA	DMRC	MMRDA	DMRC	MMRDA	DMRC
Fare Box Revenue	6001	7029	15964	18512	20975	25347
Revenue from other Sources	600	703	1596	1851	2097	2535
Total Revenue	**6601**	**7732**	**17560**	**20364**	**23072**	**27881**

The FIRR calculations with the projected ridership, fare box revenue and based on both MMRDA &DMRC fare structure under various scenarios is given in **Table 0.21**.

Table 0.21- Project FIRR under different scenarios

SCENARIO		SCENARIO	
REVENUE BASED ON MMRDA FARES	**FIRR**	**REVENUE BASED ON DMRC FARES**	**FIRR**
Cost Without Any Taxes	2.17%	Cost Without Any Taxes	4.33%
Cost With Central Taxes	1.7%	Cost With Central Taxes	3.8%
Cost With Central & State Taxes	1.6%	Cost With Central & State Taxes	3.7%

It is concluded that the project will be able to comfortably bear the O&M cost and thus, has operational sustainability.

Scenario with VGF

To calculate the Viability Gap Funding (VGF) required to get the project FIRR of 12 % has been calculated with following assumptions:

1. The cost of the project at 2011 prices inclusive of all taxes is Rs 1,49,701 Million.
2. Govt land will be given free of cost for the project.
3. Stake holder contribution of Rs 12,500 million will be available.
4. The Debt Equity Ratio of 3:2 has been assumed for calculation of IDC
5. The rate of interest for market loan is taken as 10%.

VGF required With MMRDA fare structure will be about 89 % while with DMRC fares, the VGF requirement will be about 82 %. As the VGF requirement for the project is very high, the PPP implementation mode is not considered.

0.12.2 Involvement of Government

Government contribution is essential to keep debt-servicing levels low with a view to maintain overall long term sustainability of the system. Government involvement also generates considerable amount of confidence in other players involved in the process of construction & operation. The capital investment of Line-III of Mumbai metro project is estimated to give an economic rate of return to the tune of 17% and the city/society can recover the investment within 6 to 7 years time. Thus, the involvement of Government is essential to provide integrated, efficient public transport system in the City.

0.12.3 Funding For the Project

Following assumptions are made for the finalizing the funding pattern for the project:

i. **Cost of Land:** Govt land required for the project shall be given as grant by the State Government. Cost of private land has been added to the project and included as government equity but efforts shall be made to meet this cost through TDR and higher FARs.

ii. **Exchange Rate Fluctuation Risk-** As adopted for Phase-I and Phase-II of Delhi Metro and recently approved Phase III of Delhi Metro, it is assumed that exchange rate fluctuation risk on the repayment of JICA loan shall be borne in equal proportion by the equity holders, viz, GOI & GOM.

iii. **Payment of Dividend-** As adopted for Phase-I & Phase-II of Delhi Metro, this metro corridor of Mumbai MRTS shall be exempted from the payment of dividend on equity till the senior debt has been fully repaid.

The total completion cost of the project including IDC and excluding govt land works out to Rs 217,523 Million. The funding for the same shall be as under:

a. Government Contribution – GOI & GOM will contribute a total equity of Rs 64,343 Million which is 30% of the total completion cost. This means that both GOI and GOM will share 15% of the total cost amounting to Rs 32,172 Million.

b. JICA Loan – JICA funding of 60 % of total completion cost excluding taxes, duties and land cost, works out to 48% of the total completion cost including land and taxes and amounts to Rs 104,647 million as loan.

c. Subordinate Debt: To pay back state and central taxes and duties amounting to Rs 33,109 Million which is 15% of the total completion cost of the project, interest free Subordinate Debt from GOI and GOM is considered. It includes Rs 2471 Million Octroi which can be waived off by the City agencies as the project is for the benefit of the City. The payment of this loan will be after the payment of JICA loan.

d. Stake holder Contribution: The cost of stations falling in the areas belonging to MIAL (Mumbai International Airport Authority & ASIDE (Assistance to States for Infrastructure Development for Export Promotion) will be borne by them. Total 5 stations fall in their area and cost of the stations amounting to Rs 14,563 Million (7% of the total project cost) is proposed to be contributed by these agencies as stake holder contribution.

Table 0.22 Financing of Project Completion Costs Including IDC

Year	JICA debt	Sub debt	Equity	Stake holder	Total
2012-13	-	248	483	109	840
2013-14	656	1,407	2,735	619	5,417
2014-15	1,360	3,311	6,434	1,456	12,561
2015-16	2,910	7,284	14,155	3,204	27,553
2016-17	3,166	7,946	15,442	3,495	30,050
2017-18	2,973	7,615	14,799	3,349	28,736
2018-19	1,406	3,642	7,078	1,602	13,727
2019-20	358	993	1,930	437	3,718
2020-21	25	662	1,287	291	2,265
TOTAL	**104,647**	**33,109**	**64,343**	**14,563**	**217,523**
% Share	**48%**	**15%**	**30%**	**7%**	**100%**

With above funding pattern, the project generates positive cash flows during the analysis period of 44 years. But once the payment of loan starts the project has negative cash flows for 11 years and the project is not able to meets its loan obligations. However, after these 11 years, the project has positive cash flows except two years when replacement of the equipments is required. During the negative cash flow period, the loan liability of the project can be met by soft loans from MMRDA/MMRC which will be adjusted from future surplus revenues. Thus, the project has potential to service its debt.

All over the world all metro systems do require support from government in initial years till the system gets established and its revenue generation potential is truly exploited. Mumbai Metro Line III may also be implemented on the basis of these international practices.

0.13 IMPLEMENTATION PLAN

Effective institutional arrangements need to be made in order to enable the Colaba - Bandra - SEEPZ Metro Corridor project to be implemented without any loss of time and cost over-run.

An SPV named MMRC (Mumbai Metro Rail Corporation Ltd.) was incorporated on 30.4.2008 with the mandate “To establish, Operate and Maintain Guided Urban Transit Systems in and around Mumbai City so as to meet the urban transport needs of Mumbai”.

It is suggested to have a two tier organization with well defined responsibilities for getting this project executed. At the apex will be the restructured **MMRC** (with representation of Govt. Of India) - a lean but effective organization with full mandate and total power – with accountability The second level will be a project management team called “General Consultants” who will be engaged by the **MMRC** on contract basis and who will be fully responsible for planning, design and project management. In fact they will be the “Engineers” for the **MMRC**, who is the “client”.

For expeditious resolution of various problems arising during the implementation of the project, it is recommended that a High Power Committee under the chairmanship of Chief Secretary, Maharashtra should be set up. Other members of this Committee may be the 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.

This Committee should meet once a month and sort out all problems brought before it by **MMRC**. 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.

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. It is suggested that the role of this Empowered Committee should be extended to include Mumbai Metro project also and the Chief Secretary, Maharashtra is inducted as a member.

Union Cabinet had set up a Group of Ministers (GOM) 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, Minister of Finance and Company Affairs and Deputy Chairman Planning Commission. 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 is enlarged to include Mumbai Metro. The Chief Minister, Maharashtra should be inducted as a member and attend the meetings whenever any issue concerning Mumbai Metro is to be deliberated upon.

It is recommended that the construction of Colaba – Bandra – SEEPZ metro line is taken under the Metro Railways Act 1978. As and when the comprehensive Metro Act is processed and enacted, it will give the required legal cover for the Operations and Maintenance of Colaba – Bandra – SEEPZ metro line.

Experience of Delhi Metro project has shown that the taxes and duties (including custom duty, Excise Duty, Sales Tax, Taxes on electricity, Municipal Taxes) constitute about 15 – 16% of a metro project cost. **MMRDA/ MMRC** may try to get exemption from these for the implementation of this important infrastructure project.

Further, the transfer of Govt. land required for the project could be considered free of cost or at the most at Govt. rates. The cost of private land could also be recovered through TDRs and higher FARs.

MMRDA/MMRC may consider roping in more stakeholders, who would directly/ indirectly benefit from the system, for sharing the cost of metro construction.

Additional Development Cess due to improved accessibility/ higher property rates (as a result of metro availability) may also be considered in the immediate influence area of metro corridor. MMRDA may also consider issue of Metro Bonds, exploring commercial development on Depot land and implementing TOD concept along the Corridor.