Environmental Impact Assessment (Draft)

June 2013

India: Jaipur Metro Rail Line 1 Phase-B Project

Prepared by Jaipur Metro Rail Corporation for the Asian Development Bank.

CURRENCY EQUIVALENTS

(as of 7 April 2013)

Currency unit	–	Indian Rupees (INR)
INR1.00	=	$ 0.0182
$1.00	=	INR 54.8125

ABBREVIATIONS

AAQ	–	Ambient Air Quality
AAQM	–	Ambient Air Quality Monitoring
ADB	–	Asian Development Bank
ATP	–	Automatic Train Protection
ASI	–	Archaeological Survey of India
BOD	–	Biological Oxygen Demand
BOQ	–	Bill of Quantity
BRTS	–	Bus Rapid Transit System
CCTV	–	Close Circuit Television
CGM	–	Chief General Manager
CO	–	Carbon Monoxide
COD	–	Chemical Oxygen Demand
CPCB	–	Central Pollution Control Board
CSC	–	Construction & Supervision Consultant
DFCC	–	Dedicated Freight Corridor Corporation
DG Set	–	Diesel Generating Set
DMRC	–	Delhi Metro Rail Corporation
DO	–	Dissolved Oxygen
EA	–	Executing Agency
EAC	–	Expert Appraisal Committee
EIA	–	Environmental Impact Assessment
EMP	–	Environmental Management Plan
EMOP	–	Environmental Monitoring Plan
GHG	–	Greenhouse Gas
GOI	–	Government of India
GOR	–	Government of Rajasthan
GRC	–	Grievance Redress Committee
GRM	–	Grievance Redress Mechanism
GRP	-	Glass Reinforced Plastic
JDA	–	Jaipur Development Authority
JNNURM	–	Jawaharlal Nehru National Urban Renewal Mission
EIA	–	Initial Environmental Examination
IMD	–	Indian Meteorological Department
IRC	–	Indian Road Congress
JMR	–	Jaipur Metro Rail
JMRC	–	Jaipur Metro Rail Corporation
Max	–	Maximum
Min	–	Minimum
MORSTH	–	Ministry of Road Surface Transport And Highways
MOEF	–	Ministry of Environment And Forests
NATM	–	New Austrian Tunnelling Machine
NGO	–	Nongovernmental Organization
NH	–	National Highway
NOC	–	No Objection Certificate
NOx	–	Oxides of Nitrogen
OCC	–	Operation Control Centre

OHE	–	Overhead Traction System
O & M cost	–	Operation & Maintenance Cost
PCC	–	Portland Cement Concrete
PCU	–	Passenger Car Units
PDCOR	–	Project Development Corporation
PHPDT	–	Peak Hour Peak Direction Trips
PPE	–	Personal Protective Equipment
PPT	–	Parts Per Trillion
PSU	–	Public Sector Undertaking
RCC	–	Reinforced Cement Concrete
REA	–	Rapid Environmental Assessment
RSPM	–	Respiratory Suspended Particulate Matter
RSRTC	–	Rajasthan State Road Transport Corporation
SC	–	Scheduled Caste
ST	–	Scheduled Tribe
SOx	–	Oxides of Sulphur
SPCB	–	State Pollution Control Board
SPM	–	Suspended Particulate Matter
SPS	–	ADB Safeguard Policy Statement, 2009
SPV	–	Special Purpose Vehicle
TA	–	Technical Assistance
TBM	–	Tunnel Boring Machine
TDS	–	Total Dissolve Solids
WPR	–	Work Participation Rate

WEIGHTS AND MEASURES

dB (A)	–	A-weighted decibel
ha	–	hectare
km	–	kilometre
km^2	–	square kilometre
KWA	–	kilowatt ampere
Leq	–	equivalent continuous noise level
µg	–	microgram
m	–	meter
MW (megawatt)	–	megawatt
PM 2.5 or 10	–	particulate matter of 2.5 micron or 10 micron size

NOTE

(i) In this report, "$" refers to US dollars.

Contents

EXECUTIVE SUMMARY

A. Introduction

1. Jaipur is a medium sized city with a population of about 3.07 million (2011) spread over an area of 474 km. It has about 0.82 million registered motor vehicles (2004), of which 70% are 2 wheelers. A total of 2.7 million vehicular trips are generated every day (2006). A meagre 13-19% trip is by city buses covering an average distance of about 9 km. The city has about 250 buses and some 3500 minibuses, but it is not sufficient to cater the traffic of city. Most of the people are dependent on private personal vehicles for their daily commute. The existing public transport system is grossly inadequate in terms of quality, quantity and coverage, which could not cope with ever increasing travel demand.

2. Previous studies on Urban Transport were conducted for Jaipur by NATPAC, RITES and CRRI amongst others, all of which recommended rail based transport system as a necessity for Jaipur to meet the increasing travel demands of the city. A comprehensive mobility plan (CMP) for the city of Jaipur was prepared by Wilbur Smith, which recommended two metro rail corridors for Jaipur. Now, the metro rail based mass rapid system is being implemented by the State Government of Rajasthan in Jaipur Metropolitan area in two phases. The proposed metro rail network covers north south (Phase II) and east west (Phase I) axis of the city.

3. To reduce the burden on the road based transport system and to cater to the needs of future transport demand the Government of Rajasthan (GoR) has approached Asian Development Bank (ADB) to assist in the implementation of the underground section (Phase I B) of the proposed East West Corridor of Jaipur Metro Rail. The environmental assessment for the Jaipur Metro Rail was carried out by experts of Delhi Metro Rail Corporation (DMRC) and meets the ADB safeguard requirements.

4. The project is classified environmental category “A” in accordance with Safeguard Policy Statement 2009 requiring preparation of environmental impact assessment report. The category A rating was based on the presence of significant physical cultural resources namely the Jantar Mantar, located 80 meters from the tunnel centerline is a UNESCO World Heritage site and Archeological Survey of India (ASI) protected archaeologically important monument or cultural heritage site. Other physical cultural resource (PCR) are the Chandpole Gate, Krishna Temple, *Hawa Mahal* and *Isarlat* falls at a distance of around 90m and have been declared as protected monuments under the Rajasthan Monuments, Archaeological Sites and Antiquities Act, 1961.

5. EIA - The environmental assessment is carried out in accordance with applicable laws and regulations of India and consistent to ADB’s Safeguard Policy Statement (SPS), 2009. No Environmental Clearance is required for the proposed project as Metro Rail Project is not included in the Schedule-I of the EIA Notification, 2006. Consent from State Pollution Control Board will be required for setting up hot mix plant.

B. Description of Project

6. This proposed East West Metro corridor in Jaipur will be from Badi Choupar to Mansarover via. Choti Chaupar, Chandpole, Sindhi Camp, Railway Station, civil line, Ram Nagar, Shyam Nagar, Vivek Vihar, New Atish Market, and Mansarover. The approximate length of this line is 12.067 km with 9.278 km elevated section from Mansarover to Sindhi Camp and 2.789 kms of underground section from Chandpole to Badi Choupar. The corridor is also named as Jaipur Metro Rail (JMR) Phase I where Phase I A is from Mansarovar to Chandpole and Phase I B is from Chandpole to Badi Choupar. Phase I A is at present under construction including the underground station at Chandpole. Jaipur Metro Rail Corporation (JMRC) has approached Asian Development Bank for financial assistance to construct the

underground section (Phase I B) of the East West Corridor from Chandpole to Badi Choupar.

7. The salient design features of the JMR project are as under:

- The corridors will be Standard Gauge (1435 mm)
- 25 kv ac overhead traction system (OHE) has been proposed for both the North-South and East West corridors of Jaipur Metro
- Signalling and Train Control will be through Continuous Automatic Train Control system and Computer based Interlocking
- Bulk of the telecommunication network is proposed with optical fibre cable system. In addition, Mobile Radio communication system having minimum 8 logical channels is proposed for on-line emergency communication
- Passenger announcement system will be linked to Signaling System for automatic train actuated announcements.
- Passenger Information Display System will be located at convenient locations at all stations to provide bilingual 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.
- Passenger handling facilities comprise of stairs/escalators, lifts and ticket gates required to process the peak traffic from street to platform and vice-versa
- Centralised clock system to ensure accurate display of time through a synchronization system of slave clocks driven from a Master Clock at the operation control center.
- The CCTV system shall provide video surveillance and recording function for the operations to monitor each station. The monitoring shall be possible both locally at each station and remotely from the OCC.
- Automatic Fare Collection system will be in place. At all stations, two Passenger Operated Machines (Automatic Ticket Vending Machines) each have been proposed.
- The trains will have 4/6 coaches and will have a crush carrying capacity of 1,034/1,574 passengers respectively.
- Maximum Design Speed is 95 km/h. The Maximum Operating Speed is 85 km/h

8. In underground sections, the rail levels are generally about 14 m below the ground level governed by a ground clearance of 2 m and a station box of about 14 m depth. In the elevated section, rail level is generally about 13.5 m above ground in order to maintain a clearance of 5.50 m between the road and the station structure. In order to keep the land acquisition to minimum, alignment is planned generally in middle of the road (especially at stations in underground section) and a two-level station design has been proposed in both elevated and underground sections. Entry/exit structures to the proposed stations and traffic integration areas have been planned in the open space available.

C. Description of Environment

9. **Topography and Physiography.** The terrain along the project alignment is mostly flat. The metro rail corridor runs through densely developed areas within the city. Phase I B section of the metro corridor runs through the oldest part of the city.

10. **Surface and groundwater hydrology.** There are three surface water bodies, Amanisha Nalla, Ambabadi Ka Nalla, and Jal Mahal Talab that characterise the surface water hydrology of the study area. Of these three water bodies, Ambabadi Ka Nalla crosses the metro corridor near new Aatish Market. Water quality monitoring has been done by the DMRC consultants at Amanisha Nalla, Ambabadi Ka Nalla, and Jal Mahal Talab. The results of the monitoring show that the water in the nalas has high TDS value. The level of calcium,

other anions and cations, are also on the higher side. Ground water is the dominant water source in the area. Hand pumps are commonly used to draw the water from ground. The ground water in Jaipur district is mostly bicarbonate in nature with low to medium density. However, fresh water is available in most part of the district and is potable.

11. **Soil characteristics.** The soil types found in the district are: i) Recent alluvium, ii) Aravalli pediment, iii) Soil of Aravalli hills, iv) Old alluvium, and iv) Fluvioaeolian. The physico-chemical analysis of soil samples revealed primarily dry and silt loamy in texture. The soils have moderate conductivity i.e. from 369 µs to 476 µs/cm. The pH value of the samples varied from 6.92 to 8.11 i.e. the soil is alkaline in nature. The soils also had low nutrient content and low moisture, hence are not suitable for prime agriculture purpose.

12. **Ambient air quality.** Ambient air quality monitoring has been carried out at 10 locations. The baseline data of air environment was monitored for suspended particulate matter (SPM), sulphur dioxide (SO_2), oxides of nitrogen (NO_X), and carbon monoxides (CO). Levels of SPM are on the higher side for the sensitive areas; Ajmeri gate being the highest. Levels of RSPM, SO_2 and NO_x were found to be within the prescribed limits.

13. **Noise measurements.** Hourly measurements have been carried out in day and night time at 10 locations along the Metro rail corridor. Measured noise levels are most of the time below the noise limit stipulated for residential and commercial area.

14. **Industries.** The project alignment is not passing through any industrial area. The project alignment mostly passes through developed commercial and residential areas.

15. **Physical Cultural Resources.** The following physical resources are found within 100 meters from the tunnel surface center line :

a) Chandpole Gate once served as guarded entry and exit points, of the walled city of Jaipur. After independence and with rapid urbanization and growth of the city, these structures of historic, cultural and social significance still stand tall as the guardian to the unique city of Sawai Jai Singh. Chandpole Gate is amongst the oldest gates of the walled city of Jaipur located at the west end of the walled city.
b) Isar Lat or Sargasuli - is a 7-story minaret built by Sawai Ishwari Singh to commemorate his victories over the Mewar and Maratha armies. Its latticed openings provide an excellent vantage point outside the fort.
c) Jantar Mantar is a UNESCO World Heritage Site as an astronomical observatory. Constructed in 1718 at the center of the wall city by Sawai Jai Singh II, it has more than 18 astronomical instruments. The Jantar Mantar was historical in the sense that it provided a venue for astronomers to exchange ideas being the largest built by Sawai Jai Singh II having regular astronomers taking regular observations.
d) Hawa Mahal or Palace of the Winds is a massive five story structure that is shaped like a pyramid rises to a height of 50 feet (15 m) from its high base. Built in 1799, it gave the women of the palace an advantage to see the outer world through the stone screens without being seen, since they had to observe strict "purdah" (face cover). Hawa Mahal is unique because of its semi-octagonal bays, carved sandstone grills, 900 niches, finials and domes with more than 953 small windows. Hawa Mahal was constructed with red and pink sandstone with white quick lime.

D. Anticipated Significant Environmental Impacts and Mitigation Measures

16. The significant impacts that are attributable to project construction included: vibration and ground settlement near identified PCRs, surface noise from excavation equipment near

Choti and Badi Choupars, chance find of artifacts, demolition and restoration of the Choupars for the construction of stations, spoil disposal, groundwater extraction, disruption of essential services, occupational and community health and safety, and clean-up and restoration prior to decommissioning.

17. Impact evaluation indicated the natural attenuation of sandy soil and vibration and noise reduction design considered for the rail and train will not result to elevated vibration levels that will cause cosmetic or structural damages to the PCRs. The predicted ground ground settlement under the the Chandpole gate due to tunnelling is minimal by engineering design standards. To ensure that Contractor maintains vibration and noise levels, monitoring coupled with trigger and allowable values were incorporated in the bidding documents. Ambient noise levels are already beyond national standards and the additional noise that will be generated by the construction works will be minmal in comparison. Stringent noise control devices such as mobile and fixed noise barriers and the good consruction practices will alleviate this impact. The Choti and Badi Choupars will be demolished to allow the construction of the underground metro station and wil be restored to its original state under the supervision of of the Rajathan Department of Archeology and Museums. Spoils disposal will be implemented in an environmentally sound manner. Comprehensive measures were incorporated in the bidding documents to promote occupational and community health and safety. Water conservation during construction will be strictly implemented by the CSC.

18. To protect chance find of artifacts during construction phase, JMRC will hire the services of an archaeologist as part of the CSC. The Contractor 30 days prior to tunnelling and cutting will conduct a non-invasive ground penetrating radar to indeintify the presence of these artifacts under ground and the result of which will be discussed with the Rajathan Department of Archeology and Museums for possible retrieval.

19. During operation, vibration and noise monitoring will continue as a regular program of the JSRP Safeguards cell to ensure PCRs are protected from the metro operation.

20. To mitigate and address other less significant environmental impacts on occupational health and safety, generation of waste, air pollution, traffic management etc. the contractor will be required to comply with the Safety Health and Environment (SHE) guidelines. The SHE guidelines include detailed activities on health, hygiene, occupational safety, traffic management and management of environment issues.

E. Public Consultation and Information Disclosures

21. The project has received acceptability among the local people as it will provide hassle free movement in the congested part of the city. The project rail will contribute to smooth flow of traffic and reduced travel time and fuel consumption and subsequently air emissions. The project will bring positive socioeconomic changes in the area.

22. The opinions and issues raised by public were used for identifying impacts and developing management and monitoring plan, depending on their importance and practicality.

F. Environmental Management Plan and Grievance Redress mechanism

1. Environmental Management Plan

23. Environment Management Plan (EMP) has been formulated which consists of a set of mitigation, monitoring and institutional measures applicable to design, construction, and operation stages of the project. The components of this EMP includes: (i) mitigation of

potentially adverse impacts; (ii) monitoring of impacts and mitigation measures during project implementation and operation; (iii) institutional capacity building and training; (iii) compliance to statutory requirements; and (iv) integration of EMP with project planning, design, construction and operation.

2. Environmental Monitoring Program (EMOP)

24. A comprehensive monitoring plan has been prepared for all stages of the project. This includes parameters to be measured, methods to be used, sampling locations, frequency of measurements, detection limits, cost and responsibility for implementation and supervision. The monitoring programme is designed focusing monitoring during construction and operation stages. Construction stage monitoring will be carried out by contractor under supervision of DMRC. Monitoring programme and schedule for key performance indicators covers relevant physical, biological, and social environmental components.

3. Institutional Setting and Proposed Implementation Arrangement

25. Rajasthan Government has registered Jaipur Metro Rail Corporation Ltd for implementation of Jaipur Metro under the Companies Act, 1956. This special purpose vehicle (SPV) is a public sector undertaking (PSU) of the State Government.

26. The Government of Rajasthan has already set up a “High Powered committee” under the Chairmanship of its Chief Secretary to monitor the project, before whom problems and obstacles encountered during execution of the project will be placed by Jaipur Metro Rail Corporation (JMRC) for quick redressal. This has been proved successful in negotiating with the affected persons to settle the compensation amount during land acquisition expeditiously.

27. A nodal environment officer will be recruited in JMRC to coordinate and monitor implementation of the environmental management plan for JMRC.

4. Grievance Redress Mechanism

28. Grievances related to the implementation of the project, particularly regarding the environmental management plan will be acknowledged, evaluated, and responded to the complainant with corrective action proposed. The “High Powered Committee” would perform the role of Grievance and Redress Committee (GRC). Nodal officer will interact with the Chief General Manager (CGM) as required to resolve the concern. Provision shall be made for lodging the concerns at JMRC website also. Nodal officer will be the focal point for resolution of complaints received through GRC or Web site or directly and communicating back the action taken to complainant. Nodal officer will also coordinate with GRC, summarised them about complaints received and resolution made. The name and contact details of Nodal officer and JMRC web site shall be displayed prominently within the project area.

G. Conclusions and Recommendations

29. The project benefits are wide ranging and include improvement in employment opportunities, enhancement of the economy, mobility, safety, and reduction in traffic congestion, fuel consumption, air pollution, greenhouse gases, and saving in road infrastructure. The decision to build an underground metro under the walled city avoided significant adverse impacts associated with linear development.

30. The environmental assessment of the project identified potential significant adverse impacts on heritage structures in the project area. However, through detailed analysis on

noise and vibration it was found that the project is unlikely to cause any significant residual environmental impacts. Adequate mitigation measures to avoid significant impacts have been included in the technical design of the metro rail as well as a site specific EMP. In addition stringent monitoring requirements and actions have been included in the EMOP on noise and vibration levels that will be generated during construction. The Executing Agency shall ensure that site specific EMP and EMoP together with the Safety Health and Environment (SHE) guidelines is included in Bill of Quantity (BOQ) and forms part of bid document and civil works contract. The same shall be revised if necessary during project implementation or if there is any change in the project design and with approval of ADB.

I. INTRODUCTION

A. Project Background

1. Jaipur, the ‘symphony in pink’, is the land of superlatives, where breathtaking beauty and rich art and culture blend superbly. Until the eighteenth century, Amber served as the capital of the Kachwaha clan of the Rajputs. However, due to its inaccessible tract on the Aravali hills, it was unable to meet the demands of a growing population. Sawai Jai Singh in 1727 decided to move his capital to the plains, 11 km south of Amber. Jaipur, situated in North - West part of India, was thus founded in 1727 AD and was named after its founder Sawai Jai Singh. Jaipur City was not only planned but its execution was also coordinated by Sawai Jai Singh II, in such a manner that a substantial part of the city developed within seven years of its foundation. It nestles amidst the Aravali ranges and is surrounded by rugged hills on three sides, each crowned by a formidable fort, while the city is studded with grand palaces, majestic mansions and gracefully landscaped gardens and parks. It is perhaps the first planned city of India, and was laid with great precision on the basis of principles of 'Shilpa Shastra', the ancient Hindu treatise on architecture. The city was built in the form of a rectangle divided into blocks (Chowkries), with roads and avenues running parallel to the sides. In 1863 city of Jaipur was dressed in Pink to welcome Prince Albert, consort of Queen Victoria. The colour became an integral part of the city and it came to be known as ‘The Pink City’.

2. In 19th and 20th centuries, the city’s population spread beyond its walls. After ascendance to the throne in 1922 by Man Singh II, civic buildings like the secretariat, schools, hospitals, and other public buildings were built. The municipality was reorganized in 1926 and a new municipal act was prepared in 1929. After independence in 1947, Jaipur merged with the states of Jodhpur, Jaisalmer, and Bikaner to become the greater Rajasthan in 1949. Under the State Re-Organization Act in 1956, Jaipur became the capital of the state of Rajasthan.

3. Post-independence, planned development of the city was taken up after the city became the capital of Rajasthan. Though the city has grown into a modern metropolis and a throbbing commercial centre, it is a visitor’s delight and caters to the needs of each form of tourism, ranging from historical, culture, adventure, sports, entertainment, shopping, business, conventions, and conferences. Jaipur is also a renowned handicraft centre and is also known for producing exquisite gold jewellery enamelled or inlaid with precious or semi-precious stones, blue pottery, carvings on wood, stone and ivory, block print and tie & dye textiles, leather articles, handmade paper, miniature painting etc.

4. Jaipur being the capital of Rajasthan is the focus of socio economic, cultural, and political activities of the state. The city’s transport needs are mainly met by a well-developed transport network system, based on ring and radial pattern, large fleet of buses like the Rajasthan State Road Transport Corporation (RSRTC).The majority share of travel needs of Jaipur commuters is met by road based transport systems.

5. Jaipur is a medium sized city with a population of about 3.07 million (2011) spread over an area of 474 km. It has about 0.82 million registered motor vehicles (2004), of which 70% are 2 wheelers. A total of 2.7 million vehicular trips are generated every day (2006). A meagre 13-19% trip is by city buses covering an average distance of about 9 km. The city has about 250 buses and some 3500 minibuses, but it is not sufficient to cater the traffic of city. Most of the people are dependent on private personal vehicles for their daily commute. The existing public transport system is grossly inadequate in terms of quality, quantity and coverage, which could not cope with ever increasing travel demand.

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7. To reduce the burden on the road based transport system and to cater to the needs of future transport demand the Government of Rajasthan (GoR) has approached Asian Development Bank (ADB) to assist in the implementation of the underground section (Phase I B) of the proposed East West Corridor of Jaipur Metro Rail. The environmental assessment for the Jaipur Metro Rail was carried out by experts of the Delhi Metro Rail Corporation (DMRC). This report has been updated to meet ADB safeguard requirements.

B. Nature, Size and Location of the Project

8. Jaipur Metro Rail Project is being implemented by Jaipur Metro Rail Corporation Ltd. (JMRC), a wholly owned company of the State Government created as an SPV for the purpose. The project plans to construct 2 corridors namely Phase I - the East-West Corridor from Mansarovar to Badi Choupar and Phase II – Sitapura to Ambabari. It is targeted to start the financial functioning part line of Phase 1 by August 2013. The project details of Phase I and Phase II corridors are provided below..

Table 1: Project Details of Phase I and Phase II of Jaipur Metro (in kms)

Description	Under Ground Section	Elevated Section	Total
Phase I (East West Corridor) Mansarovar to Badi Choupar	2.789	9.278	12.067
Phase II (North South Corridor) From Sitapura to Amba Bari	5.095	18.004	23.099
Total	**7.884**	**27.282**	**35.166**
Number of Stations- Phase I	3	8	11
Number of Stations- Phase II	5	15	20

9. At present, the East-West Corridor (Phase 1) is under construction from Mansarovar to Badi Choupar. Once completed, the corridor will have part elevated section i.e. phase 1 A from Mansarovar to Chandpole (9.278 km) with underground station at Chandpole (0.44 km) and part underground i.e. phase 1 B from Chandpole to Badi Choupar (2.789 km). The corridor from Mansarovar to Badi Choupar will have 8 elevated stations and 3 underground stations. It is the phase 1B section which is proposed for financing by ADB.

C. Environmental Categorization

10. The environmental screening has been carried out for the proposed project as per ADB Safeguard Policy Statement (SPS) 2009. The proposed project is an extension (2.789 km) of the East West Corridor that nearing completion of construction from Mansarovar to Chandpole (9.278 km). The Rapid Environmental Assessment (REA) checklist has screened the project proposed for ADB funding considering the aspects of project siting, potential environmental impacts including climate change and disaster risk. Although, the proposed project will bring in many benefits to the area, there is potential for environmental impacts on the above ground pink city and heritage structures due to vibration from tunnelling works during construction and future operation of the metro. Therefore, the project has been

classified as category 'A' and requires Environmental Impact Assessment (EIA) Report as per ADB's SPS.

D. Purpose of the Study

11. This EIA report documents the environmental assessment of the underground section of JMR project and identifies the environmental issues to be considered at project planning and design stage. In this report, the different activities that are likely to take place to achieve the project objectives, have been analysed and the potential impacts that may accompany them have been discussed. The EIA addresses the environmental management requirements of: (i) the Government of India (GOI), (ii) the ADB, and (iii) the Project. In general, the EIA addresses the following:

- Provides information about the baseline environmental setting of the subproject;
- Provides information on potential environmental impacts of the proposed subproject activities with its magnitude, distribution and duration.
- Provides information on required mitigation measures with cost to minimize the impacts.
- Analyses the alternatives options considering alternative locations, designs, management approaches, for selection of most feasible and environmental acceptable options.
- Provides details of stakeholders consultation
- Formulate environmental management and monitoring plan with institutional measures for effective implementation of mitigative measures proposed.

E. Extent of EIA

12. This EIA has been prepared based on the proposed alignment and the nature of construction. It covers all activities viz. site clearance (tree cutting, shifting of utilities etc.), construction activities including material sourcing (borrowing, quarrying, and transportation) and operation (traffic movement). The corridor of impact is taken as 10 meters either side of the alignment. However, the study area impact zone is considered up to 10 km on both sides of the project alignment to allow for a larger analysis of land use and other environmental features. Assessment is carried out on the following environment components: terrestrial and aquatic ecology, soil, water, air, noise, and socio economic aspects.

F. EIA Content

13. This EIA report is presented in eight chapters listed below, consistent with the ADB's Safeguard Policy Statement (SPS), 2009. This includes this introduction, and individual chapters describing the subprojects, description of exiting environment, anticipated environmental impacts and mitigation measures, environmental management plan, public involvement and disclosure, and conclusion.

Chapter 1- Introduction
Chapter 2- Policy, Legal and Administrative Framework
Chapter 3- Description of Project
Chapter 4- Description of Environment
Chapter 5- Anticipated Impacts and Mitigation Measures
Chapter 6- Information Disclosure, Consultation, and Participation
Chapter 7- Environment Management Plan and Grievance Redress Mechanism
Chapter 8- Conclusion and Recommendations

G. Methodology

14. The methodology for EIA has been adopted to accomplish the study in line with ADB Safeguard Policy Statement (SPS) 2009. The study was carried out using reconnaissance survey, field visits, consultation with stakeholders, review of existing data, identification of adverse impacts and preparation of EMP and post-project environmental monitoring programme. As the first step, project scoping exercise was undertaken identifying the parameters needed to be considered for the study and to outline the activities for collecting data on each parameter. The stepwise activities include:

- Review of legal requirements
- Review of feasibility study
- Reconnaissance survey for identification of key issues, data requirement and preliminary consultation.
- Primary and secondary data collection
- Consultation with stakeholders
- Identification of impacts and mitigation measures

1. Information / Data Sources

15. Data pertaining to all facets of environment viz. physical, ecological and socioeconomic environment both through primary and secondary sources were collected. The objective of data collection was to provide a database on existing conditions that can be used for predicting the expected changes and for monitoring such changes. For preparation of EIA, the key relevant information sources were summarized below.

Table 2: Primary and Secondary Information Sources

Environmental Parameters	Information Sources
Project objectives, Technical information on the project	Jaipur Metro Rail Corporation
Inventorisation of environmental features; viz. water bodies, community structures, environmentally sensitive locations/areas, congested locations, etc.	Ground physical surveys and Design Consultant (DMRC)
Climatic Condition	Indian Meteorological Department
Geology, Seismicity, Soil and Topography	Geological survey of India, primary data collection
Land Use/ Land Cover	Observation during survey
Drainage Pattern	Survey of India Toposheet and field observation
Status of forest areas Compensatory afforestation norms etc.	Forest Department, Government of Rajasthan
Cultural and heritage sites	Department of Archaeology, Govt. of Rajasthan

II. POLICY, LEGAL AND ADMINISTRATIVE FRAMEWORK

16. India has 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 international community under various conventions and protocols as well. ADB has also defined their Environmental and Social Safeguard policies. This assessment is about the applicability of above laws and regulations, and safeguards. This chapter summaries the following:

- Applicability of various national and local laws and regulations at different stages of project implementations
- Applicability of ADB safeguard policies and categorisation of the project

A. Country's Legal Framework and Regulatory Requirements for the Project

17. The legal framework of the country consists of several acts, notifications, rules, and regulations to protect environment and wildlife. Review of Indian legal system has been carried out to identify its applicability to the project.

18. The following rules, notifications and standards under the Environment (Protection) Act, 1986 are particularly relevant in this case:

- Environment (Protection) Rules, 1986 and its amendments
- EIA Notification, 1994 and its amendments
- Ash Utilization Notification, 1999 and its amendments
- The Forest (Conservation) Act 1980 (Amended 1988) and Rules 1981 (Amended 2003)
- The Wildlife (Protection) Act, 1972 (Amended 1993)
- The Water (Prevention and Control of Pollution) Act 1972 (Amended 1988) and Rules 1974
- The Air (Prevention and Control of Pollution) Act, 1981(Amended 1987) and Rules 1982
- The Noise Pollution (Regulation and Control) Rules, 2000 (Amended 2002) and
- Hazardous Waste (Management, Handling and Trans-boundary Movement) Rules 2008 (Amended 2009)

1. Requirement of Environmental Clearance

19. As per provisions of the EIA Notification, 14 September 2006 as amended up to 1 December 2009, any person who desires to undertake any new project in any part of India or the expansion or modernization of any existing industry or project listed in Schedule-I of the said notification shall submit an application to the Ministry of Environment and Forests, Government of India in accordance with the guidelines issued by the Central Government in the Ministry of Environment and Forests from time to time. Metro Rail project is not included in the Schedule-I of the EIA Notification, 2006. Thus, the project does not require an environmental clearance certificate from the Ministry of Environment and Forests, Government of India[1].

[1] Other metro projects such as the Delhi Metro was not required to secure any Environmental Clearance

2. Forest Clearance

20. As per Indian "Forests Conservation Act (1980), every project requiring diversion of forest land for non-forestry purposes require forest clearance from MoEF. The forestry clearance is granted through two-stage process. Stage 1 refers, in principle agreement, to the project proposal in which usually the conditions relating to transfer, mutation and declaration as RF/PF under the Indian Forest Act, 1972, of equivalent non-forest land for compensatory afforestation and funds for raising compensatory afforestation thereof are stipulated while Stage II involves formal approval under the Act after receipt of compliance report from the State Government in respect of the stipulated conditions.

21. Since no diversion of forest land is involved in Phase I (B) of JMR project, no forest clearance is required for this project.

3. Permission to Withdraw Ground Water

22. As per the power granted under Environmental Protection Act, 1986, permission from Central Ground Water Authority is required for extracting ground water for construction purposes, from areas declared as critical or semi critical from ground water potential prospective.

4. Required Clearances/Permissions

23. For the Phase IB of JMR project, required clearances/ permissions related to environment have been summarized below.

Table 3: Permissions/Clearances Required for Phase I (B) JMR Project

Sl. No.	Permissions/ Clearances	Acts / Rules / Notifications / Guidelines	Concerned Agency	Responsibility
A. Pre-construction Stage				
1	Permission for felling of trees	Forest Conservation Act (1980) Procedural Guidelines developed by the Department of Environment, GoR; Tree removal will be guided as per state government rules.	District Forest Office/State Forest Department	JMRC
2	Permission for construction within the regulated/ prohibited zone	Rajasthan Monuments, Archaeological Sites and Antiquities Act, 1961	Archaeological Dept., GoR	JMRC
B. Implementation Stage				
3	Permission for withdrawal of groundwater for construction	Environment (Protection) Act, 1986	Central Ground Water Board	Contractor
4	Permission for sand mining from river bed	Environment (Protection) Act, 1986	Mining Department/ MoEF	Contractor
5	Authorization for Disposal of Hazardous Waste	Hazardous Waste (Management and Handling) Rules 1989	Rajasthan State Pollution Control Board	Contractor

Sl. No.	Permissions/ Clearances	Acts / Rules / Notifications / Guidelines	Concerned Agency	Responsibility
6	Disposal of bituminous and other wastes	Hazardous Waste (Management and Handling) Rules 1989	Intimate local civic body to use local solid waste disposal site	Contractor
7	Consent for disposal of sewage from labour camps.	Water (Prevention and Control of Pollution) Act 1974	Rajasthan State Pollution Control Board	Contractor
8	Pollution Under Control Certificate	Central Motor and Vehicle Act 1988	Department of Transport, Govt. of Rajasthan authorised testing centres	Contractor
9	Mandatory Roof Top Rain Water Harvesting	Roof Top RWH has been made mandatory in State owned buildings of plot size more than 300 Sq.m with effect from 03.01.2006. For violation of building by-laws, punitive measures, viz. disconnection of water supply, has also been made. Compulsory installation of rainwater harvesting system in all newly and existing construction building and Govt. offices vide order dated 31.05.2000 and 12.12.2005.	Central Ground Water Authority (CGWA)	Contractor
10	Employing Labour/ workers	The Building and Other Construction Workers (Regulation of Employment and Conditions of Service) Act, 1996	District Labour Commissioner	Contractor

B. Asian Development Bank Safeguard Policies

24. The ADB has defined its safeguard requirements under its SPS, 2009. The prime objectives of these safeguard policies are to: (i) avoid adverse impacts of projects on the environment and affected people, where possible; and (ii) minimize, mitigate, and/or compensate for adverse project impacts on the environment and affected people when avoidance is not possible. Since JMR project is likely to have potential environmental risks and impacts and requires compliance with the safeguard requirement of SPS.

25. **Category of the Project as per SPS.** The project has been evaluated considering the outcome of latest ADB‟s Rapid Environmental Assessment Checklist (**Annexure-1**). The Phase I (B) of JMR project neither passes through nor is located within 10 km from any Wildlife Sanctuary, National Park, or any other environmentally sensitive or protected areas. However, the alignment goes under the old pink city with a number of heritage structures.

Due to potential for impacts on these structures from vibration from tunnelling works during construction, the project has been classified as Category “A” in accordance with ADB‟s Safeguard Policy Statement 2009.

III. DESCRIPTION OF THE PROJECT

A. Rationale and Project Settings

26. Rapid industrialization and intense commercial developments in the past decades have resulted in steep rise in travel demand, putting Jaipur's transport infrastructure to stress. With the projected increase in the city's population, strengthening, and augmenting the existing transport infrastructure has assumed urgency.

27. The present public transport system available for the city is not properly organized and is inadequate in terms of frequency and comfort. The fleet of about 250 buses is being operated under public transport system, which connects the suburban areas to core area of the city. The private mini bus operators operate about 1,800 buses mostly in city area. The private mini bus operators dominate and compete with public bus system. Their routes are in-efficiently rationalized and are not properly regulated with too many buses on some routes where as other routes have very less frequency.

28. The other transport facility available is rickshaws. Cycle rickshaws operate mostly inside walled city area for short trips and auto rickshaws operates in whole study area. The present bus transport system is insufficient to cater to the need of city due to which the share of public transport has decreased from 26% to 19% in last decade. Commuters prefer to use personalized transport. The average annual growth rate of the vehicles in Jaipur is about 12% which is causing congestion on city roads. For city with a population of 1 million, the share of public transport should be 40%-45% and progressively increase to 75% when population reaches 5 million.

29. The State Government has taken up the project of Bus Rapid Transport System (BRTS) under Jawaharlal Nehru National Urban Renewal Mission (JNNURM) scheme at a cost of Rs. 4800 million. Under BRTS project, pilot dedicated corridor is being developed from C-Zone bypass to Ambabari measuring 7.1 km. Also, a 45.0 km BRT corridor on wider road sections of the city is being implemented. About 400 new low floor modern buses will be introduced into city transport system[2].

30. However, BRT has its own limitations and constraints. The capacity of a BRT system at best be only 10,000 to 12,000 PHPDT (Peak Hour Peak Direction Trips) and that of a tramway system about 8,000 to 10,000 PHPDT. The BRT takes away two lanes of the road for dedicated use pushing rest of the road vehicles crowded into the remaining road space. Therefore, unless the road widths are more than three lanes in each direction, BRT is not feasible and even then the non-bus riders will be put to tremendous inconvenience. In Delhi, the experience of BRT has not been a success[3].

31. In the case of a Metro system, the road width is not encroached. If the Metro is elevated, only the central median of the road to a width of 2 to 3 m. is occupied for locating the columns carrying the rail deck. If the metro is underground, there is no encroachment at all on the road width. Jaipur City, with its present population (in 2013) of about 4 Million and employment of 1.55 Million has a travel demand of 3.6 Million passenger trips every day of which 10% trips are performed during peak hour. With growing population and mega development plans the travel demand will grow steeply. With the growing economy and inadequate public transport services, the passengers shall shift to private modes, which is already evident from the high vehicle ownership trends in the region. This would not only

[2] DPR – Jaipur Metro Phase I
[3] Ibid

aggravate the congestion on streets but also increase the pollution. Hence, it has become essential to plan and provide for a light to medium metro system[4] in Jaipur.

32. Metro systems have an advantage over other modes because they provide higher carrying capacity, faster, smoother and safer travel, occupy less space, are non-polluting and energy-efficient. To summarise the benefits, a Metro system:

- Requires 1/5th energy per passenger km compared to road-based system
- Causes no air pollution in the city
- Causes lesser noise level
- Occupies no road space if underground and only about 2 metres width of the road if elevated
- Carries same amount of traffic as 5 lanes of bus traffic or 12 lanes of private motor cars (either way), if it is a light capacity system.
- Is more reliable, comfortable and safer than road based system
- Reduces journey time by anything between 50% and 75% depending on road conditions.

B. Description of the Project Details

33. The proposed East West and North South Corridors of JMR project is approximately 35.666 km in length. The East-West Corridor is currently being implemented and referred to as Phase 1 while the North-South corridor is Phase 2. Phase I has an elevated portion from Mansarovar to Chandpole (9.278 km) and an underground station at Chandpole (0.44kms), known as Phase IA and at present is under final stage of construction with Government of Rajasthan (GoR) funding. The underground section of this corridor i.e. Phase IB from Chandpole to Badi Choupar has a length of 2.349 km and will have 2 underground stations, Choti Choupar and Badi Choupar. It is the phase 1B section which is proposed for financing by ADB. The route-wise descriptions of the two alignments of JMR are as under:

Phase 1: - East West corridor under Phase - 1 will be from Badi Choupar to Mansarover via. Choti Chaupar, Chandpole, Sindhi Camp, Railway Station, civil line, Ram Nagar, Shyam Nagar, Vivek Vihar, New Atish Market and Mansarover. The approximate length of this line is 12.067 km with about 9.278 km elevated from Mansarover to Chandpole and 2.789 km of underground section from Chandpole to Badi Choupar.

Phase 2: - North South corridor under Phase – 2 will be starting from the Sitapura Industrial Area to Ambabari Via. Pratap Nagar, Haldi Ghati Gate,Sanganer,Laxmi Nagar, Durgapura, Mahavir Nagar, Gopalpura, Dev Nagar, Tonk Phatak, Gandhi Nagar, SMS Stadium, Narayan singh Circle, SMS Hospital, Ajmeri gate, Government Hostel, Sindhi Camp, Subhash Nagar, Panipetch, Ambabari. The approximate length of this line is 23.099 km with about 18.044 km elevated and 5.05 km underground.

[4] Light rail metro system (LRTS) has the capacity of up to 25,000 PHPDT while a medium capacity metro syste can handle as much as 50,000PHPDT

34. The alignment map showing the JMR corridors is presented in the succeeding Figure 1.

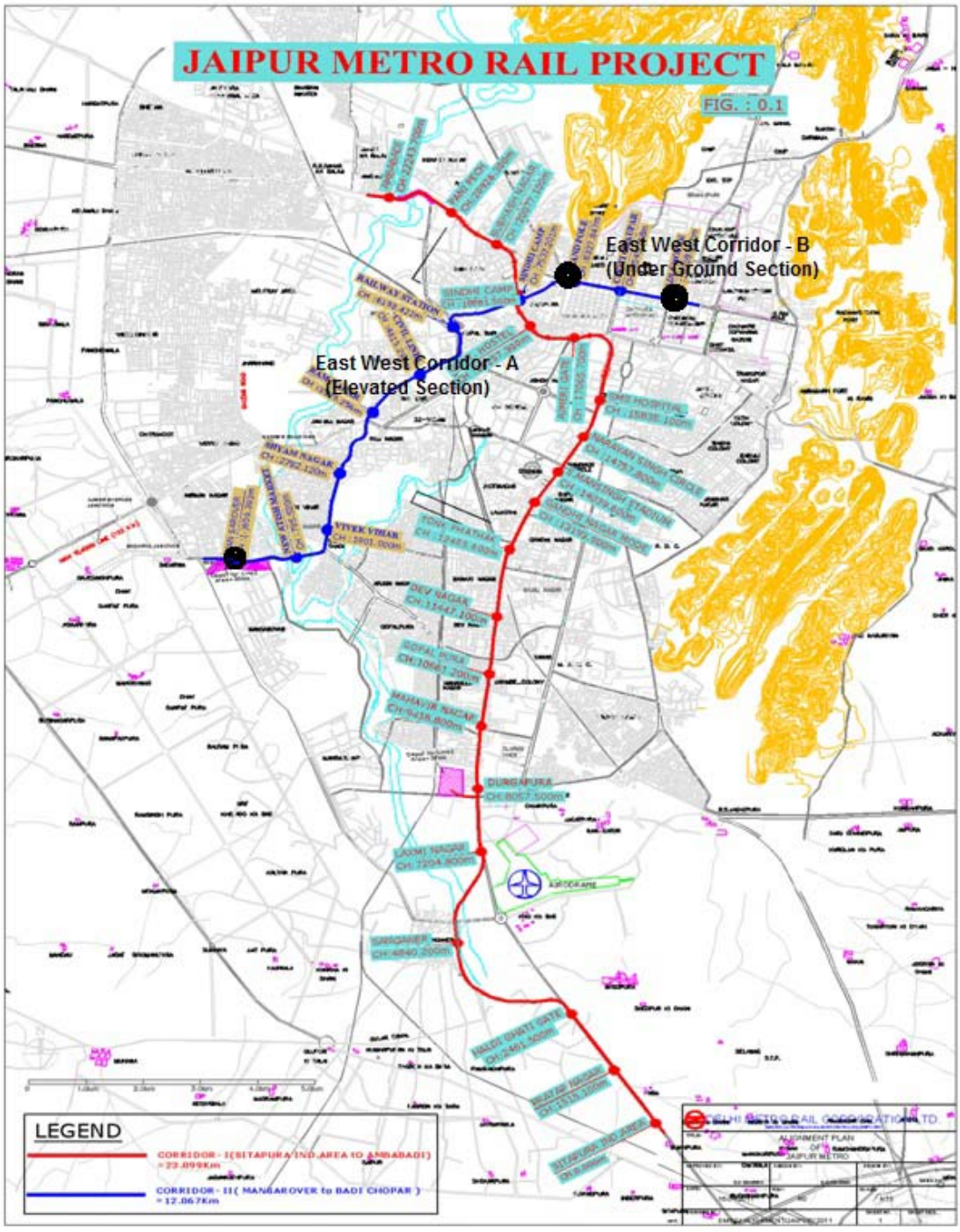


Figure 1: Jaipur Metro Rail Alignment of East West (Phase I) and North-South (Phase II) Corridors

Figure 2: Alignment of East West Corridor (Phase I-B: Chandpole to Badi Choupar) Proposed for ADB Funding

35. Phase 1 will have a capacity of 4 cars/train which will operate at 6,4,2.5 minutes headway and will have PHPDT capacities of 13,160; 19,740; and 31,584, for the planning years 2014, 2012, and 2013, respectively[5]. The modern aluminium rolling stock will have 2.90m width longitudinal seating arrangement and 1,034 passengers for the 4 coaches. The maximum permissible speed on the section is limited to 85 kms. Total electricity requirement is estimated at 23.6 MVA of which about a quarter will be used for traction.

36. Phase 1A is the elevated section from Mansorovar to Chandpole Stations is 9.275 km with 8 elevated, and 1 underground station. The breakup of the alignment is provided below.

Table 4: Breakup of alignment length

Sl. No.	Description	Chainage (M)		Length (m)
		From	To	
1	Elevated	-1,218.93	7,800	9,018
2	Switch Over Ramp	7,800	8,220	420
3	Underground (Cut & Cover)	8,220	8,500	280
4	Underground (TBM)	8,500	10,220	1,720
5	Underground (Cut & Cover)	10,220	10,848	628
Alignment length (Total)				12,067

Source: Jaipur Metro Rail Project, DPR-Phase I, DMRC

37. The salient design features of the JMR project are below:

- The corridors will be Standard Gauge (1,435 mm)
- 25 KV AC overhead traction system (OHE) has been proposed for both the North-South and East West corridors of Jaipur Metro
- Signalling and Train Control will be through Continuous Automatic Train Control system and Computer based Interlocking
- Bulk of the telecommunication network is proposed with optical fiber cable system. In addition, mobile radio communication system having minimum 8 logical channels is proposed for on-line emergency communication
- Passenger announcement system will be linked to Signaling System for automatic train actuated announcements.
- Passenger Information Display System will be located at convenient locations at all stations to provide bilingual 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.
- Passenger handling facilities comprise of stairs/escalators, lifts and ticket gates required to process the peak traffic from street to platform and vice-versa
- Centralised clock system to ensure accurate display of time through a synchronization system of slave clocks driven from a Master Clock at the operation control center.
- The CCTV system will provide video surveillance and recording function for the operations to monitor each station. The monitoring shall be possible both locally at each station and remotely from the Operation Command Center (OCC).
- Automatic Fare Collection system will be in place. At all stations, two Passenger Operated Machines (Automatic Ticket Vending Machines) each, have been proposed.

[5] Capacities based on 8 person/m^2 standing area

- The trains will have 4/6 coaches and will have a crush carrying capacity of 1034/1574 passengers, respectively.
- Maximum design speed is 95 km/h and the maximum operating speed is 85 km/h.

38. Phase 1B is the underground section starting from Chandpole gate station, passing through Choti Choupar and then to end-of-the-line in Badi Choupar. Rail level at midsection in tunneling portion shall be kept at least 12.0 m below the ground to maintain a cover of at least 6m available over the tunnel. At stations, the desirable depth of rail below ground level is 12.5m. The track centre in underground section to be constructed by Tunnel Boring Machine (TBM) is 13.05m to accommodate a 10m wide island platform. Figure 3 and Figure 4 present the typical cross-section and dimensions of the tunnel.

39. All the underground stations will have island platforms except Badi Choupar station where side platforms have been planned. The general layout design of Chhoti Choupar and Badi Choupar stations are presented in Figure 5 and Figure 6, respectively.

40. The underground section will be constructed using the New Austrian Tunnelling Method (NATM) and partly by cut and cover method for the two remaining stations at Chhoti and Badi Choupar (Chandpole station is already under construction). All three underground stations will be constructed through cut and cover with top-down method. The diaphragm walls for such station constructions would be 60 to 100 cm. thick and will function as a permanent side wall of the station. The diaphragm walls will be watertight and with the required concrete strength similar in the Delhi Metro station constructions. By resorting to top-down method the surface could be restored quickly and further excavations and construction of the station will not hamper the surface activity.

C. Planning and Design Criteria for Stations

1. Design Criteria

41. Standard gauge (1435mm) to comply with India's no "right-of-way"[6] reserved or metro system which often have sharp curves and right angle bends. Standard gauge permits adoption for sharper curves as compared to broad gauge which requires more land acquisition along alignments. Standard gauge also allows "off-the-shelf" rolling stock, subject to constant upgrades, and promote India's export of technology to other countries that uses standard gauge.

42. Ballast-less track will be used, except in the depot to minimize regular maintenance and train downtime. The track will be joint-less to minimize vibration and noise level. Rails will be made of 1080 Head Hardened material complying with India Rail Standard T-12-96 except in the depot which will be of 880 grade.

43. A distance to go automatic train protection and automatic subsystem will be installed to provide high level of safety for trains running at close headway to ensure continuous and safe separation, eliminate accidents due to driver error, maintain safe speeds, optimize speed, maximize turn-around, and monitor trackside and train-bourne equipment to enable on-time preventive maintenance.

44. Telecommunication and transmission media will include fiber optic system as the main telecommunication bearer, telephone exchange, mobile radio, passenger announcement system, passenger information display, closed circuit television, and network management system to diagnose communication faults.

[6] The metro alignments have to follow the major arterial roads

45. Automatic fare collection allowing for smart card for multiple journeys and contact less smart token for single journey.

46. The rolling stock will have an stainless steel bodies with bogies overhaul interval of 420,000 kms and equipped with air springs and vertical hydraulic damper to maintain level at all possible loadings, smoother ride, and minimize vibration and noise. Automatic doors, air-conditioning, emergency detrainment door, communication, passenger safety (fire retarding material, emergency door, crash worthiness, gangways, and continuous automatic train protection).

47. The stations can be divided into public and non-public areas (those areas where access is restricted).The public areas can be further subdivided into paid and unpaid areas. Keeping this mind the following planning and design criteria has been adopted:

48. The platform level has adequate assembly space for passengers for both normal operating conditions and a recognized abnormal scenario.

49. The platform level at elevated stations is determined by a critical clearance of 5.5 m under the concourse above the road intersection, allowing 3.5 m for the concourse height, about 3 m for concourse floor and 1.5 m for structure of tracks above the concourse. Further, the platforms are 1.09 m above the tracks. This would make the rail level in an elevated situation at least 13.5m above ground.

50. In the underground stations, platform level is determined by a critical clearance of 2.50 m above the station box, which would be 13.7 m high. Allowing about 80 cm for the box structure, 70 cm for rails /supporting structure and 1.09 m for rail to platform ht, would make the platforms in an underground situation at least 13.5 m below ground.

51. The concourse contains automatic fare collection system in a manner that divides the concourse into distinct areas. The 'unpaid area' is where passengers gain access to the system, obtain travel information and purchase tickets. On passing through the ticket gates, the passenger enters the 'paid area', which includes access to the platforms.

- The arrangement of the concourse is assessed on a station-by-station basis and is determined by site constraints and passenger access requirements. However, it is planned in such a way that maximum surveillance can be achieved by the ticket hall supervisor over ticket machines, automatic fare collection (AFC) gates, stairs and escalators. Ticket machines and AFC gates are positioned to minimize cross flows of passengers and provide adequate circulation space.
- Sufficient space for queuing and passenger flow has been allowed at the ticketing gates.
- Station entrances are located with particular reference to passenger catchment points and physical site constraints within the right-of-way allocated to the MRTS.
- Office accommodation, operational areas and plant room space is required in the non-public areas at each station.
- The DG set, bore well pump houses and ground tank would be located generally in one area on ground.
- The system is being designed to maximize its attraction to potential passengers and the following criteria have been observed:
  - Minimum distance of travel to and from the platform and between platforms for transfer between lines.
  - Adequate capacity for passenger movements.

- Convenience, including good signage relating to circulation and orientation.
- Safety and security, including a high level of protection against accidents.

52. Passenger handling facilities comprise of stairs/escalators, lifts and ticket gates required to process the peak traffic from street to platform and vice-versa (these facilities must also enable evacuation of the station under emergency conditions, within a set safe time limit). The numbers and sizes of staircases/escalators are determined by checking the capacity against AM and PM peak flow rates for both normal and emergency conditions such as delayed train service, fire etc. In order to transfer passengers efficiently from street to platforms and vice versa, station planning has been based on established principles of pedestrian flow and arranged to minimize unnecessary walking distances and cross-flows between incoming and outgoing passengers**.**

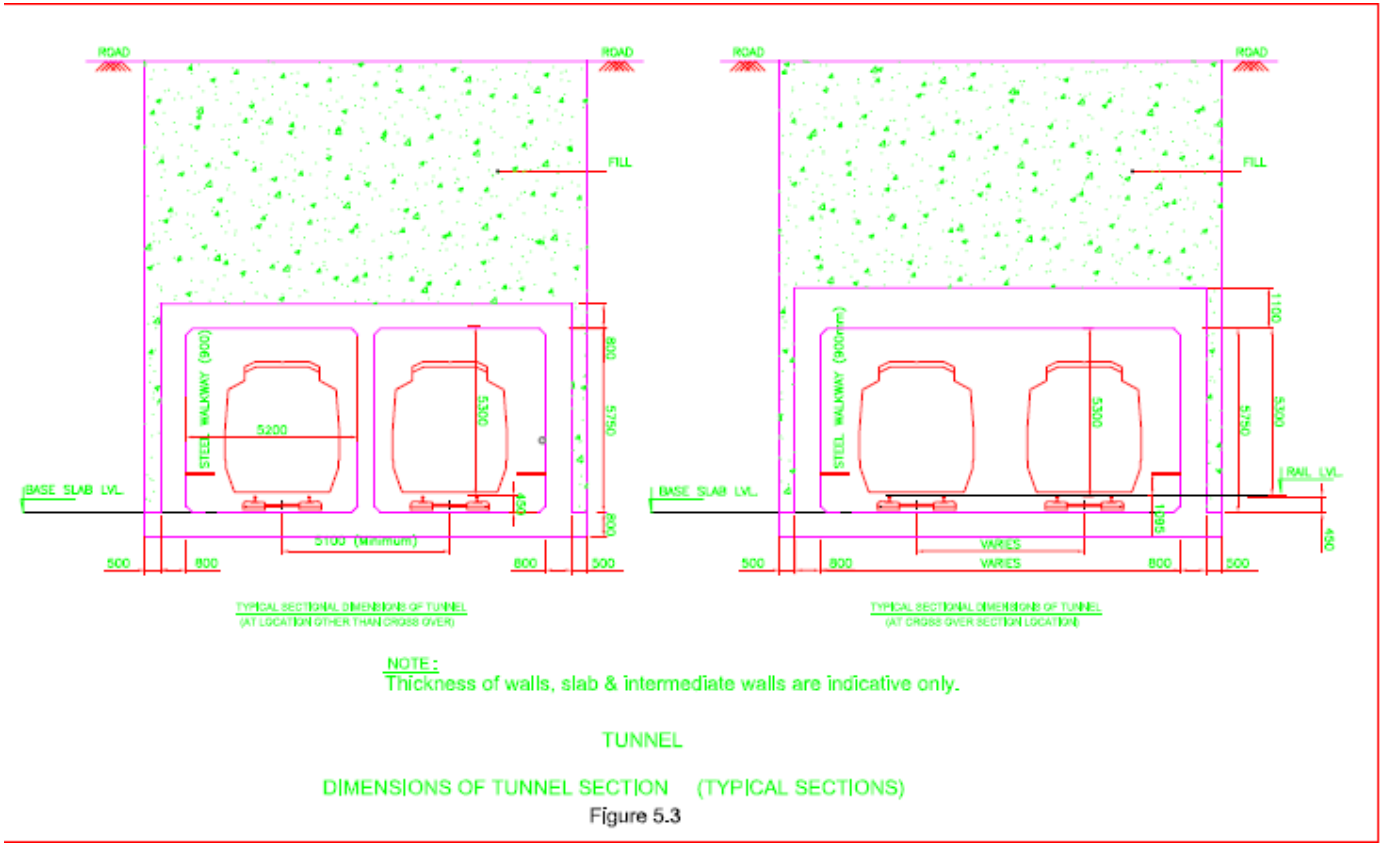


Figure 3: Typical Dimensions of the Tunnel Section (DPR, 2011)

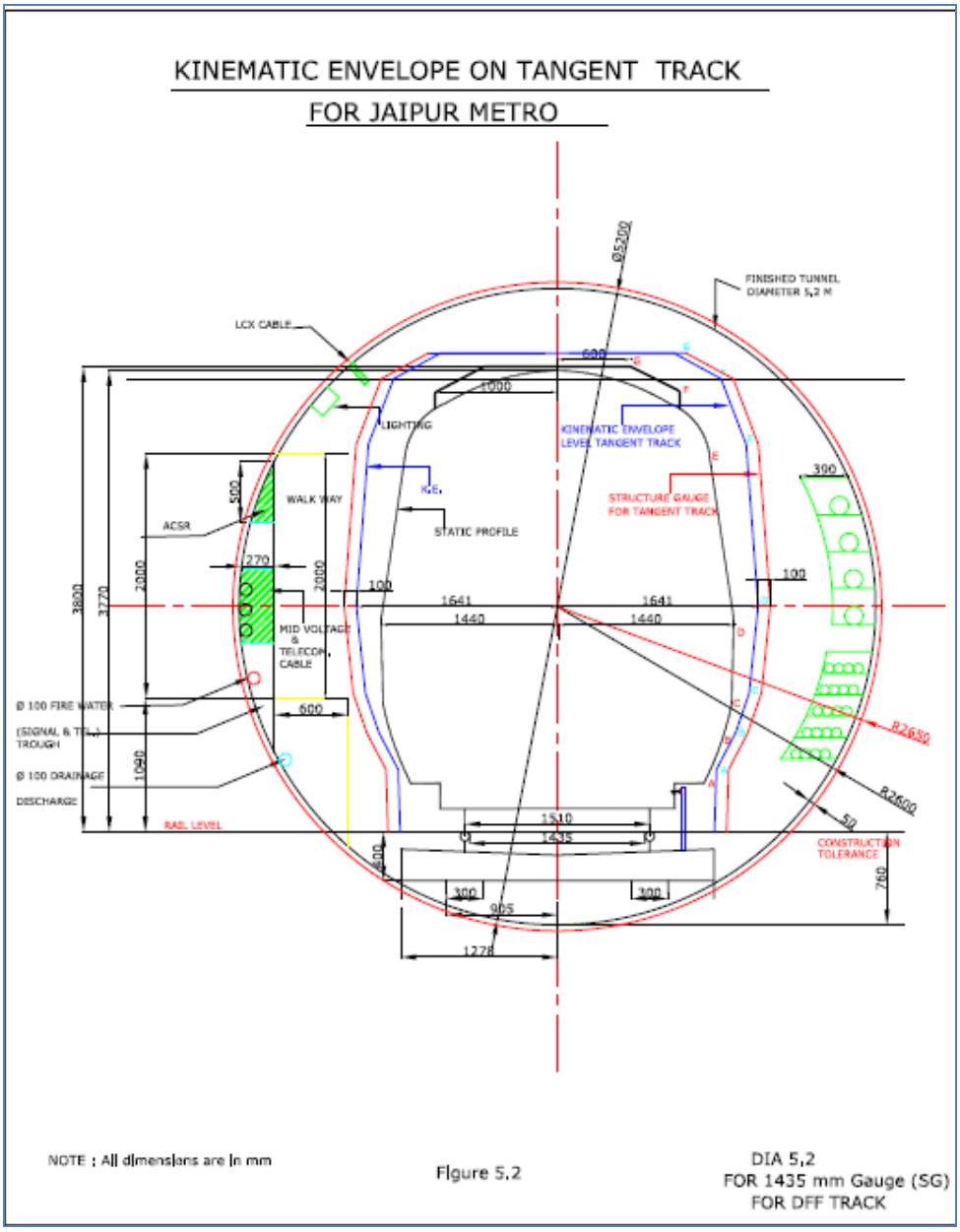


Figure 4: Typical Cross-Section of Tunnel (DPR, 2011)

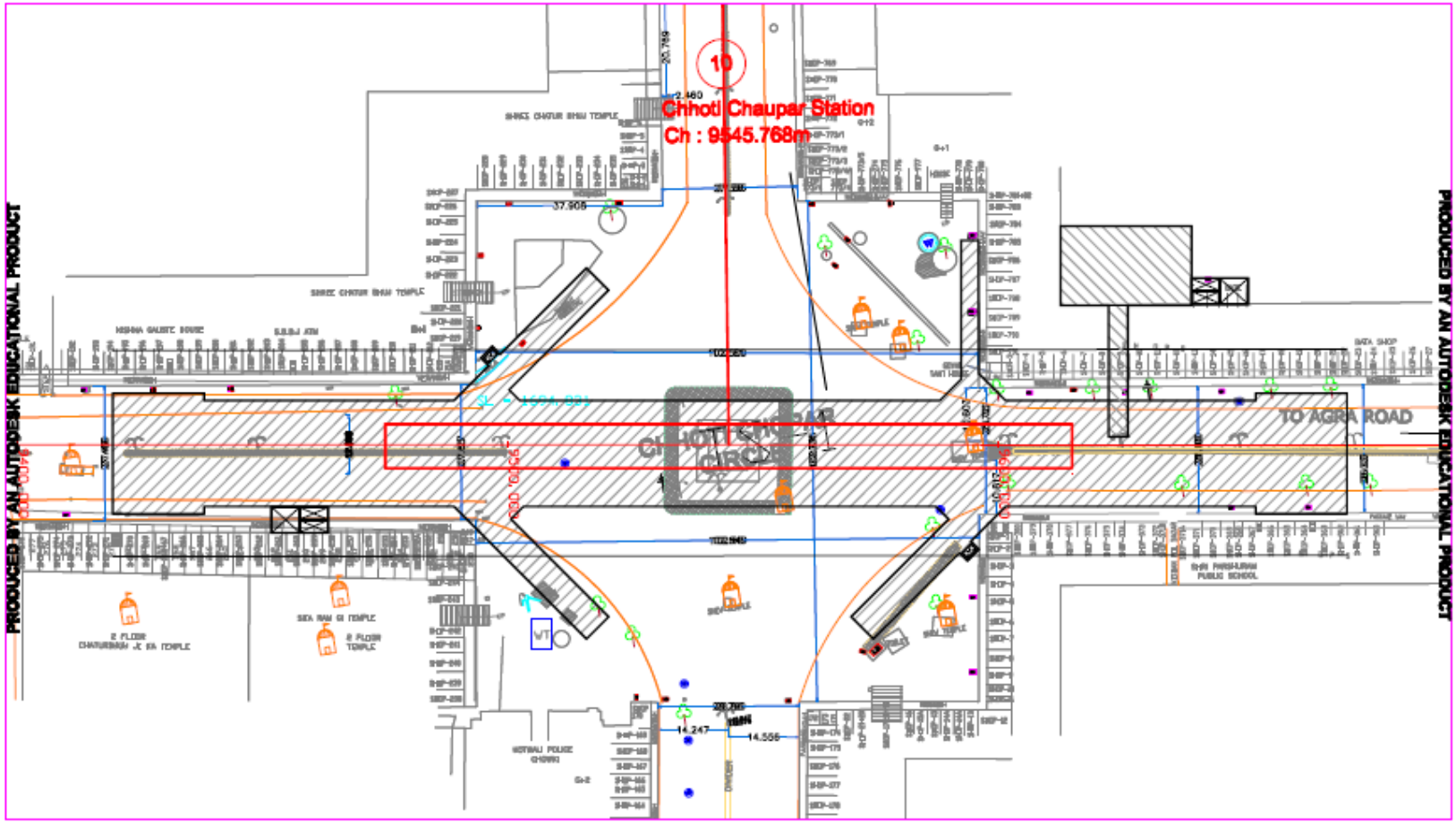


Figure 5: General Layout Plan (Chhoti Choupar Metro Station)

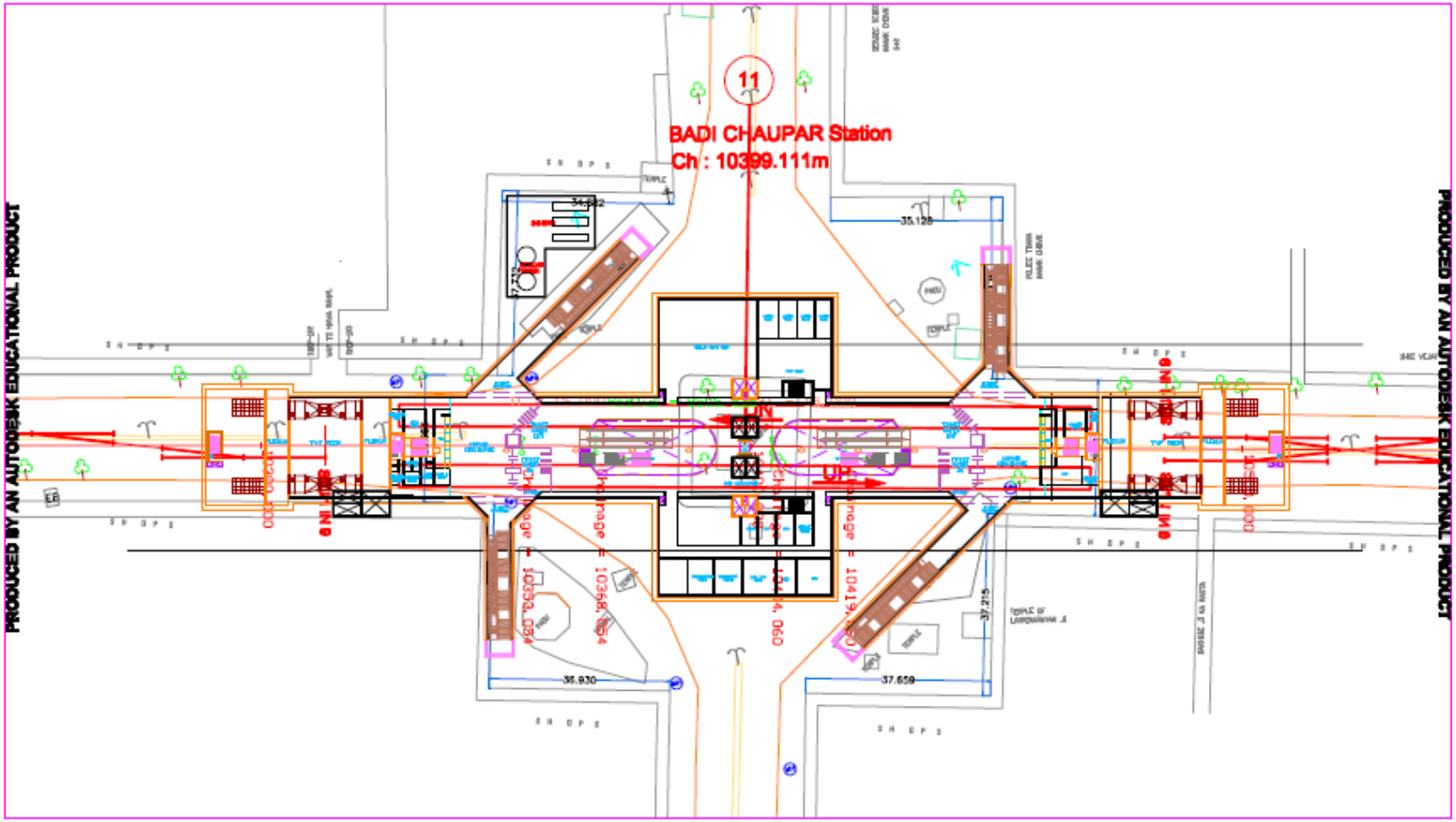


Figure 6: General Layout Plan (Badi Choupar Metro Station)

2. Typical Underground Station

53. The typical underground station is a two-level station with platforms at the lower level and concourse on the upper level. Concourses are provided in such a manner that the total height of underground station, and hence the cost, is kept to the minimum. The upper level has, in addition to the concourse, all the passenger amenities, ECS plant rooms, electrical and S&T equipment rooms, station operation areas such as Station Control Room, Station Master's Office, Waiting Room, Meeting Room, UPS and Battery Room, Signaling and Train Crew Room, Train Crew Supervisor's Office, Security and Station Store Room, Staff Toilets, etc. Lower level has platforms, tracks, seepage sump, pump room, and similar ancillary spaces beyond the platforms on either side.

54. Ventilation shafts, equipment hatch, entrances, and chiller plants for ECS plant are above ground structures associated with the underground station and are being provided on the open spaces by the roadside acquired land. Generally, four entrances have been provided to the station, two at each end (one each from either side of the road). Two emergency staircases are also being planned in the traffic islands. Other above ground structures is suitably located near the station. The station accommodations are provided below.

Table 5: Station Accommodation

1. Station Control Room	2. Cleaner's Room
3. Station Master's Office	4. Security Room
5. Information & Enquiries	6. First Aid Room
7. Ticket Office	8. Miscellaneous Operations Room
9. Ticket Hall Supervisor & Excess Fare Collection (Passenger Office)	10. Platform Supervisor's Booth
11.Cash and Ticket Room	12. Traction Substation (alternate Stations)
13.Staff Area	14. Fire Tank and Pump Room
15.Staff Toilets	16. Commercial Outlets and Kiosks
17.Station Store Room	18. UPS and Battery Room
19.Refuse Store	20. Signaling / Communication Room
21. Public Toilets	22. Auxiliary sub-station
23.Electrical switch room	
Additional Accommodation in Under Ground Stations	
24. Environ control system plant room	25.Tunnel ventilation system plant rooms
26. Insert gas room	27.Inert gas room
28. CDMA /Gas room	29. DB Panel room
30. Sewage/ seepage tanks and pump rooms	31.Chiller plant room
32. Pump room	

3. Source of Power Supply

55. To ensure high reliability of power supply during metro operation, adequate redundancies in the transmission and distribution were incorporated in the design. Power demand estimated for the east-west corridor for years 2014, 2021, and 2031 are 9.5, 11.3, and 14.0 MVA, respectively. Coordination with the Rajathan Rajya Vidyut Prasaran Nigam Limited (RVPN) to include two receiving sub-stations 132/33/25 KV at Mansorovar and SindhiCamp will be installed.

4. Mansorovar Depot cum Workshop

56. There is no connectivity between east-west and north-south corridors requiring the construction of 2 depots in Mansorovar and Bamballa Nala, respectively. The Mansorovar depot is in the final stage of construction and upon completion will have stabling shed, inspection shed, heavy repair/minor repair workshops, cleaning of rolling stock, electrical and mechanical services, power supply and distribution, water supply, and drainage and sewerage treatment and disposal facilities including rain harvesting.

5. Platforms

57. A uniform platform width of 8 to 12 m wide is proposed for the underground stations. In elevated stations, 4.5m wide side platforms have been proposed. These platform widths also have been checked for holding capacity of the platform for worst-case scenario. Since the rise to road from the concourse is about 8m, it is proposed to provide lifts in addition to stairs for vertical movement of passengers from street to concourse.

6. Water for Construction

58. Water for construction of the project will be taken from ground water sources after obtaining necessary permissions. No public water sources will be used for construction of the project.

7. Construction Camps

59. Existing facilities for construction of the elevated section will be utilized for constructing the underground section. Setting up of new construction camp is not envisaged.

IV. DESCRIPTION OF THE ENVIRONMENT

A. Introduction

60. The collection of baseline information on biophysical, social, and economic aspects of the project area is the most important reference for conducting an EIA. The description of environmental settings includes the characteristic of area in which the project activities would occur and cover area affected by all impacts. The existing baseline line conditions has been analysed based on primary data collection with regard to air quality, water quality, noise, soil, and socio- economic aspects, and secondary data collection from published source and various government agencies. Efforts were made to collect the latest information both at regional as well as local level especially along the project alignment. This will help to predict likely changes in the environment due to the proposed project activities. The existing baseline data and analysis in the project area is presented in the following sections

B. Physical Environment

1. Topography, Physiography, Geology

61. Jaipur Region is situated in North Eastern part of Rajasthan. Jaipur district is one of the 33 districts of Rajasthan and is located between $26^0$23'N to $27^0$51'N latitude and $74^0$55'E to $74^0$55'E longitude. The district has an area of 11151 Sq.Km and occupies 3.3% of the state. The general slope direction of Jaipur city and its surroundings is from north to south and then to south-east with nearly all the ephemeral streams flowing in this direction. Higher elevations in the north exist in the form of low, flat-topped hills of Nahargarh (587 meters above mean sea level). Jaigarh, Amber, and Amargarh are deeply dissected and eroded. An isolated hillock called "Moti Dungari" upon which an old royal castle exists is near the Rajasthan University. Further in the south, topographical levels of the plain areas varies between 280 meters along Bandi and Dhund rivers in the south to some 530 meters in the north east of Chomu near Samod hills. The overall trend is a decline of level from the areas bordering the hills in the north to plain in the south. The proposed alignment of JMR Phase I B alignment passes through the old city area of Jaipur that is located south of the dissected hills of Jaigarh and Amber. The area has a flat terrain devoid of any surface water bodies.

62. Jaipur district is watered by river Banas and its tributaries and the fertile soil sustains mixed xerophytic and mesophytic vegetation. Cultivation crops like barley, gram, wheat, mustard are grown in the rabi season.

63. The region is characterized by north – easterly part of the Aravalli range and presents an excellent arch type of folded mountain belt reduced to its penultimate stage of denudation. The geological structure of the region shows that the rocks of the Delhi Super group constitutes the main Aravalli mountain and extended continuously from Gujarat border in south to Delhi in the north-east over a distance of nearly 700 kms.

64. Geomorphologically, district Jaipur is classified into fifteen geomorphic units, spread over district namely alluvial plain, alluvial plain (sandy), valley fill, palaeochannel, salt encrustation/Playa, Ravine, flood plain, pediment, buried pediment, intermontane valley, sandy plain, Aeolian plain, denudational hill, structural hill and linear ridge. Location of these units are mentioned in succeeding Table.

Table 6: Location of Landforms within the Project Area

Landform Units	Occurrence in the district
Fluvial origin alluvial plain	Entire southern boundary, north of Bassi, surrounding Chomu, Shahpura and Kotputli town, west of Kanota village i.e. along river Dhundh.
Alluvial plain (Sandy)	Mainly concentrated in central and western part of the district and covers the project area of JMR Phase I B.
Valley fill	Marginally in eastern part between hills.
Salt encrustation/Playa	South of Sambhar lake
Palaeochannel	West of Chomu town & north of Sabrampura
Ravine	Wind ward side of hills in eastern part, south east of Phulera town.
Flood plain	Along rivers Dhundh & Mendha
denudational hill, origin pediment	Along hills in eastern and northern part of district also west of Sanganer town.
Buried pediment	Mainly scattered in north and north east
Intermontane valley	Marginally in between hills near Benrath village
Aeolian origin sandy plain	South of Sambhar Lake, east of Hingonia Sagar
Aeolian plain	South of Kotputli town
Hills, Denuded hills	East and north east of Jaipur city, around Jamwa Ramgarh lake.
Structural hill	Scattered in northern and eastern part
Linear ridge	Scattered in eastern part

65. Geo-technical study was conducted in December 2009 by the DMRC for JMRC along the Phase 1 corridor. Three boreholes along the underground section were established; i) near Manak Chowk Police Station in Badi Choupar, and ii) near Mandir Shree Khrishna Chandra Ji, Choti Chaupar, and iii) near Shiv Mandir, Chandpol. (see Figure 7). The subsurface profile up to 30 meters indicated silty sand and mixed with gravel formation having loose structure of to a depth of 3.00 meters and increases in density as it go deeper.

Table 7: Sub-surface Profile Near Manak Chowk Police Station Badi Choupar

Depth	Type of Soil/Rock	Soil/Rock Characteristics
0.00-0.30	Filled-up Strata	Loose
0.30 to 3.00	Silty Sand	Loose
3.00 to 5.50	Silty Sand	Medium Dense
5.50 to 10.50	Silty Sand with Gravels	Medium Dense
19.50-13.00	Silty Sand	Dense
13.00 to 17.50	Silty Sand with Clay and Gravels	Dense
17.50 to 19.50	Silty Sand	Dense
19.50 to 30.00	Silty Sand with Gravels	Very Dense

Table 8: Sub-surface Profile Near Mandir Shree Kishna Chandra Ji Choti Choupar

Depth	Type of Soil/Rock	Soil/Rock Characteristics
0.00 to 0.60	Filled-up Strata	Loose
0.60 to 3.00	Silty Sand	Loose
3.00 to 5.00	Silty Sand	Medium Dense
5.00 to 7.50	Silty Sand with Gravels	Medium Dense
7.50 to 8.00	Silty Sand with Gravels	Dense
8.00 to 10.50	Silty Sand	Dense
10.50 to 27.00	Silty Sand	Very Dense
27.00 to 30.00	Silty Sand with Gravels	Very Dense

Table 9: Sub-Surface Profile Near Shiv Mandir Chandpole

Depth	Type of Soil/Rock	Soil/Rock Characteristics
0.00 to 0.40	Filled-up Strata	Loose
0.40 to 4.50	Silty Sand	Loose
4.50 to 6.00	Silty Sand	Medium Dense
6.00 to 9.00	Silty Sand with Gravels	Medium Dense
9.00 to 10.50	Silty Sand	Medium Dense
10.50 to 15.00	Silty Sand	Dense
15.00 to 17.50	Silty Sand with Clay	Dense
17.50 to 19.20	Sandy Silt with Gravels	Dense
19.20 to 19.50	Silty Sand	Dense
19.50 to 30.00	Silty Sand	Very Dense
Below 30.00	Silty Sand with Gravels	Very Dense

66. Chemical analysis of the soil and water from the boreholes indicate suitability for construction as pH, chlorides, sulphate (SO4), sulphite (SO3) are within standards.

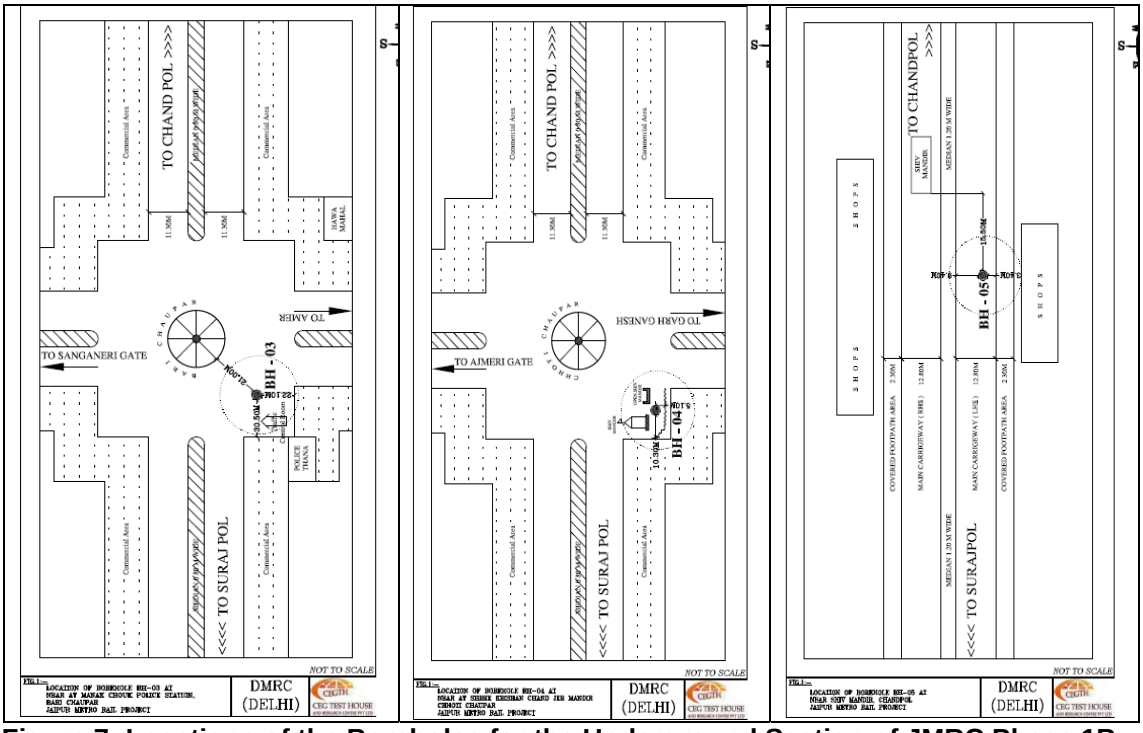
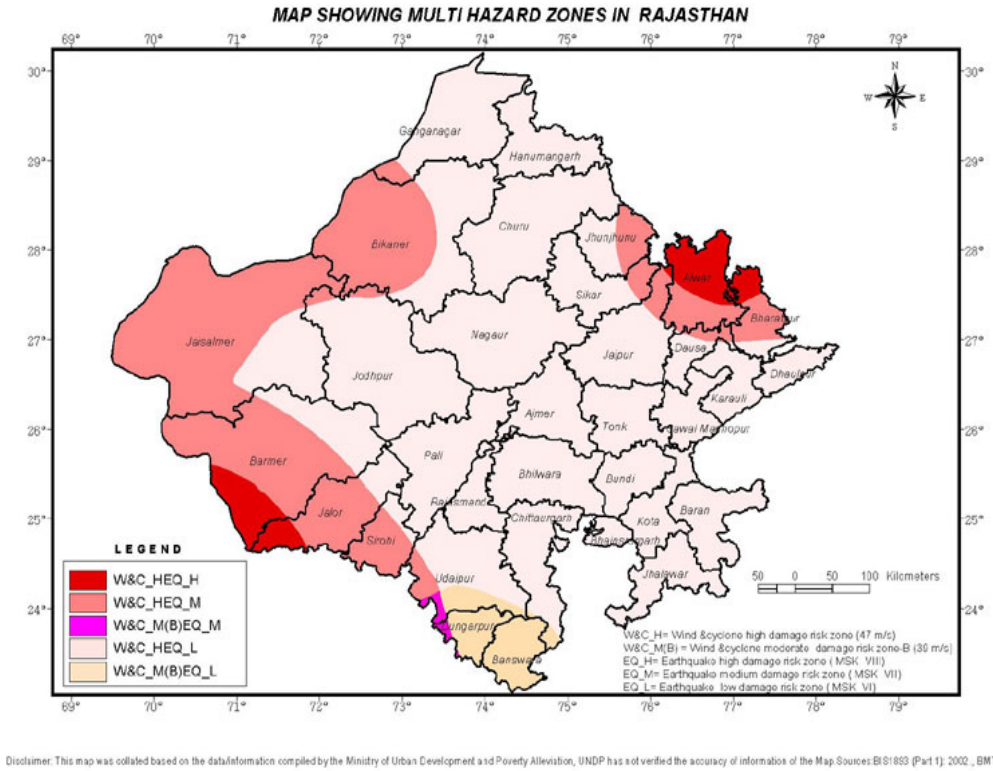


Figure 7: Locations of the Boreholes for the Underground Section of JMRC Phase 1B

2. Seismicity

67. The seismic hazard map of India was updated in 2002 (refer Figure) by the Bureau of Indian Standards (BIS). Apart from the merging of Zones I and II, there are no major changes in the new hazard map of the state of Rajasthan, as compared with the previous 1984 BIS map. Jaipur City is classified as earthquake low damage risk zone. Western parts of the districts of Barmer and Sirohi as well as northern sections of Alwar district lie in Zone IV, where the maximum intensity could reach VIII (MSK). The remaining areas of Barmer and Sirohi districts, as well as the districts of Bikaner, Jaiselmer, and Sirohi lie in Zone III. The north-eastern districts of Jhunjhunu, Sikar, Bharatpur and the rest of Alwar also lie in Zone III. The maximum intensity expected in these areas would be around MSK VII. The rest of the state, including the capital, Jaipur, lie in Zone II, where the maximum intensity

expected would be around MSK VI. It must be noted that BIS estimates the hazard, based in part, on previous known earthquakes. Among the most recent occurrences of earthquakes, the strongest was of magnitude 4.3 that struck the Jaipur region in north-eastern Rajasthan on 24 December 2006 at 04:13 local time. Tremors from the earthquake were felt in many parts of Jaipur for up to 30-seconds.



Source: http://www.rajrelief.nic.in/rajmultihazard.htm

Figure 8: Multi-Hazard Zone Map, Rajathan (2002)

3. Surface and Ground Water Hydrology

68. Rajasthan is one of the naturally water scarce regions in India due to very low to medium rainfalls, high inter-annual variability in rainfall magnitudes, very few rainy days, and high aridity7. A wide range of rainfall occurs across the state with 100 mm in Jaisalmer receiving 100 mm/year and around 900 mm in Udaipur. Rajasthan's vulnerability to droughts is one of the highest in the country, more so in the western parts, with the probability of occurrence as high as 25 per cent (Sinha and Wale, 2006).

a. Surface Water Hydrology

69. There are three surface water bodies, Amanisha Nalla, Ambabadi Ka Nalla and Jal Mahal Talab that characterise the surface water hydrology of the study area. Of these three water bodies, Ambabadi Ka Nalla crosses the metro corridor near new Aatish Market. Water quality monitoring has been done by the DMRC consultants at Amanisha Nalla, Ambabadi Ka Nalla and Jal Mahal Talab and the results are presented in succeeding. Secondary

[7] Kumar, D.M et. al. (undated). "Groundwater Management in Rajasthan: Identifying Local Management Actions. Final report." Institute for Resource Analysis and Policy Hyderabad.

data collected from the Central Pollution Control Board (CPCB) also shows that the water in the nalas has high TDS value.

b. Groundwater

70. According to the Central Ground Water Resources Board, Ministry of Water Resources India8, Rajasthan is divided into three hydrogeological units namely, unconsolidated sediments, semi-consolidated sediments and consolidated rocks. The unconsolidated sediments constitute a major aquifer east of Bikaner occupying an area of 1400 sq.km, aquifer thickness is 40 to 80 m, and well yielding 100 to 150 m3/hr. Unconsolidated sediments occur in two forms alluvial sediments and aeoline deposits which are found in Barmer, Jalore and Jodhpur district, consisting of sand, clay, gravel and cobbles. Semi-consolidated formations include sandstones, limestones and Aur beds, covering Jaisalmer and Barmer districts with dugwells yielding 13 to 68 m3/day. The yield prospect is limited unless the well is located near major lineaments or any other weak planes. The ground water quality is in general poor (brackish to saline) at deeper levels.

71. Unconsolidated porous regionally extensive formations, with low groundwater potential cover the northern and north eastern and southern parts the state, comprising the entire Ganganagar, most parts of Churu, Pali, Balmer, Jaipur and Alwar districts with some pockets havig high yields (see succeeding Figure).

72. The ground water in Jaipur district is mostly bicarbonate in nature with low to medium density but still potable. According to the Jaipur Development Authority9 higher concentration of nitrate more than 100ma/L occurs in the northern part of the district. The fluoride concentration in Jaipur district is below 1.5mg/L in most part, and salinity 0-2000ps/cm range is available in more than 80% in Amber block (80%), Bairath block (84%) and Bassi block (100%). Water criticality that has been arrived at by all the three layers like salinity, fluoride and nitrate and the project area falls in the medium water criticality level.

73. Ground water samples were taken from a borehole in Chandpole about 600 meters from the proposed tunnel alignmenThe quality of the well water was compared with the National Standards of Drinking Water Quality (IS: 10500, 1992). 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 analyzed iron, copper, zinc, chromium, magnesium, cadmium, selenium, mercury and arsenic were not detected or were within stipulated limits. The results are given in Table 4.5.

- **pH:** All the samples of ground water meet the desirable limit (pH ranges from 6.5 to 8.5) as per IS: 10500.
- **Total Dissolved Solids:** Bore well at GWQ2 had minimum TDS value of 1,050 mg/l and maximum value of 1,897 mg/l was encountered at Sitapura Industrial Area (GWQ1). As per the IS-10500 standards, if alternate source of drinking water is not available; the limit of TDS for potable water is relaxed up to 2,000 mg/l. Thus, the water samples of all the monitoring stations including GWQ 8 (Chandpole that is on the JMR Phase I B project alignment) conform to the specification.
- **Chlorides:** The chloride concentration in groundwater at all the monitoring stations were more than the prescribed limit of 200 mg/l, Saras Dairy (GWQ 2) showing the highest value of 969.9 mg/l.
- **Sulphate:** Sulphate content in the ground water sample ground water ranges from 20 mg /l (GWQ1) to 28 mg/l (GWQ5).

[8] http://cgwb.gov.in/gw_profiles/st_Rajasthan.htm
[9] Master Development Plan 2025

- **Fluoride:** Fluoride contents in the ground water sample were below the detectable limit of 1.23 mg/l.
- **Other Parameters:** Iron was found to be more than the permissible limt at 3 out of the 10 monitoring stations. It was found to be more than the permissible limit at Chandpole (GWQ 8) on the JMR Phase I B alignment.

74. The analysis results are indicative of high TDS due to presence of higher level calcium and chlorides in the water. However, most of the parameters analyzed suggest that water may be used for potable purpose if there is no alternative source of water available as per BIS standard for drinking water (IS 10500: 1991). The pH range of the samples varies from neutral to alkaline. The values of the parameters appear to be within the prescribed limits and may be utilized as potable water source after conventional treatment.

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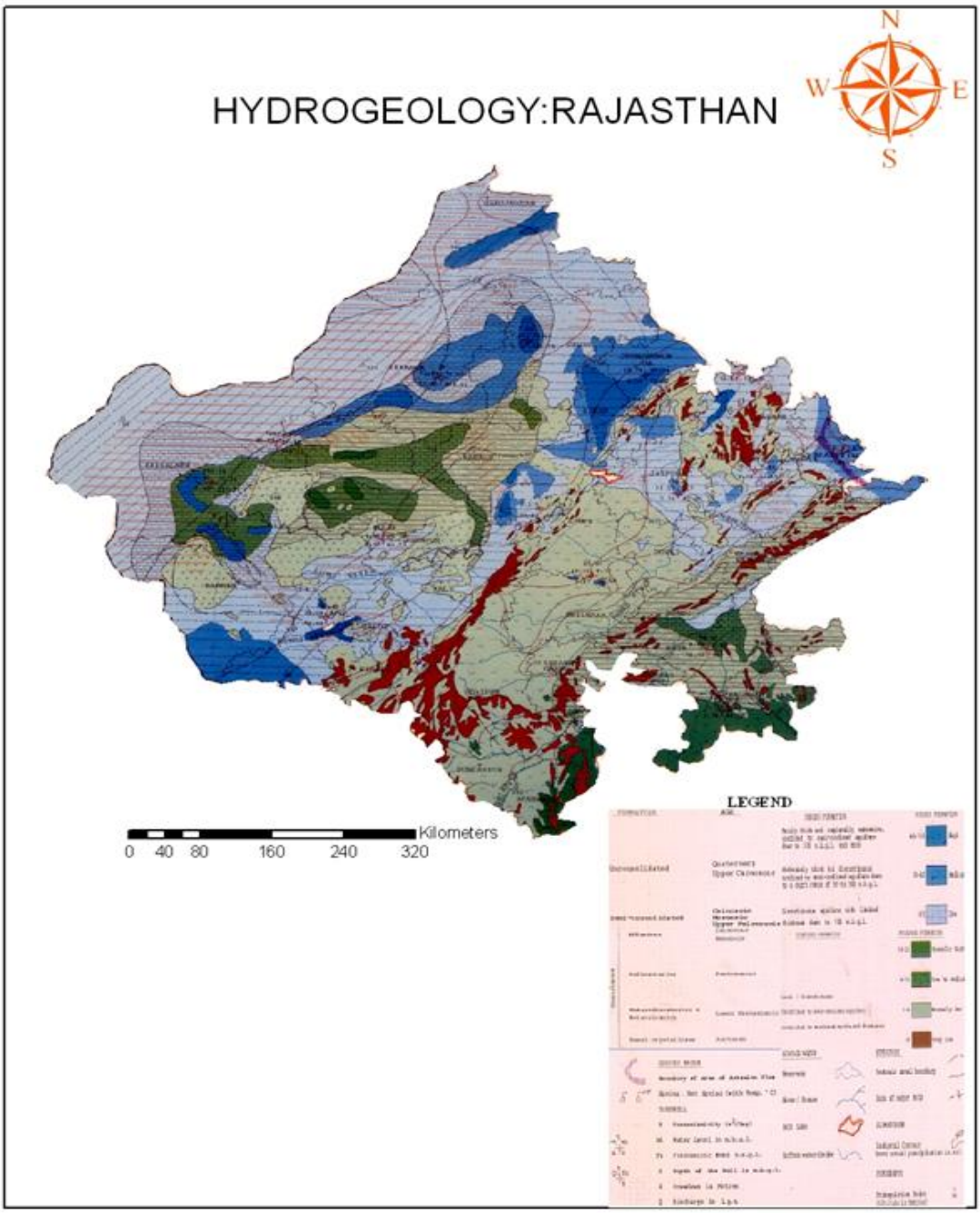


Figure 9: Hydrogeology Map of Rajasthan

Table 10: Physico-chemical Quality of Surface Water

S. No.	Parameters	Unit	Amanishah Nala	Ambabadi ka Nala	Jal Mahal Talab	Desirable limit
1	Colour	Hazen	C/L	C/L	C/L	50
2	Odour	-	U/O	U/O	U/O	U/O
3	Turbidity	NTU	18	20	12	25
4	pH	--	7.7	7.8	7.2	6.5-8.5
5	Conductivity	uS/cm	720	680	460	1000
6	Total Dissolve Solids	mg/l	2152	2151	1320	1500
7	Alkalinity as $CaCO_3$	mg/l	385	390	315	600
8	Total Hardness as $CaCo_3$	mg/l	471	482	501	600
9	Calcium as Ca	mg/l	142.0	148.0	124.0	200
10	Magnesium as Mg	mg/l	131.0	115.0	110.0	100
11	Sodium	mg/l	39.0	38.0	20.0	200
12	Potassium	mg/l	11.0	15.0	8.0	NA
13	Bicarbonate	mg/l	230	232	140	NA
14	Chloride as Cl	mg/l	952	1129	932	1000
15	Sulphate as SO_4	mg/l	666.0	625.0	726.0	400
16	Nitrate as NO_3	mg/l	4.0	3.6	3.80	45
17	Cadmium	mg/l	BDL	BDL	BDL	0.01
18	Chromium as Cr^{+6}	mg/l	BDL	BDL	BDL	0.05
19	Iron	mg/l	0.2	0.2	0.05	1.0
20	Copper	mg/l	BDL	0.004	BDL	1.5
21	Lead	mg/l	BDL	BDL	BDL	0.1
22	Manganese	mg/l	BDL	BDL	BDL	0.5
23	Mercury	mg/l	BDL	BDL	BDL	0.001
24	Zinc	mg/l	1.9	1.4	0.9	10.0
25	Dissolve Oxygen	mg/l	30.4	30.0	60.4	>5.0#
26	BOD(3)days at 27°C	mg/l	150.0	280.0	120.0	5.0#
27	COD	mg/l	42.0	45.0	40.0	10.0#
BDL- Below Detectable Level, C/L- Colourless, O/U-Unobjectionable						

Note: Indian Standard Drinking Water Specification-IS 10500:1991(Relaxed Standards for certain circumstances such as no alternate source being available)
Bureau of Indian Standards (BIS)
Source: DMRC Survey, 2009

Table 11: Physico-Chemical Quality of Groundwater in the Study Area

S. No.	Parameters	Chandpole Borehole	Desirable limit
1.	Colour,	< 5	5
2.	Odour	U/O	U/O
3.	Taste	Agreeable	
4.	Turbidity	<5	5
5.	pH	7.50	6.5-8.5
6.	Total Hardness as $CaCO_3$	270	300
7.	Total Iron as Fe	0.5	0.3
8.	Chloride as Cl	899.3	250
9.	Residual Free Chlorine	Nil	-
10	Total Dissolved Solids	1,050	500
11	Calcium as Ca	56.00	75
12	Magnesium as Mg	31.85	30
13	Copper as Cu	<0.05	0.05

S. No.	Parameters	Chandpole Borehole	Desirable limit
14	Manganese as Mn	<0.10	0.1
15	Sulphate as SO_4	26.09	200
16	Nitrate as NO_3	6.25	45
17	Fluoride as F	0.92	1
18	Phenolic Comp. as C_6H_5OH	BDL	0.001
19	Selenium as Se	BDL	0.05
20	Arsenic as As	BDL	0.05
21	Zinc as Zn	BDL	5.0
22	Chromium as Cr^{+6}	BDL	0.05
23	Total Alkalinity as $CaCO_3$	450.0	200
24.	Aluminum as Al	BDL	0.03
25.	Boron as B	BDL	0.1

Note: BDL: Below Detectable Level, C/L; Colourless, U/O: odourless

c. Climate

i. Temperature

75. The only meteorological observatory in the district is at Sanganer Airport at Jaipur city. The period from March to June is one of continuous rise in temperature, May and the first half of June being the hottest part of the year. The mean daily maximum temperature in May is 40.60C and the mean daily minimum is 25.80C. The night temperature in June is a little higher than in May. In May and June the maximum temperature some-times reaches 470C. The setting in of the southwest monsoon after the middle of June lowers the temperature but the relief from the heat is not marked because of the added discomfort from the increase in humidity brought in by the southwest monsoon air. After the withdrawal of the monsoon by mid-September, days become hotter and in October a secondary maximum in day temperature is reached. The nights become progressively cooler. After mid-November both day and night temperatures drop rapidly till January which is the coldest month with the mean daily maximum temperature at 22.00C and the mean daily minimum at 8.3^0C. Table 12 presents the average maximum and minimum temperatures, precipitation and wet days.

Table 12: Jaipur - Temperature & Rainfall

Month	Average Minimum Temperatures (in ^{0}C)	Average Maximum Temperature (in ^{0}C)	Average Rainfall/ Precipitation (mm)	Rain Days
January	7.8	22.5	7.9	0.6
February	10.7	25.7	11.7	0.9
March	15.8	31.5	6.1	0.7
April	21.4	37.0	4.1	0.5
May	25.4	40.3	16.2	1.1
June	27.2	39.3	66.0	3.6
July	25.5	33.9	216.3	10.8
August	24.3	32.0	231.2	11.6
Sept.	22.9	33.2	80.3	5.1
October	18.6	33.4	22.6	1.2
November	13.1	29.0	3.2	0.3
December	9.1	24.4	3.3	0.4

76. The Ombrothermic graph below indicates that the climate of the project area would be classified as continental climate since the rainfall is mostly restricted to two months i.e. July and August. A prolonged dry period prevails during January to June and again October to December.

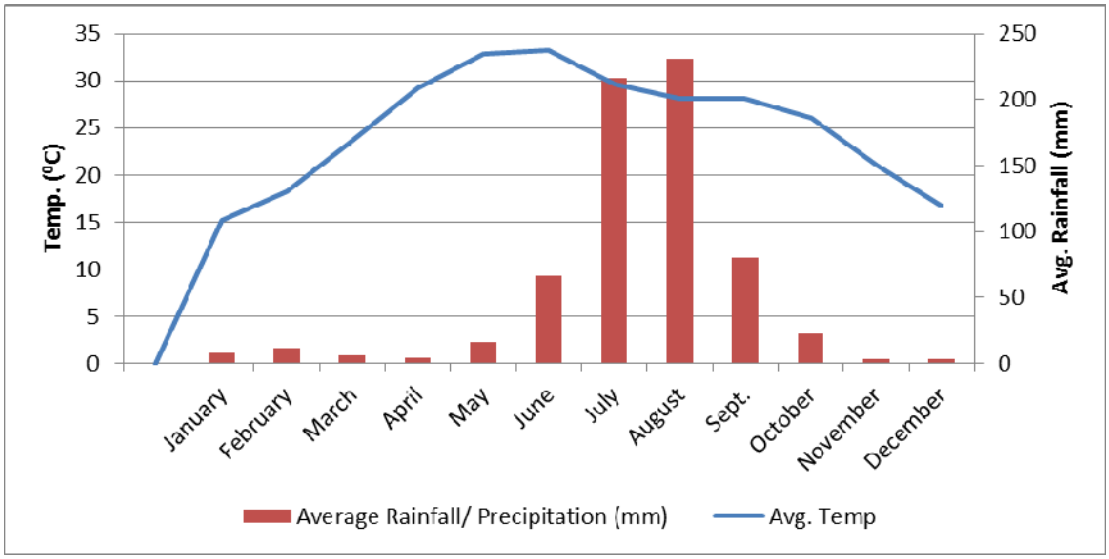


Figure 10: Ombrothermic Graph

ii. Humidity

77. During the brief southwest monsoon period the relative humidity are generally over 60%. Rest of the year the air is dry. In the summer season, afternoon humidity may be as low as 15-20%. The average humidity in 2009 was 47%.

Table 13: Average Monthly Relative Humidity

Months	Relative humidity (%)	
	Avg. at 08.30 Hrs.	Avg. at 17.30 Hrs.
January	52	58
February	32	24
March	17	73
April	20	9
May	19	23
June	21	22
July	64	120
August	44	70
September	78	33
October	30	33
November	24	36
December	49	56
Average	**37.3**	**46.1**

Source: IMD station, Jaipur (2010)

iii. Cloudiness

78. During the southwest monsoon skies are moderately to heavily clouded and overcast on some days. In the rest of the year, clear or lightly clouded skies prevail. On few days in

the winter season skies become cloudy when the district is affected by passing western disturbances.

iv. Winds

79. Winds are generally light to moderate, but in summer and the early southwest monsoon season winds may strengthen for some days. Westerly to south westerly winds prevail in the southwest monsoon season. In the post monsoon and winter months winds are mostly from west and north directions. In the summer season, winds blow from southwest and northwest. Wind speed is generally light during the post monsoon and winter months. The wind speed increases during the summer and monsoons. Except the monsoon months of July, August, and September the dominant wind direction is from the west and northwest directions. During the monsoon months, the wind blows from the east and southeast. Calms are reported at an annual average of 9%

80. During the southwest monsoon season the district is sometimes affected by depressions which originate in the Bay of Bengal and move across the central parts of the country, causing widespread heavy rainfall. Thunderstorms occur practically in all the months of the year, but they are more frequent during the period May to September. Along with thunderstorms, hail may also occur occasionally. In the hot season dust storms also occur.

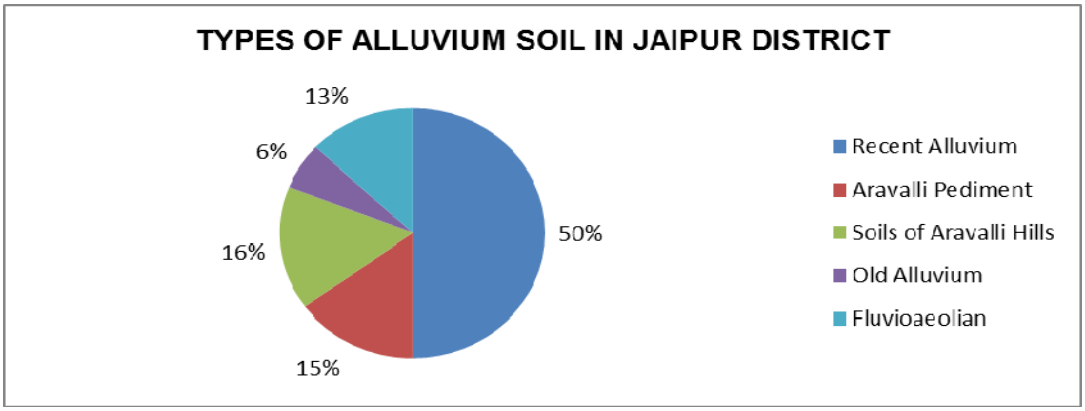
Table 14: Wind Profile of the Study Area

Months	Wind Speed (km/hr)	Predominant Direction	Months	Wind Speed (km/hr)	Predominant Direction
January	0.0	Calm	July	17.6	East
February	11.1	NE	August	11.1	WNW
March	15.7	East	September	10.2	North
April	10.2	NNW	October	9.25	SW
May	11.1	WNW	November	0.95	Variable
June	9.3	WNW	December	6.5	East

Source: IMD Sanganer, Jaipur

4. Soil Characteristics

81. The soil types found in the district are: i) Recent alluvium, ii) Aravalli pediment, iii) Soils of Aravalli hills, iv) Old alluvium and iv) Fluvioaeolian. Distribution of various soils in the district by types of alluvium is presented in the succeeding Figure 10.



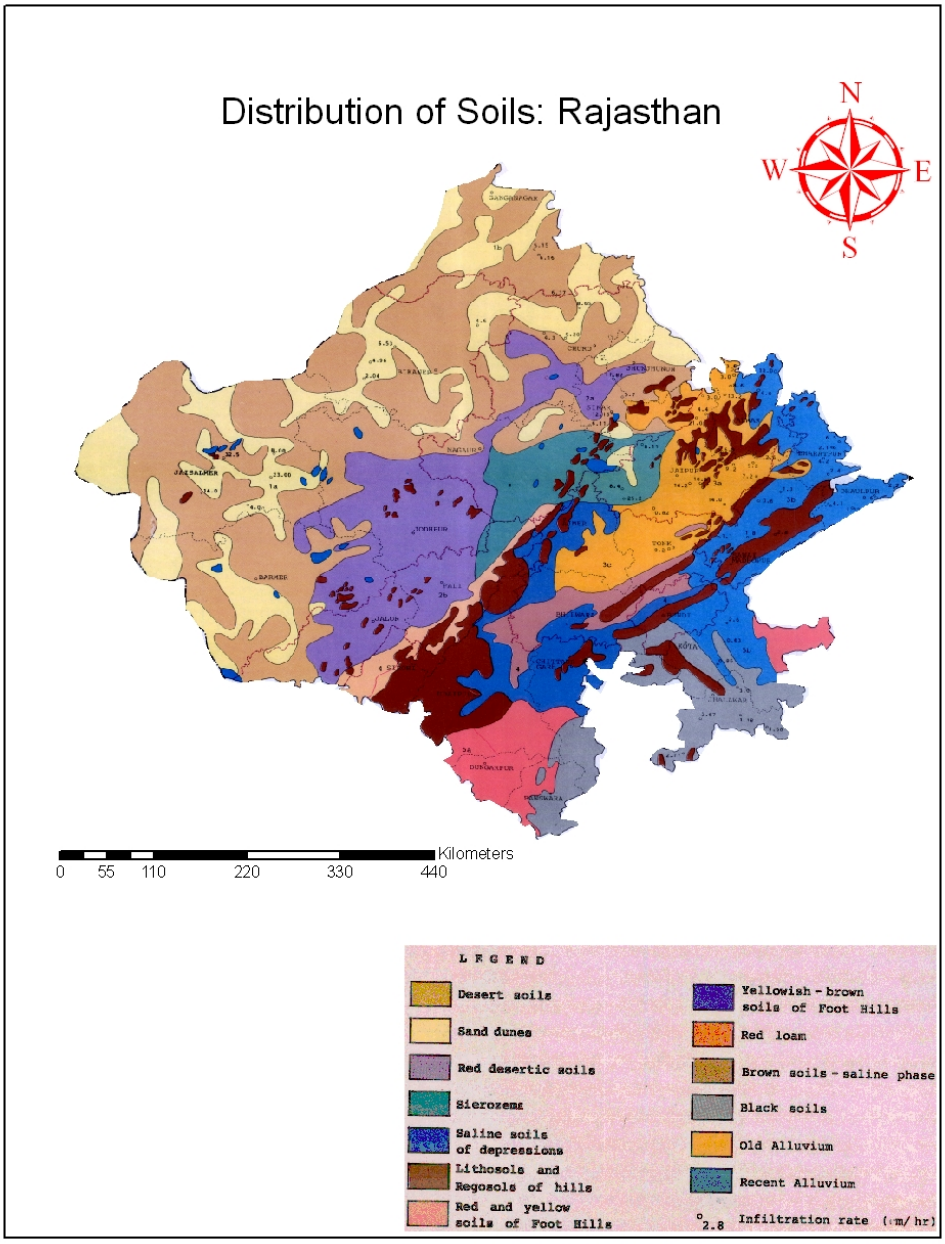
Source: Outline Development Plan, Jaipur, JDA

Figure 11: Distribution by Type of Alluvium Soil

82. The above mentioned soils are scattered in the region but major share is of alluvial soil followed by clayey and sandy soil which is found basically on the top of the hills and rocky outcropped areas and these areas are mostly in the forest boundary. Jaipur soil is yellowish brown and non-calicle brown. Red and yellow soil is poorer in carbonate and humus content; calcium carbonate is absent and salt content is low. Alluvial soils of Jaipur are deficient in lime, phosphoric acid and humus. The soil is poor in humus with organic carbon content less than 0.2 % and water retaining capacity is very poor. Figure 12 presents soil types of Rajasthan.

83. The study area has soils of recent alluvial plains which are characterized by deep moderate to well drained, calcareous, fine-loamy soil on gentle slopes with loamy sand surface. These soils are also characterized by slight erosion and slight salinity. The colour of the soil in this region is brown to pale brown (sandy loam) to brown and yellowish brown. The proposed metro corridors mostly run through commercial area and a few patches have residential areas. Hence there is very little exposed soil along the route. However, soil samples were collected and analyzed and the results are presented in Table **15**15. Soil samples were collected from 10 different locations in project influence area. Soil samples were collected during December 2009. A number of parameters were determined which are indicative of physical, chemical and fertility characteristics.

84. From the analysis, the soils collected are primarily dry and silt loamy in texture, have moderate conductivity ranging from 369 µs to 476 µs/cm, and alkaline pH with values ranging from 6.92 to 8.11. The soils also had low nutrient content and low moisture, hence are not suitable for prime agriculture purpose.



Source: Kumar, D. M. (undated)

Figure 12: Distribution of Soils in Rajasthan

Table 15: Soil Sampling Station

S. No.	Location	Soil texture	Sand (%)	Silt (%)	Clay (%)
1	Ramganj Choupar	sandy	68	21	11
2	Chand pole	Sandy	68	19	13
3	Vesta Hotel, Nr. Railway station, Jaipur junction	Sandy Loam	59	25	16
4	Kapil Gyan peeth, Mansarover Jaipur	Sandy Loam	68	21	11

Table 16: Physico-Chemical Quality of Soil Samples

Parameter	Unit	S1	S2	S3	S4
Color	-	Yellow	Yellow	Yellow Cream	Yellow Cream
pH (1:2, W/V)		8.11	8.06	7.95	6.93
Conductivity	(µS/cm)	366	455	476	375
Cation Exchange capacity	(Meq/100Gm)	8.8	9.6	7.7	8..3
Moisture	%	4.54	3.55	5.26	5.27
Chlorides as Cl	%	0.027	0.023	0.034	0.035
Sulphate as SO_4	%	0.016	0.015	0.017	0.015
Total Carbonates	%	0.38	0.40	0.22	0.22
Total Organic Matter	%	0.38	0.40	0.21	0.21
Nitrogen as N	%	0.027	0.025	0.026	0.025
Phosphorus as P	%	BDL	BDL	BDL	BDL
Potassium as K	%	0.247	0.236	0.245	0.244
Total Soluble solids	%	0.17	0.18	0.26	0.25
Zinc	Mg / Kg.	BDL	BDL	BDL	BDL
Copper	Mg / Kg.	BDL	BDL	BDL	BDL
Chromium	Mg / Kg.	BDL	BDL	BDL	BDL
Cadmium	Mg / Kg.	BDL	BDL	BDL	BDL
Nickel	Mg/Kg.	BDL	BDL	BDL	BDL
Lead	Mg/Kg	BDL	BDL	BDL	BDL

5. Ambient Air Quality

85. DMRC consultants carried out ambient air quality monitoring for the parameters SPM, RSPM, and SO2 by setting up ambient air quality monitoring stations at 10 locations. The ambient air quality stations were selected taking into view traffic flow and metro terminals. Sampling was done on Dec 2009 along the proposed alignment. The locations are given in Table **17** 17. Location no. 8 Chandpole falls on the proposed JMR Phase IB alignment. Results of the monitoring is shown in Table 19.

Table 17: Details of Ambient Air Quality Monitoring Locations

Sr. No.	Name of Location/village	Corridor	Distance w.r.t. alignment
1	Near Sitapura Industrial Area	Corridor-I	150 m
2	Near Durgapura Bus Stand	Corridor-I	150 m
3	Hanuman Temple, Narayan Singh Circle	Corridor-I	150 m
4	Rajasthali, Ajmeri gate	Corridor-I	500 m
5	Banipark behind bus stand	Corridor-I	250 m
6	Desert Inn Ambabadi	Corridor-I	400 m
7	Ramganj Choupar	Corridor-II	500 m
8	Chand pole	Corridor-II	600 m
9	Hotel Vesta near Jaipur Jn. Rly. Stn.	Corridor-II	50 m
10	Kapil Gyan peeth, Mansarover Jaipur	Corridor-II	500 m

Table 18: Results of Air Quality Monitoring

National Ambient Air Quality Standards (Concentration in µg/mg^3) 24 hours**	98 Percentile Values (µg/mg^3)		
	SPM	RSPM	SO_2
Industrial Area	500	150	120
Residential, Rural & Other Areas	200	100	80
Sensitive Areas	100	75	30

Ambient Air Quality Station Name	SPM	RSPM	SO_2
Near Sitapura Industrial Area	187.5	55.8	7.4
Near Durgapura Bus Stand	175.5	87.3	8.1
Hanuman Temple , Narayan Singh Circle	185.3	72.5	8.5
Rajasthali Ajmeri gate	188.7	72.3	8.8
Banipark behind bus stand	164.2	56.9	7.5
Desert Inn Ambabadi	159.1	55.3	7.6
Ramganj Choupar	182.9	68.4	7.5
Chand pole	187.8	77.8	8.5
Ram Mandir, Nr. Railway station, Jaipur junction	175.3	71.3	8.3
Kapil Gyan peeth, Mansarover Jaipur	156.3	64.3	7.4

Notes: 1) Unit – $\mu g/mg^3$

(2) 24 hourly/ 8 hourly values should be met 98% of the time of the year. However 2% of the time it may exceed but not on two consecutive days

Source: DPR (2011)

86. Rajasthan State Pollution Control Board (RSPCB) also monitors air quality over the years at some prominent locations in Jaipur City especially around the Diwali festival. The ambient air quality before the festival has been recorded at 6 stations including Chandpole that is a location on the proposed JMR Phase IB alignment. The results are presented in Table 19.

87. The following inferences can be drawn from the air quality monitoring of the city of Jaipur along the corridor route:

- SPM, RSPM, SO_2, and NO_x sampling results meet the industrial, and residential, rural and other areas standards as prescribed by the GoI.
- Levels of SPM are on the higher side for the sensitive areas; Ajmeri gate being the highest. This is because of the high traffic volume in the area. In other locations also the SPM levels were high mostly because of the high traffic volume. Chand Pole is the busy area where one can see mixed residential and commercial land use.
- Levels of RSPM are also slightly high in Chandpole area due to the heavy traffic and resulting dust, however, the level is within the permissible limit.
- Levels of SO_2 are well within the prescribed limits of NAAQS at all locations.
- Levels of NO_X are also within prescribed limit at some receptors.

6. Noise Quality

88. In terms of traffic Jaipur is no better than any other metro city. It was observed that three wheelers, trucks and motor cycles remain the chief source of noise pollution on Jaipur roads and closely followed by generators in residential and commercial areas.

Table 19: Results of Air Quality Monitoring by RSPCB (in µg/m3)

Location Type of Locality	Year																			
	2008				2009				2010				2011				2012			
	SO_2	NO_x	RSPM	SPM	SO_2	NO_x	RSPM	SPM	SO_2	NO_x	RSPM	SPM	SO_2	NO_x	RSPM	SPM	SO_2	NO_x	RSPM	SPM
Standard	80	80	100	200	80	80	100	-	80	80	100	-	80	80	100	-	80	80	100	-
Jhalna Residential	5.1	24.8	113	230	5.1	21.3	74	162	5.2	28.0	122	217	6.6	36.2	102	209	7.7	47.0	137	235
Regional Office Jaipur Residential	5.7	35.9	110	233	7	43.7	188	382	6.7	38	374	592	12	60.9	253	485	12	64.5	371	890
Ajmeri Gate Residential	6.5	43.2	147	330	7.2	45.5	69	190	7.3	46.4	255	580	8.1	51.7	145	469	8.5	55.3	234	659
Chandpole Residential	7.1	41.4	120	361	7.1	47.1	281	490	7.8	54.2	272	700	8.4	57.6	148	373	11	58.2	180	470
Vishwakarma Indl. Area Industrial	7.2	44.9	293	529	7	43.7	155	371	7	51	447	826	8.7	47	288	693	10	59.6	315	699
Malviya Indl Area Industrial	5.9	37	95	219	5.6	28.6	72	159	5.9	36.4	115	224	6.9	41.4	136	220	8	46.7	127	254

Source: Rajasthan State Pollution Control Board Website (rpcb.nic.in)

89. Rajasthan State Pollution Control Board has undertaken noise level monitoring at five commercial areas viz. Choti Chopad, Badi Chopad, Tonk Road, Ajmeri Gate and Raja Park; five residential areas viz. Railway Station, Civil Lines, Gandhi Nagar, Mansarovar and Jawahar Nagar and three silence zones viz. Near High Court, SMS hospital, and SDM hospital in October 2011 and November 2012. The Residential, Commercial, and Silence zones were monitored during day and night in light of the Ambient Air Quality Standards in respect of Noise prescribed under the provisions of Noise Pollution (Regulation and Control) Rules, 2000. The noise monitoring was conducted from 11.11.2012 to 14.11.2012. The noise level was monitored from 3.00 PM – 10.00 PM and 10.00 PM – 03.00 AM and at mid night. Measurements were taken for time weighted average of 30 minutes. The comparison of the results of monitoring conducted during the study period in all the areas has been depicted in Table 20 in terms of Leq dB(A). The noise level at all three silence zones was observed in the range of 55.8 Leq dB(A) – 64.8 Leq dB(A) in day time and in night time the range was observed 49.7 Leq dB(A) – 62.5 Leq dB(A). The noise level at all five commercial areas was observed in the range of 67.1 Leq dB(A) – 79.5 Leq dB(A) in day time and in night time the range was observed 62.7 Leq dB(A) – 75.4 Leq dB(A). The noise level at all five residential areas was observed in the range of 59.7 Leq dB(A) – 79.1 Leq dB(A) in day time and in night time the range was observed 56.3 Leq dB(A) – 71.8 Leq dB(A).

Table 20: Noise Level Ranges at Different Use Zones in Jaipur (in dB (A))

S No.	Location and Use Zone	Time	Date of Survey			
			24.10.11	25.10.11	11-11-2012	12-11-2012
1	Choti Chopad (Commercial)	Day	76.7	82.1	77.2	78.1
		Night	72	80.8	74.4	74.8
2	Badi Chopad (Commercial)	Day	77.9	79.9	75.7	79.5
		Night	76.9	77.7	73.6	75.4
3	Tonk Phatak Commercial	Day	76.2	71	76.1	76.5
		Night	70.6	75.6	73.2	72.7
4	Ajmeri Gate Commercial	Day	67.5	72.5	67.1	66.2
		Night	68.3	77.5	62.7	65.4
5	Raja Park Commercial	Day	82.1	80.3	72.8	73.3
		Night	73.9	74.8	71.9	72.4
6	Near High Court Silence	Day	67.6	66.4	59.5	59.4
		Night	63.2	66	49.7	59.6
7	SMS Hospital Silence	Day	60.8	67.4	55.8	58.5
		Night	73.8	74.9	56.4	57.3
8	SDM Hospital Silence	Day	68.1	64.6	63	64.8
		Night	67.5	66.8	59.7	62.5
9	Railway Station Residential	Day	70.5	71.2	71.7	71.8
		Night	68.9	66.8	70.6	71.8
10	Civil Lines Residential	Day	69.8	68.5	65.9	65.9
		Night	67.8	65.6	58.7	67.4
11	Gandhi Nagar Residential	Day	68.5	67.6	70.7	67.7
		Night	59.9	73.7	61.7	69.3
12	Mansarovar Residential	Day	67.7	75.1	59.7	63.3
		Night	64.7	69.5	56.3	56.8
13	Jawahar Nagar Residential	Day	70.3	71.6	67.2	79.1
		Night	62.3	67.4	65.2	68.8

Source: Rajasthan Pollution Control Board website- rpcb.nic.in.

90. It was observed that 15 of the 46 residential locations surveyed have noise levels within the permissible range for 90% of the time in the day but on the other hand there is an extreme situation in few locations where the noise levels are above the permissible levels round the clock. Even silence zones like hospital areas are alarmingly noisy. Areas around important hospitals like SMS hospital have recorded sound levels above 70dB which is about 100 times that of levels permitted even in residential areas. Apart from this, the major traffic corridors of the city crosses even the critical 100db mark in peak hours. The rise in noise levels in the last two decades can be well accounted for by the unprecedented rise in the vehicular population in the city from about 0.1 million vehicles in 1971 to about 1.6 million in 2008.

91. To assess the noise levels in the study area, ambient noise monitoring was carried out by DMRC Consultants in the project area. The locations of the ambient noise monitoring stations were selected within 1 km on either side of the proposed metro alignment for measurement of present status of Ambient Noise Levels Noise Levels covering commercial and residential areas as well as the silence zones. Following consideration were taken in to account while selecting the monitoring stations:

- Obstruction free exposure of equipment
- Away from temporary noise generating sources to monitor true background levels
- Accessibility of the location during day and night
- Security and safety of the instrument

92. Ambient noise levels were measured at 10 locations along the project alignment at 2.0 m away from the source as per standard practice. The locations are shown in Figure and Figure 13. The noise level ranges are summarized in Table 20 & 21. Ambient noise level or sound pressure levels (SPL) were measured by a portable sound level meter having built in facilities to read noise level directly in dB(A). Since loudness of sound is important for its effects on people, the dependence of loudness upon frequency is taken into account by the A-weighting filters in-built in the noise meter which gives a direct reading of approximate loudness. A-weighted equivalent continuous sound pressure level (Leq) values were computed from the values of A-weighted SPL measured with the help of noise meter. Noise measurement was conducted as per IS: 4954 as adopted by CPCB.

93. From Table 20, it can be observed that the day noise level was highest at Chand Pole Gate, which falls on the JMR Phase IB alignment and is one of the busiest intersections of the city. Noise levels during day time as well as night time are exceeding the prescribed standards of CPCB (65 dB(A) and 55 dB(A) for day and night time respectively.

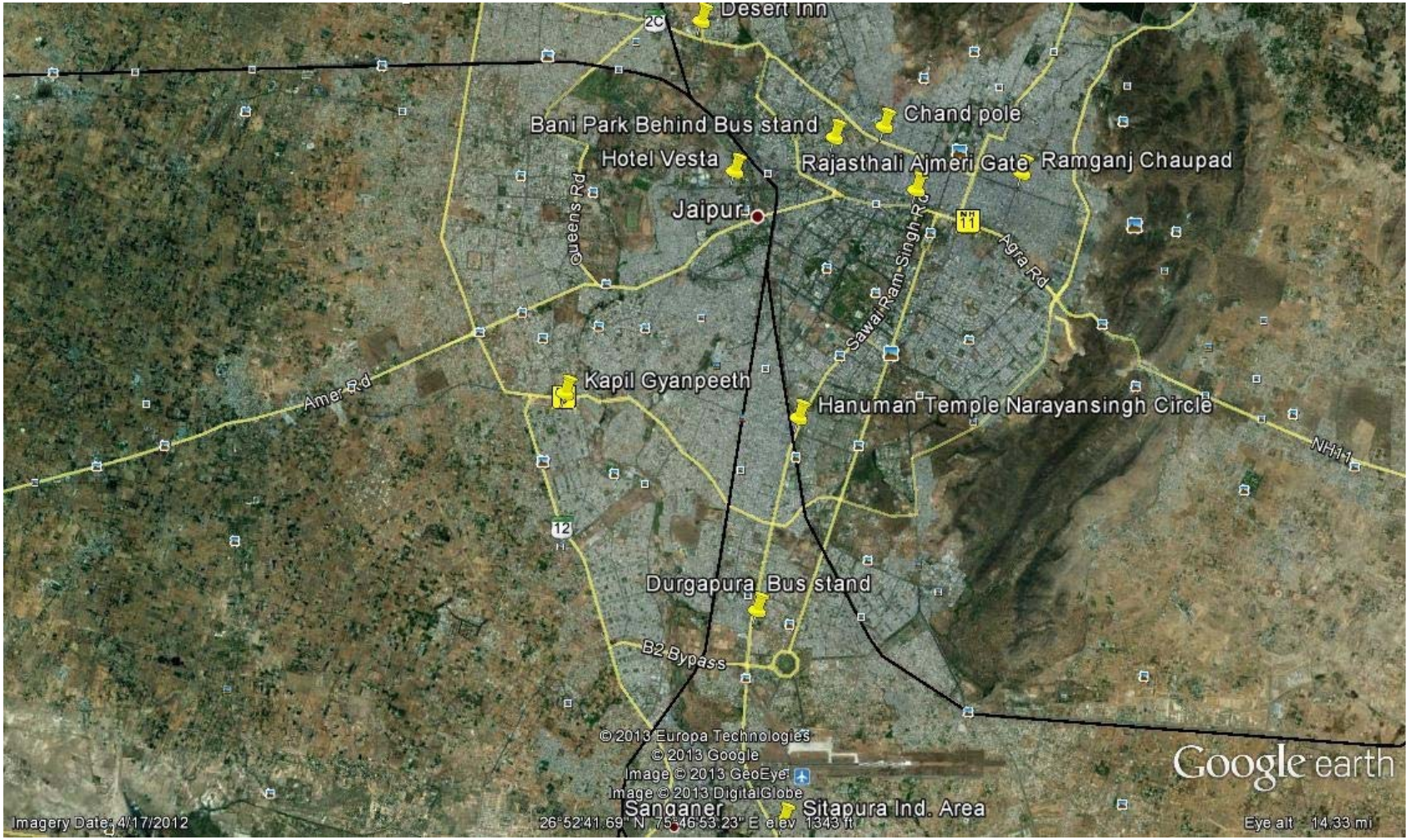


Figure 13: Ambient Air Quality Monitoring Locations

Table 21: Noise Level Ranges at Different Locations

Noise Level \ Location		Navyoug Auto parts , Pratap Nagar	Vipul Motors, Gopalpura	Indralok Garden, Narayan Singh Circle	Ramnivas Garden Ajmeri gate	Banipark behind bus stand	Desert Inn Ambabadi	Ramganj Choupar	Chand Pole Gate	Ram Mandir, near , Jaipur Jn. Rly. Stn	Kapil Gyan peeth, Mansarover
DAY	LMax	72	73	74	74	73	72	79	82	79	75
	LMin	62	63	63	64	62	63	67	68	66	67
	Leq	70.6	69.3	68.4	70	70.6	69.3	71.8	74.2	72.2	71.8
	L10	73	71.5	71	73.5	73	71.5	74.5	77	75	74.5
	L50	71	69	68	67.5	71	69	70.5	73	71	70.5
	L90	64	64.5	64	64.5	64	64.5	67	68.5	66.5	67
NIGHT	LMax	62	62	64	63	62	62	66	68	66	66
	LMin	57	58	59	60	57	58	57	64	62	57
	Leq	59.4	60.1	61.9	61.6	59.4	60.1	62.7	66	64	62.7
	L10	61.3	62	63.3	62.3	61.3	62	65.3	67.3	65.3	65.3
	L50	58.5	59.5	61.5	62	58.5	59.5	62	65	63	62
	L90	57	58	59.7	60	57	58	57	64.7	62.7	57

Source: - Field data collection by E.C. Engineers, Jaipur, 2009. Chandpole gate falls on the JMR Phase IB alignment.
Note: L10, L50 and L90 are the sound level, which is exceeded 10%, 50% & 90% of the total time

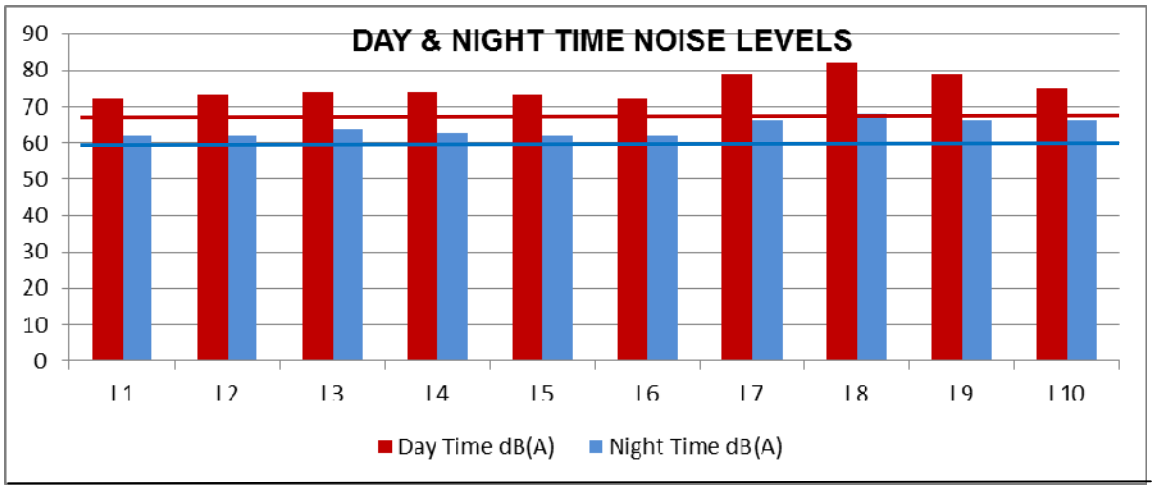


Figure 14: Noise Monitoring Results for 10 Stations in the Project Area, in dB(A)

C. Ecological Resources

1. Forest

94. There is no forest land along the project alignment. Jhalana Reserve Forest, falls outside 10km radius from the project alignment.

2. Trees along the Project Alignment

95. An inventory survey of the trees falling within 20m band of the metro corridor was carried out by DMRC consultants. Although, no tree was present within this band, for Phase I B corridor from Chandpole to Badi Choupar 25 trees were counted to be present along the entire corridor from Mansarovar to Badi Choupar as presented in Table 4.18. The main species are Githithi, Babul, Seshum, Neem, Peepal, Keekar, Pilkhan, Kakri, Chokar, Laspasia, Sahtut, Bargad, Gulmohar, Baikan etc.

Table 22: Ecological Parameters in 20m band of Metro Rail (Phase I)

Sub-Section	Description of Sub-Section	Length in km	No. of Trees	Remarks
ST-1	Proposed Badi Choupar Stn.	0.5	0	The metro corridor does not pass through any forest land.
S-1	Badi Choupar To Choti Choupar	0.853	0	
ST-2	Proposed Choti Choupar Stn.	0.2	0	
S-2	Choti Choupar to Chand Pole	1.221	0	
ST-3	Proposed Chand pole Stn.	0.2	0	
S-3	Chand pole to Sindhi Camp	0.786	0	
ST-4	Proposed Sindhi Camp Stn.	0.2	5	
S-4	Sindhi Camp to Railway Station	1.338	0	
ST-5	Proposed Railway Station Stn.	0.2	5	
S-5	Railway Station to Civil Line	1.583	0	
ST-6	Proposed Civil Line Stn.	0.2	2	
S-6	Civil Line to Ram Nagar	1.086	0	
ST-7	Proposed Ram Nagar Stn.	0.2	2	
S-7	Ram Nagar to Shyam Nagar	0.747	0	
ST-8	Proposed Shyam Nagar Stn.	0.2	6	
S-8	Shyam Nagar to Vivek Vihar	0.881	0	
ST-9	Proposed Vivek Vihar Stn.	0.2	2	
S-9	Vivek Vihar to New Atish Market	1.105	0	
ST-10	Proposed New Atish Market Stn.	0.2	1	
S-10	New Atish Market to Mansarover	1.105	2	
ST-11	Proposed Mansarover Stn.	0.2	0	
Total			**25**	

D. Economic Development, Social and Cultural Resources

1. Demographic Details

96. As per 2011 Census, the state has a population of 68.62 million and with a decadal population growth of 21.44% is the 8th fastest growing state in the country. With about 25% of the population living in urban areas, it is the 10th lowest urbanized state in the country. Jaipur district with a population of 6.66 million contained 9.71% of the population of the entire state. The district with an urban population of 3.5 million alone comprised 20.49% of the total urban population of the state. Within the district, 52.51% population was living in urban areas.

Table 23: Historical Population and Decadal Growth Rate of Jaipur City and District

Year					
	Population	Decadal Growth Rate (%)		Population	Decadal Growth Rate (%)
1991	14,58,483	-		3,887,895	-
2001	23,22,575	59.25		5,251,071	35.06
2011	3,073,350	32.33		6,663,971	26.91

Source: Census of India, 2011

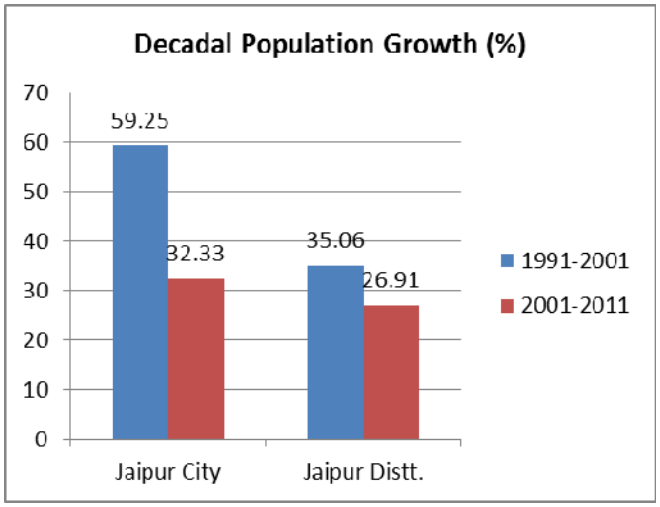


Figure 15: Decadal Population Growth Rate

97. In terms of population, Jaipur City is the 10th largest metropolitan city of India. The city has been growing at a higher rate compared to the population growth in the district. The development area of the city as per Jaipur Master Plan 2025 extends over 600 sq. km. Table below provides a comparative picture of the demographic profile of the district and the state as per Census 2011.

Table 24: Demographic Profile of Rajasthan and Jaipur District

Attributes	Jaipur District			Rajasthan State		
	Total	Rural	Urban	Total	Rural	Urban
Actual Population	66,63,971	31,64,767	34,99,204	6,86,21,012	5,15,40,236	1,70,80,776
Male	34,90,787	16,48,975	18,41,812	3,56,20,086	2,66,80,882	89,39,204
Female	31,73,184	15,15,792	16,57,392	3,30,00,926	2,48,59,354	81,41,572
Population Growth	26.91%	47.49%	52.51%	21.44%	19.05%	29.26%
Area Sq. Km	11,146			3,42,239		
Population Density/km^2	598			201		
Proportion to Rajasthan /India Population	9.71%			5.67%		
Sex Ratio (Per 1000)	909	919	900	926	932	911
Child Sex Ratio (0-6 Age)	859	865	852	883	886	869
Literates	43,95,012	18,40,416	25,54,59	3,89,70,50	3,21,30,18	1,37,89,31

			6	0	3	0
Male Literates	26,17,028	11,65,918	14,51,110	2,41,84,782	2,06,75,015	79,70,194
Female Literates	17,77,984	6,74,498	11,03,486	1,47,85,718	1,14,97,451	58,23,666
Average Literacy	76.44%	68.43%	83.48%	67.06%	62.34%	80.73%
Male Literacy	87.27	83.63%	90.43%	80.51%	77.49%	89.16%
Female Literacy	64.63	52.07%	75.82%	52.66%	46.25%	71.53%
Total Child Population (0-6 Age)	9,14,327	4,75,330	4,38,997	1,05,04,916	83,19,914	21,85,002
Male Population (0-6 Age)	4,91,960	2,54,904	2,37,056	55,80,212		
Female Population (0-6 Age)	4,22,367	2,20,426	2,01,941	49,24,704		
Child Proportion (0-6 Age)	13.72%	15.02%	12.55%	15.31%	16.14%	12.79%
Male Proportion (0-6 Age)	14.09%	15.46%	12.87%	15.67%		
Female Proportion (0-6 Age)	13.31%	14.54%	12.18%	14.92%		

Source: Census of India, 2011

98. Comparison of some other key demographic characteristics show that Rajasthan has a higher proportion of Scheduled Caste (SC) and Scheduled Tribe (ST) population compared to the all India average figures. The average household size in the city, the district and the state are also higher than the all India average.

Table 25: Selected Key Demographic Features

Attributes	Jaipur City	Jaipur District	Rajasthan State	India
Average Household Size	7	6.4	6.05	5.3
Proportion of SC (%)	14	15	17	16.2
Proportion of ST (%)	5	8	13	8.2

2. Educational Profile

99. The state of Rajasthan with an average literacy rate of 67.06%, which ranks 3rd lowest among all the states in India. The literacy rate in Jaipur district is higher in terms of both male and female population compared to the state scenario in urban as well as the rural areas. Proportion of female population who have had no education is significantly high in Rajasthan compared to the national average. Male population who have had no education is almost half of the female uneducated. A large proportion of female who have not attended school where at least half of females' aged six years or more have no education.

Table 26: Educational Attainment of Population (in %)

Level of Education	Rajasthan		India	
	Female Household Population	Male Household Population	Female Household Population	Male Household Population
No education	56.2	25.2	41.5	21.9
<5 years complete	17.1	21.7	18.1	20.9
5-7 years complete	13.0	20.5	15.7	18.4
8-9 years complete	6.4	14.6	10.2	14.8
10-11 years complete	2.7	7.2	6.7	10.6
12 or more years complete	4.5	10.8	7.6	13.2
Don't know/missing	0.0	0.0	0..2	0.2
Total	100.00	100.00	100.00	100.00

Source: NFHS-3

3. Occupational Status

100. In terms of Work Participation Rate- WPR (percentage of workers to total population), Rajasthan shows a higher rate than the national average. Proportion of cultivators and marginal workers are higher in the state than the all India average reflecting a high degree of dependence on agriculture and related activities.

Table 27: Occupational Status

Attributes	Jaipur City	Jaipur District	Rajasthan State	India
Work Participation Rate (%)	28	35	42	39.1
% of Main Workers	26	30	31	30.4
% of Marginal Worker	2	5	11	8.7
% of non Workers	72	65	58	60.9
Proportion of Cultivators (%)	14	36	55	31.7
Proportion of Agrl. Labourers (%)	3	4	11	26.5
Proportion of workers in HH.Industry (%)	6	4	3	4.2
Proportion of Other workers (%)	77	55	31	37.6

Source: Census of India, 2011

101. The findings of National Family and Health Survey Data reveal that about 45% of women in Rajasthan have not been employed compared to a national average of 57%. Suceeding Table shows that the men are more likely to be employed than the women.

Table 28: Employment Status

Employed in the 12 months preceding the survey		Not Employed in the 12 months preceding the survey	Total	Employed in the 12 months preceding the survey		Not Employed in the 12 months preceding the survey	Missing	Total
Currently employed	Not Currently employed			Currently employed	Not Currently employed			
46.0	9.4	44.6	100.0	82.6	2.5	14.9	0.0	100.0
36.3	6.5	57.2	100.0	84.5	2.5	13.0	0.1	100.0

Source: NFHS-3

102. The percentage of children working is significantly highest in Rajasthan compared to the national average. The occurrence of children at work in rural areas is more than double of the national average.

Table 29: Children at Work

State/ Country	Work for someone who is not a member of the household[10]		Household chores for 28 or more hours per week	Other family work[11]	Total working[12]
	Urban	Rural			
Rajasthan	1.7	7.0	4.6	9.2	19.6
India	2.2	2.9	3.1	4.8	11.8

Source: NFHS-3, (2005-06)

4. Standard of Living

103. The percentage of households without electricity is higher in Rajasthan compared to the national average. The findings of National Family and Health Survey showed that Rajasthan is yet to provide improved source of drinking water to almost one-fifth of its population while the all India figure for the same is about 12%. Access to toilet is less than one-third of the population in the state. Fuel for cooking still continues to be solid fuel. Almost half the population in Rajasthan lives in pucca houses. The mean number of persons per room used for sleeping is slightly higher in the state compared to the average all India figure.

[10] Any work, paid or unpaid, for someone who is not a member of the household by children age 5-11 and for 14 or more hours by children age 12-14.

[11] Includes any work on the farm, in a business, or selling goods in the street by children age 5-11 and for 14 or more hours by children age 12-14

[12] Includes children age 5-11 years who, in the 7 days preceding the survey, worked for someone who is not a member of the household, with or without pay, or did household chores for 28 or more hours or engaged in any other family work and children age 12-14 years who in the 7 days preceding the survey, worked for someone who is not a member of the household, with or without pay, for 14 or more hours or did household chores for 28 or more hours or engaged in any otther family work for 14 or more hours.

Table 30: Housing Characteristics

With electricity	With improved source of drinking water	With toilet facility	Using solid fuel for cooking[13]	Living in a Pucca house
66.1	81.8	30.8	77.2	50.1
67.9	87.9	44.6	70.8	45.9

Source: NFHS-3 (2005-06)

5. Expenditure Pattern

104. The proportion of population having higher monthly per-capita household consumer expenditure is almost half compared to the national average. Rajasthan has more population in the lower bracket of per-capita consumer expenditure compared to the national figures.

Table 31: Distribution of Monthly per Capita Household Consumer Expenditure by Per 1000 household

Consumer expenditure range (Rs.)	Rajasthan		India	
	HHs	%age	HHs	%age
Less than 335	61	6.1	33	3.3
335 - 395	65	6.5	32	3.2
395 - 485	115	11.5	73	7.3
485 - 580	124	12.4	93	9.3
580 - 675	114	11.4	97	9.7
675 - 790	90	9	93	9.3
790 - 930	99	9.9	99	9.9
930 - 1100	80	8	97	9.7
1100 - 1380	110	11	113	11.3
1380 -1880	58	5.8	121	12.1
1880 - 2540	44	4.4	75	7.5
2540 & above	40	4	74	7.4
All classes	1000	100	1000	100

Source: NSS 61st Round

E. Infrastructure

105. Rapid industrialization of the area in the last couple of decades led to high population growth since independence and has led to a high population density. In a recent international survey Jaipur was ranked the 7th best place to visit in Asia and in another poll it was ranked third among twelve major Indian cities. Modern facilities are developing fast, and in many cases surpass those of larger cities like Delhi and Calcutta. The city is expanding very quickly and has become a hot spot for development in Rajasthan. Jaipur International Airport is located at a satellite location of Sanganer and offer flights to Delhi, Mumbai, Ahmedabad, Bangalore, Kolkata and Guwahati along with sporadic services to International locations such as Muscat, Sharjah, Dubai, and Bangkok. Since 2000 Jaipur has become a centre for education. The city is very peaceful and many north Indian families prefer to send their offspring to Jaipur for higher and technical education. Jaipur has more than 60 engineering colleges, 40 business management institutes, 15 pharmacy institutes, 4 hotel management institutes, 3 medical colleges and 6 dental colleges. It also has 8 universities including Rajasthan University. Malaviya National Institute of Technology, Jaipur is one of the best technical institutes in India.

[13] Includes coal/lignite, charcoal, wood, straw/shrubs/grass, agricultural crop waste, and dung cakes.

106. Jaipur has a well maintained road network with flyovers and traffic lights with closed circuit cameras. Police control room (PCR) vans are being equipped with GPS to monitor locations and help maintain law and order. Jaipur boasts of International Living standards with well-planned colonies of grid like patterns (sectors and blocks) and parks well maintained by JDA (Jaipur Development Authority). Two new colonies Anupam vihar and Abhinav vihar have been recently added to Jaipur by JDA. There are many shopping malls and Multiplex which offer a urban lifestyle to Jaipurites.

107. SMS Cricket stadium is also located here, which is a popular venue for many international matches and for Indian Premier League matches. Events like India Stonemart, Jaipur Jewellery Show and Jaipur Literature Festival are offering a common platform for people not only from India but from other countries also, giving Jaipur a cosmopolitan image. SMS Hospital, SDMH (Durlabhji Hospital) and Fortis Hospital are among the most famed hospitals of Jaipur. Apart from these, there are more than 40 small and midsized hospitals in the city. Old city of Jaipur is highly congested, whereas suburbs of Jaipur provide wide and free flowing roads. .

F. Economy

108. Forty-eight large and medium scale units, 19,544 small scale units are working in 19 industrial areas (Bagru, Bassi, Bais Godam, Bindyaka, Dudu, Hirawala, Jetpura, Jhotwara, Kaladera, Kanakpura, Kartarpura, Malviya Nagar, Phulera, Renwal, Sanganer, Shahpura, Sitapura, Sudarshanpur and Vishwakarma) developed by Rajasthan State Industrial Development & Investment Corporation (RIICO) Special Economic Zone (SEZ) built by Mahindra Group has already become operational. Jaipur district is a centre for both modern and traditional industries. The main industrial products include: acetylene gas, ACSR (aluminum conductor steel reinforced) cable, ball bearings, , durries, dyeing and printing, edible oil, engraving on brass items, ferrous and non-ferrous castings, gems and jewellery, general engineering and manufacturing, granite slabs and tiles, handicraft items, household electrical appliances, marble statues, marble tiles and slabs, perfumes, printed cloth and textiles, readymade garments, woollen and silk carpets.

109. Jaipur has been ranked 31 among the 50 emerging global outsourcing cities. Genpact and Infosys have their BPO already established and running successfully. In fact, Genpact has the fastest growing location in Jaipur. Real estate business is flourishing well for the last 2–3 years. Some of the companies already present here include JCB, MICO, Coca Cola, IBM, Ericsson, and NEI popularly known as NBC Bearings. Jaipur has regional office of Reserve Bank of India and many other prominent international banks. India's largest integrated IT SEZ Mahindra World City, planned by Jurong Consultant Singapore, covers nearly 3,000 acres (12 km2) and is located on Jaipur Ajmer National Highway at a distance of 15 km from Jaipur and has already attracted major companies like Infosys, TCS, Wipro, Tech Mahindra, Trueworth, and Deutsche Bank.

110. India's one of its kind World Trade Park is also under construction in Malviya Nagar. It will be having luxury hotel, business halls, five screen multiplex, underwater restaurant and many showrooms of international brands. In coming years it will be the hub for modern business development in Jaipur. An International standard Convention Centre, Golf course and film city on Jaipur Agra National highway are also being planned. Tourism is a significant part of Jaipur's economy. Some of the world's best hotels are located here.

G. Land Use

111. The DMRC consultants to record various types of land utilization and key environmental features carried out an inventory of built-up properties in a band of 20m width on either side of the metro line. The nature of land utilization in this zone has been studied

to understand the key environmental features in the influence area of the project. The built-up properties in the bandwidth of 20m from the metro corridor are 177 out of which 65 per cent are G+1. The development is sparse with low density in the start of the corridor. The density increases towards the end of the corridor. The increase in density leads to more congestion at the nodes and decrease in road width and increase in environment impacts.

Table 32: Built-up Properties in 20m band of Metro Rail (Phase I)

Sub-Section	Description of Sub-Section	Length in km	Type of Structures			
			Residential	Commercial	Mixed	Total
ST-1	Proposed Badi Choupar Stn.	0.5	From Badi Chpad to Sindi Camp track proceed underground			
S-1	Badi Choupar To Choti Choupar	0.853				
ST-2	Proposed Choti Choupar Stn.	0.2				
S-2	Choti Choupar to Chand Pole	1.221				
ST-3	Proposed Chand pole Stn.	0.2				
S-3	Chand pole to Sindhi Camp	0.786				
ST-4	Proposed Sindhi Camp Stn.	0.2				
S-4	Sindhi Camp to Railway Station	1.338	23	68	14	105
ST-5	Proposed Railway Station Stn.	0.2	0	5	0	5
S-5	Railway Station to Civil Line	1.583	9	10	11	30
ST-6	Proposed Civil Line Stn.	0.2	0	0	3	3
S-6	Civil Line to Ram Nagar	1.086	0	0	0	0
ST-7	Proposed Ram Nagar Stn.	0.2	0	0	0	0
S-7	Ram Nagar to Shyam Nagar	0.747	0	0	0	0
ST-8	Proposed Shyam Nagar Stn.	0.2	2	8	10	20
S-8	Shyam Nagar to Vivek Vihar	0.881	0	0	0	0
ST-9	Proposed Vivek Vihar Stn.	0.2	0	9	5	14
S-9	Vivek Vihar to New Atish Market	1.105	0	0	0	0
ST-10	Proposed New Atish Market Stn.	0.2	0	0	0	0
S-10	New Atish Market to Mansarover	1.105	0	0	0	0
ST-11	Proposed Mansarover Stn.	0.2	0	0	0	0
Total			**34**	**100**	**43**	**177**

Source: DMRC Survey

112. There are 15 public and semi-public properties within impact zone of proposed metro corridor. Table 33 below presents section wise details of number of public and semi-public uses in impact zone.

Table 33: Properties under Public and Semi-public use in 20m band (Metro - Phase I)

S. No.	Description of Sub-Section	Length in km	Properties with Public and Semi-Public Use					
			Parks & Play-ground	School	College	Hospital	Govt Office	Total
ST-1	Proposed Badi Choupar Stn.	0.2	0	0	0	0	0	0
S-1	Badi Choupar To Choti Choupar	0.875	0	1	0	0	0	1
ST-2	Proposed Choti Choupar Stn.	0.2	0	0	0	0	0	0
S-2	Choti Choupar to Chand Pole	0.807	0	0	1	0	0	1
ST-3	Proposed Chand pole Stn.	0.2	0	0	0	0	0	0
S-3	Chand pole to Sindhi Camp	1.027	0	0	0	1	1	2
ST-4	Proposed Sindhi Camp Stn.	0.2	0	0	0	0	1	1
S-4	Sindhi Camp to Railway Station	1.429	0	0	0	1	2	3
ST-5	Proposed Railway Station Stn.	0.2	0	0	0	0	0	0
S-5	Railway Station to Civil Line	1.34	1	0	0	0	0	1

S. No.	Description of Sub-Section	Length in km	Properties with Public and Semi-Public Use					
			Parks & Play-ground	School	College	Hospital	Govt Office	Total
ST-6	Proposed Civil Line Stn.	0.2	0	0	0	0	0	0
S-6	Civil Line to Ram Nagar	1.099	1	1	0	1	1	4
ST-7	Proposed Ram Nagar Stn.	0.2	0	0	0	0	0	0
S-7	Ram Nagar to Shyam Nagar	1.368	0	0	1	1	0	2
ST-8	Proposed Shyam Nagar Stn.	0.2	0	0	0	0	0	0
S-8	Shyam Nagar to Vivek Vihar	1.1	0	0	0	0	0	0
ST-9	Proposed Vivek Vihar Stn.	0.2	0	0	0	0	0	0
S-9	Vivek Vihar to New Atish Market	0.9	0	0	0	0	0	0
ST-10	Proposed New Atish Market Stn.	0.2	0	0	0	0	0	0
S-10	New Atish Market to Mansarover	1.1	0	0	0	0	0	0
ST-11	Proposed Mansarover Stn.	0.2	0	0	0	0	0	0
Total			**2**	**2**	**2**	**4**	**5**	**15**

Source: DMRC Survey

113. There are 38 religious properties along the corridor in 20m band, which includes temples etc. Table 34 below gives details of cultural properties within the 20m band.

Table 34: Inventory of Religious Properties along a 20-m band of the East-West Corridor

Sub-Section	Description of Sub-Section	Length in km	Cultural/Religious Properties				
			Temple	Shrine	Grave	Mosque	Church
ST-1	Proposed Badi Choupar Stn.	0.5	2	0	0	0	0
S-1	Badi Choupar To Choti Choupar	0.875	5	0	0	0	0
ST-2	Proposed Choti Choupar Stn.	0.2	5	0	0	0	0
S-2	Choti Choupar to Chand Pole	0.807	8	0	0	0	0
ST-3	Proposed Chand pole Stn.	0.2	1	0	0	0	0
S-3	Chand pole to Sindhi Camp	1.027	1	0	0	1	0
ST-4	Proposed Sindhi Camp Stn.	0.2	0	0	0	0	0
S-4	Sindhi Camp to Railway Station	1.429	2	0	0	2	0
ST-5	Proposed Railway Station Stn.	0.2	0	0	0	0	0
S-5	Railway Station to Civil Line	1.34	1	0	0	0	0
ST-6	Proposed Civil Line Stn.	0.2	0	0	0	0	0
S-6	Civil Line to Ram Nagar	1.099	1	0	0	0	0
ST-7	Proposed Ram Nagar Stn.	0.2	0	0	0	0	0
S-7	Ram Nagar to Shyam Nagar	1.368	3	0	0	0	0
ST-8	Proposed Shyam Nagar Stn.	0.2	0	0	0	0	0
S-8	Shyam Nagar to Vivek Vihar	1.1	4	0	0	0	0
ST-9	Proposed Vivek Vihar Stn.	0.2	1	0	0	0	0
S-9	Vivek Vihar to New Atish Market	0.9	1	0	0	0	0
ST-10	Proposed New Atish Market Stn.	0.2	0	0	0	0	0
S-10	New Atish Market to Mansarover	1.1	0	0	0	0	0
ST-11	Proposed Mansarover Stn.	0.2	0	0	0	0	0
Total			**35**	**0**	**0**	**3**	**0**

Source: DMRC Survey

114. There are electricity poles, transformers, water supply, sewer line, manholes, and telecommunication lines within 20m band of metro rail corridor. Table 35 gives the detail of utilities within the proposed corridor.

Table 35: Utilities in 20m band of Metro Rail (Phase I)

Sub-Section	Description of Sub-Section	Length in km	Types of Utilities					
			Electric Pole	Trans-former	Man-holes	Open well	Tube well	Total
ST-1	Proposed Badi Choupar Stn.	11	11	1	2	0	1	15
S-1	Badi Choupar To Choti Choupar	20	20	0	1	0	1	22
ST-2	Proposed Choti Choupar Stn.	3	3	0	2	0	2	7
S-2	Choti Choupar to Chand Pole	21	21	0	5	0	3	29
ST-3	Proposed Chand pole Stn.	7	7	0	0	0	0	7
S-3	Chand pole to Sindhi Camp	24	24	0	9	0	2	35
ST-4	Proposed Sindhi Camp Stn.	2	2	1	4	0	0	7
S-4	Sindhi Camp to Railway Station	35	35	4	12	0	2	53
ST-5	Proposed Railway Station Stn.	0.2	3	0	0	0	0	3
S-5	Railway Station to Civil Line	1.34	30	2	8	0	2	42
ST-6	Proposed Civil Line Stn.	0.2	5	0	2	0	0	7
S-6	Civil Line to Ram Nagar	1.099	30	3	14	2	1	50
ST-7	Proposed Ram Nagar Stn.	0.2	7	0	4	0	0	11
S-7	Ram Nagar to Shyam Nagar	1.368	35	0	3	0	1	39
ST-8	Proposed Shyam Nagar Stn.	0.2	5	0	2	0	0	7
S-8	Shyam Nagar to Vivek Vihar	1.1	28	0	15	0	4	47
ST-9	Proposed Vivek Vihar Stn.	0.2	6	0	0	0	1	7
S-9	Vivek Vihar to New Atish Market	0.9	24	2	7	0	5	38
ST-10	Proposed New Atish Market Stn.	0.2	5	1	2	0	0	8
S-10	New Atish Market to Mansarover	1.1	29	2	8	0	2	41
ST-11	Proposed Mansarover Stn.	0.2	4	0	1	0	1	6
Total			**334**	**16**	**101**	**2**	**28**	**481**

Source: DMRC Survey

H. Physical Cultural Resources Inventory

115. The JMRP Phase 1B will pass directly underneath the Chandpole and Tripolia Bazar Roads considered as part of the main arterial road in the Walled City. The Walled City of Jaipur was established and designed by Sawai Jai Singh in 1727 as the new capital for the 18th century Dhoondhar as the Amber Fort is getting congested and to make a strong political statement and as hub for trade and commerce in the region.

116. The entire walled city in general can be considered a physical cultural resource at the national level and within its confines are several structures of international importance. The ADB Safeguard Policy Statement, 2009 defines physical cultural resources (PCRs) as:

> "Defined as movable or immovable objects, sites, structures, groups of structures, and natural features and landscapes that have archaeological, paleontological, historical, architectural, religious, aesthetic, or other cultural significance. Physical cultural resources may be located in urban or rural settings and may be above or below ground or under water. Their cultural interest may be at the local, provincial, national, or international level." (Foonote 13, SR1, ADB SPS 2009).

1. Potential Impact of the JMRC Phase 1B on Physical Cultural Resources

117. A review of the JMRC Phase 1B construction and operation activities and the experiences from similar other underground metro has exposed several project activites that are like to pose adverse impacts on physical cultural resources. Discussions with design consultants on tunneling and metro rail operation and heritage authorities like the Jaipur

Department of Archeology and Museums and expert in PCRs in Jaipur14 allowed the construction of the following activity-impact receptor matrix.

Table 36: JMRC Phase 1B Activties Likely to affect PCRs

Project Activity	Description of impacts	Likely PCR to be Affected
Construction		
Tunnel boring under the Chandpole and Tripolia Bazaar Roads	Noise and Vibration may cause structural or cosmetic damage Disturbance or annoyance to people in the vicinity Destruction of buried artifacts which may be discovered by chance Ground settlement	Chandpole Gate, Krishna Temple, Isar Lat, Jantar Mantar, Hawa Mahal, Underground canals and pipes , Chandpole Bazar Road, Tripolia Bazar Road
Cut and cover method in constructing the Choti Chaupar and Badi Choupar Underground Terminals	Temporary obliteration of the Chaupars Elevated dust, noise, and vibration	Choti Chaupar, Badi Chaupar
Operation of heavy excavating equipment in the underground terminals	Noise and vibration	Hawa Mahal, Krishna Temple
Hauling of excavated materials across the Walled the City	Noise, vibration, and dust	Chandpole Gate, Krishna Temple, Isar Lat, Jantar Mantar, Hawa Mahal, Underground canals and pipes , Chandpole Bazar Road, Tripolia Bazar Road
Work camps	PCR Theft	Buried artifacts
Operation		
Metro rail operation	Noise and vibration	Chandpole Gate, Krishna Temple, Isar Lat, Jantar Mantar, Hawa Mahal

2. Description of PCRs

a. Chandpole Gate

118. The gates once served as guarded entry and exit points, of the walled city of Jaipur. After independence and with rapid urbanization and growth of the city, these structures of historic, cultural and social significance still stand tall as the guardian to the unique city of Sawai Jai Singh. Chandpole Gate is amongst the oldest gates of the walled city of Jaipur located at the west end of the walled city. Chandpole name was derived from the western direction of the moon (chand). The architectural features of the gate were in harmony with the prevailing architectural vocabulary of that period, which includes Tibaries, Chhateries, Arches, Kangooras, Pan Pattas, and Burjs. A big central archway with two small gates on

[14] Ms. Sikha Jain, UNESCO Study Team Leader, Rajasthan-Jaipur-Indian Heritage Cities Network

either side was the common feature of all the gates, The Tibaries at the first floor level in the central archway are at two different levels, a distinct feature of Chandpole gate.

119. Like other Gate structures and their enclosure, the whole area under consideration has undergone changes over the past two and a half centuries. Chandpole gate is among the most chaotic, encroached, abused and congested entry point to the walled city. The Chandpole gate has recently completed structural strengthening, re-plastering and repainting of whole surface, provision/repair of electrical fixtures such as lamppost and cosmetic lighting to light up the gate structure, provision of saucer drains for disposal of storm water, provision of pathways, parking for 2- and 4-wheeler, and the opening of one arched for 2-wheelers.

Figure 16: Chandpole Gate

b. Isar Lat or Swargasuli

120. Located in the western side of the walled city near Choti Chaupar, Isar Lat is a 7-story minaret built by Sawai Ishwari Singh to commemorate his victories over the Mewar and Maratha armies. Its latticed openings provide an excellent vantage point outside the fort.

Figure 17: View of the Isar Lat

c. Jantar Mantar

121. Jantar Mantar is a UNESCO World Heritage Site as an astronomical observatory. Constructed in 1718 at the center of the wall city by Sawai Jai Singh II, it has more than 18 astronomical instruments that include a Vrihat Samrat Yantra (the largest existing sundial in the world), Sasthamsa Yantra (sun declination and zenith measuring instrument), Jai Prakash Yantra (twin hemispherical bowl reflecting sky above), Nadivalaya Yantra (equinoctial dial helps measure time), horizontal sun dial, Krantivrrita Yantra (measures celestial latitude and longtitudes), Dakshionottara Bhitti Yantra (meridian dial), Yantra Taj (astrolabe fro measuring ascendant latitude, time, position of the sun and some celestial objects), Chakra Yantra (measures declination of celestial body), Unnathamsa Yantra (measures altitude or angular height of a celestial body), Rasivalaya Yantra (measures celestial latitude and longtitude of zodiacs), Kapala Yantra (hemispherical dial), Ram Yantra (measures the local coordinates of altitude and azimuth), and Dhurva Darshaka Yantra (north star indicator). Jantar Mantar most extant, best preserved, has the maximum number of functional condition of pre-telescopic masonry astronomical instruments. The Jantar Mantar was historical in the sense that it provided an venue for astronomers to exchange ideas being the largest built by Sawai Jai Singh II having regular astronomers taking regular observations.

122. The UNESCO management plan for Jantar Mantar vision is to “conserve, protect, and enhance the outstanding universal value…to celebrate astronomy and the contribution to society and culture.” The plan intends to achieve this by addressing 6 issues, namely: i) conform to the guidelines as prescribed in the World Heritage Convention, ii) coordination of natural and state level policies and planning schemes, iii) byelaws to control buffer zone development, iv) existing landscape of the site to be reviewed in context of its past ambience and its present and future use as a tourist monument, v) conservation of built fabric of the instruments should be of primary importance, vi) the functioning of astronomical instruments is crucial for protecting the OUV of the site, vii) approach to Jantar Mantar

needs to be reviewed in context of the traffic congestion and ease of access for tourists visiting the site, viii) enhancement of visitor management and visitor facilities, ix) interpretation of site, x) education and outreach, xi) the congestion on access roads and approach to the site, xii) parking for the site, xiii) scholarly research on the site, xiv) risk preparedness, xv) buffer zone management land use, xvi) financial resources for the site. The plan has identified the Department of Archeology and Museums responsible for the management and ownership of the site. Figure below presents the Jantar Mantar core and buffer zone areas.

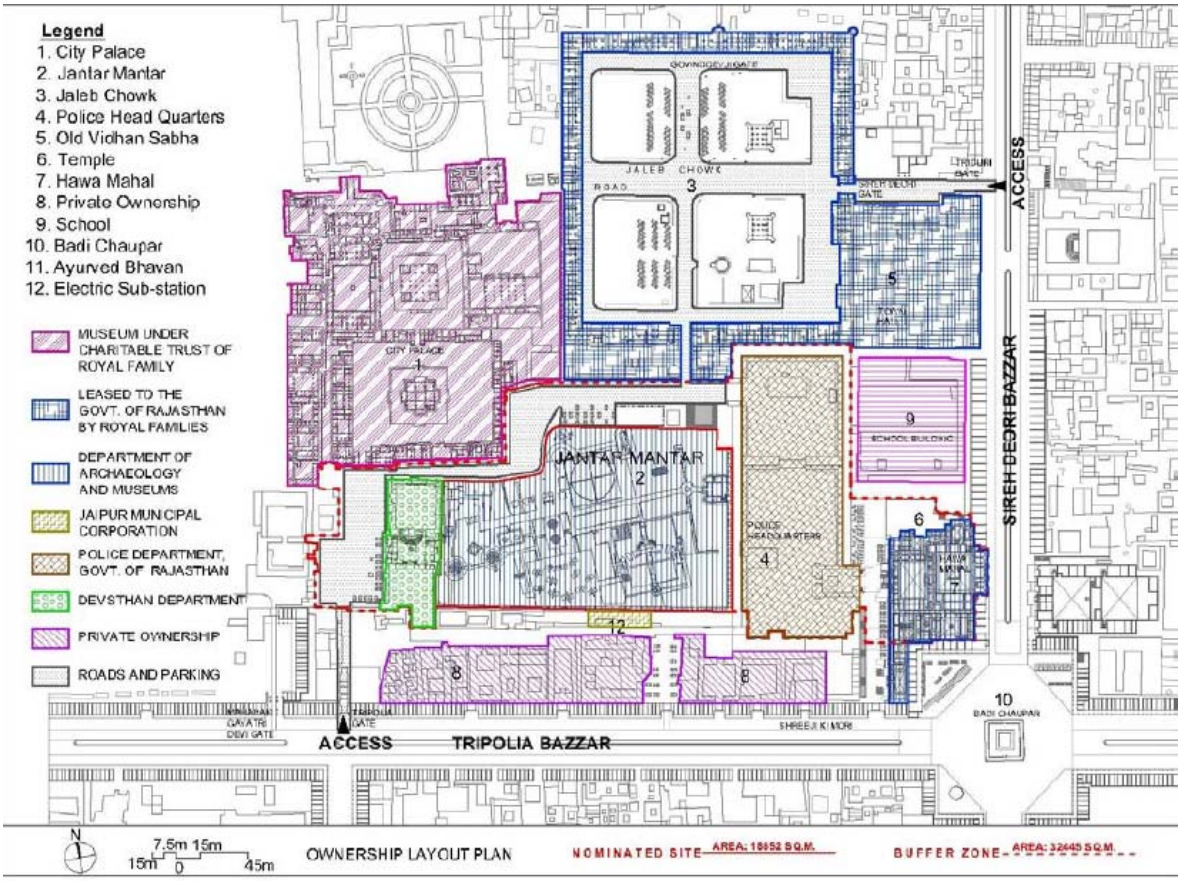


Figure 18: Jantar Mantar Protected and Buffer Zone Areas

d. Hawa Mahal

123. Hawa Mahal or Palace of the Winds is a massive five story structure that is shaped like a pyramid rises to a height of 50 feet (15 m) from its high base. Built in 1799 Maharaja Sawai Pratap Singh and was designed by Lal Chand Usta in the form of the crown of Krishna, gives the women of the palace an advantage to see the outer world through the stone screens without being seen, since they had to observe strict "purdah" (face cover). Hawa Mahal is uniqueness because of its semi-octagonal bays, carved sandstone grills, 900 niches, finials and domes with more than 953. Hawa Mahal was constructed with red and pink sandstone with white quick lime.

Figure 19: Façade of the Hawa Mahal

V. CLIMATE RISK SCREENING AND MITIGATION

124. The JMRP-Phase 1B was classified by ADB as Category B (low to medium) in terms of climate risk and found no risk for earthquake, landslide triggered by earthquake, and fire, and low to medium risk for flooding and landslide triggered by precipitation. The screening noted that although precipitation is low at 650 mm/year on the average coupled with a flat terrain result to low risk of landslide and flooding, the projected increase in precipitation by 2050s will magnify this risk should be addressed.

125. The risk screening conducted by ADB15 involved risk mapping in terms of land slide, flooding, drainage capacity and overlayed against precipitation scenario. Appendix B presents the the climate risk screening matrix.

126. The following engineering designs have been incorporated in the project to address the risk of landlslide and flooding:

- Seepage pump and pump rooms for each underground station
- Drainage pipes along the tunnel
- Structure underground station is essentiallyn a concrete box about 20m wide, 14.6m high, 140m long and 1.2m thick RCC
- A diaphragm walls for underground station of 80 to 100cm thick to function as permanent side wall which is absolutely watertight

127. Avoided greenhouse gas emission from modal shift in transportation was estimated for the entire east-west corridor. Upon project operation, a total reduction of 21,996 trips is expected to occur of which more than 50% will come from reduction bus trips (public transport), and about 25% will be from 2-whellers. By 2013, this is expected to increase by 10 folds.

Table 37: Expected Decrease in Trips by Mode, 2014 and 2031

Year	Mode Share	w/o Metro	w/ Metro	Decrease/ Increase in Trips	Attribution
2014	2 wheeler	112,737	107,238	5,499	25%
	Car	38,496	35,746	2,750	13%
	Auto	24,747	24,747	-	0%
	Taxi	32,996	30,247	2,749	12%
	Public Transport	65,993	76,991	10,998	50%
	Total			21,996	100%
2031	**Mode Share**	**w/o Metro**	**w/ Metro**		
	2 wheeler	296,882	243,596	53,286	25%
	Car	159,860	129,410	30,450	14%
	Auto	68,511	60,899	7,612	4%
	Taxi	98,961	83,736	15,225	7%
	Public Transport	137,023	243,596	106,573	50%
	Total			213,146	100%

128. To estimate the carbon emission reduction from the decrease in trips, emission factors developed by the CBCP/MOEF (2007)16 were used and provided in Table 37. It

[15] ADB-SAOD

[16] Draft Report on Emission Factor Development for Indian Vehicles. The Automotive Research Association of India. P.O. Box 832, Pune-4. India

was estimated that as much 54.30 ton of equivalent carbon emission per day will be avoided from the operation of the Phase 1.

Table 38: Emission Factors to Estimate Carbon Emissions (g/km)

Emission Source	Emisson Factor													
	CO (g/km)			HC (g/km)			PM (g/km)			CO2 g/km			CH4 g/km	N2O g/km
	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg	Avg	avg
2 wheeler	0.16	11.41	3.10	0.15	7.70	1.95	0.01	0.07	0.04	0.01	45.60	27.39	0.18	0.004
Car	0.04	6.78	1.94	0.08	0.85	0.04	0.00	0.19	0.04	95.65	172.95	138.33	0.17	0.017
Auto Rickshaw	0.41	23.16	3.61	0.14	6.04	1.72	0.02	1.20	0.24	54.50	-	84.89	0.18	0.052
Taxi	0.04	6.78	1.94	0.08	0.85	0.04	0.00	0.19	0.04	95.65	172.95	138.33	0.01	0.02
Public Transport	3.72	19.30	8.95	0.16	3.75	1.59	0.00	0.03	0.01	602.00	920.77	773.53	0.09	0.03

VI. ANTICIPATED ENVIRONMENTAL IMPACTS AND ITS MITIGATION MEASURES

129. The potential impacts and risks were analyzed in the confines of the tunnel's direct impact area, which is defined in this study as 100 meters on both sides of the metro's center line. Influence area where most of the socio-economic and cumulatve impacts will occur is defne as the entire confine of the walled city of Jaipur.

130. The ADB Rapid Environmental Assessment Checklist for Roads was adapted to facilitate the screening and identification of likely impacts attributable to the tunnelling and terminal construction under Phase IB. The project road section is classified as Category A mainly due to project siting and its proximity to physical cultural areas like Jantar Mantar, located 80 meters from the tunnel centerline which is a UNESCO World Heritage site and Arcehological survey of India (ASI) protected archaeologically important monument or cultural heritage site. Other physical cultural resources are the Chandpole Gate, Krishna Temple, Hawa Mahal and Isarlat falls at a distance of around 90m and have been declared as protected monuments under the Rajasthan Monuments, Archaeological Sites and Antiquities Act, 1961. Other significant impacts screened are:

- Increased local air pollution due to rock crushing, cutting and filling works, and chemicals from asphalt processing
- Risks and vulnerabilities related to occupational health and safety due to physical, chemical, biological, and radiological hazards during project construction and operation
- Dislocation or involuntary resettlement of people as there will be a need for small land acquisition near Chandpole
- Dislocation and compulsory resettlement of people from 8 shops living near the Chandpole station
- Noise and vibration due to tunnelling boring machine, excavation machines, and materials haluing.
- Hazardous driving conditions where construction of terminals in the Choupars interferes with existing roads
- Increased noise and air pollution resulting from traffic volume during construction

A. Expected Benefits from the Project

131. The project's implementation is consistent with the macro-plan elucidated in the Comprehensive Mobility Plan approved in 2010. The principal benefit in adopting and underground metro inside the walled city is to avoid impacts normally associated with linear projects such as shifting of structures, relocation of people, and preserving the architectural integrity of the site.

132. The project's objective of reduction in congestion and improvement in mobility will enhance the economy, road safety, and reduce fuel consumption, air pollution, and greenhouse gas emissions. More specifically, the project will:

- Require 1/5th energy per passenger km compared to road-based system
- Causes no air pollution in the city
- Causes lesser noise level
- Occupies no road space if underground and only about 2 metres width of the road if elevated
- Carries same amount of traffic as 5 lanes of bus traffic or 12 lanes of private motor cars (either way), if it is a light capacity system.
- Is more reliable, comfortable and safer than road based system

- Reduces journey time by anything between 50% and 75% depending on road conditions.
- Maximize growth of the Jaipur economy by enhancing its competitive position and facilitating future employment and population growth;
- Delivers a step change by opening a new era in the speed and quality of public transport service linking major growth locations in and around Jaipur area with the city centre and strategic employment areas;
- Supports and facilitate the sustainable growth of Jaipur, recognizing the importance of its city centre to the future economy of the Jaipur city region.
- Improves the efficiency of the city's public transport and road networks;
- Creates a system with the flexibility to adapt to development phased over several years;
- Promote quality of life through a safe and healthy built and natural environment;
- Increases overall public transport patronage on the corridors served and achieves a mode shift from the car;
- Promotes equality of opportunity by improving accessibility to employment, goods and services;
- Improve the overall journey experience for passengers using the system by providing high quality information, better waiting and vehicle environments and enhanced safety and security;
- Assists in building vibrant, confident and cohesive communities in the city;
- Provides levels of segregation from traffic and public transport priority sufficient to ensure consistently high standards of punctuality and reliability;
- Creates a system that is well integrated with the wider transport network and public real.

B. Impact on Physical Environment

1. Climate

133. The Project is classified as Category B in terms of climate risk and vulnerability with no risk for earthquake, landslide triggered by earthquake, and fire, and low to medium risk for flooding and landslide triggered by precipitation. The project will help reduce the greenhouse gas (GHG) emission by as much 54.2 tons per day carbon equivalent due to expected modal shift from road-based system to the metro rail. For the project (Corridor Phase I B), no tree will be cut.

2. Natural Hazard

134. The proposed project is located in seismic zone II (very feeble damage risk zone) as defined by the vulnerability zoning system.

Mitigation Measures

135. Relevant IS codes have been adopted while designing the civil structures to sustain the earthquake of highest magnitude in Seismic zone II.

3. Vibration from Tunnel Boring Machine and Metro Operation

136. Annex C presents the vibration modelling during tunnel boring and metro train operation. The predicted Peak Particle Velocity (PPVs) on the PCRs were compared against limits set by various international vibration codes (Table 40) as the Government of India has not prescribed its limits. The predicted vibration levels, the highest of which is at the Chandpole Gate at 0.682 mm/s during tunnel boring and 0.450 mm/s during metro operation are both below the guideline values reviewed as presented in Figure 20.

Referring to Table 40, even during operation the predicted level is lower than 2.5mm/s guideline value for structures with intrinsic importance. The predicted levels are also lower that the 2.0 mm/s DIN 4150 shock limit for ruins and buildings of historical interest as by Mohanan, V and O. Sharma[17] (1998).

137. Although no structural damage to PCRs is expected from construction and operation activities, the values, human beings are known to be very sensitive to vibration, with the threshold of perception being typically in the PPV range of 0.14 mm/s to 0.3 mm/s. Vibrations above these values can disturb, startle, cause annoyance or interfere with work activities.

Table 40: Selected International Vibration Codes

Country	Vibration Code	Year
Germany	DIN4150	1975-1999
Brasil	CETESB D7.013	1998
Scotland	PAN50	2000
US	USBMR18507	1980
Spain	UNE22-381-93	1993
France	Recommendation GFEE	2001
ISO	ISO4866	1990
Italia	UNI9916	1991
Portugal	NP2074	1983
United Kingdom	BS16472	1992
Sweden	SS460-48-46	1991
Switzerland	SN40312	1992

[17] National Physical Laboratory, Acoustic Section (1998). “A Technical Report on Noise and Vibration Study In and Around Certain Historic Monuments/Structures Near the Proposed Metro Route in Delhi.” New Delhi

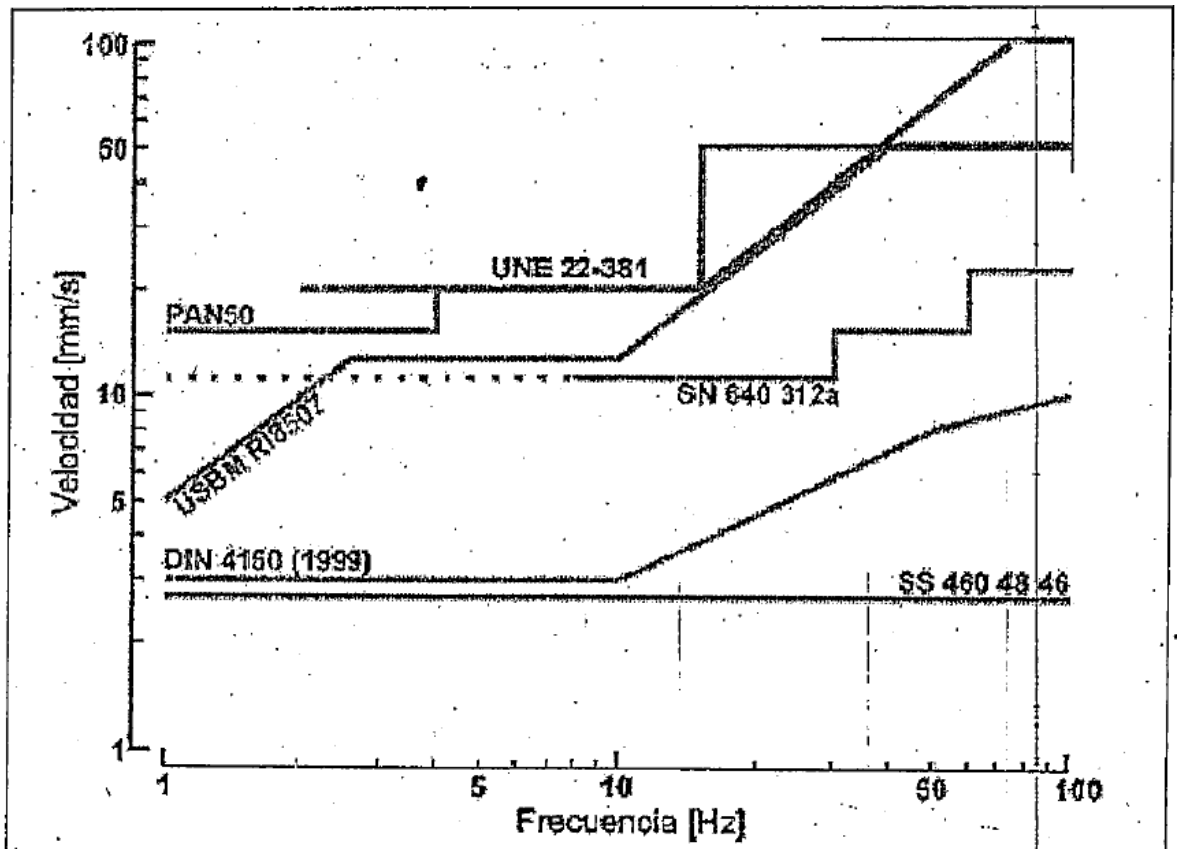


Figure 20: Graphical Limit Values of Selected International Vibration Codes

Table 41: DIN 4150 Guideline Values

Type of structure	Frequency	Peak-Velocity		Location of Measurement
		Short-Term	Long-Term	
Buildings used for commercial purposes, industrial buildings and similar design	1-10 10-50 50-100 All	20 20-40 40-50 40	- - - 10	Foundation of structure Foundation of structure Foundation of structure On horizontal plane of highest floor
Dwellings and buildings of similar design or occupancy	1-10 10-50 50-100 All	5 5-15 15-20 15	- - - 5	Foundation of structure Foundation of structure Foundation of structure On horizontal plane of highest floor
Structure that, because of their sensitivity to vibration cannot be classified under lines 1 and 2 and are of great intrinsic value (e.g. listed building under	1-10 10-50 50-100 All	3 3-8 8-10 8	- - - 2.5	Foundation of structure Foundation of structure Foundation of structure On horizontal plane

preservation order)				

Table 42: Peak Particle Velocity (PPV) During Tunnel Boring Predicted for Each PCR Along the Alignment

Archeological Monument	Distance to Tunnel (m)	TBM Source Rating PPV (mm/s) @ 1m	Predicted PPV from TBM in mm/s	Metro Rail Source Rating PPV (mm/s) @ 30m	Predicted PPV from Metro in mm/s
Chandpole Gate	9.35	10	0.682	0.453	0.450
Khrisna Temple	19.75		0.184		0.177
Isar Lat	23.97		0.121		0.128
Jantar Mantar	85.11		0.00126		0.003
Hawa Mahal	83.48		0.00141		0.003

Mitigation Measures

138. Predicted levels of vibrations from contruction and operation phases are lower than 2.0mm/s for sensitive receptors such as PCRs and are not expected to cause cosmetic or structural damage to the PCRs. At the Chandpole Gate which is a short distance away from the vibrating tunnel wall of 9.35m registered the highest vibration levels are above the threshold of human beings vibration detection and at worst case will cause annoyance and complains but can be tolerated if prior warning and explanation has been given to residents. All vibration levels beyond the 2-tunnel diameter distance where Jantar Mantar and Hawa Mahal are located will be beyond the human being vibration perception level of 0.14mm/s.

139. The low predicted vibration level was achieved in the engineering design adopted from the Delhi Metro Rail. The design already included vibration control mechanisms to attenuate noises 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.

140. The designed track incorporated the following measures:

- To prevent development of surface irregularities on the rail, a fairly heavy rail section of 60kg/m, 90 UTS supported at every 60cm has been proposed.
- rail grinding at regular intervals by rail grinding machine and also lubrication of rail by vehicle mounted lubricator have been contemplated.
- rail will be continuously welded and also will be laid to fine tolerances, so that any noise/vibration on account of irregular track geometry could be reduced.
- used elastic fastening system

141. The bogies selected are bolster-less type having secondary air spring to reduce vibration.

4. Noise

a. Construction Stage

142. Ambient noise level may increase temporarily in the close vicinity of various construction activities, maintenance workshops and vehicles and earthmoving equipment. The major sources of noise pollution during construction are movement of vehicles for transportation of construction material, waste materials to/from the construction site and the noise generating activity at the construction site itself. The metro construction is equipment intensive, particularly the underground section.

143. Based on the construction of the Metro Rail in Delhi underground section, the types and number of equipment needed to operate at the same location at the same time and their corresponding noise levels are provided in Table 43.

Table 43: Noise Level Prediction during Construction

Distance (m)	Concrete Batch Plant + Concrete Mixer Truck		Auger Drill Rig +Dump Truck + Generator + Slurry Plant		Dump Truck + Excavator + Pneumatic Tools	
	Lmax	Leq	Lmax	Leq	Lmax	Leq
5	103.0	97.8	104.4	102.9	105.2	103.6
10	97.0	91.8	98.3	96.8	99.2	97.6
15	93.5	88.3	94.8	93.3	95.6	94.1
20	91.0	85.8	92.3	90.8	93.1	91.6
25	89.0	83.8	90.4	88.9	91.2	89.6
30	87.4	82.2	88.8	87.3	89.6	88.0
35	86.1	80.9	87.5	86.0	88.3	86.7
40	84.9	79.7	86.3	84.8	87.1	85.5
45	83.9	78.7	85.3	83.8	86.1	84.5
50	83.0	77.8	84.4	82.9	85.2	83.6
55	82.2	77.0	83.5	82.0	84.4	82.8
60	81.4	76.2	82.8	81.3	83.6	82.0
65	80.7	75.5	82.1	80.6	82.9	81.3
70	80.1	74.9	81.4	79.9	82.3	80.7
75	79.5	74.3	80.8	79.3	81.7	80.1
80	78.9	73.7	80.3	78.8	81.1	79.5
85	78.4	73.2	79.8	78.2	80.6	79.0
90	77.9	72.7	79.3	77.8	80.1	78.5
95	77.4	72.2	78.8	77.3	79.6	78.0
100	77.0	71.8	78.3	76.8	79.2	77.6

Source: Environmental Impact Assessment – Delhi Metro Phase III, RITES Ltd.

144. Superimposing applicable noise levels on the project site, in this case Badi Choupar (see Figure 21), un-mitigated noise levels from the heavy equipement will result to elevated noise levels that are above the standard as presented in **Error! Reference source not found.**. The shops immediately in front of the construction area may experience noise levels from 85.8-93.5 dB(A), the bus terminals and immediate structures my be exposed to noie levels from 74.9-83.6 dB(A) while at Hawa Mahal it could be 73.7-81.1 dB(A).

Figure 21: Predicted Noice Level at the Badi Choupar During Cut and Fill Operation

Mitigation Measures

145. Noise level may increase during construction stages of project near the sensitive receptors like hospitals, schools, and religious structures. Surface level construction activities will be at the two underground stations (Badi and Chhoti Choupar). Among the sensitive receptors, it has been observed (Table 4.29) that 7 nos. small temples are located within 20m from these two proposed stations. During the cut and fill constructions for the stations, there may be intermittent increase in noise levels in these areas; barricading and noise barriers will be provided at these locations.

146. 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. Mitigation measures to be implemented by the Contractors are:

- liase with local residents on how to best minimize construction noise along the Choti and Badi Chaupars.
- 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 Choupars
- 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

b. Operation Stage

147. 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. Sources of wayside airborne noise are:

- Wheel / Rail Noise : Due to wheel /rail roughness
- Propulsion Equipment: Traction motors, cooling fans for TM, reduction gears etc.
- Auxiliary Equipment: Compressors, motor generators, brakes, ventilation systems, other car mounted equipment

148. US data shows that the noise levels inside the rail transit cars range from about 65 to 105 dB(A) during normal operation. Wide range of noise levels depends on following factors:

- Train speed (V): Car interior noise levels vary from 15 log 10 V to 40 log 10 V.
- Type of Way structure: Noise levels lowest on AG ballast and tie-welded track and highest for operations on light-weight structures and in tunnels with concrete track bed and no acoustic treatment.
- Sound Insulations of car body: Single leaf or Sandwich construction.
- Type & Design of Mechanical Equipment: Propulsion system & Auxiliary Equipment (A/C system ,compressors and motor generator sets).
- Wheel and Rail conditions: Rail corrugations and wheel flats can increase the noise levels by 10-15 dB(A)

Mitigation Measures

149. Underground Metros are not known to generate audible sound at the ground level. However, since the Metro has an an elevated section Phase 1A, the following noise attenuation measures from the moving trains were integrated in the design to minimize noise from: (i) rail-wheel interaction (ii) equipment like blower, compressor, air conditioner, door, and inverter, and (iii) traction motor. 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 via-duct 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.

5. Ground Settlement During Construction

150. Ground movement associated with the construction of underground railway tunnels is inevitable. As the tunneling face progresses forward the lack of support for the overburden causes the ground above the tunnel to subside. Although there area a number of measures to control subsidence that includes compensation grouting and earth pressure balance tunnel-boring machines that will employed in the Project, they cannot fully negate subsidence during and after the tunneling process[18].

[18] Jones, W.J. (2010). "Ground Vibration from Underground Railways: How Simplifying Assumptions Limit Prediction Accuracy." A dissertation submitted to the University of Cambridge for the degree of Doctor of Philosophy.

151. Ground settlement is crucial to ensure that no damage is incurred in PCR particularly the Chandpole gate where the tunnels will be dug immediately under the structure.

152. The vertical settlement due to tunnel boring was estimated using the Gauss distribution through the following equation.

$$S(x) = S_{max} e^{(-x^2/2i^2)}$$

Where:

$S(x)$ = settlement at x distance from the tunnel axis

S_{max} = maximum settlement at tunnels axis

$= Vs/(2\pi i)^{1/2}$

Where:

Vs = section loss as a percent of the excavation volume
= 0.45%

i = distance of the inflexion point to the tunnel
= ZOK

Where: ZO=depth of the axis
K = geologic value
= 0.5 for cohesive soil

153. Maximum settlement from tunnel boring during construction is estimated at 2.54 mm.

Mitigation Measures

154. The contractor will ensure that no inadvertent damage is incurred to the Chandpole gate.

155. Ground settlement cannot be avoided in tunneling works due to the loss of volume loss, which is estimated at 0.45% for the JMRP. Estimated settlement under the Chandpole gate must be less than 5mm. The contractor will ensure that the design value is not exceed and the trigger value = 3.5mm and Allowable value = 4.2 mm are implemented.

156. Tilt meters will be installed at key positions on the gate to ensure the 2/1000 design value is observed with trigger and allowable values of 1.4/1000 and 1.7/1000, respectively

157. Crack meters will be installed at key positions to ensure design value of 3.0mm is not exceeded with 2.1mm trigger value and 2.5 mm allowable value

158. The contractor will immediately cease all operation if any of the trigger values (3.5 mm) are breached. The CSC will advise the contractor mitigation measures and practices to control settlement, tilt, and cracks to include but not limited to structural reinforcement and operation parameters of the TBM.

159. The contractor will ensure that no structural damage is incurred and cosmetic damages are repaired under the supervision and control of the Jaipur Archeology Department.

6. Utilities Shifting and Safety Planning

a. Construction Phase

160. The cut and cover method adopted in the construction of the underground station will affect various utilities located along the road/construction area. The affected utilities include 21 electric poles, 1 transformer, 4 manholes and 3 tube wells. Certain small structures like

the fountains in the Chhoti as well as the Badi Choupar will be affected for construction of the stations. Temporary disturbances to the traffic and disruption of supply (water, electricity etc.) to the local community may also happen.

Mitigation Measures

161. The railway tracks in the proposed project section will be underground, about 14m below the surface. Stations and traffic integration areas in Phase I B will be located on existing open spaces. Adequate safety provisions like crash barriers, rumble strips to regulate speed, and retro-reflective warning sign boards shall be provided at the construction site. All utilities requiring shifting will be made before start of construction without affecting any essential supplies like water supply and electricity. The Contractor with support from the JMRC Safeguards Cell will coordinate with the agencies listed in

162. The Contractor will ensure that the public will be minimally affected when constructing in close proximity to essential services through:

- coordinate and secure necessary permits for utility shifting with the Jaipur Development Authority and other service utility agencies to locate al services prior to construction in any particular area
- inform residents of planned interruptions through local media, fliers, and public address system
- all planned interruptions schedules will be submitted to the safeguards cell of JMRC no later than 10 working days before the interruption
- all affected landowners, tenants, institutions, and businesses to be notified in writing prior to commencement and kept updated in changes of schedule
- in the event of unforeseen disruptions, the contractor will take all reasonable actions to have the service promptly restored
- relevant utility agencies will be informed of the construction proximity to essential service line and be kept on standby in the event of unforeseen disruption

163. All unplanned interruption will be immediately reported to the safeguards cell within 24 hour through an incident report.

Table 46: Utility Departments that will be Consulted by the Contractor

S No	ORGANIZATION/ DEPARTMENT	UTILITY SERVICES
1.	Jaipur Nagar Nigam Jaipur Development Authority	Surface water drains, nallahs, Sewerage and drainage conduits, sewerage treatment plants, pumping stations,
2	PHED Jaipur	Water mains and their service lines, including hydrants, water treatment plants, pumping stations, Gardens etc.
3	Public Works Deptt. (PWD) and JDA Jaipur	Road construction & maintenance of State highways, Municipals Roads etc.
4	Bharat Sanchar Nigam Ltd. (BSNL) Airtel, Tata Indicom, Reliance, MTS, Vodaphone.	Telecommunication cables, junction boxes, telephone posts, O.H. lines, etc.
5	Jaipur Traffic Police	Traffic signal posts, junction boxes and cable connections, etc.
6	District Revenue Office	Land Development & Housing etc.
7	Railway	Railway crossings, signals, railway bridges, etc.
8	RVVNL Jaipur	OH & Under Ground Electric cables and Electric poles

Source: DPR (2012)

7. Air Quality

a. Design and Construction Phase

164. **Design Stage:** The stone aggregate will be sourced from licensed quarries only and no new quarries will be established. Pollution related to quarry operation are independently complied by the owner. The aggregate will be transported in the covered trucks to the construction yards through existing roads.

165. **Construction Stage:** Potential sources of air emission are: (i) dust from earth works during site preparation, (ii) emissions from the operation of construction equipment and machines, (iii) fugitive emissions from vehicles plying on the road, (iv) fugitive emissions during the transport of construction materials, (v) air emissions other than dust arise from combustion of hydrocarbons particularly from the hot mix plants, and (vi) localised increased traffic congestion in construction areas. Most of the emissions will be in the form of coarse particulate matter that will settle down in close vicinity of construction site. Hot mix plant will emit carbon monoxide (CO), un-burnt hydrocarbon, sulphur dioxide, particulate matters, and nitrogen oxides (NOx). This may affect the air quality of nearby areas especially due to emission, discharge from low stack height. Current air quality of the project area meets national ambient standards. Increase in air pollution levels from mobile and stationary sources is predicted, which reveals that there shall not be significant contribution from the project.

166. Following measures will be implemented to minimise the dust and emission generation.

- Haul trucks shall be covered.
- Loading and unloading of construction materials shall be made at designated locations in project area with provisions of water fogging.

- Storage areas should be located downwind of the habitation area.
- Regular maintenance of machinery and equipment and ehicular pollution check shall be made mandatory.
- Mixing plants and asphalt (hot mix) plants shall be located at least 1 km downwind of the human settlements. Hot mix plant shall be fitted with stack of adequate height as may be prescribed by SPCB or CSC to ensure enough dispersion of exit gases.
- Only crushers licensed by SPCB shall be used.
- Regular water sprinkling of unpaved construction areas, haul and access roads particularly near community areas, and maintenance depot.
- Mask and other PPE shall be provided to the all construction workers.
- Diesel generating (DG) sets shall be fitted with stack of adequate height as per regulations.
- Low sulphur diesel shall be used in DG sets as well as construction machineries.
- Air quality monitoring should be carried out during construction phase. If monitored parameters are above the prescribed limit, suitable control measures shall be taken.

Ongoing Constructions at Mansarovar Depot

b. Operation Phase

167. 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.

8. Impact on Land and Soil

a. Design and Construction Phase

168. **Design Stage:** The proposed project corridor passes through densely developed and heritage areas of the city. Stringent development control norms apply for any change in the land use and for new constructions. Insignificant change in land use is expected along the Phase IB corridor as the stations will be underground and their entry and exit points are planned at vacant areas free of any vegetative cover.

169. **Construction Stage:** The top soil at Badi Chaupar and Choti Chaupar shall be disturbed during the construction stage due to excavation and movement of vehicles and equipment.

170. Problems could arise from dumping of construction spoils (concrete and bricks) waste materials (from contractor camps) causing surface and ground water pollution. The spillage of oil from the machinery or cement residual from concrete mixer plants might contaminate the soil if not properly collected and disposed-of. Oil spills from the operation of the diesel pumps and diesel storage, during transportation and transfer, parking places, and diesel generator sets. Improper waste disposal facilities at the temporary residential facilities for the labour and officers may also contaminate the soil. Refuse from railway stations include garbage, rubbish, and floor sweepings that also needs proper disposal.

Mitigation Measures

171. It is proposed to have mix concrete directly from batching plant for use at site. Batching plants located at Mansarovar site for use in the elevated section, will be used for the proposed project (Phase I B). The other construction material such as steel, and bricks will be housed in a fenced stored yard. The balance material from these yards will be removed for use/disposal. Mitigation measures include careful planning, cleaning, redressing and landscaping. No excavation work will be allowed during monsoon season. Septic tank will be constructed at the temporary camps for labour and officers for proper waste disposal. The total refuse generated at all the stations of the present section under consideration is estimated to be about 1.32 tonnes/day with the assumption that only about 25% of the passengers visiting various stations will be producing refuse[19]. For the maintenance of adequate sanitary facilities, containers/collection bins not exceeding 120 litres and equipped with side handles will be appropriately designed and installed at stations and platforms.

Labour Camp – Mansarovar Depot **Construction Yard – Chandpole Station**

172. Approximately 300,000 cum[20] of excavation is expected for the two under ground stations of Phase - 1B (Badi and Chhoti Choupar) out of which about 25 % will be used for back filling. Rest will be disposed off in designated dumping yard at "Papad Wale Hanumanji" which is around 10-12 KM away from site (see Figure 22). This site is already in use for dumping construction waste materials for Phase I A.

173. A spoil management plan will be implemented that details the location of spoil disposal sites, transporting soil, and disposing of soil. The Contractor will perform the following:

- disposed spoils on permitted sites as instructed by the JMRC

[19] This assumption is based on the design standard adopted in case of Delhi Metro-
[20] DMRC Estimate

- ensure the adequacy of the disposal site to handle the volume of spoils the will be generated
- Prepare, submit and seek approval from the CSC a spoil dump plan that provides the: i) dump size, layout, and form, ii) means of controlling water and wind erosion, iii) measures to prevent spoil dump contamination, vehicular, and public access.
- Explore the possibility of using spoil materials to rehabilitate borrow pits to
- All hauling vehicles should be maintained at an acceptable working order and serviced regularly
- Haul vehicles should be routed away from noise sensitive areas
- Speed limit in built up areas is 40 km/h
- All haul vehicles should be covered or soil sprayed with water before leaving the site specially during windy condition
- Spoil dumps shall have slopes no steeper that 1V:2.5H
- Final shaping, topsoiling, and immediate revegetation

174. For removal of debris, wastes and its disposal MoRSTH guidelines will be followed. The JMRC has taken clearances from Jaipur Development Authority (JDA) for waste disposal at *'Papad wale Hanumanji'*.

9. Ground and Surface water

a. Design and Construction Stage

175. Water will be required primarily at the construction yards and for domestic purpose in the workers camp. Water for construction activities and domestic purpose for workers camp will be mainly sourced from groundwater. Following are the most susceptible locations for contamination of water during construction:

- Waterlogged areas;
- Surface and ground water resources close to construction material storage yard, concrete mixer plants and maintenance sites of construction vehicles; and
- Surface water bodies close to labour camps.

176. Within the vicinity of project site no major / designated water body except the Amanisha Nalla is present and since all construction related activities will primarily be confined to the enclosed corridor, hence no major impacts on the nallah are anticipated.

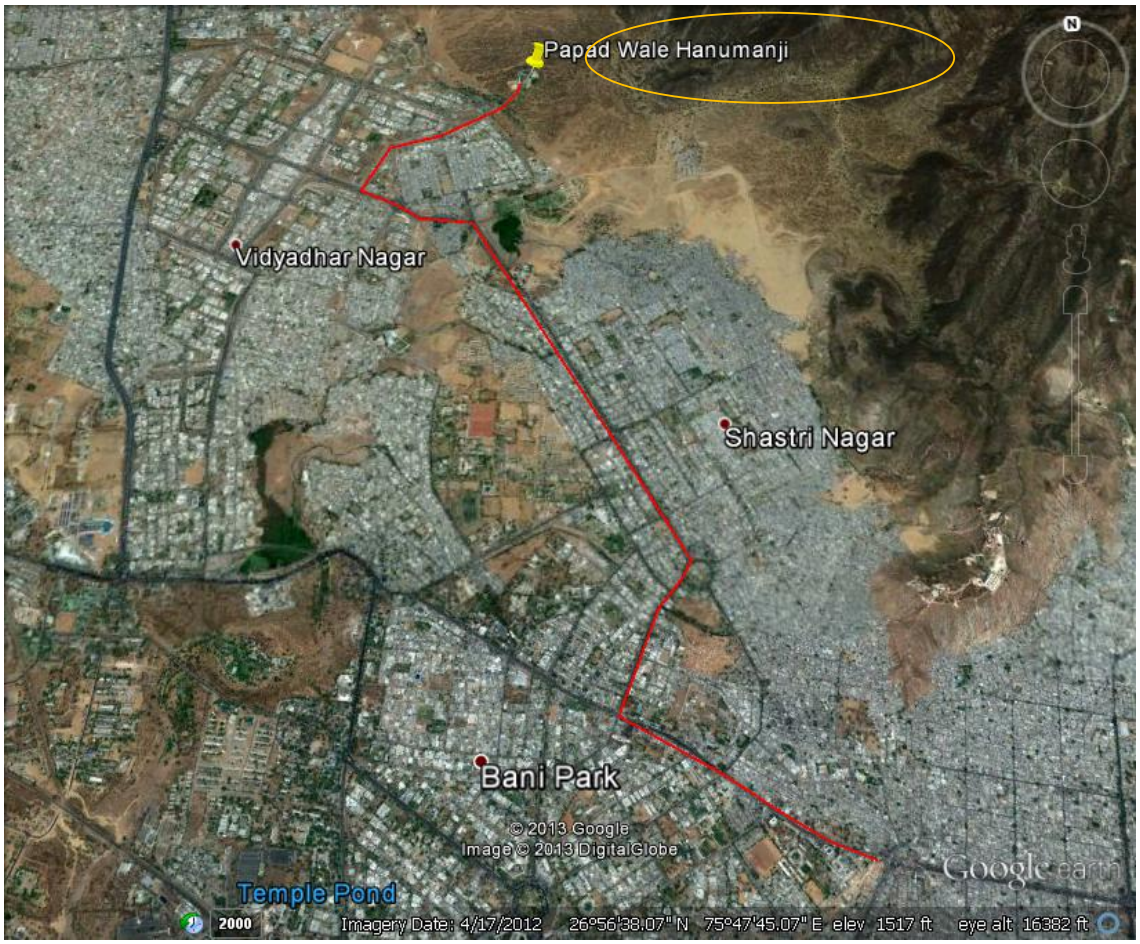


Figure 22: Location of Waste Disposal Site

Mitigation Measures

177. The Contactor shall secure necessary permits from pertinent groundwater authorities before establishing borewells.

178. Water conservation and recycling will be observed in all aspects of constructions to include water main breaks, watering roads for dust control, spraying concrete, equipment cleaning and site clean-up.

b. Operation Stage

179. The Metro's operation will require substantial groundwater. The experience from Delhi Metro indicated that that each station will require 18,000 liters per day, platform washing is 5 liters/square meter, 70,000 li.day for car washing, and plus passenger water requirement.

Mitigation Measures

180. JRMC will install rain water harvesting facilities at the Mansorovar station. All stations will employ a cooling water recirculation system for airconditioning. Recycled water will be use for facility cleaning and landscape irrigation. All toilets will be equipped with low-flow fixtures.

C. Impact on Biological Environment

1. Terrestrial Ecology

a. Design and Construction Stage

181. There is no national park, wildlife sanctuaries or any other similar eco-sensitive areas within 10 km distance of the project area. No tree also falls within 20 m distance from the proposed alignment of Phase I B corridor. However, some trees are likely to be affected for the Metro corridor Phase I. A total of 25 trees are likely to be affected due to the proposed Metro Corridor. The cutting of trees will have minor to negligible impact on local environment.

Mitigation Measures

182. Requisite permission will be taken from district commissioner. Compensatory plantation will be carried out as per prevailing guidelines of State Forest Department's on 1:10 basis replacement rate or as per permission granted by district authorities for cutting of tree located on non-forest land, which vary from 1:3 to 1:10. For compensatory afforestation, JMRC has already paid the required amount to the Forest Department for plantation of the trees. A site on Jaipur - Agra road has been identified for the compensatory afforestation.

D. Socio-Economic Impact

1. Involuntary Resettlement

a. Design and Construction Stage

183. The project will have both positive and negative impact on socioeconomic aspects. To avoid significant impact due to construction of the metro corridor in a highly developed area, this section alignment will be the underground section of the Phase I corridor to avoided involuntary land acquisition. However, in constructing the Chandpole station, a total of 130.43 sq.m of commercial land belonging to 8 affected persons has been acquired.

184. The construction could result due to influx of migrant workers and associated induced development. The influx may cause a rise in the consumption of consumer goods in the local area, which will tend to boost up the local economy. As local labours will be hired, initial conflict is not envisaged. To the extent possible, local labour shall be utilized for the construction purpose and all the activities related to construction worker shall be confined to the project site only to minimize conflict. The positive impacts of the project would include (i) reduction in travel time, (ii) better and comfortable mode and frequency of transport, (iii) better access to quality health care facilities, educational and other infrastructural facilities, (iv) enhanced tourism activities in the area and state which in many terms will boost the local economy, and (v) better investment climate for industries creating more employment opportunities to local people.

Mitigation Measures

185. JMRC has provided compensation to the affected persons irrespective of their legally tenable ownership rights for the affected land. The shops located at Chandpole station were acquired for construction of the station and metro route from Chandpole to Badi Choupar. During consultation/negotiation, the PAPs requested for allotment of alternate land in proximity and suggested for a plot of land near Siker House. With the intervention of high level officials of GoR, the land was allotted to JMRC and the same was allotted to the PAPs. In the process the PAPs could receive land that was in excess of the land acquired with roof right while they did not have the same at Chandpole. This enables them to construct shops

in more than one floor as per the building bylaws. They were also paid compensation for the affected structure. The final settlement also included the difference of DLC rate at Chandpole and Siker house.

2. Safety

a. Construction Stage

186. The project construction activities may create various unsafe situations. This will require attention to the following safety aspects: (i) safety of construction workers, (ii) safety of road users including pedestrian and cyclists, (iii) safety of local community (iv) unsafe/ hazardous traffic conditions due to construction vehicle movement need to be considered during design and construction stage, and (v) conduct of safety audit.

Mitigation measures

187. JMRC has included in the bidding documents a Safety, Health, and Environment (SHE) provision specifying requirements for solid and liquid waste generation, communicable diseases, hazardous materials storage re-fueling, lighting, emergency preparedness, excavation and tunnelling, personal protective equipment, and energy management. Some of the safety features adopted during construction of Corridor Phase IA are presented in Figure 23 below.

Figure 3: Safety features adopted during construction of Corridor Phase IA

b. Operation phase

188. Important issues related with safety during operational phase are monitoring of emergencies and establishing procedures to carry out rescues during sudden emergency such as accidents.

Mitigation Measures

189. In view of the hazards potential involved due to failure of system and accident the onsite and offsite emergency measures have been formulated and will be implemented. Emergency conditions during operation includes fire inside the tunnel generating smoke in the tunnel or station track way. During such situation, the tunnel ventilation system will automatically activate providing smoke-free path for evacuation of passengers and for the fire fighting purposes. The ventilation system is operated in a 'push-pull' supply and exhaust mode with jet fans or nozzles driving tunnel flows such that the smoke is forced to move in one direction, enabling evacuation to take place in the opposite direction depending upon the location of Fire on the train. All trains will have public address systems to warn the passengers of any emergency situation.

3. Obstruction and Disruption of Traffic

a. Construction Phase

190. Disruption of access to infrastructure or social resource due to construction activity will cause nuisance and to a certain extent additional cost to the public in terms of longer travel period due to diversion or traffic. It will also pose risk of accident to motorist at night if these blockages and disruption are not clearly demarcated. Some of the precaution measures adopted during construction of Corridor Phase 1A are presented in the succeeding Figures 24-25.

Figure 4: Ongoing construction in Corridor Phase I with safety precautions

Figure 5: Traffic Flow conditions at Chandpole during construction of Chandpole Station

Mitigation Measures

191. To avoid disruption of the existing traffic due to construction activities, comprehensive traffic management plan shall be drawn up by the contractor. Retro-reflectorized traffic caution signs shall be used during construction. Regular safety audit or periodic review shall be made to assess the effectiveness of safety measures adopted during construction. During construction of Corridor Phase IA, The contractors monitored regular safety checks at the construction yards, work sites, trained their personnel on safety measures at the workplace, disaster management and maintained tie-ups with local hospitals/nurshing homes for meeting emergencies. They also maintained a register on safety measures adopted at the work sites. These will be continued with during the construction of Corridor Phase IB.

192. During construction, traffic diversions on roads will be essentially required. As most of the construction activities will be confined to centre of the road and most of the roads are 60m wide, it will be appropriate that the side lanes may also be utilised for traffic and ensure smooth progress of construction activities. Advance information on communication systems will be implemented to users of any particular road. A traffic diversion plan has been prepared by DMRC consultants for the construction period and the same is presented in the succeeding Figure 26.

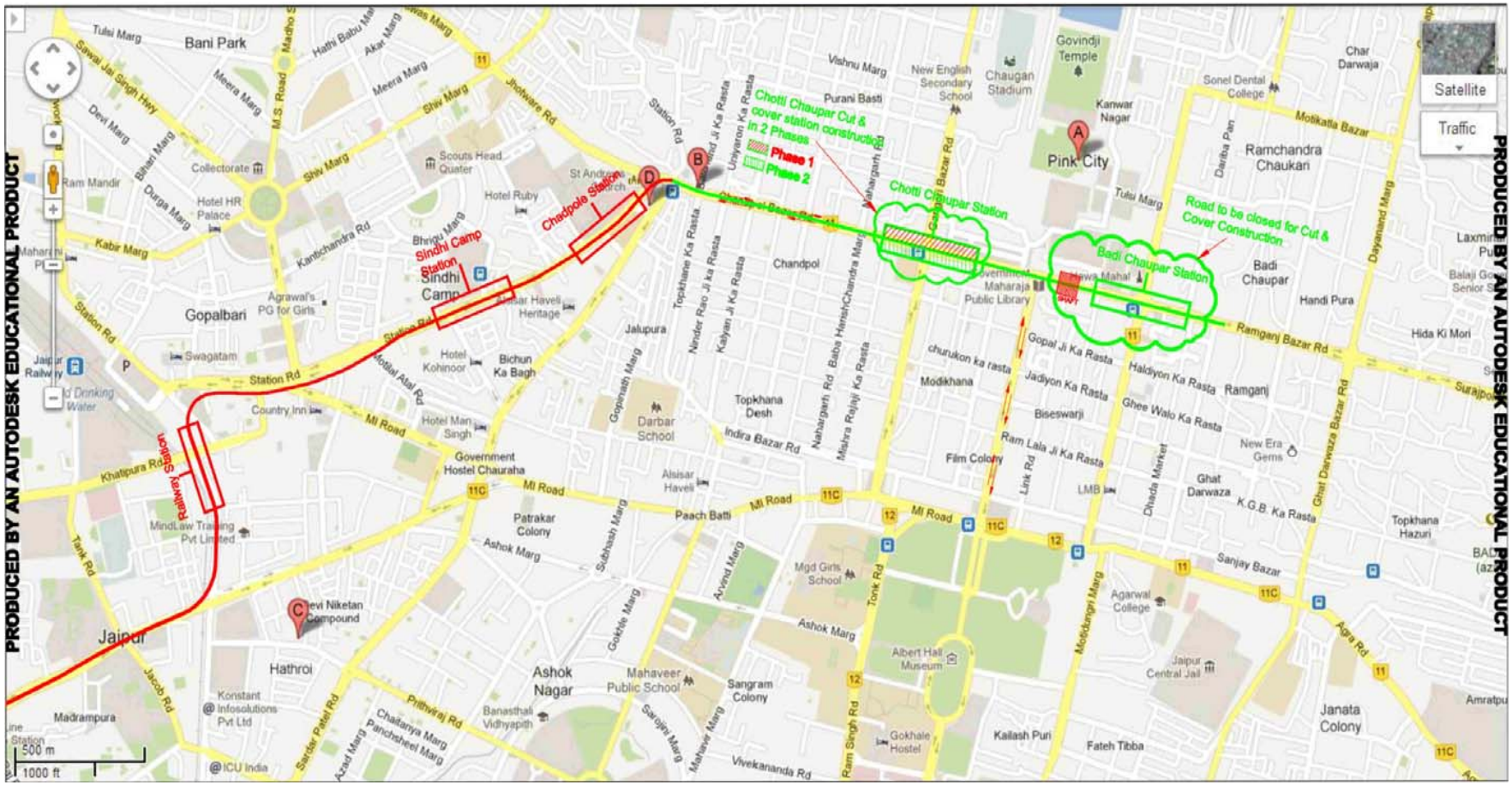


Figure 26: Proposed Traffic Diversion Scheme During Construction of Corridor Phase IB

4. Chance heritage finds during tunneling and cut-and-cover

193. Chandpole and Tripura Bazaar roads where the tunnels will be carved are the main road of the walled city where the main markets, havelis and temples were constructed by the state in the 18th century. Even the widths of the roads have intrinsic value, "the junctions of the main axial streets formed the two square public open spaces called chaupars (Badi chaupar and Chhoti chaupar). The width of the square chaupars was three times that of the main street. Historically, the chaupars were outlets for intense social use with water structures connected by underground aqueducts, supplying numerous sources of drinking water at street level. Presently, the centre of each chaupar has square enclosures with ornamental fountains.[21]"

194. It is very likely that artifacts are buried along the bazar road and valuable water conveyance structures under the Choupars that are worth preserving before the tunnelling and digging starts.

Mitigation Measures

195. At least 30 days before the start of tunneling, the Contactor with supervision from the Archeology Department will employ a ground penetrating radar (GPR), detect the presence of buried artifacts along the tunnel alignment.

196. The Contractor, in behalf of the JMRC, will coordinate with the Archeology Department to designate an on-site representative during the entire duration of the project.

197. All workers will undergo a briefing with the Archeology Department to ensure safeguarding of heritage resource and cultural/religious practices.

198. A proof of compliance to this requirement to include the name of participants and date and location of briefing will form part of the monthly report to the CSC.

199. The contractor will comply with the FIDIC Sec. 4.24 on Fossils. Recording (including chain of custody) will be made by the contractor to be validated by the CSC, and expert verification will be made by the Archeology Department. Temporary work stoppage in the immediate area of the chance find for up to 72 hours to allow for the on-site representative of Archeology Department to visit the site to make an assessment and provide instructions. Work in the areas adjacent to the chance find will continue as provided in the detailed design.

[21] Jain, Shikha (2011). "Walking Into the Microcosm of Jaipur." A Concept Paper. UNESCO and Government of Rajasthan Urban Development, Housing and Loal Self-Government Department

VII. ANALYSIS OF ALTERNATIVES

E. Need to Connect the Walled City to Outside Area

200. The JMRP is part of Jaipur Development Authority's Comprehensive Mobility Plan (CMP) which included motorized and non-motorized modes. The metro was conceived in recognition to the heavy reliance of the population to private buses as public transport. The bus system is inadequate and routes are unregulated causing confusion and congestion. Bus terminals are only located at Sindhi Camp and Transport Nagar with inadequate facilities with no intermodal connections. JDA has set the goal of public transport share at 50% of the total trips.

F. Need to Increase Public Transport Share

201. Jaipur's urban sprawl is limited by topography, where the eastern border is contrained by hills and most of the economic activities are taking place inside the walled city. In terms of physical development, Jaipur is divided in two: the walled city and outside the walled city. However, as one of the strategies being pursued of increasing public traport trips by road and rail from 31% to 48%, the following alternatives were considered.

Table 47: Alternatives Considered to Increase Public TRasport Share to 48%.

Alternatives	Description
Bus Augmentation	Rationalizatin of the bus route system, replace and modernize the bus fleet, and provide additional routes. Increase public transport share to 24%.
Commuter Rail/ Regional Rail Augmentation	Install dedicated lines and improvement in terminals every 1-2 kms along with access to terminals. Increase public transport share to 27%.
Bus Rapid Transit System	Increase the speed and capacity of public transportation by dedicated ransport corridors. Increase public transport share to 32%
Higher Order Mass Trans	Jaipur need several corridors with PHPDT greater than 7000 warranting the development of a high capacity public transport system as expected ridership from Ambabari to Durgapura and Badi Choupar to Mansorovar and Ambabari to Govindpura will reach 20000 PHPDT. Public transport modal share will increase to 48%.

G. Mass Transit Options

202. Within the mass transit option, several alternatives were also assessed, as provided in the succeeding Table 48.

Table 48: Mass Transit Options

Transit Mode	Metro	Monorail AGT	LRT	BRT
Station Spacing (Approx)	1-2 km	1 km	1.5 km	0.5 km
Vehicles	High platform cars operating in multiple car trains sets	High platform cars operating in multiple car trains sets, electric propulsion	Articulated, double articulated low floor can operate in multiple car sets, electric propulsion	Standard, articulated double articulated low or high platform cars diesel/hybrid propulsion, Electric Trolley Bus
Seated Capacity	60-80 Per Car	30-75 Per Car	65-85 Per Car	40 Standard 65 Articulated 85 double articulated
Passenger Throughput	Up to 40,000 PPHPD	Up to 15,000 PPHPD	Up to 30,000 PPHPD (Elevated LRT)	Up to 5,000
Min.Curve Radius	120 m	30 m	30 m	15 m
App O & M Cost per km	100-200 Lakhs	40-60 Lakhs	50-60 Lakhs	10 Lakhs
App Capital Cost per km	200 Crores	120 Crores	150 Crores	15 Crores
Implemented Cities (International)	Bangkok, Kuala Lampur, Mexico City, Cairo	Tokyo, Kuala Lampur, Sydney, Seattle	Hongkong, Shanghai, Kuala Lampur	Istanbul, Taipei, Bogota, Curitiba, Pitts Adelaide
Implemented Cities (India)	Delhi, Kolkata, Under implementation	Under Implementation in Mumbai	Kolkatta	Ahmedabad, Delhi

H. Design alternatives

203. The final alignment for the JMRC corridors have been finalised after taking into account environmental and social concerns, considerations of traffic, integration with the existing system and importantly, the overall economic and financial viability. The underlying principles for evaluation for each corridor, without affecting the overall usefulness of the corridor, are:

- Minimum private land acquisition,
- Least disturbance to properties,
- Minimum disturbance to people and
- Minimum disturbance to ecology/ biodiversity

204. A comparison of the scenario with Broad Gauge and Standard Gauge has been carried out and it has been decided that JMR corridors will be Standard Gauge (1,435 mm) for the following reasons:

- Metro alignments will pass through heavily built-up areas for optimal passenger utilisation and this imposes severe restrictions on the selection of curves. As in most of the cities in India no 'right of way' has been reserved for metro systems, the alignments have to follow the major arterial roads. These roads may often have sharp curves and right-angle bends. In such a situation adoption of Standard Gauge is advantageous since, it permits adoption of sharper curves compared to Broad Gauge to minimise property acquisition along the alignments.

205. The Standard Gauge has 1 in 7 and 1 in 9 turn-outs22, which occupy lesser length and are feasible compared to 1 in 8 ½ and 1 in 12 turn-outs required for Broad Gauge. Length of crossovers for Standard Gauge is thus lesser than for Broad Gauge. Land requirement for depots where a large number of lines connected together in the shape of ladder is also reduced. Standard Gauge is, therefore, more suited for use in built up environment where land availability is scarce.

206. For Standard Gauge, optimised state-of-the-art rolling stock designs are available 'off-the-shelf'. This is not so for Broad Gauge where new designs for rolling stock have to be specially developed which entails extra time and cost.

207. Because of the availability of a very large market, constant up-gradation of technology takes place for Standard Gauge coaches. Thus, upgraded technology is available on a continued basis in case of Standard Gauge. This is not so in case of Broad Gauge.

208. Once technology for Standard Gauge coaches get absorbed and a manufacturing base for them is set up in India, there will be considerable export potential for the coaches, since almost all the countries use Standard Gauge for their metros. This is not so in case of Broad Gauge.

[22] A railroad switch, turnout or *[set of]* points is a mechanical installation enabling railway trains to be guided from one track to another

VIII. PUBLIC CONSULTATION AND INFORMATION DISCLOSURE

209. Public consultation and participation is a continuous two way process, involving, promoting of public understanding of the processes and mechanisms through which developmental problems and needs are investigated and solved. The public consultation, as an integral part of environmental and social assessment process throughout the project preparation stage not only minimizes the risks and unwanted political propaganda against the project but also abridges the gap between the community and the project formulators, which leads to timely completion of the project and making the project people friendly.

210. Therefore, keeping in mind the above objective public consultation with the people of different sections of the society along the project alignment, shopkeepers, and influential persons of the project area were made. Moreover, potential vulnerable people like, squatters, encroachers, schedule caste and other backward section (OBC) of society are also consulted with the aim to make people aware and identify adverse impacts of the project.

211. The consultation process in the project started early with the start up of Phase IA corridor that has a number of issues relating to land acquisition, rehabilitation of affected persons, structures. JMRC held extensive consultation with the local community to appraise them on the project benefits, resettlement and rehabilitation measures in the project, redressal of grievances etc.

212. Besides the local community, consultations were held on 13 May 2013 with the officials of Department of Archaeology, GoR to assess the concerns relating to protected monuments/heritage sites within the project area and statutory as well as remedial measures required for the project. Consultations were also held with the officials of Forest Department, GoR for the compensatory afforestation requirements.

A. Consultation with Stakeholders

213. As required for Category A projects, consultations were conducted at the early stage of EIA preparation, mostly involving local communities and organizations. Successive consultations are being conducted by the JMRC after the initial drafting of this report which included representatives of local communities and national entities tasked with the regulation of the road development and environmental protection. These consultations were also undertaken in compliance with the GoI environmental policies and rules and in coordination with relevant institutions described in Chapter 3.

B. Compliance with Regulatory and Funding Agency Requirement

214. As per Indian Environmental Regulations, public hearing is not required, as railway projects do not attract EIA Notification 2006, amended 2009.

215. The meaningful consultation was undertaken in consistent to the ADB requirements. All the five principles of information dissemination, information solicitation, integration, co-ordination and engagement into dialogue were incorporated in the consultation process. A framework of different environmental impacts likely from the project was strengthened and modified based on opinions of all those consulted, especially in the micro level by setting up dialogues with local people from whom information on site facts and prevailing conditions were collected.

C. Consultation with Executing Agency

216. The officials of executing agency provided technical information about the project. All issues related to effective implementation of EMP, grievance redress mechanism, various clearances/consent and permission required prior to and during implementation were discussed.

D. Details of Consultation

217. The project corridor Phase IB passes through the old city area predominated by the traditional commercial activities. Consultations were held with the local business community at Chhoti and Badi Choupar on 12th May 2013 for their active participation in the project implementation. Details including attendance sheet of the participants and photographs of consultations are shown in Figures 27 and 28.

E. People's Perception and their Adaptability

218. The project has received acceptability among the local people as it will provide smooth flow of traffic and reduce travel time and fuel consumption and subsequently air emissions. The project will bring positive socioeconomic changes in the area. Aiming at building confidence and good rapport among the potential affected people and to incorporate their feasible needs and suggestions, the project authorities formed a negotiation Committee for settling the outstanding issues of the affected persons. The detailed facts and perception of both the likely affected persons (APs) and other stakeholders are given below:

- It has been observed that by and large all the stakeholders involving local people, affected persons and other stakeholders are aware of the project.
- Local people showed happiness during public consultations as the project will provide hassle free movement in the congested part of the city.
- Local people requested that suitable mitigation measures should be taken to mitigate the adverse environmental impacts during the construction period due to shifting of utilities, movement of heavy equipments and noise pollution etc.
- Suitable safety measures should be taken in the project during construction and operation phases. .
- During construction phase, traffic management is a big issue therefore, traffic on the roads should be managed in such a way that it should not cause congestion of traffic and accidents during construction phase.
- Construction labour camps should not be located near the core city area that is frequented by the tourists.

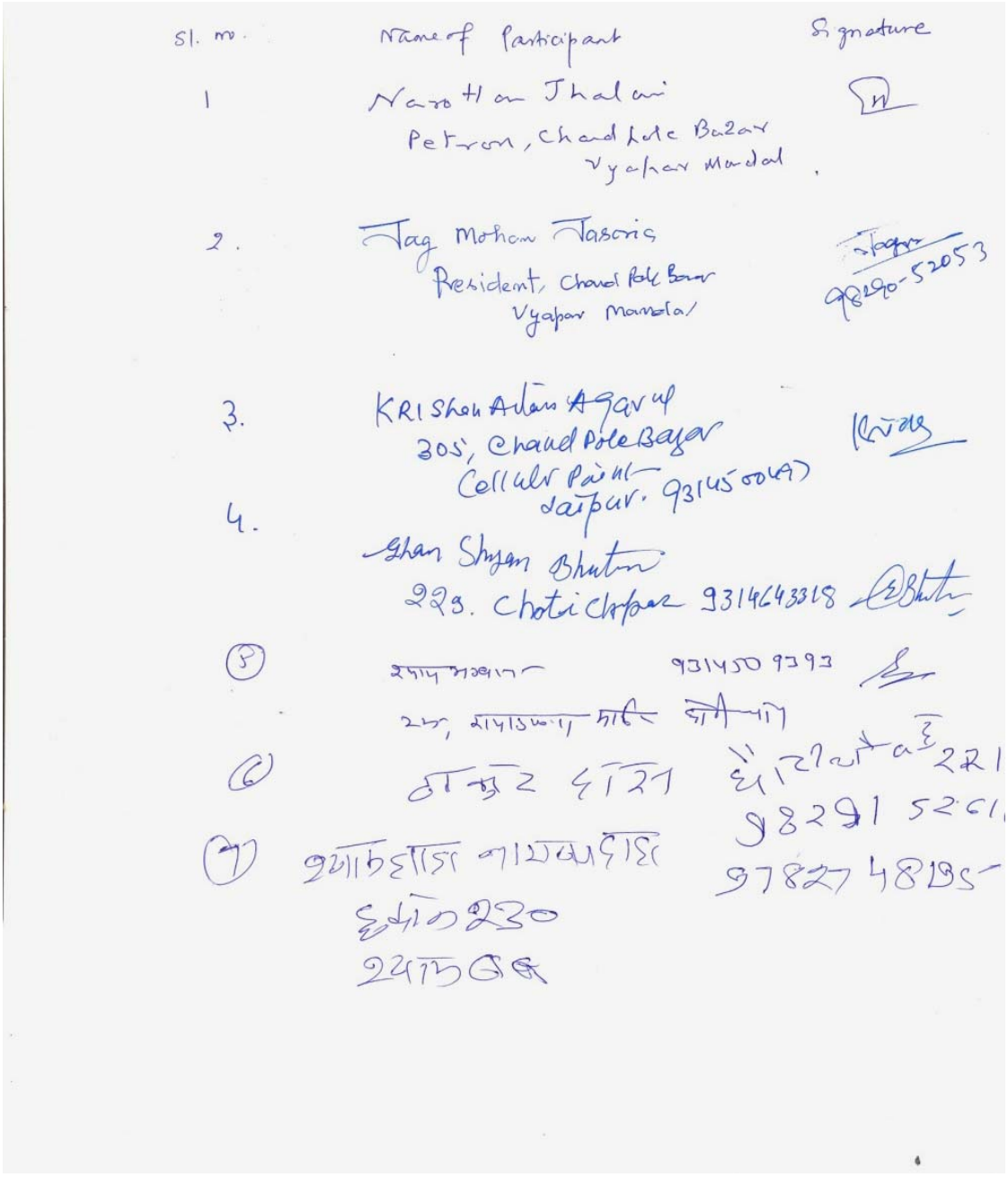
Figure 27: Public Consultation
Place: Badi Choupar
Date: 12th May 2013, Time – 4.30 PM

List of Participants

Sl. no.	Name	Signature
(1)	Sh. Trilok Chand Agarwal 188, Johri Bajar M/s Gopiram Deulal, Jaipur	9829052155
(2)	Sh. Rajkumar Wadhwani 71, M/s Ananyki & Co. Johri Bajar Jaipur	94140-42171
(3)	Mr. Sanjay Lukhadia. M/s Vandanam. 5, Khanda Hawa Mahal Badi Chopad Jaipur. Ph. 0141-2615839,	9414992861
(4)	Lalit Narain GOYAL M/s Moghalal Ramgopal. 180, JOHARI BAZAR JAIPUR.	9460387941
(5)	Sh. Mahesh Chand Gupta, 184, M/S Gyarsilal Omprakash Johri Bazar	9460473486

Figure 28: Public Consultation
Place: Chhoti Choupar
Date: 12th May 2013, Time – 3.30 PM

List of Participants



Sl. no.	Name of Participant	Signature
1	Narottam Jhalani Patron, Chandpole Bazar Vyapar Mandal.	
2.	Jag Mohan Tasoria President, Chandpole Bazar Vyapar Mandal	98290-52053
3.	Krishan Adam Agarwal 305, Chandpole Bazar Cellular Point Jaipur. 9314500497	
4.	Ghan Shyam Bhutra 229. Chotichopar 9314643318	
(5)	9314500393	
(6)		
(7)	9782748295	

(8) श्री राम मार्केटिंग
224 होलसेलर्स, अमरुत
9820160157

(9) मीना हौसिंग कम्पनी
225/ राधाकृष्ण मार्केट
राधारमण अग्रवाल
9352203596

(10) गोपाल स्टोर
225/ राधा कृष्णा मार्केट
गोपाल अग्रवाल
9950140028

PHOTOPLATES OF CONSULTATION AT OTHER LOCATIONS ALONG THE E-W CORRIDOR







METRO

Stakeholder Consultation Meeting
Date: 4/6/2013 Time: 1500 hrs.
Venue: Conference Hall - JMRC

The meeting was convened by JMRC to discuss the draft Environmental Impact Assessment Report and seek opinion and suggestions from key stakeholders on the proposed Phase 1B corridor. Participants in the meeting included JMRC officials, prominent citizen's, representatives from traders association, NGOs working in the field of women and children welfare, related government departments viz. PHED, Housing Board, Archaeology, State Pollution Control Board, Police, Jaipur Development Authority, Project Management Consultants, Contractors working on the Metro Project etc. List of Participants is provided herewith.

Points discussed during the meeting and the opinion/suggestions received are as under:

Sl No.	Participant/ Representative	Opinion/Suggestion	Remarks
1	Deptt. of Archaeology, GoR	• Detailed noise and vibration studies should be carried out by JMRC before applying for permission from Archaeology Department for the project	Noise monitoring has been done at selected locations on the alignment. Vibration studies will be carried out.
2	RSPCB	• Proper Disaster Management Plan should be in place. • Specific site conditions of Delhi and Jaipur may not be same. Site specific study must be done to assess the impact of noise and vibration on the old structures. • Although the project does not need EC clearance, care should be taken for waste water disposal from the depot, type of equipments to be used like DG set etc. • RSPCB should be consulted in finalizing the EIA and Mitigation plans.	Disaster Management Plan is part of the design Site specific noise monitoring already done. Studies. Vibration studies will be carried out. The project provides for waste water treatment before disposal from the maintenance depot. Only low noise DG sets are in use. Extensive consultation with various stakeholders have been carried out in the project. The EIA document will be disclosed in the website.
3	Housing Board	• JMRC should study whether there are other routes/ alternatives where metro route should be constructed than the old walled city. • Parking should be provided near the stations.	The route alignments have been finalized after a detailed feasibility study and analysis of alternatives. It is planned to provide parking at selected stations depending on land availability.

Sl No.	Participant/ Representative	Opinion/Suggestion	Remarks
3	Housing Board (Contd.)	• Integration of the metro with other modes of transport should be studied in detail	Provision of facilities for integration of the metro stations with BRTS is already in the plan.
4	Civil society	• JMRC should ensure that after construction is over, the land under metro elevated section is not encroached by people. • Debris should be properly cleared after the construction is over	JMRC will coordinate with JDA and other related agencies in this matter. This is a condition in all contracts and JMRC will monitor this aspect.
5	NGO (Human Settlement Technology Center)	• How much impact expected in terms of removal of people and demolition of properties for constructing the stations? Adequate provisions should be provided for their resettlement.	Only 8 nos. shops were impacted for Chandpole station. No other private land or structure will be affected for the construction of Phase 1B corridor.
6	JDA (Jaipur Development Authority)	• Load on infrastructure will increase due to more floating population. Overall plan for infrastructure provision should be reviewed to ensure that the provisions are adequate.	Project design has taken care of the infrastructure requirements and additional facilities have been provided wherever required like waste water treatment in the depot etc.
7	Police	• How much parking space is being provided? Proper plan should be in place for reaching and dispersal from the metro stations. Chaos should not be created at the Choupars by the para-transit modes to bring and taking away passengers to/from the stations.	There is plan in place for proper entry and exit from the stations. It is planned to provide parking at selected stations depending on land availability.
8	PHED (Public Health Engineering Department)	• Proper plan to be in place for shifting utility lines. Adhoc plans/ arrangements to address the issues locally reduce efficiency of piped infrastructure like water supply due to more bends in the network. In old city area, the main water supply line is under the road median. For constructing the stations, these will be disturbed.	Before construction starts JMRC will identify utility structures that will get affected and discuss shifting plans with the concerned department/ authority

JAIPUR METRO

JAIPUR METRO RAIL CORPORATION LIMITED
(A Government of Rajasthan Undertaking)
Khanij Bhawan, Tilak Marag, C-Scheme, Jaipur-302005
Tel. No. 0141- 2385790

Ref. No. : F7(D-4)/JMRC/EIA/2011/1242-58 Date: 31.05.2013

Meeting Notice

A Meeting to discuss the draft Environmental Impact Assessment (EIA) report of the Jaipur Metro Rail Project Phase-I B will take place on 4th June, 2013 at 3.00 PM in the Board Room of JMRC (located at III floor , Khanij Bhawan, Tilak Marg,C-Scheme, Jaipur). The main purpose of the meeting is to present the findings of the draft EIA to all the key stakeholders and solicit feedback and advise for improvements.
Please find enclosed the meeting agenda for your information

Following are requested to please nominate the concerned representative from your office.

1. Commissioner, Rajasthan Housing Board, Jaipur
2. Secretary, Jaipur Development Authority, Jaipur
3. Director, Woman & Child Development, Jaipur
4. Member Secretary, Rajasthan State Pollution Control Board, Jaipur
5. Dy. Commissioner(Traffic), Jaipur
6. C.E.O., Nagar Nigam, Jaipur
7. Director, Archaeology Department, Jaipur
8. Chief Engineer, PHED, Jaipur
9. Chief Project Manager, DMRC, Jaipur
10. Dy.Conservator of Forest, Jaipur
11. Sh. Vijay Singh Nemiwal, ITS, DGM, BSNL Jaipur
12. Contractors (C1-C7) working in Phase-I A through DMRC, Jaipur.
13. Chairmen, Chandpole Shopkeepers Association
14. Representatives from 22 Godam Association through RIICO.
15. Mrs. Neeraj Khanna (NGO), Human Settlement Technology Centre
16. Mr. Vijay Singh Poonia, Advocate

(R.C.Sharma)
GM (Administration)

JAIPUR METRO RAIL CORPORATION LIMITED
(A Government of Rajasthan Undertaking)
Khanij Bhawan, Tilak Marg, C-Scheme, Jaipur-302005
Tel. No. 0141- 2385790

Ref. No. : F3(D-4)/JMRC/EIA/2011/1242-58 Date: 31.05.2013

Copy to:

1. P.S. to Commissioner, Rajasthan Housing Board, Jaipur
2. P.S. to Secretary, Jaipur Development Authority, Jaipur
3. P.S. to Director, Woman & Child Development, Jaipur
4. P.S. to Member Secretary, Rajasthan State Pollution Control Board, Jaipur
5. P.S. to Dy. Commissioner(Traffic), Jaipur
6. P.S. to C.E.O., Nagar Nigam, Jaipur
7. P.A. to Director, Archaeology Department, Jaipur
8. P.A. to Chief Engineer, PHED, Jaipur
9. P.A. to Chief Project Manager, DMRC, Jaipur
10. Dy.Conservator of Forest, Jaipur
11. Sh. Vijay Singh Nemiwal, ITS, DGM, BSNL Jaipur
12. Contractors (C1-C7) working in Phase-I A through DMRC, Jaipur.
13. Chairmen, Chandpole Shopkeepers Association
14. Representatives from 22 Godam Association through RIICO.
15. Mrs. Neeraj Khanna (NGO), Human Settlement Technology Centre
16. Mr. Vijay Singh Poonia, Advocate
17. GM(PC), Incharge Environment Cell/DD(P)/DGM(CM)/Manager(Civil)/05.06.2013
18. PRO, JMRC to invite 2-3 Media Persons in the meeting.

C.C.also to- *Mr. Kar,ADB in reference to his e-mail dated 30.05.2013.*

GM (Administration)

Meeting Agenda

3.00 PM - 3.45PM	Welcome Address and brief about the project by JMRC.
3.45 - 4.15 PM	Presentation on ADB's Safeguard Policy Statement by Mr.P.K.Kar.
4.15 - 4.45 PM	Presentation of the draft EIA by Mr.P.K.Kar.
4.45 - 5.45 PM	Open forum conducted by JMRC PRO.
5.45 PM	Concluding remarks by JMRC.

ATTENDANCE SHEET

Meeting Date: 04.06.2013

Sr. No.	Name & Designation	Department/Company	Mobile	E-mail	Signature
1.	Lalit Kumar Sharma DY CE. PMIJPIS.	D.M.R.C.	9571746111	LKSharma.24@gmail.com	
2.	R.C-Sharma	GmCAdm/	9667556704	jmrc.gmadm@gmail.com	
3.	S.C. Gupta	ACE NNJ	9829405609	sethankgupta2008@yahoo.com	
4.	Alok Khandelwal	Dainik Bhaskar	9672977707	aaa.alok@yahoo.co.in	
5.	Ravi Mohan Mathur	JMRC Ltd.	9667556715	ravimathur@jmrc.com	
6.	K.M.Meena	BSNL	9414001760	dectsmplg@gmail.com	
7.	Rajendra Kandpal	JTO JTO (Gen) JV	9414793426	Rkandpal240@yahoo.com	
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9	L.K. Gaur	ACF JPR	9829823577	dfosouthjpr@gmail.com	
10.	Umrao Singh	Archaeology and Museums JP	9929142476	museum.rajasthan.gov.in	
11.	Vivek Sharma FE JDA	J.D.A	9414066198	Vivjda@gmail.com	
12.	P.K. Kar.	Staff Car Driver	9899131243	pkumarkar@gmail.com	
13.	V.S. BRIJVASI	RAJ. STATE POLLUTION CONTROL BOARD	9414163961	brijvasi.vs@gmail.com	
14.	Madan Raj Singh Chauhan	Dy.Mgr (Civil) JMRC.	9460479578	madanrajsingh@jmrc.com	
15.	J.P. Sharma	Dy. Director Proj. JMRC	9667556713	jmrc.project@gmail.com	
16.	Manmohan Harsh	PRO, JMRC	9667556788	jmrc.pro@gmail.com	
17.	Dinesh Sharma	SE PHED city	9414059944	phedsecfor_phed@yahoo.co.in	
18.	Rameshwar lal.	ACP. Traffic South.	9414279855		
19.	V.S. Porwal	Advocate	9829054148		
20.	Meera Khanna	NGO	9314422722	hstc@rediffmail.com	
21.	Damodar Agrawal	Shopkeeper.	9314932056		
22	SIRAJ AHMAD	Shop Keeper	9829050593		
23.	D.S JOHAR	Shop Keeper	9414058529		

IX. ENVIRONMENTAL MANAGEMENT PLAN AND GRIEVANCE REDRESS MECHANISM

219. The environmental impacts associated with any development project are eliminated or minimised to an acceptable level through development of appropriate mitigation measures based on most suitable techno-economic options. The Environmental Management Plan (EMP) is a well established tool to ensure effective implementation of the recommended mitigations measures throughout the subsequent project development stages. The EMP also ensures that the positive impacts are conserved and enhanced. An EMP provides location and time specific actions to be taken with defined responsibility. It also provides measures for institutional strengthening and effectiveness assessment through defined monitoring plan, reporting and corrective & preventive action planning.

A. Environmental Management Plan

220. The plan outlines existing and potential problems that may adversely impact the environment and recommends corrective measures where required. Also, the plan outlines roles and responsibility of the key personnel and contractors who are charged with the responsibility to manage the proposed metro corridor. The EMP is generally:

- Prepared in accordance with rules and requirements of the Ministry of Environment and Forests (MoEF) and the Central Pollution Control Board (CPCB);
- To ensure that the component of facility are operated in accordance with the design;
- Process that confirms proper operation through supervision and monitoring;
- System that addresses public inconvenience during construction and operation of the facility; and
- Plan that ensure remedial measures are implemented immediately.
- The key benefits of the EMP are that it provides the organization with means of managing its environmental performance thereby allowing it to contribute to improved environmental quality. The other benefits include cost control as improved relations to the stakeholders.

221. The project specific Environment Management Plan has been formulated which consists of a set of mitigation; monitoring and institutional measures applicable to design, construction and operation stages of the project (Annexure - D). The components of this EMP includes (i) mitigation of potentially adverse impacts (ii) monitoring of impacts and mitigation measures during project implementation and operation (iii) institutional capacity building and training (iii) compliance to statutory requirements (iv) integration of EMP with project planning, design, construction and operation.

B. Environmental Monitoring Plan (EMOP)

222. The purpose of the environmental monitoring program is to ensure that the envisaged objectives of the project are achieved and result in desired benefits. To ensure the effective implementation of the mitigation measures and Environmental Management Plan (EMP), it is essential that an effective monitoring program be designed and carried out. The board objectives of environmental monitoring plan are:

- To evaluate the performance of mitigation measure proposed in the EMP,
- To evaluate the adequacy of Environmental Assessment
- To suggest improvements in management plan, if required,
- To assess change in environmental quality,

C. Environmental Monitoring Plan

223. A comprehensive monitoring plan has been prepared for all stages of the project (Annexure E). This includes parameters to be measured, methods to be used, sampling locations, frequency of measurements, detection limits, cost and responsibility for implementation and supervision.

a. Institutional Setting and Proposed Implementation Arrangement for EMP Implementation

224. The succeeding Figure illustrates the functional relationship between the principal agents in implementing the EMP and EMOP.

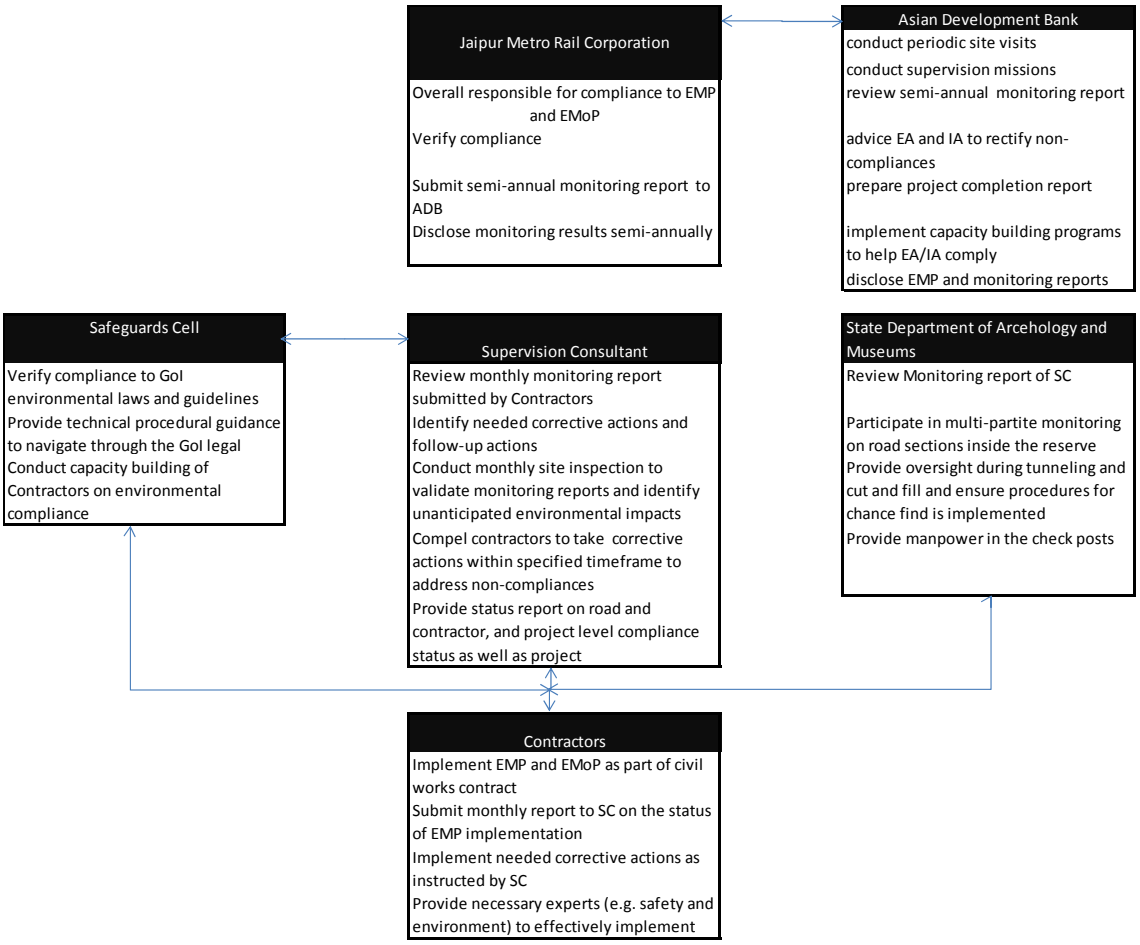


Figure 27: Institutional Arrangement to Implement the EMP

225. The Supervision Consultant's team will include a heritage expert who will monitor the heritage sites above ground on a monthly basis during construction and early stages of operation. In case of any type of damage to the heritages structures the heritage expert will immediately alert JMRC, the contractor and with the advice of the Archaeology Department prepare a restoration plan to address the damage.

B. Grievance Redress Mechanism

226. Grievances related to the implementation of the project, particularly regarding the environmental management plan will be acknowledged, evaluated, and responded to the complainant with corrective action proposed. The High powered Committee formed during construction of Phase IA would perform the role of GRC. Nodal officer will interact with CGM as required to resolve the concern. Provision shall be made for lodging the concerns at JMRC website also. Nodal officer will be the focal point for resolution of complaints received through GRC or Web site or directly and communicating back the action taken to complainant. Nodal officer will also coordinate with GRC, summarised them about complaints received and resolution made. Nodal officer may refer a complaint to GRC for resolution. The Nodal officer would ensure faster resolution of any complaint received. The GRM framework is shown in the succeeding Figure 28. The name and contact details of Nodal officer, and JMRC web site shall be displayed prominently within the project area.

227. As per experience during construction of the elevated section, all the grievances have been adequately redressed. The grievances were primarily related to land ownership as revenue records are not regularly updated. Jaipur being an old city, there were issues relating to unauthorised of properties, non-permitted uses etc. Some small scale industries operating within residential areas that got affected due to metro alignment and other metro activities have been shifted there by improving the local environment. As the GRC members are operating from the same office premises headed by high power officials, none of the grievances remained unattended to and were resolved within a month’s time. The same practice would continue during the construction of Phase IB corridor.

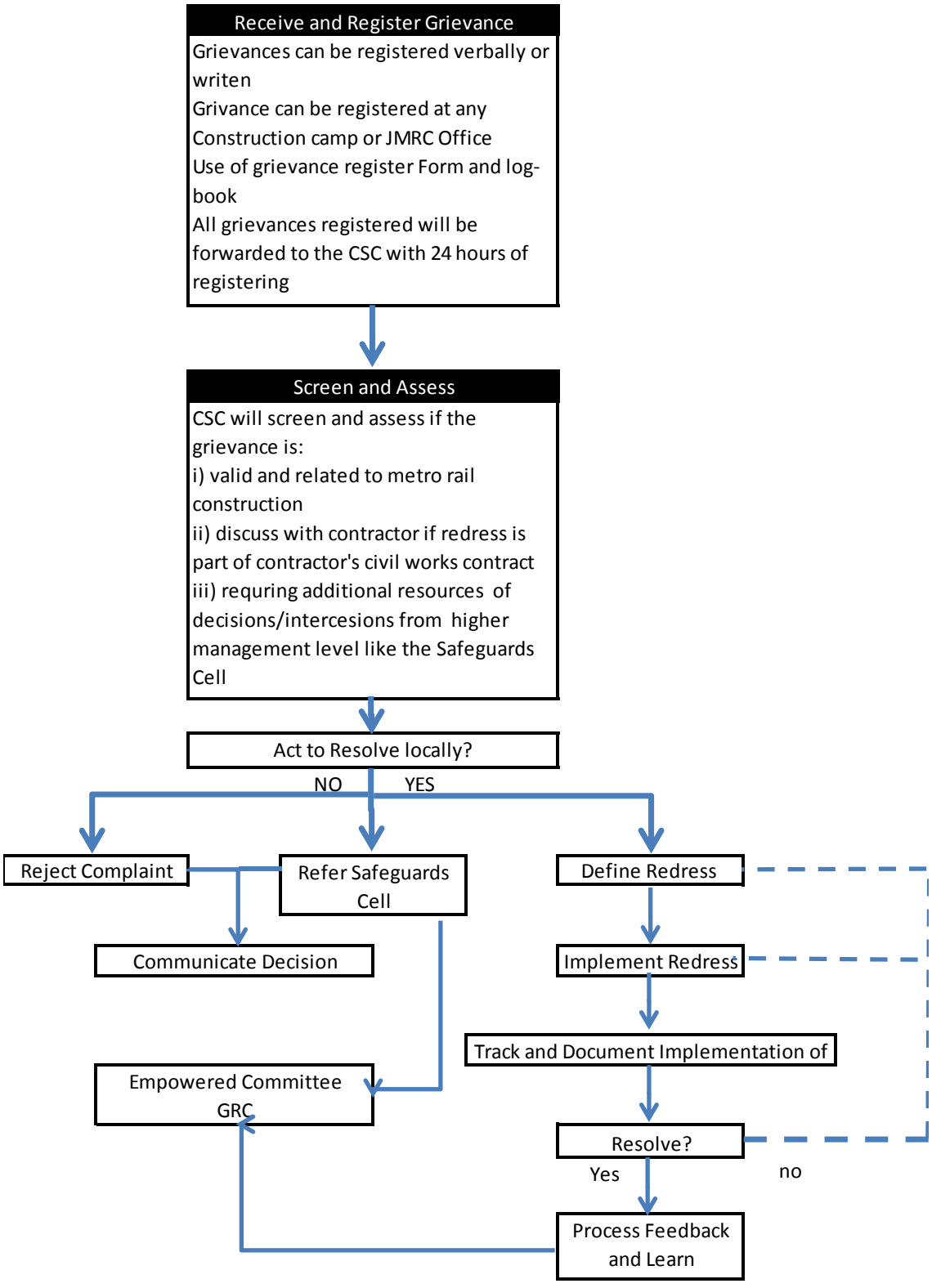


Figure 68: Grievance Redress Mechanism

X. CONCLUSIONS AND RECOMMENDATIONS

228. The Jaipur Metro Rail Corporation is currently implementing the east-west corridor of the Jaipur Metro Rail Project from from Mansorovar to Badi Choupar referred to as Phase 1. Phase I has an elevated portion (9.278 km) known as Phase IA and at present is under final stage of construction with Government of Rajasthan (GoR) funding from Mansarovar to Chandpole including the underground station at Chandpole. The underground section of this corridor i.e. Phase IB from Chandpole to Badi Choupar has a length of 2.628 km and will have 2 underground stations, Choti and Badi Choupars and proposed for funding by the ADB.

229. The project is one of the key components of the Comprehensive Mobility Plan, the city's transport master plan, to ensure Jaipur City will have high class sustainable and efficient transport that will enhance tourism and meet the needs of economic development. The project benefits are wide ranging and include improvement in employment opportunities, enhancement of the economy, mobility, safety, and reduction in traffic congestion, fuel consumption, air pollution, greenhouse gases, and saving in road infrastructure. The decision to build an underground metro under the walled city avoided significant adverse impacts associated with linear development.

230. The project is classified environmental category "A" in accordance with Safeguard Policy Statement 2009 requiring preparation of environmental impact assessment report. The category A rating was based on the presence of significant physical cultural resources namely the Jantar Mantar, located 80 meters from the tunnel centerline is a UNESCO World Heritage site and Arcehological Survey of India (ASI) protected archaeologically important monument or cultural heritage site. Other physical cultural resource (PCR) are the Chandpole Gate, Krishna Temple, Hawa Mahal and Isarlat falls at a distance of around 90m and have been declared as protected monuments under the Rajasthan Monuments, Archaeological Sites and Antiquities Act, 1961.The environmental screening has been carried out as per ADB Safeguard Policy Statement (SPS) 2009.

231. The significant impacts that are attributable to projet construction included: vibration and ground settlement near identified PCRs, surface noise from excavation equipment near Choti and Badi Choupars, chance find of artifacts, demolition and restoration of the Choupars for the construction of stations, spoil disposal, groundwater extraction, disruption of essential services, occupational and community health and safety, and clean-up and restoration prior to decommissioning.

232. Impact evaluation indicated the natural attenuation of sandy soil and vibration and noise reduction design considered for the rail and train will not result to elevated vibration levels that will cause cosmetic or structural damages to the PCRs. The predicted ground settlement under the the Chandpole gate due to tunnelling is minimal by engineering design standards. To ensure the Contractor maintains vibration and noise levels, monitoring coupled with trigger and allowable values were incorporated in the bidding documents. Ambient noise levels are already beyond national standards. The additional noise that will be generated by the construction works during construction will be minimal in comparison. Stringent noise control devices such as mobile and fixed noise barriers and the good construction practices will be enforced to minimize issues related to noise. The Choti and Badi Choupars will be demolished to allow the construction of the underground metr station and wil be restored to its original state under the supervision of of the Rajasthan Department of Archeology and Museums. Spoils disposal will be implemented in an environmentally sound manner. Comprehensive measures were incorporated in the bidding documents to promote occupational and community health and safety. Water conservation during construction will be strictly implemented by the CSC.

233. To protect chance find of artifacts during construction phase, JMRC will hire the services of an archaeologist as part of the CSC. The Contractor 30 dyas prior to tunnelling and cutting will conduct a non-invasive ground penetratin radar to indeintify the presence of these artifacts under ground and the result of which will be discussed with the Rajathan Department of Archeology and Museums for possible retrieval.

234. During operation, vibration and noise monitoring will continue as a regular program of the JSRP Safeguards cell to ensure PCRs are protected from the metro operation.

235. In general, the project received immense support from local people. The local people appreciated modernization of public transport and its ability to handle large amount of passengers.

236. The environmental assessment of the project indicated that the significant adverse impacts can be mitigated and is unlikely to cause any significant residual environmental impacts. The Executing Agency shall ensure that EMP and EMOP is included in Bill of Quantity (BOQ) and forms part of bid document and civil works contract. The same shall be revised if necessary during project implementation or if there is any change in the project design and with approval of ADB.

Annexure 1: Rapid Environmental Assessment Checklist

Instruction

(i) The project team completes this checklist to support the environmental classification of a project. It is to be attached to the environmental categorization form and submitted to the Environment and Safeguards Division (RSES), for endorsement by Director, RSES and for approval by the Chief Compliance Officer.

(ii) This checklist focuses on environmental issues and concerns. To ensure that social dimensions are adequately considered, refer also to ADB's (a) checklists on involuntary resettlement and Indigenous Peoples; (b) poverty reduction handbook; (c) staff guide to consultation and participation; and (d) gender checklists.

(iii) Answer the questions assuming the "without mitigation" case. The purpose is to identify potential impacts. Use the "remarks" section to discuss any anticipated mitigation measures.

Country / Project Title: India: Jaipur Metro Rail Project (Phase I B)

Sector Division*:* Transport Sector

Screening questions	Yes	No	Remarks
A. Project Siting Is the project area adjacent to or within any of the following environmentally sensitive areas?			
Cultural heritage site	X		Jantar Mantar, located 80 meters from the tunnel centerline is a UNESCO World Heritage site and Arcehological survey India (ASI) protected archaeologically important monument or cultural heritage site. Other physical cultural resource are the Chandpole Gate, Krishna Temple, *Hawa Mahal* and *Isarlat* fall at a distance of around 90m and have been declared as protected monuments under the Rajasthan Monuments, Archaeological Sites and Antiquities Act, 1961.
Wildlife Protected Area		X	No wildlife-protected area is located close to the alignment and nearby (assessment made up to 10 Km) area.
Wetland		X	No protected or classified wet land is located close to the project alignment..
Mangrove		X	Project road is not located in Coastal Area
Estuarine		X	No Estuary is located in the project area.
Buffer zone of protected area		X	No such area is located in the project vicinity.
Special area for protecting bio-diversity		X	No such area is located in the project vicinity.
B. Potential Environmental Impacts			
Encroachment on historical/cultural areas; disfiguration of landscape by embankments, cuts, fills, and quarries?		X	The topography of the project area is mainly plain. There is no encroachment of historical places. Opening of New Quarries is not envisaged. Only operational and licensed quarry will be used for sourcing materials for the

Screening questions	Yes	No	Remarks
			project
Encroachment on precious ecology (e.g. Sensitive or protected areas)?		X	There is no National Parks, Wild Life Sanctuaries or any other similar eco-sensitive areas in and around the project area. Only cutting of few trees is involved. Attempts have been made to minimise the cutting of trees.
Alteration of surface water hydrology of waterways crossed by project alignment, resulting in increased sediment in streams affected by increased soil erosion at construction site?		X	The proposed metro alignment (JMR Phase IB) does not cross any surface water body. Some drains (nalas) are located close to the project alignment.
Deterioration of surface water quality due to silt runoff and sanitary wastes from worker-based camps and chemicals used in construction?		X	Adequate sanitary facilities will be provided at construction camps, which will be set-up away from habitat and water bodies. No harmful ingredients are likely to be used in the construction activities. As such, no impact on surface water quality is anticipated due to construction.
Increased local air pollution due to rock crushing, cutting and filling works, and chemicals from asphalt processing?	X		Localised air pollution level is likely to increase for short duration during construction period due to construction vehicle movement and asphalt processing. The asphalt mixing plant (hot mix plant) will 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?	X		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 blasting and other civil works?		X	No blasting is involved. No significant noise generation is expected during construction activities except normal construction equipment's operational noise. These noise levels will be impulsive in nature and its impact will be confined within few meters of either side of the project alignment. All stationary noise making sources equipment like DG set, compressors will be

Screening questions	Yes	No	Remarks
			installed with acoustic enclosures. Provision of noise berries will be made wherever noise level is likely to increase beyond the prescribed ambient noise levels
Dislocation or involuntary resettlement of people	X		The project-affected persons are expected to be very less as the metro corridor will generally follow the road medians and underground tunnelling has been proposed in the old city area. There will be need for small land acquisition near Chandpole. This aspect will be addressed as per Govt. rules and ADB‟s Social Safeguard Policies (SPS-09) separately.
Dislocation and compulsory resettlement of people living in right-of-way?	X		Displacement of 8 shops are expected at Chandpole. Compensation as per Govt. rules and alternate site for shops have been provided for the displaced persons.
Disproportionate impacts on the poor, women and children, Indigenous Peoples or other vulnerable groups?		X	No such impact is anticipated.
Other social concerns relating to inconveniences in living conditions in the project areas that may trigger cases of upper respiratory problems and stress?		X	No such social concern is expected. Concern may arise during construction stage due to increase in ambient air pollution level, which is expected to be localised and temporary in nature. This aspect will be effectively controlled with the proposed dust suppression and other mitigation measures.
Hazardous driving conditions where construction interferes with existing roads?	X		Hazardous driving condition may arise around construction areas. To minimize the impact suitable traffic management plan will be designed and implemented by the contractor to prevent any hazardous driving condition in above situations.
Poor sanitation and solid waste disposal in construction camps and work sites, and possible transmission of communicable diseases from workers to local populations?		X	Proper provisions for sanitation, health care (drinking water supply and periodic health check-ups) and solid waste disposal facilities will be made at each construction camp. Awareness will be created amongst the workers about hygiene and health protection.
Creation of temporary breeding habitats for mosquito vectors of disease?		X	No such condition is anticipated.
Accident risks associated with increased vehicular traffic, leading to accidental spills of toxic materials and loss of life?		X	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	X		Increase in noise and air pollution is

Screening questions	Yes	No	Remarks
resulting from traffic volume?			expected during construction phase but is likely to be confined within few meters of either side of the project alignment. Adequate mitigation measures will be adopted to minimise the same. During operation stage, metro will provided 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?	X		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)?		X	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?		X	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?		X	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 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.		X	No such impacts are anticipated. Adequate awareness will be created amongst people and workers through information disclosure, safety signage and public consultation about safety aspects.

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		X	The project area is located in a semi-arid region on the fringe of the Thar desert in Rajasthan and as per BIS categorization falls in Zone II indicating 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		X	The proposed project for funding will be underground. The project design has been based on projects already in operation in other cities in similar climatic conditions.

sustainability (eg. increased erosion or landslides could increase maintenance costs, permafrost melting or increased soil moisture content could affect sub-grade).			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 (eg., high incidence of marginalized populations, rural-urban migrants, illegal settlements, ethnic minorities, women or children)?		X	No such condition exists or anticipated. The project location is within the densely developed old walled city with limited open spaces to encourage emergence of illegal settlement, rural-urban migration etc.
• 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)?		X	No such condition is anticipated.

Annexure 2: ADB Climate Change Risk Screening

Date: 2013-02-08

Project Information				
Project Title	**Country/Province**	**Sector/Type**	**Modality**	**Stage**
Jaipur Metro Rail Project	India/Rajasthan	Transport & ICT	Loan/TA	Concept Paper
Rapid Screening of Natural Hazards				
Type	**Risk/Score**	**Evaluation**	**CC Implications**	**Maps**
Earthquake	None		N/A	
Landslide Triggered by Earthquake	None		N/A	
Landslide Triggered by Precipitation	Low	Annual total precipitation is about 650mm, and slopes are averaged at 1 degree therefore the threats of landslide are low	Risk is likely to escalate due to projected increase in precipitation by 2050s. The risk level may not escalate due to the relatively flat terrain	Map1
Fire	None	The risks of wild fires are low because of the urban/built environment		
Flood	Low/Medium	On the 1km global estimated index of flood hazard map, the city is free of flood hazard. This is primarily due to the low spatial resolution of the dataset. In addition, the map does not seem to include hazard induced by flash floods. Based on known information, flash floods occur within the project area.	Jaipur City receives about 650 mm of rainfall annually, and more than 50% fall within August and September (Monsoon). Annual precipitation is projected to increase by 200mm (2050s -A2A -Ensemble). Projected scenario does not seem to indicate any significant change in seasonality, although precipitation during the monsoon season is projected to increase by about 2%. Urban flash flood risk may escalate thus imposing threats to the 2.3.km underground portion (Phase B of Line1). This is supported by the fact that the drainage capacity is relatively poor, and land use is largely of impervious surfaces.	Maps 2 - 6
Integrated Multi-hazard Index	**0**[23]			Map 7
	Category B[24]			

[23] The integrated multi-hazard index is still problematic at the moment. One problem is that the flood hazard map used to generate the multi-hazard index does not seem to include hazard induced by flash floods. The bigger problem is, how can future scenarios be adequately and quantitatively evaluated.

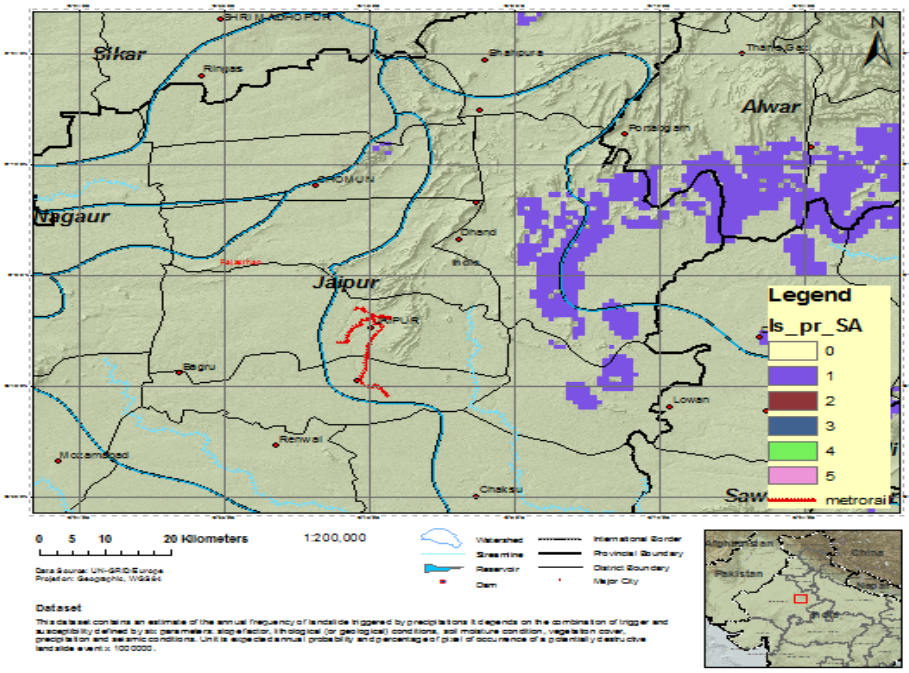
Sector-Specific Climate Risks				
Sensitive Components	**Variable/Implications**	**Baseline**	**Projected Scenarios**	**Impact/Scoring**
None				
Indirect Impacts				
None				
Emissions/Mitigation				
		Relevance	**Significance**	**Method used[25]**
Emissions (GHG Accounting)	Deforestation	No		
	Emission from land Use and Land Cover conversion	No		
	Carbon Emission from machinery during project construction	Yes	Low	
Mitigation	Estimated emission reduction from modal shift for Line1 is approximately 20,000 tons/year for CO2 equivalents, the amount shared by Phase B (the loan project is roughly 23%	Yes	Medium/high	
Summary of Screening Results				
Natural Hazard	1). Urban Flash Floods The risk of flash flooding within the city of Jaipur appears to be low. However, the city experiences monsoon showers in the months of August and September with frequent thunderstorms. Due to flat terrain formations, predominantly impervious urban surface cover, relatively poor drainage capacity, the projected increase in precipitation and possibly increased chances of extreme weather conditions may cause urban flash floods.			
Project Components				
Required Action				
Recommendations	1). Both current and future risks of urban flash floods as well as the adequacy of the existing drainage and stormwater collection systems within the area of the underground portion need to be assessed. 2). The Initial Environment Evaluation (EIA) should contain a chapter that is specifically devoted to climate risk assessment.			
TOR for Consultants	1). The climate change specialist shall conduct a detailed assessment on the risks of flash floods within the region where the underground section of the rail project is located; 2). The assessment should also consider future scenarios of precipitation change and extreme weather conditions; 3). Assess the capacities and adequacy of the existing stormwater sewer systems taking into account future climate scenarios; 4). Recommend options for adaptation for the design standards to curb flash floods.			

[24] Categorization is based on not only the overall scoring (as indicated by the multi-hazard index) but also the preliminary screening/analysis of the flash flood hazard.

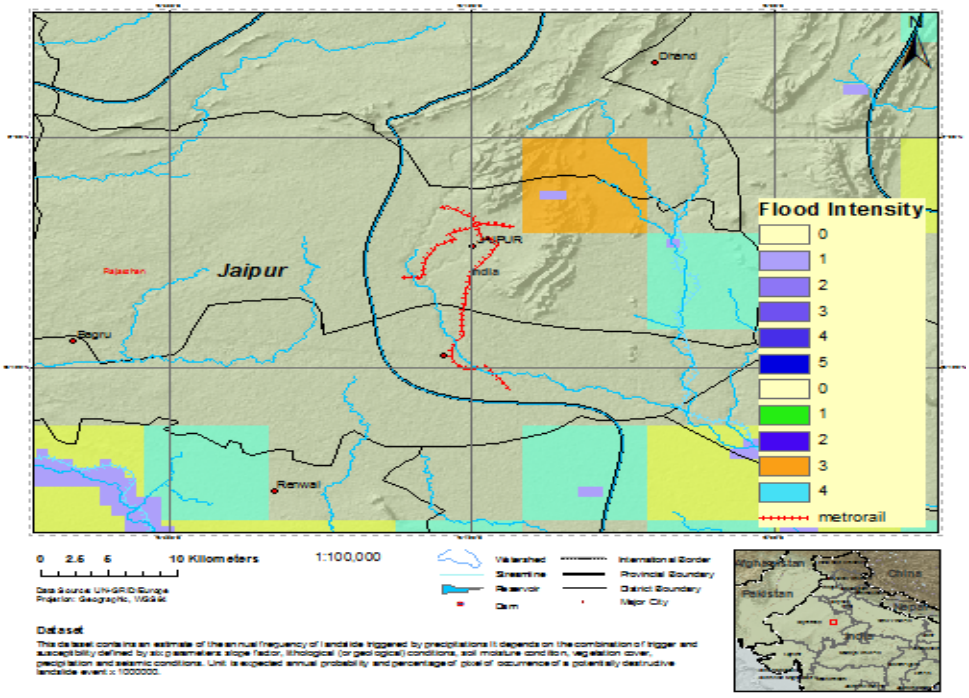
[25] GHG accounting methodologies/tools developed at present are sector specific.

Appendix – Maps

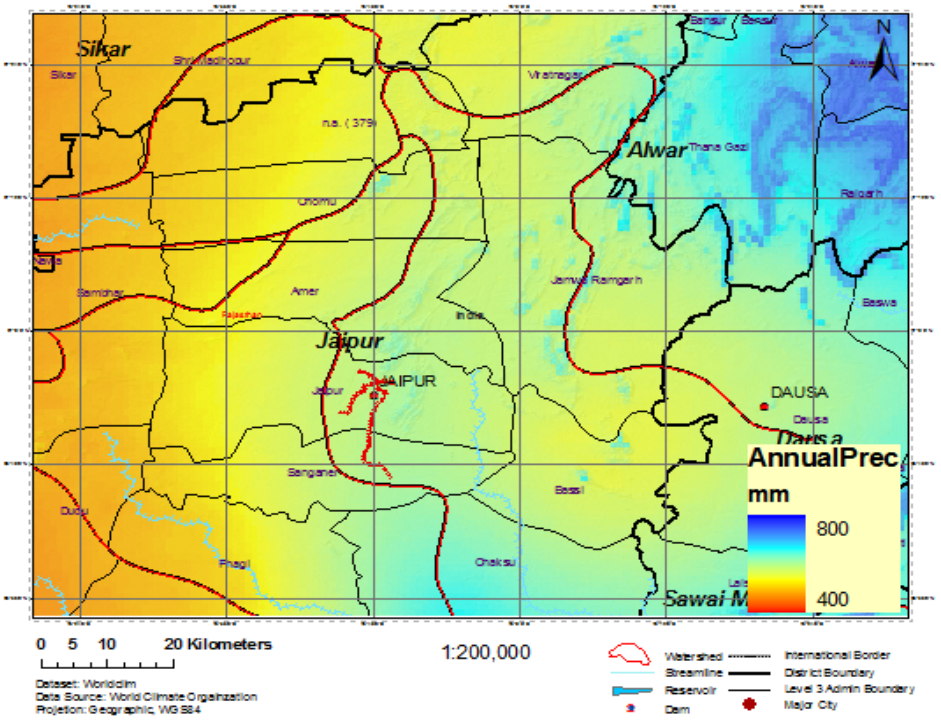
Map 1 – Landslide Triggered by Precipitation.



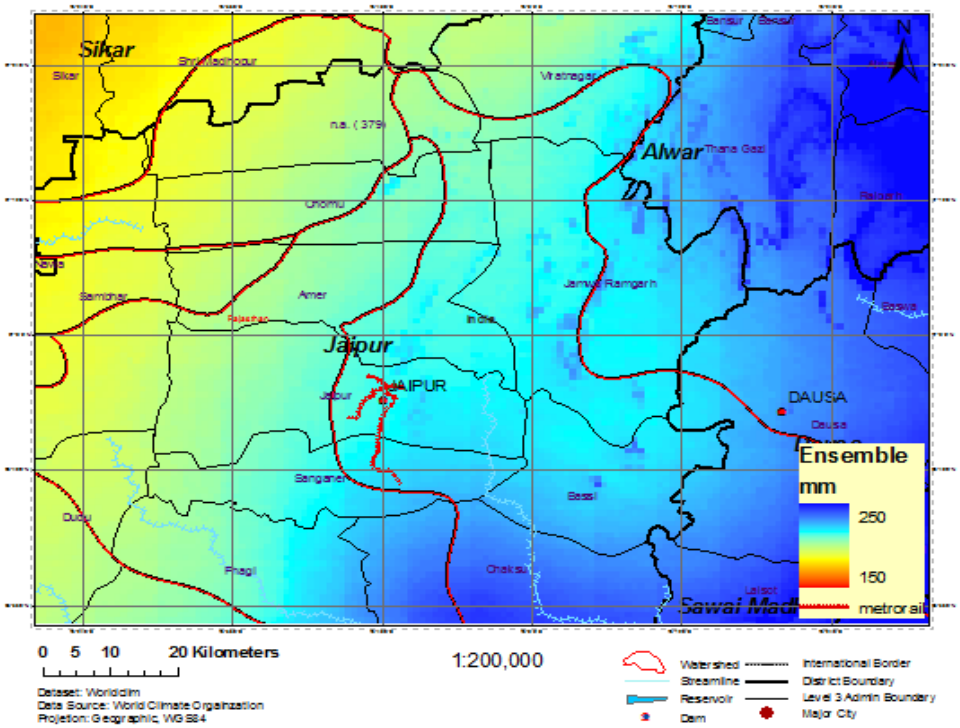
Map 2 - Flood Hazard Map



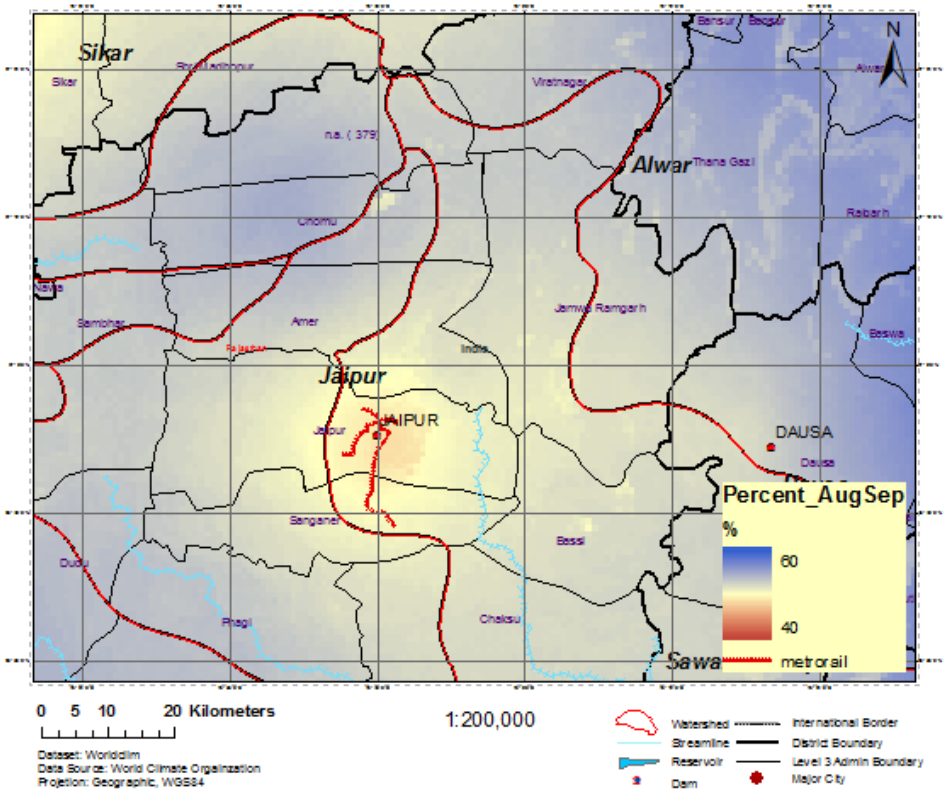
Map 3 - Annual Precipitation - Baseline



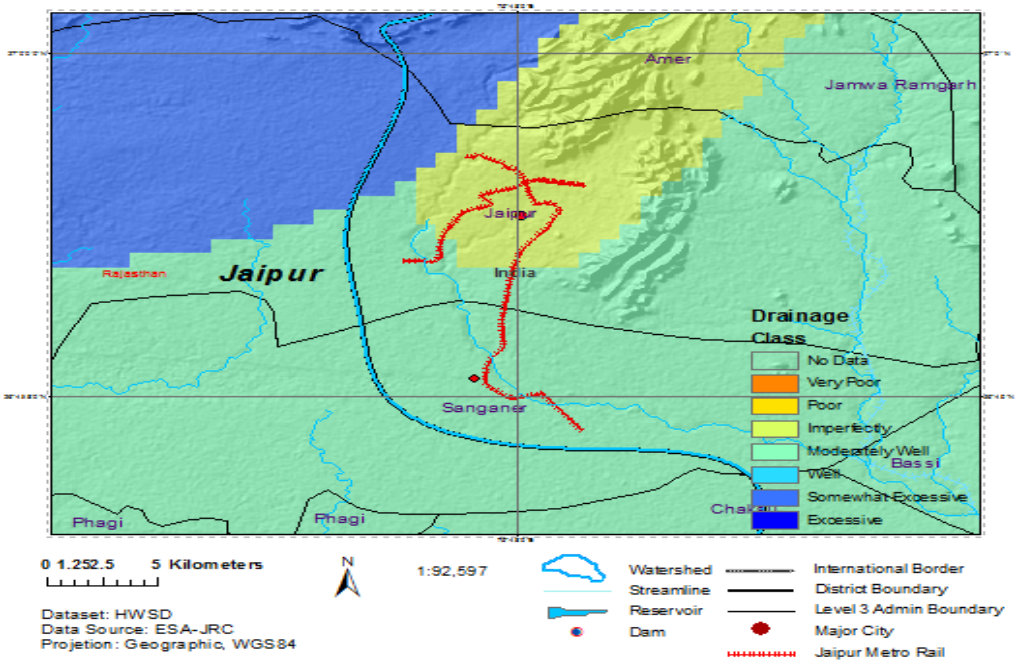
Map 4 - Projected Change in Annual Total Precipitation
(2050s/A2A-Ensemble)



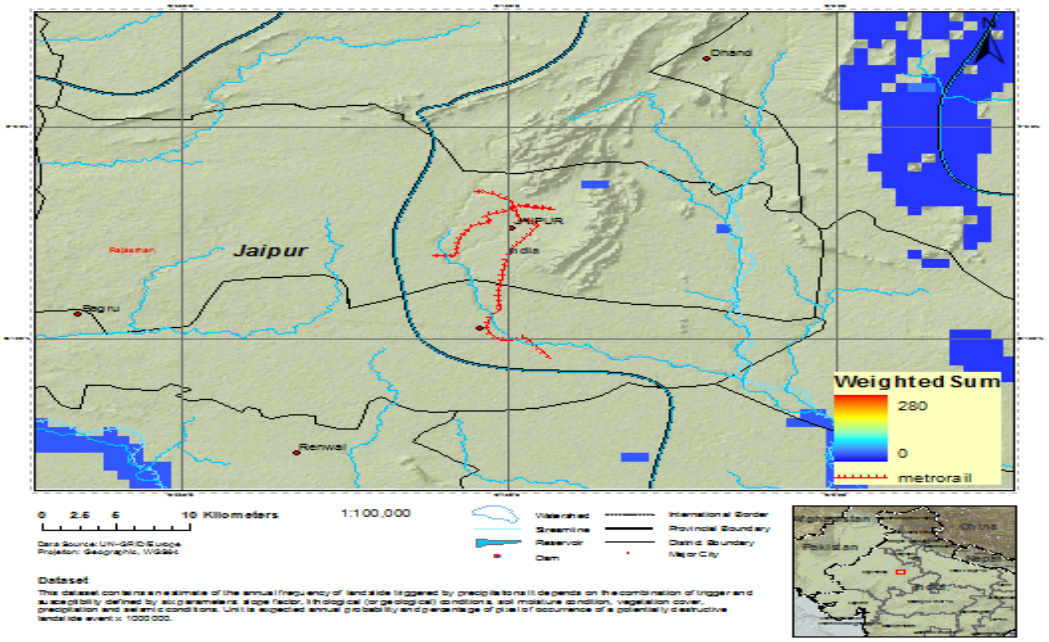
Map 5 - Percentage Precipitation during August-September (Monsoon).



Map 6 - Drainage Capacity



Map 7 – Integrated Multi-hazard Index



Annexure 3: Vibration Analysis for the Underground Section of the Proposed Jaipur Metro Rail Project

I. Introduction

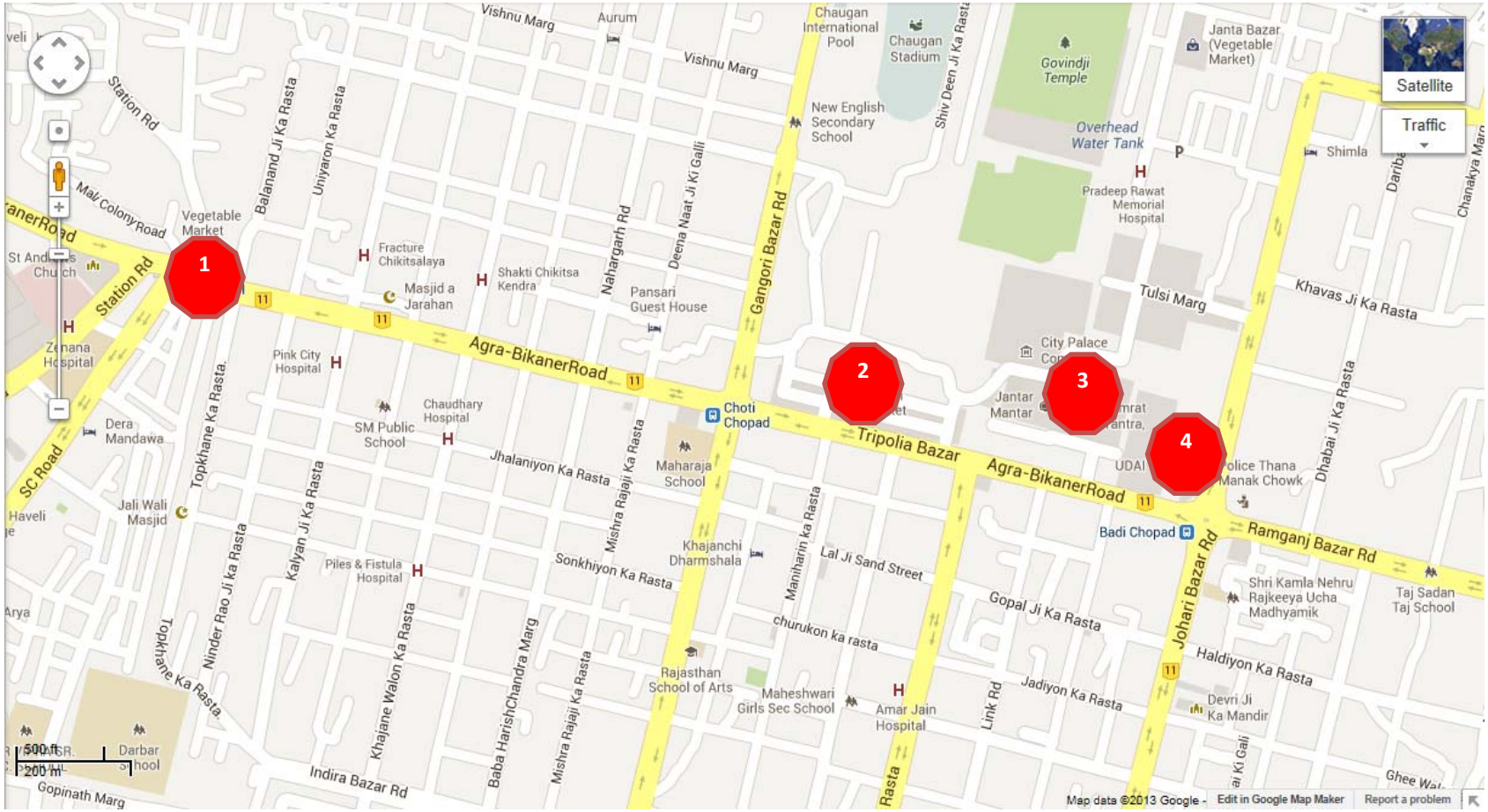
1. Phase 1B of the Jaipur Metro Rail Project will require tunneling under the Chandpole and Tripolia bazaar roads with two underground stations in Choti Chaupar and Badi Chaupar. The tunnel will be constructed near 4 archeological monuments, namely: i) Chandpole Gate, ii) Isar Lat, iii) Jantar Mantar, and ii) Hawa Mahal. The contractor will employ a tunnel boring machine (TBM) and other equipment that will generated vibrations which may cause cosmetic or structural damage during construction. Also, the metro rail operating at high speed will also generate vibration mainly from the wheel and track interaction. This study will predict and assess the potential vibration levels during construction and operation phases.

II. Project Description

2. The project tunnel will start in Chandpole Station outside the walled city, with two 5.70 internal diameter twin tunnels which run under low overburden at least 9.25m. In between the Chandpole Station and the Badi Choupar Station (end of the line) will pass 5 monuments with cultural significance including the Jantar Mantar which is a UNESCO World Heritage site as an observatory.

Table 2: Inventory of Physical Cultural Resource at Risk from Tunnel Boring and Train Operation due to Vibration

Archeological Monument	Minimum Overburden (m)	Distance to Nearest Tunnel Wall (m)	Horizotal Distance to road center point
Chandpole Gate	2.65	9.35	0
Khrisna Temple		19.75	18.92
Isar Lat		23.97	23.76
Jantar Mantar		85.11	86.84
Hawa Mahal		83.48	85.29



Legend

1 – Chandpole Gate

2 –Isar Lat

3 –Jantar Mantar

Figure 29: Plain View of JMRCPhase 1B tunnel and the archeological monuments along structure

III. Geological Description

1. Geology of the Region and State

3. Jaipur Region is situated in North Eastern part of Rajasthan. Jaipur district is one of the 33 districts of Rajasthan and is located between $26^0$23'N to $27^0$51'N latitude and $74^0$55'E to $74^0$55'E longitude. The district has an area of 11151 Sq.Km and occupies 3.3% of the state.

4. The general slope direction of Jaipur city and its surroundings is from north to south and then to south-east with nearly all the ephemeral streams flowing in this direction. Higher elevations in the north exist in the form of low, flat-topped hills of Nahargarh (587 meters above mean sea level). Jaigarh, Amber, and Amargarh are deeply dissected and eroded. An isolated hillock called "Moti Dungari" upon which an old royal castle exists is near the Rajasthan University. Further in the south, topographical levels of the plain areas varies between 280 meters along Bandi and Dhund rivers in the south to some 530 meters in the north east of Chomu near Samod hills. The overall trend is a decline of level from the areas bordering the hills in the north to plain in the south. The proposed alignment of JMR Phase I B alignment passes through the old city area of Jaipur that is located south of the dissected hills of Jaigarh and Amber. The area has a flat terrain devoid of any surface water bodies.

5. Jaipur district is watered by river Banas and its tributaries and thus the fertile soil sustains mixed xerophytic and mesophytic vegetation. Cultivation crops like barley, gram, wheat, mustard are grown in the rabi season.

6. The region is characterized by north – easterly part of the Aravalli range and presents an excellent arch type of folded mountain belt reduced to its penultimate stage of denudation. The geological structure of the region shows that the rocks of the Delhi Super group constitutes the main Aravalli mountain and extended continuously from Gujarat border in south to Delhi in the north-east over a distance of nearly 700 kms.

7. Geomorphologically, district Jaipur is classified into fifteen geomorphic units, spread over district namely alluvial plain, alluvial plain (sandy), valley fill, palaeochannel, salt encrustation/Playa, Ravine, flood plain, pediment, buried pediment, intermontane valley, sandy plain, Aeolian plain, denudational hill, structural hill and linear ridge. Location of these units are as mentioned in the Table below.

Table 3: Location of Landforms within the Project Area

Landform Units	Occurrence in the district
Fluvial origin alluvial plain	Entire southern boundary, north of Bassi, surrounding Chomu, Shahpura and Kotputli town, west of Kanota village i.e. along river Dhundh.
Alluvial plain (Sandy)	Mainly concentrated in central and western part of the district and covers the project area of JMR Phase I B.
Valley fill	Marginally in eastern part between hills.
Salt encrustation/Playa	South of Sambhar lake
Palaeochannel	West of Chomu town & north of Sabrampura
Ravine	Wind ward side of hills in eastern part, south east of Phulera town.
Flood plain	Along rivers Dhundh & Mendha
denudational hill, origin pediment	Along hills in eastern and northern part of district also west of Sanganer town.
Buried pediment	Mainly scattered in north and north east
Intermontane valley	Marginally in between hills near Benrath village

Landform Units	Occurrence in the district
Aeolian origin sandy plain	South of Sambhar Lake, east of Hingonia Sagar
Aeolian plain	South of Kotputli town
Hills, Denuded hills	East and north east of Jaipur city, around Jamwa Ramgarh lake.
Structural hill	Scattered in northern and eastern part
Linear ridge	Scattered in eastern part

2. Geology at the Archeological Monument Locations

8. Geo-technical study was conducted in December 2009 by the DMRC for JMRC along the Phase 1 corridor. Three boreholes along the underground section were established; i) near Manak Chowk Police Station in Badi Choupar, and ii) near Mandir Shree Khrishna Chandra Ji, Choti Chaupar, and iii) near Shiv Mandir, Chandpol.

9. The subsurface profile up to 30 meters indicated silty sand and mixed with gravel formation having loose structure of to a depth of 3.00 meters and increases in density as it go deeper. The boreholes indicated that the materials above the tunnel will be silty sand and silty sand with gravel.

10. Geo-technical study were conducted in December 2009 by the DMRC for JMRC along the Phase 1 corridor. Three boreholes along the underground section were established; i) near Manak Chowk Police Station in Badi Choupar, and ii) near Mandir Shree Khrishna Chandra Ji, Choti Chaupar, and iii) near Shiv Mandir, Chandpo. (see Figure 29). The subsurface profile up to 30 meters indicated silty sand and mixed with gravel formation having loose structure of to a depth of 3.00 meters and increases in density as it go deeper.

Table 4: Sub-surface Profile Near Manak Chowk Police Station Badi Choupar

Depth	Type of Soil/Rock	Soil/Rock Characteristics
0.00-0.30	Filled-up Strata	Loose
0.30 to 3.00	Silty Sand	Loose
3.00 to 5.50	Silty Sand	Medium Dense
5.50 to 10.50	Silty Sand with Gravels	Medium Dense
19.50-13.00	Silty Sand	Dense
13.00 to 17.50	Silty Sand with Clay and Gravels	Dense
17.50 to 19.50	Silty Sand	Dense
19.50 to 30.00	Silty Sand with Gravels	Very Dense

Table 5: Sub-surface Profile Near Mandir Shree Kishna Chandra Ji Choti Choupar

Depth	Type of Soil/Rock	Soil/Rock Characteristics
0.00 to 0.60	Filled-up Strata	Loose
0.60 to 3.00	Silty Sand	Loose
3.00 to 5.00	Silty Sand	Medium Dense
5.00 to 7.50	Silty Sand with Gravels	Medium Dense
7.50 to 8.00	Silty Sand with Gravels	Dense
8.00 to 10.50	Silty Sand	Dense
10.50 to 27.00	Silty Sand	Very Dense
27.00 to 30.00	Silty Sand with Gravels	Very Dense

Table 6: Sub-Surface Profile Near Shiv Mandir Chandpole

Depth	Type of Soil/Rock	Soil/Rock Characteristics
0.00 to 0.40	Filled-up Strata	Loose
0.40 to 4.50	Silty Sand	Loose
4.50 to 6.00	Silty Sand	Medium Dense
6.00 to 9.00	Silty Sand with Gravels	Medium Dense
9.00 to 10.50	Silty Sand	Medium Dense
10.50 to 15.00	Silty Sand	Dense
15.00 to 17.50	Silty Sand with Clay	Dense
17.50 to 19.20	Sandy Silt with Gravels	Dense
19.20 to 19.50	Silty Sand	Dense
19.50 to 30.00	Silty Sand	Very Dense
Below 30.00	Silty Sand with Gravels	Very Dense

IV. Vibration Prediction

a. General Theoretical Background

11. TBM excavation and train operation generate vibration. In turn, these vibrations might generate a dynamic state of stress in surrounding structures, that is, super imposed to the pre-existing static state of stress might affect them under certain conditions.

12. Vibration is simply the movement of a particle wave as wave passes and can be resolved into three orthogonal components. It can be defined by four parameters: frequency, displacement, velocity and acceleration. Displacement units are usually expressed in mm, velocity units are in mm/sec, while acceleration units are mm/sec^2. The rate of movement of a surface is the frequency which is measured in Hz or sec-1.

13. Among these variables, the vibration velocity of a particle is directly related to the stress generated in the structures, and it is one of that is usually measured to evaluate the influence on structures or perception of people. For the same reason, the limits defined by norms are mostly in terms of vibration velocity or more strictly speaking peak particle velocity (PPV).

14. On the other hand, given a certain level of vibration, the structural response of a structure to an excitation also depends on its dynamic behaviour and in particular of its natural period of frequency. That is the reason why the second main variable for evaluating the effects of vibration on a structure is the predominant frequency.

15. In any case, the possible influence to a structure is subjected to vibrations depends on many factors such as: i) duration of vibration, ii) the state of stress to which the structure is subjected, iii) the properties of structure, like foundation type, the quality of materials, the method of construction, and its current state.

16. It must be considered that the characteristics of the vibration such as amplitude and frequency content are modified as the wave propagates through the ground. The ground acts as a flter typically attenuating the amplitude of waves and also filtering the higher frequencies. This is a consequence of the damping of the waves due to material deformation characteristics, that is, the particular attenuation and filtering characteristics of a given ground depend on its elastic parameters, density, and porosity among other attributes. Higher frequencies are attenuated more than lower frequencies since damping or loss of energy is a function of the number of cycles the number of cycles, not distance. Thus the high frequency vibrations which undergo more cycles dissipate more energy over the same distance than lower frequency which undergo less cycles.

17. Considering accurately all these factors for the evaluation of the possible effects that can be caused to a structure by a certain source of vibration in most cases is not economically feasible. First of all it would require structural evaluation and seismic response and in-situ measurements of wave propagation properties. Instead, a general approach in which empirical attenuation equation adequate for the source and expected ground conditions are used to predict peak particle velocities and then these predicted values are compared to standards and recommendations for relevant type of building and expected frequency content of the vibration source is more commonly employed.

18. The existing vibration codes are mostly based on experience and statistical information from vibration damage cause by blasting and other construction activities and thus they can be applied to the specific source of vibration for which they are deployed. A distinction is often made between short and long term vibrations. According to the commonly used German Standard DIN 4150-3, short term vibrations are those in which the "vibration does not occur often enough to cause structural fatigue and which does not produce resonance." Resonance occurs when the natural oscillation frequency of the structure matches the predominant frequency of the vibrations induced by construction machinery that reach the structure producing an amplification of the response of the structure during excitation. They define long term vibrations as any that fall outside the definition of short term vibration.

b. Induced Vibration from TBM during Construction Phase

19. As mentioned, the effects induced by vibrations on structure depends on nature of vibration (frequency content, dominant type of wave) which is dependent on the type of excavation method; type of ground (propagation characteristics); and nature of affected structure. The vibration induced by mechanized excavation methods such as roadheaders and tunnel boring machines (TBM) are usually on the high frequency side and are gradually applied and of a continuous nature in contrast to drill and blast induced vibrations which tend to be of lower frequency and of impulsive type. It is widely acknowledged that gradually applied force such as those applied by the picks of a roadheader or the disks and soil tools of TBMs, the vibration source generated high frequency vibration which tend to be attenuated faster and in shorter distances by the ground compared to low frequency sources. Furthermore, TBM excavation generates mainly compressional waves (body waves) when trusting against the face, which in turn are also attenuated faster than surface waves such as Rayleigh waves[2627].

20. This perhaps explain why there is a substantial lack of studies on vibrations caused by mechanized tunnelling[28] as compared to excavation methods such as drill and blast or impact hammer. In fact, the available studies in the technical literature show through measurements of actual PPV values at different distances from the source how the TBM induced vibrations although sometimes perceptible as a deep rumble are below damage causing thresholds according to commonly used codes. Hiller and Hope cite in turn Hiller and Bowers (1997) after extensive literature review on vibration data baused by mechanized tunnelling concluded that "mechanized tunnelling generates levels of ground vibration that are unlikely to cause damage to most structures. However, disturbance to people could occur at quite considerable distance from the works."

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[26] Davis, D. (2010). "A review of prediction methods for ground-borne noise due to construction activities", Proceedings of 20th Interational Congress on Acoustics

[27] Dowding, C, (1996). "Construction vibrations", Prentice Hall

[28] Hiller, D.M. ad Hope, V.S. (1998) "Groundborne vibration generated by mechanized construction activities". Proceedings. Institution of Civil Engineers Geotechnical Engineering, 131, October.

21. Figure 30 shows a comparison provided by a roadheader manufacturer of the typical range of PPV measured values by a roadheader as compared to drill and blast excavation induced vibration. As may be observed at a distance of 10 meters from the source, the PPV values produce by a roadheader are already below 3 mm/s which is the threshold established in codes for specially sensitive or historical buildings as well will be discussed later. The vibrations produced by a TBM are usually of less amplitude than those produced by a roadheader as pointed out by Speakman and Lyons[29]. It is to be expected that the range of vibrations expected from a TBM at a distance of 10m from the source will be below 0.1-3 mm/s range expected for roadheaders.

22. Regarding the second type of factor, the type of ground, it may be said that, in general, soils tend to absorb more energy and thus attenuate the vibrations more efficiently than rock mediums. In soils, damping is very quick and efficient as compared to rock. In turn, the higher the shear wave velocity of the ground the lower the damping shall be. This behaviour is illustrated in the succeeding Figure were it may be observed how for soil PPV values registered 10m of the source is already below 0.5 mm/s while for rock it may still reach up to 2 mm/s depending on the site condition. Thus, if the propagation medium is in soils the relevance of TBM vibrations and the possibility that nearby structures may suffer structural or cosmetic damage is greatly diminished and becomes almost irrelevant. On the other hand, in rock although expected peak particle velocity values are still low, TBM vibrations should be evaluated.

23. A recent technical paper by Hiller (2011)[30] on this issue, cites the UK's Transport Research Laboratory (TRL) Report 249 in which a graph compiling field data on TBM vibration measured by TRL as well as from other published report sources were included. The graph seemed to indicate that among mechanical excavation methods, the resulting PPV values seemed to depend more on geology that on the excavation method. In fact, the conclusion of TRL 249 Report was that it is the type of ground being excavated, rather than the mechanized excavation method or tunnel boring diameter that dictates the magnitude of vibration quantified in terms of PPV. Hiller presents an amended version of the graph in which data from the Ramsgate Harbour Approach Road tunnel excavation in UK which was performed using the "prevault" tunnelling method. Again, as shown in the Figure, the data for Ramsgate corresponding to excavation chalk fall together with that of the roadheader excavation in chalk from the original graph while data from excavation in weak, soil-like chalk falls in the same range as the data of excavations in clay, sandy clay and sand of the original graph despite the fact that the excavation method used at Ramsgate is different. It is clear that not only a significant difference exists between tunnelling in rock and soft ground but also as Hiller concludes it is very likely that "*it is the type of ground being excavated rather than the type or size of excavator that determines the vibrations*." This hypothesis is supported by the available data and also followed implicitly by several researches which have proposed attenuation equations based only on the geological medium characteristics and distance as will be discussed in the succeeding section.

[29] Speakman, C. et Lyons, S.(2009) "Tunneling induced ground-borne noise modeling", Proceedings of ACOUSTIC 2009 Adelaide, Australia

[30] Hiller, D.M. (2011). "The prediction and mitigation of vibration impacts of tunneling". Proceedings ACOUSTICS 2011, Paper No. 5.

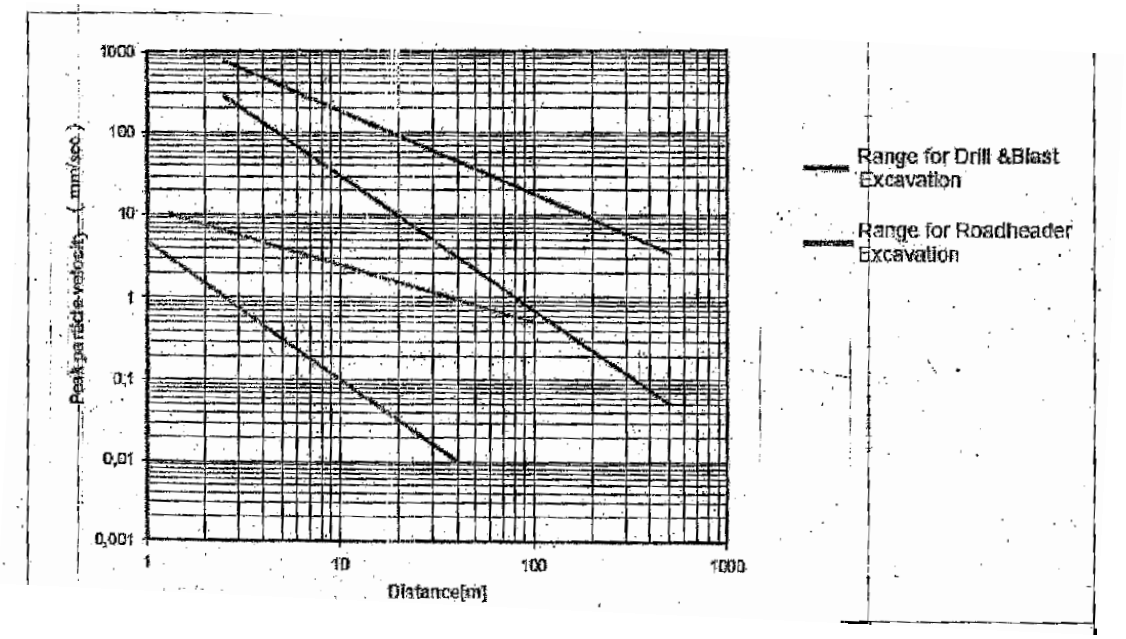


Figure 30: Typical ranges of PPV values for different sources.

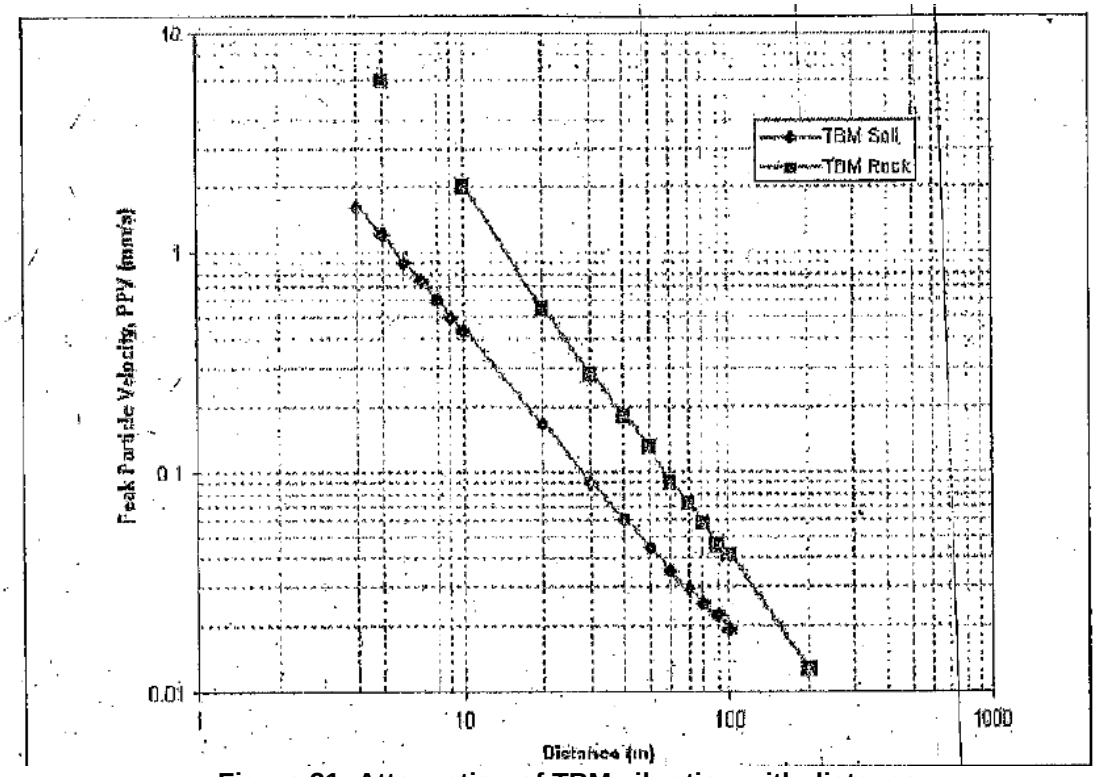
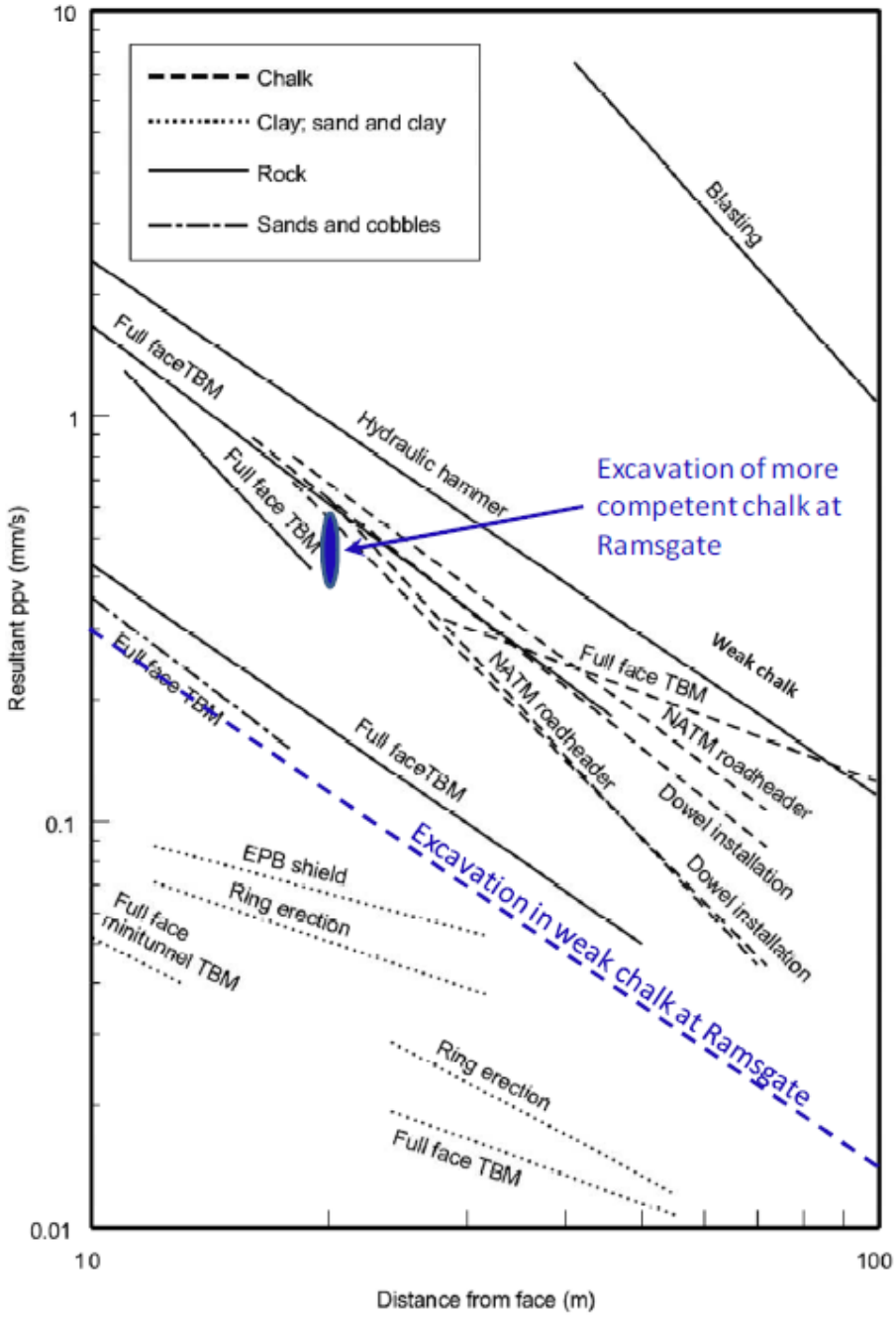


Figure 31: Attenuation of TBM vibration with distance



V. Attenuation Laws

24. There are many vibration prediction equations for blasting and piling in the technical literature, but not many directly developed for mechanized tunnelling. In any case, attenuation equations tend to be a function of distance to the source and may, or may not take into account site-specific parameters. A commonly used equation is that proposed by Godio et. al. (1992) asn cited by UK Transportation Research Laboratory Report No. 249 which has the form $V=Ar^{-1.3}$, where V is the predicted peak particle velocity at a distance r, and A s a constant dependent on stiffness. However, the equation does not consider the source of vibration frequency and using a unique value of stiffness to describe the ground is very rough. Others have developed more elaborate equations that take into account not only

site-specific ground conditions but also machine characteristics. One such equation was used in a project in Brisbane, Australia cited by Speakman (2009). This equation however are proprietary and not publicly available.

25. One method for deriving site specific attenuation equations for TBM induced vibrations is that developed by Orr and Rahman[31] for the Dublin Port Tunnel. Their approach takes into account the propagation parameters of the local ground as well as the source frequency and can be modified to derive equations for other ground conditions.

a. Selected Attenuation Laws in its Generalized Form

26. The vibration prediction deriving methodology proposed by Orr and Rahman has been selected for predicting the vibration produced by the TBMs which will excavate the underground section of the Jaipur Metro Rail Project from Chandpole to Badi Choupar Stations. The proposed attenuation equation in its generalized form is based on the equation of Dowding (1996) as follow:

$$V_1/V_o = (r_o/r_1)^{\beta}\, e^{-\alpha\,(r1-ro)} \qquad (1)$$

Where:

V_1 = peak particle velocity at a distance r1 from the source

V_o = peak particle velocity at a distance ro from source

β = geometric spreading term dependent on wave type

= 1 for compressional waves, 0.5 for Rayleigh waves

α = ground adsorption coefficient

$= 2\pi Df/Vs$ (from Massarsch[32]) (2)

Where:

D=material damping

f = predominant vibration frequency of the signal

Vs = shear wave velocity

27. In the case of TBMs as pointed earlier, the majority of wave forms are of compressional type and thus β = 1. Also, assuming the vibration at the source will be approximately equal to that of a distance of 1 meter (r_o =1), equation 1 may be written as:

$$V_i/V_o = r_1^{-1} e^{-\alpha(r1-1)} \qquad (3)$$

b. Site-Specific Parameters

28. To adjust equation (3) to the specific conditions the ground adsorption coefficient has to be estimated and vales for shear wave velcity and materials damping are necessary. To estimate the shear wave velocity corresponding to the different soils found in the borehole near the underground stations. The result of standard penetrating tests (NSPT) for silty sands ranges from 14-60 blows with an average of 33 and using equation below to correlate to multichannel analysis of surface waves (MASW), the shear velocity is computed:

$$Vs=102.98(N_{SPT})^{0.3438}$$

29. Shear velocities for silty sand ranges from a minimum of 250 m/s, maximum of 400 m/s and average of 350 m/s. The damping factor also varies depending on the type of ground. There are many references in the technical literature for damping factor ranges for different soil types developed for piling design. One widely used damping factors was

[31] Orr, T.L.L. and Rahman, M.E. (undated). "Prediction of ground vibrations due to tunneling." www.rod.ie/images/assets/pub010.pdf

[32] Op. cit.

developed by Rausche et.al[33] (1985) which provides a damping factor of 0.20-.45, the lower value is used to be on the safe side.

30. The typical vibration at the source from a TBM excavating in soft ground are in the range of 10-20 Hz[34]. The proposed attenuation equation for the underground section of the JMRP Phase 1B is given as follow:

$$V_1/V_o = r_1^{-1}e^{-0.053856(r1-1)}$$

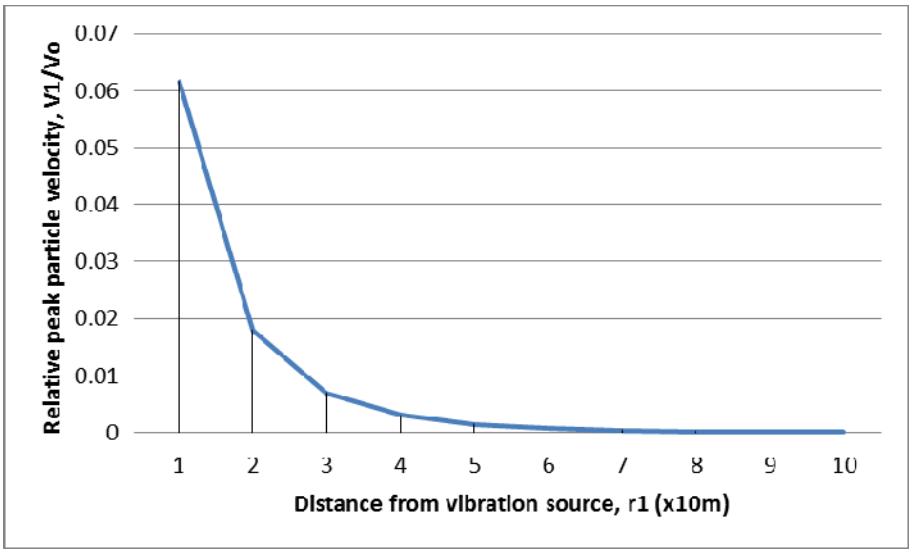


Figure 32: Derived attenuation of equation for Jaipur Metro Rail Project Phase 1B Tunnel Boring

c. Estimated Induced Peak Particle Velocities (PPVs) Using Derived Equation

31. The Table below presents the predicted peak particle velocity (PPV) in mm/s RMS for each PCR identified at risk along the tunnel alignment.

Table 7: Peak Particle Velocity (PPV) During Tunnel Boring Predicted for Each PCR Along the Alignment

Archeological Monument	Distance to Tunnel (m)	Soucre PPV (mm/s)	Predicted PPV (mm/s)
Chandpole Gate	9.35	10	0.682
Khrisna Temple	19.75		0.184
Isar Lat	23.97		0.121
Jantar Mantar	85.11		0.00126
Hawa Mahal	83.48		0.00141

[33] Rausche, F., et al. (1985). "Dynamic determination of pile capacity". ASCE Journal of Geotechnical Engineer Division, iii(3) 367-383

[34] Orr, T.L and Rahman (Undated) and Speakman C. et Lyons, S. (2009)

d. Ground Vibration during Metro Operation

32. There is popular notion that metros put underground will not produce noise. However, this does not imply no impacts on humans and structure will occur as pure vibration can be more unnerving and disturbing because there is no visible or audible traits. Concerns are also expressed on underground metros causing damage to nearby building foundations.

33. To predict the vibration caused by the operation of underground metros, the generalize attenuation equation of Dowding (1996) can be applied with the following as follow changes: i) β is set at 0.5 for Rayleigh waves as the dominant energy accounting for 67% of the total mode propagation (Lamb, 1904), and ii) Vo=0.453 mm/s at 30 meters as observed in the Delhi Metro which will have the same train and rail properties according to the NVH Division of the Institute of Sound and Vibration[35].

$$V_1/V_o = (r_o/r_1)^{\beta} e^{-\alpha (r1-ro)}$$

Where: β = 0.5 for rayleigh waves, according to
r_o = 30 m
α = 0.053856
Vo =0.453 mm/s from (The Institute of Sound and Vibration, 2012)

34. The succeeding Figure 33 and Table 54 present the predicted vibration during metro operation.

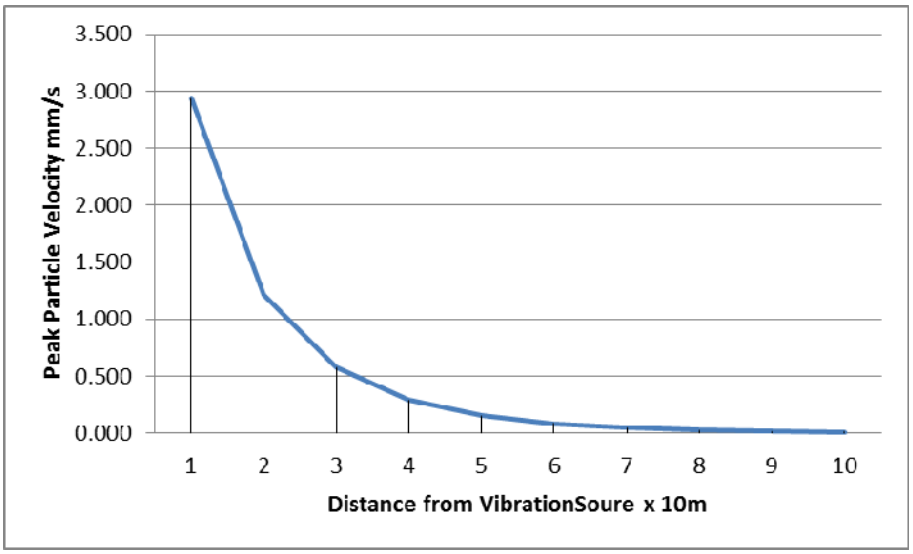


Figure 33: Derived Attenuation Equation for Jaipur Metro Rail Project Phase 1B Single Train Passing

[35] NVH Division, The Institute of Sound and Vibration (2012). Vibration Assessment Along Airport Line for Delhi Metro Corporation. Metro Bhawan, New Delhi.

Table 8: Peak Particle Velocity (PPV) During Train Operation for Each PCR Along the Alignment

Archeological Monument	Distance to Tunnel (m)	Source PPV (mm/s) at 30m	Predicted PPV (mm/s)
Chandpole Gate	9.35	0.453	0.450
Khrisna Temple	19.75		0.177
Isar Lat	23.97		0.128
Jantar Mantar	85.11		0.003
Hawa Mahal	83.48		0.003

VI. Assessment of Results

35. The predicted PPVs on the PCRs were compared against limits set by various international vibration codes (Table 40) as the Government of India has not prescribed its limits. The predicted vibration levels, the highest of which is at the Chandpole Gate at 0.682 mm/s during tunnel boring and 0.450 mm/s during metro operation are both below the guideline values reviewed as presented in Figure 20. Referring to Table 46, even during operation the predicted level is lower than 2.5mm/s guideline value for structures with intrinsic importance. The predicted levels are also lower than the 2.0 mm/s DIN 4150 shock limit for ruins and buildings of historical interest as by Mohanan, V and O. Sharma[36] (1998).

36. Although no structural damage to PCRs is expected from construction and operation activities, the values, human beings are known to be sensitive to vibration, with the threshold of perception being typically in the PPV range of 0.14 mm/s to 0.3 mm/s. Vibrations above these values can cause minimal disturbance, annoyance or interfere with work activities. As can be seen in table 45 the PPV values fall above the maximum value of 0.3mm/s only at the Chandpole gate. The Chandpole gate area is already a highly congested area with high traffic. Therefore it is unlikely that train movement underground will cause any significant additional disturbance.

Table 9: Selected International Vibration Codes

Country	Vibration Code	Year
Germany	DIN4150	1975-1999
Brasil	CETESB D7.013	1998
Scotland	PAN50	2000
US	USBMR18507	1980
Spain	UNE22-381-93	1993
France	Recommendation GFEE	2001
ISO	ISO4866	1990
Italia	UNI9916	1991
Portugal	NP2074	1983
United Kingdom	BS16472	1992
Sweden	SS460-48-46	1991
Switzerland	SN40312	1992

[36] National Physical Laboratory, Acoustic Section (1998). "A Technical Report on Noise and Vibration Study In and Around Certain Historic Monuments/Structures Near the Proposed Metro Route in Delhi." New Delhi

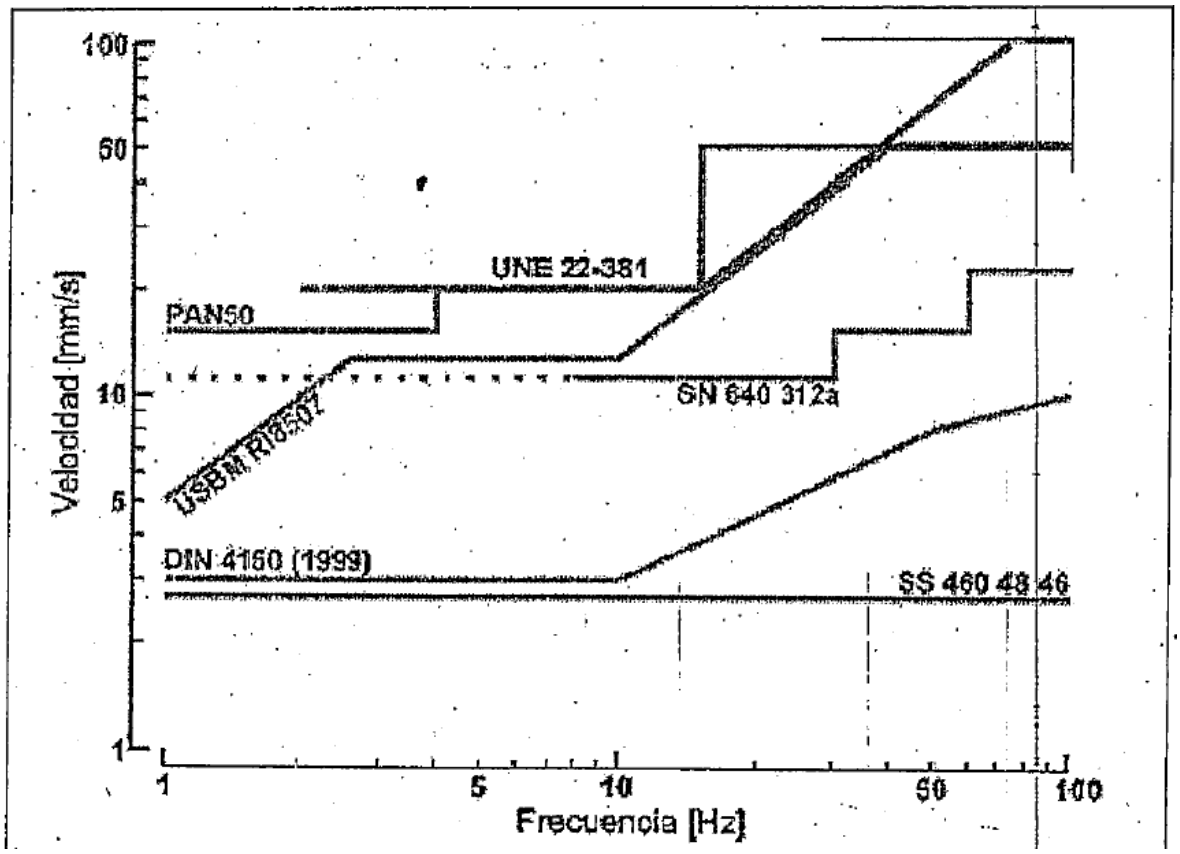


Figure 34: Graphical Limit Values of Selected International Vibration Codes

Table 10: DIN 4150 Guideline Values

Type of structure	Frequency	Peak-Velocity		Location of Measurement
		Short-Term	Long-Term	
Buildings used for commercial purposes, industrial buildings and similar design	1-10 10-50 50-100 All	20 20-40 40-50 40	- - - 10	Foundation of structure Foundation of structure Foundation of structure On horizontal plane of highest floor
Dwellings and buildings of similar design or occupancy	1-10 10-50 50-100 All	5 5-15 15-20 15	- - - 5	Foundation of structure Foundation of structure Foundation of structure On horizontal plane of highest floor
Structure that, because of their sensitivity to vibration cannot be classified under lines 1 and 2 and are of great intrinsic value (e.g. listed building under preservation order)	1-10 10-50 50-100 All	3 3-8 8-10 8	- - - 2.5	Foundation of structure Foundation of structure Foundation of structure On horizontal plane

Annexure 4: ADB Environment Management Plan

SN	Project Activity	Potential Impact	Mitigation measures	Institutional Responsibilities	Cost Estimate
PRE-CONSTRUCTION					
PC1	Contractor Preparatory Works (Upon issuance of Notice to Proceed)		The Contractor will complete the following activities no later than 30 days upon issuance of Notice to Proceed 1.) Submit appointment letter and resume of the Contractor's Health and Safety Officer (HSO) and environmental focal person to CSC 2.) HSO will engage CSC-Environment Specialist to a meeting to discuss in detail the EMP, seek clarification and recommend corresponding revisions if necessary 3.) HSO will request CSC-ES copy of monthly monitoring formats and establish deadlines for submission. 4.) HSO will submit for CSC-ES approval an action plan to secure all permits and approvals needed to be secured during construction stage which include but not limited to: i) operation of crushers and hot mix plants, ii) transport and storage of hazardous materials (e.g. fuel, lubricants, explosives), iii) waste disposal sites and disposal management plan, iv) temporary storage location, iv) water use, and v) emission compliance of all vehicles. Arrangements to link with government health programs on hygiene, sanitation, and prevention of communicable diseases will also be included in the action plan. 5) HSO will submit for approval of CSC-ES the construction camp layout before its establishment.	Contractor and CSC	Part of contractor's cost
PC2	Coordinate with the Jaipur Development Authority on Traffic Management Plan	Nuisance from traffic congestion	The Contractors wil discuss and coordinate the implementation of the traffic re-routing scheme particularly in Choti Chaupar and Badi Chaupar when it starts the cut and cover activities and the hauling and disposal of excavated materials to the Ambabari village. At the minimum, the traffic management plan will have the following components: construction traffic, ensuring access to properties, accommodating pedestrians, parking, access by construction vehicles, faulty traffic lights and problem interchanges, use of public roads, parking provision during construction, use of residential streets and traffic diversion due to temporary road closures, and construction and use of temporary access roads.	Contractor and CSC	Part of Contractor's cost
PC3	Community Liaison	Complaints	To ensure that ongoing feedback is provided on the progress of the JMRP together with feedback on the environmental management performance of the project. Contractor will provide provide a minimum of two (2) weeks notification to directly affected residents, businesses and other relevant groups of	Contractor, CSC and JMRC Safeguards cell	Part of Contractor's cost

SN	Project Activity	Potential Impact	Mitigation measures	Institutional Responsibilities	Cost Estimate
			the intended construction commencement date. In providing a mechanism for communication between the contractor and the community and informing the public of construction details (timing, expected impacts), the concessionaire will undertake consultation and information activities.		
PC4	Ground staking	Chance find of artifacts	At least 30 days before the start of tunneling, the Contactor with supervision from the Archeology Department will employ a ground penetrating radar (GPR), detect the presence of buried artifacts along the tunnel alignment. The Contractor, in behalf of the JMRC, will coordinate with the Archeology Department to designate an on-site representative during the entire duration of the project.	Contractor, CSC	Part of construction cost
PC5	Briefing on working near heritage resource.	Damage to heritage resource. Cultural conflicts	All workers will undergo a briefing with the Archeology Department to ensure safeguarding of heritage resource and cultural/religious practices. A proof of compliance to this requirement to include the name of participants and date and location of briefing will form part of the monthly report to the CSC.	Contractor, CSC	Part of construction cost
			CONSTRUCTION		
C1.0	Tunnel boring and cut and fill	Damage to heritage resources. Tunnel boring namely Chandpole Gate, Krishna Temple, Isar Lat, Jantar Mantar, Hawa Mahal, Choti Chaupar, and Badi Chaupar.	No heritage resources are inadevertenly damaged during construction.		
C1.1	Ground Settlement under the Chandpole Gate	Ground settlement	The contractor will ensure that no inadvertent damage is incurred to the Chandpole gate. Ground settlement cannot be avoided in tunneling works due to the loss of volume loss, which is estimated at 0.45% for the JMRP. Estimated settlement under the Chandpole gate is less than 5mm. The contractor will ensure that the design value is not exceed and the trigger value = 3.5mm and Allowable value = 4.2 meters are implemented. Tilt meters will be installed at key positions on the gate to ensure the 2/1000 design value is observed with trigger and allowable values of 1.4/1000 and 1.7/1000, respectively	Contractor and CSC	Part of Contactor's cost

SN	Project Activity	Potential Impact	Mitigation measures	Institutional Responsibilities	Cost Estimate
			Crack meters will be installed at key positions to ensure design value of 3.0mm is not exceeded with 2.1mm trigger value and 2.5 mm allowable value The contractor will immediately cease all operation if any of the trigger values are breached. The CSC will advise the contractor mitigation measures and practices to control settlement, tilt, and cracks to include but not limited to structural reinforcement and operation parameters of the TBM. The contractor will ensure that no structural damage is incurred and cosmetic damages are repaired under the supervision and control of the Jaipur Archeology Department.		
C1.2	Vibration from the tunnel boring machine	Cosmetic and Structural damages to the structures along the underground metro alignment along Chandpole Bazar and Tripolia Bazar.	Expected vibration at the Chandpole Gate during tunneling is 0.682 mm/s which is lower that internationally accepted 5mm/s. However, to b on the safe side and as practice in DMRC, the Contractor is to ensure that vibration levels at the Chadpole Gate foundation will not exceed 2.0 mm/s	Contractor and CSC	Part of Contractors Cost
C1.3	Surface noise from excavating equipment in Chooti and Badi Choupar	Damage and nuisance to Krishna Temple, Jantar Mantar, and Hawa Mahal. Disturbance of patients in the Pink City Hospital near Chandpole, Chaudary Hospital, Majaraja School at the corner of Choti Chaupar.	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. Mitigation measures to be implemented by the Contractors are: i) liase with local residents on how to best minimize construction noise along the Choti and Badi Chaupars. 2) 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 3) equipment compounds will be located off-site 4) noise barriers will be installed at critical work areas particularly around the Choupars 5) enclose especially noisy activities if above the noise limits 6) employ transportable noise screens between noise sources and identified noise sensitive areas for the duration of noisy construction activities 7) maximize the possibility of scheduling noisy activities at the same time to minimize the duration of exposure Noise from vehicles particularly for hauling of excavated materials to the dump site will be controlled through strict adherence to operating		

SN	Project Activity	Potential Impact	Mitigation measures	Institutional Responsibilities	Cost Estimate
			and maintenance instructions, routing of heavy vehicles way from noise sensitive areas whenever possible, conform with speed limits, and construction vehicles will only use routes specified in the traffic management plan.		
C1.4	Demolition of of Choti and Badi Chaupars	Loss of heritage structures	The project calls for the demolition of the Choti and Badi Chaupars and its restoration to its original condition as a requirement from Jaipur Development Authority. The demolition and restoration will be under the supervision and control of these agencies.	Contractor, CSC	Part of construction cost
C1.4.1		Chance heritage finds during the cut and fill operations	Please refer to FIDIC Sec. 4.24 Fossils. Recording (including chain of custody) will be made by the contractor to be validate by the CSC, and expert verification will be made by the Jaipur Archeology Department. Temporary work stoppage in the immediate area of the chance find for up to 72 hours to allow for the on-site representative of Archeology Department to visit the site to make an assessment and provide instructions. Work in the areas adjacent to the chance find will continue as provided in the detailed design.	Contractor and CSC	
C2	Spoil Disposal (Ambabari Village)	Generate sediment laden runoff from the work site during monsoon. Contamination of disposal sites from construction debris. Community hazard of uncollected and improperly disposed materials.	A spoil management plan will be implemented that details the location of spoil disposal sites, transporting soil, and disposing of soil. The Contractor will perform the following: 1) disposed spoils on permitted sites as instructed by the JMRC 2) ensure the adequacy of the disposal site to handle the volume of spoils the will be generated 3) Prepare, submit and seek approval from the CSC a spoil dump plan that provides the: i) dump size, layout, and form, ii) means of controlling water and wind erosion, iii) measures to prevent spoil dump contamination, vehicular, and public access. 4) Explore the possibility of using spoil materials to rehabilitate borrow pits to 5) All hauling vehicles should be maintained at an acceptable working order and serviced regularly 6) Haul vehicles should be routed away from noise sensitive areas 7) Speed limit in built up areas is 40 km/h 8) All haul vehicles should be covered or soil sprayed with water before leaving the site specially during windy condition 9) Spoil dumps shall have slopes no steeper that 1V:2.5H 10) Final shaping, topsoiling, and immediate revegetation 11) No vehicles are to be allowed to enter n revegetated spoils dump		
C3	Grounwater Extraction	Depletion of groundwater	The Contactor shall secure necessary permits from pertinent groundwater authorities before establishing borewells.	Contractor and CSC	Part of Construction

SN	Project Activity	Potential Impact	Mitigation measures	Institutional Responsibilities	Cost Estimate
		Compete with existing groundwater users	Water conservation and recycling will be observed in all aspects of constructions to include water main breaks, watering roads for dust control, spraying concrete, equipment cleaning and site clean-up.		Cost
C4	Disruption of essential services	Nuisance from temporary damage or shifting in utilities particularly buried water pipes and electrical lines	The Contractor will ensure that the public will be minimally affected when constructing in close proximity to essential services through: 1) coordinate and secure necessary permits for utility shifting with the Jaipur Development Authority and other service utility agencies to locate al services prior to construction in any particular area 2) inform residents of planned interruptions through local media, fliers, and public address system 3) all planned interruptions schedules will be submitted to the safeguards cell JMRC no later than 10 working days before the interruption 4) all affected landowners, tenants, institutions, and businesses to be notified in writing prior to commencement and kept updated in changes of schedule 5) in the event of unforeseen disruptions, the contractor will take all reasonable actions to have the service promptly restored 6) relevant utility agencies will be informed of the construction proximity to essential service line and be kept on standby in the event of unforeseen disruption All unplanned interruption will be immediately reported to the safeguards cell within 24 hourr thorugh an incident report.		
C5	Construction camp, Batching plant and casting yard operations, and occupational safety	Solid and liquid waste generation. Communicable diseases Hazardous materials storage Re-fueling Lighting Emergency preparedness Excavation and tunneling Personal protective equipment Energy management	Please refer to SHE.	Contractor and CSC	Part of construction cost
	Cleanup Operations, Restoration and Rehabilitation		Contractor shall prepare site restoration plans, which shall be subject for review and approval by the CSC, JMRC Safeguard Cell, Jaipur Development Authority and the Archeology Department to ensure consistency with zoning and town plans. The clean-up and restoration	Contractor and CSC	Part of construction cost

SN	Project Activity	Potential Impact	Mitigation measures	Institutional Responsibilities	Cost Estimate
			operations are to be implemented by the Contractor prior to demobilization. All spaces excavated and not occupied by the foundation or other permanent works shall be refilled with earth up to surface of surrounding ground.		
			OPERATION		
O1	Noise and Vibration	Vibration from train operation may cause structural or cosmetic damage to Chandpole Gate, Krishna Temple, Isar Lat, Jantar Mantar, and Hawa Mahal.	The JMRC will continue and maintain the monitoring sites established by the contractor for noise and vibration and will observe the same trigger values	JMRC	Operating cost
O2	Waste water from Depot	Contamination of groundwater by petroleum laden waste	JMRC will install wastewater treatment plant at the Mansorovar depot station capable for removing petroleum contaminants and will meet national standards before re-injection to the groundwater.	JMRC	Operating Cost
O3	Depletion of groundwater	Water requirement for train and facility cleaning, and water for commuters. Each station will require 18,000 liters per day, platform washing is 5 liters/square meter, 70,000 li.day for car washing, and plus passenger water requirement.	Rain water harvesting facilities will be installed at he Mansorovar station. All stations will employ a cooling water recirculation system for airconditioning. Only recycld water will be use for facility cleaning and landscape irrigation. All toilets will be equipped with low-flow fixtures.	JMRC	Operating Cost

Annexure 5: Environmental Monitoring Plan

Envtl Indicators	Parameters	Methods/Guidelines	Tentative Location	Frequency and duration	Standards	Approx. Cost	Implementation	Supervision
Construction Phase								
Air Quality	TSPM, PM_{10}, NOx, SOx, COx	Qualitative analysis of dust development at selected sites/sensitive spots through High Volume Sampler	2 locations at Choti and Badi Choupar where cut and fill activities will be implemented	24 hours continuous every month until the stations are completed	National Ambient Air Quality Standards (NAAQS)	36@10,000 =Rs. 360,000	Contractor	CSC
Water Quality	DO, Turbidity, Conductivity, pH, E.Coli, TSS, Oil and Grease and TDS	• Collect and analyze sample from source • Observation of blockage of waterways - extent and secondary impacts • Water pollution incidents due to unsafe disposal of waste and spoil, analyzing effects on local fisheries • Observations on vehicle and equipment washing practices in rivers •	Ground water at construction camps and	Quarterly	National Drinking Water Quality Standards (NDWQS) and Water Quality Guidelines	12@3,750 =Rs. 45,000	Contractor	CSC,
Noise Levels	(1 hr L_{eq} dB(A)) WHO Standards	• Point source measurements in dB (A) at settlement sites/sensitive spots for noise level at 2, 5 and 15 m from road shoulder • Traffic volume measurements	Krishna Temple, Jantar Mantar, and Hawa Mahal. Pink City Hospital near Chandpole, Chaudary Hospital, Majaraja School at the corner of Choti Chaupar	Monthly	Indian Ambient Air Quality Standards for Noise	8x12x3@2,450 =Rs. 705,600	Contractor	SC, PD/DOR
Vibration	PPV mm/s	Accelerometer	Krishna Temple, Jantar Mantar, and Hawa Mahal. Pink City Hospital near Chandpole, Chaudary Hospital, Majaraja School at the corner of Choti Chaupar	Monthly	Commercial: 10 mm/s (day), Archeological structures: 2.5 mm/s	36*200,000 = Rs7,200,000	Contractor	CSC
Undergrou nd artifacts	Number and location	Ground Penetrating Radar	Along the entire tunnel length	Once 30 days before tunneling	None	Rs200,000	Contractor	CSC

Envtl Indicators	Parameters	Methods/Guidelines	Tentative Location	Frequency and duration	Standards	Approx. Cost	Implementation	Supervision
Operation Phase								
Water Quality	DO, Turbidity, Conductivity, pH, E.Coli, TSS, Oil and Grease and TDS	• Collect and analyze sample from source • Observation of blockage of waterways - extent and secondary impacts • Water pollution incidents due to unsafe disposal of waste and spoil, analyzing effects on local fisheries Observations on vehicle and equipment washing practices in rivers	2 stations	Annual	National Drinking Water Quality Standards (NDWQS) and Water Quality Guidelines	Rs. 45,000	JMRC	SPCB
Vibration	PPV mm/s	Accelerometer	Krishna Temple, Jantar Mantar, and Hawa Mahal. Pink City Hospital near Chandpole, Chaudary Hospital, Majaraja School at the corner of Choti Chaupar	Annual	Commercial: 10 mm/s (day), Archeological structures: 2.5 mm/s	Rs200,000	JMRC	Department of Archeology