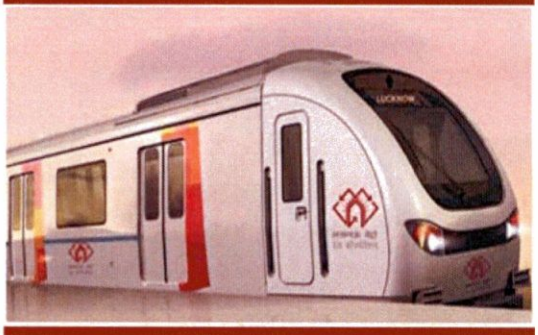
LUCKNOW METRO

LUCKNOW METRO RAIL CORPORATION

ENVIRONMENT IMPACT ASSESSMENT FOR NORTH-SOUTH CORRIDOR OF LUCKNOW METRO RAIL PROJECT



AUGUST 2015

Delhi Metro Rail Corporation
Metro Bhawan, Fire Brigade Lane
Barakhamba Road, New Delhi – 110001

EKO PRO ENGINEERS PVT. LTD.
32/41, South Side of GT Road
UPSIDC Industrial Area,
Ghaziabad (U.P) -
201009

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ABBREVIATIONS

AFC	-	Automatic Fare Collection System
AFD	-	Agence Française de Développement
AMASR	-	Ancient Monuments And Archaeological Sites and Remains
ASI	-	Archaeological Survey of India
ATO	-	Automatic Train Operation
ATP	-	Automatic Protection System
BIS	-	Bureau of Indian Standards
CATC	-	Continuous Automatic Train Control
CGWB	-	Central Ground Water Board
CO	-	Carbon Monoxide
CPCB	-	Central Pollution Control Board
CRRI	-	Central Road Research Institute
CTE	-	Consent To Establishment
DMRC	-	Delhi Metro Rail Corporation
DPR	-	Detailed Project Report
EIA	-	Environmental Impact Assessment
EIB	-	European Investment Bank
EIRR	-	Economic Internal Rate of Return
EMP	-	Environmental Management Plan
EPA	-	Environmental Protection Act
EPR	-	Extended Producer Responsibility
ETP	-	Effluent Treatment Plant
FIRR	-	Financial Internal Rate of Return
GHG	-	Green House Gas
GSDP	-	Gross State Domestic Product
IMD	-	Indian Meteorological Department
KLD	-	Kilo Liter Per Day
LMRC	-	Lucknow Metro Rail Corporation
LMRP	-	Lucknow Metro Rail Project
MCD	-	Municipal Development Corporation
MGD	-	Million Galan Per Day
MoEF	-	Ministry of Environmental and Forest
MRTS	-	Mass Rapid Transit System
MSK	-	Medvedev–Sponheuer–Karnik
NGO	-	Non Government Organization
NHAI	-	National Highway Authority of India
NOC	-	No Objection certificate
NOx	-	Oxides of Nitrogen
NSDP	-	Net State Domestic Product
OHE	-	Over Head Equipment
PAP	-	Project Affect People
PIU	-	Project Implementation Report
PM_{10}	-	Particulate Matter of size less than 10µm
$PM_{2.5}$	-	Particulate Matter of size less than 2.5µm
R & R	-	Rehabilitation and Resettlement
SOx	-	Oxides of Sulphur
SPCB	-	State Pollution Control Board
SPM	-	Suspended Particulate Matter
STP	-	Sewage Treatment Plant
TBM	-	Tunnel Boring Machine
VVVF	-	Variable Voltage Variable Frequency
WHO	-	World Health Organization

CHAPTER – 1
INTRODUCTION

1.1 BACKGROUND

Lucknow is popularly known for its cultural and intellectual traditions as well as its current status as a nucleus of service industry, education & research. Lucknow is the capital of Uttar Pradesh & administrative headquarters of Lucknow district & division. With its 2.2 (COI, 2001 Estimates) million inhabitants Lucknow Urban Agglomeration has currently over 3 million population. The master plan has projected a population of about 3.2 million and 4.0 million by years 2011 & 2021 respectively. Being an important cultural and trading centre Lucknow continues to grow and attract large number of people to the city. The rapid growth of the city and the associated urban sprawl has accentuated the demand supply mismatch amidst the constrained transport infrastructure resulting in economic and social externalities.

1.2 TRANSPORT

The inadequate commuter transportation system in Lucknow is overwhelmed by upsurge of private automobiles. Private vehicles (motorized 2-wheelers and cars) constitute 90 percent of total vehicles registered in Lucknow City. The supply of city buses being only 6 per lakh population is inadequate for a city's size like Lucknow. The benchmark is between 70 to 80 buses per lakh residents in an urban area in India.

1.3 OBJECTIVE AND SCOPE OF THE STUDY

The objective of the study is to facilitate the Lucknow Metro Rail Corporation (LMRC) for EIA report as per requirement of funding agency. The scope of EIA includes the impacts resulting from pre construction and operation phases of the proposed Metro corridors, Depots and sub-stations. LMRC plans for funding for the proposed corridor from European Investment Bank (EIB). In addition it also proposed to establish environmental baseline and safeguard measures for protection of environment for sustainable development during project cycles. As per the MoEF, Government of India, office memorandum, dated 20th September 2013 and their Gazette Notification dated 14th September 2006 and its amendment dated 1st December 2009, metro rail projects do not require environmental clearance from MoEF.

However, as per the requirements of the funding agency, an Environmental Impact Assessment has been carried out and a report has been prepared for the proposed corridor. Nevertheless, if the built-up area of stations exceeds 20,000 sq.mtrs, prior

Environmental Clearance will be obtained from State Environmental Impact Assessment Authority.

The scope of the study is framed as per European Investment Bank (EIB) guidelines for Environmental and Social safeguard policies. The objectives of the EIB guidelines are to encourage project proponents to have appropriate consideration for environmental and social impacts.

1.3.1 EIB Requirements

EIB believes in promoting comprehensive approach to the management of environmental and social impact as well as risk. Significant Environmental and Social standards of EIB are reproduced below:

- The promoter must provide, as a basic obligation that the Energy or resources are used efficiently and necessary measures will be taken to prevent accident.
- The environmental sensitivity of geographically area must be considered seriously.
- Absorbing capacity of natural environment must be taken with grave concern prior to releasing wastes into water or soil.
- The promoter will also ensure that the release of emissions into air, soil and water is controlled and will not exceed the associated levels recommended.
- The promoter will put in place adequate measures to prevent emissions to soil and groundwater and regularly monitor these measures so as to avoid leaks, spills, and incidents.
- Proper Environmental Management Plan will be prepared for this purpose.
- By tackling noise emission at source, the promoter shall ensure that the project is designed, constructed and operated so as to avoid, prevent or reduce the harmful effects.
- Environmentally proven and best techniques must be opted for the treatment, destruction and final disposal of the waste generated.
- Ensure that any eviction which may be exceptionally required is carried out lawfully, respects the rights to life, dignity, liberty and security of those affected who must have access to an effective remedy against arbitrary evictions.
- In addition, the EIB is committed to upholding the **Aarhus Convention**, which emphasizes the citizen's right to justice, to be consulted and to enjoy access to information on projects and plans.
- Affected people should be informed well in time and will be effectively consulted.
- Affected **stakeholders should be compensated** as far as possible.
- All affected persons will be paid fair compensation in good time for expropriated assets compensation should be provided for any loss of personal, real or other property, goods or assets.
- The promoter will provide the EIB with adequate documentation in relation thereto, namely an **acceptable Resettlement Policy Framework (RPF)** or **Resettlement Action Plan (RAP)**.
- Promoter will have to make sure **vulnerable groups** including women, girls, minorities and indigenous people will be taken care of very prudently.

- **Public consultation must be integrated** at each stage of project.
- The EIB will not finance the project involving **child labour**.
- **Labour in any case will not be forced** on any person or there should be no provision for compulsory labour.
- **Compliance with labour standards** should be screened for all operations financed by the EIB.
- EIB procedures are derived from the premise that **promoters are fully responsible for implementing projects financed by the EIB**, including all environmental and social management aspects, such as studies, EIA/ESIA processes, and the implementation of environmental and social management, measures and monitoring the effectiveness of these measures after implementation.
- The EIB`s role is to satisfy itself that the **promoter has met the EIB and E&S requirement**s and to monitor and verify that the project is being implemented in accordance with the conditions attached to its financing.
- Conditions for signature-meaning these environmental and social matters must be completed to the **satisfaction of EIB prior to signature of the finance** contract between the EIB and the borrower.
- The promoter is responsible for making the documents available to the public in a language appropriate for **local consultation and stakeholder engagement**.

1.4 LEGAL, POLICY AND INSTITUTIONAL FRAME WORK

India is at the cusp of a major urban transition. 75 percent of India's GDP is expected to come from cities over the upcoming 12^{th} to 15^{th} plan periods. By 2030, 70 percent of all net new jobs are expected to come from cities. India's national competitiveness depends on the competitiveness of its cities and the sustainability of its urban transport process.

The existing pattern of urbanization in India is also one rife with numerous stresses and dysfunctions: rapidly expanding urban sprawl, inadequate and unreliable urban infrastructure, high land prices, proliferating slums, growing congestion and travel times, reduced agglomeration economies, intense local air pollution and growing levels of GHG emissions. There is a need to identify urban policies and programs at the national, state and local levels directed towards sectors such as transportation that can help foster smarter and more efficient urban growth that is equitable, economically vibrant and climate-smart.

The need for a well-developed legal mechanism to conserve resources, protect the environment and ensures the health and well being of the people in India was felt. Keeping the pace with international laws, the Ministry of Environment and Forest enacted Environmental Protection Act in 1986. Over the years, the Government of India has framed several policies and promulgated number of Acts, Rules and Notifications aimed at management and protection of the environment. During last three decades an extensive network of environmental legislation has grown and presently it has a fairly complex body of environmental legislation aimed at ensuring that the development

process meets the overall objective of promoting sustainability in the long run. The available legal Acts and Legislation referred during the study are:

- The Water (Prevention and Control of Pollution) Act, 1974 (Amendment 1988).
- The Water (Prevention and Control of Pollution) Cess Act 1977, (Amendment), 2003.
- The Water (Prevention and Control of Pollution) Cess Rules, 1978, 1991.
- The Air (Prevention and Control of Pollution) Act 1981, amended 1987.
- The Air (Prevention and Control of Pollution) (Union Territories) Rules, 1982, 1983
- Noise Pollution (Regulation and Control) Rules, 2000 amendment 2002, 2006.
- Municipal Solid Waste Rules, 2000
- The Environment (Protection) Act, 1986, amended 1991.
- The Environment (Protection) Rules,1986.
- The Indian Forest Act, 1927.
- Forest (Conservation) Act, 1980, amended 1988.
- Forest (Conservation) Rules, 2003.
- The Wild Life (Protection) Act 1972, Amendment, 2002
- Minimum Wages Act, 1948
- Contract Labour Act, 1970
- The Bonded Labour System (Abolition) Act, 1976
- Child Labour (Prohibition and Regulation) Act 1996 along with Rules, 1988
- Children (Pledging of Labour) Act, 1933 (as amended in 2002)
- The Building and Other Construction Workers Welfare Act,1996
- The Persons with Disabilities (Equal Opportunities, Protection of Rights and Full Participation) Rules, 1996
- Fire Safety Act, 2002
- Nation Building Code of India (Fire & Life Safety)
- Disaster Management Act, 2005

The EIA is conducted as per "Guidelines for Environmental and Social considerations" of EIB. The study covers the proposed on-site and off-site activities such as the transportation of the generated waste to the waste disposal sites.

1.4.1 Water and Water Pollution

The use of water resources and also the discharge of polluted water (sewerage) are primarily regulated by the Water (Prevention and Control of Pollution) Act, 1974 amended in 1988. The Water Cess Act, 1977 amended in 1992 and 2003, including Rules 1978 and 1991 provides for levy and collection of Cess on water consumed with a view to generate resources for prevention and control of water pollution. The Act assigns functions and powers to the Central Pollution Control Board (CPCB) and State Pollution Control Board (SPCBs) for prevention and control of water pollution.

The Environment (Protection) Act 1986 amended in 1991 and Rules also lays down specific standards for quality of water effluents to be discharged into different type of water bodies (sewers, surface water bodies like lakes and rivers, marine discharge). Additionally, the water supplied to users for drinking shall also conform to the National Drinking Water Standard, IS-10500 **(Annexure 1.1)**. **Annexure 1.2** summarizes the general standards for discharge effluent in Inland Surface Water Bodies. To ascertain and categorize the existing water quality, the results of the analysis of water quality need to be compared with the water quality standards given in **Annexure 1.3.**

Off late, with rapid depletion of groundwater resources in several areas of the country, efforts have been initiated to regulate the use of groundwater resources. The focus of such acts and rules is to provide for mechanisms that would lead to replenishment of groundwater reserves through techniques like rain water harvesting. The Central Ground Water Board, (CGWB) the statutory authority set up by the Central Government has also restricted the drilling of tube wells and bore wells in certain water scarce areas in the country.

1.4.2 Air Quality

The Air (Prevention and Control of Pollution) Act, 1981 and amended in 1987 including Rules 1982 and 1983 was enacted to prevent, control and reduce air pollution. According to Section 21 of the Act, no person shall establish or operate any activity, which can cause air pollution without obtaining Consent to Establish (CTE) as per the Air Act. The Act also lays down national ambient air quality standards for pollutants like SPM, Sulphur dioxide, Oxides of Nitrogen, Carbon monoxide, Lead, Ozone, Ammonia, Benzene and Benzo pyrene with the intent of managing air quality for different category of areas (residential, industrial and sensitive). Ambient Air Quality Standards have been notified by the CPCB vide Gazette Notification dated 16th November 2009, refer **Annexure 1.4.**

However, the State Pollution Control Board (SPCB), on a case to basis, can also make the emission standards more stringent on the considerations of the carrying capacity of a specific air shed and the existing pollution levels of ambient air quality.

1.4.3 Noise Quality

With the objective of regulating ambient noise quality in the environment, the Central Government has notified the Noise Pollution (Regulation and Control) Rules, 2000 amended in 2002 and 2006 under the EPA. The noise standards for different category of areas are based on the weighted equivalent noise level (Leq). Equipment noise standards for DG sets and Construction Equipment, which would be in use for the project are also laid down. Ambient Noise level standards have been notified by the MoEF as Noise Pollution (Regulation and Control) Rules 2000, under Environmental (Protection) Act 1986. It is based on the 'A' weighted equivalent noise level (L_{eq}). These are presented in **Annexure 1.5.**

1.4.4 Solid Waste Management

Project construction and operation generates solid waste at site. The LMRC would be responsible for collection and handling of solid waste as per the provisions of the Municipal Solid Waste Rules, 2000. The Hazardous Wastes (Management and Handling) Fourth Amendment Rules, 2010 require facilities to classify wastes into categories, manage them as per the prescribed guidelines and obtain prior authorization from the SPCB for handling, treatment, storage and disposal of Hazardous Wastes.

1.5 INSTITUTIONAL FRAMEWORK

The Ministry of Environment and Forests (MoEF) is the nodal agency in the administrative structure of the central government for planning, promotions, co-ordination and overseeing the implementation of India's environmental and forestry policies and programs. The major responsibilities of MoEF include:

- Environmental resource conservation and protection, including environmental impact assessment, clearance of developmental projects;
- Co-ordination with the other ministries and agencies, voluntary organizations and professional bodies for environmental action plans;
- Promotion of research and development, manpower planning and training and creation of environmental awareness;
- Liaison and coordination with international agencies involved in environmental matters.

1.5.1 Central and State Pollution Control Boards

The Central Pollution Control Board is responsible for pollution control throughout the country. In addition to the control of air, noise and water pollution it is also responsible to ensure effective control of disposal of hazardous wastes and storage and handling of hazardous chemicals and substances. With the enactment of air and water pollution laws, states have set-up their own State Pollution Control Boards (SPCBs) to monitor industrial emissions and effluents and to approve the operation of new industries after careful scrutiny. The functions of the SPCBs include:

- The planning of comprehensive state programs for the prevention and control of air and water pollution and to ensure the implementation thereof;
- Inspection of pollution control equipment/ plants for monitoring of their efficiency

The SPCB in consultation with the Central Pollution Control Board may establish norms for air quality, gaseous emission and noise level etc.

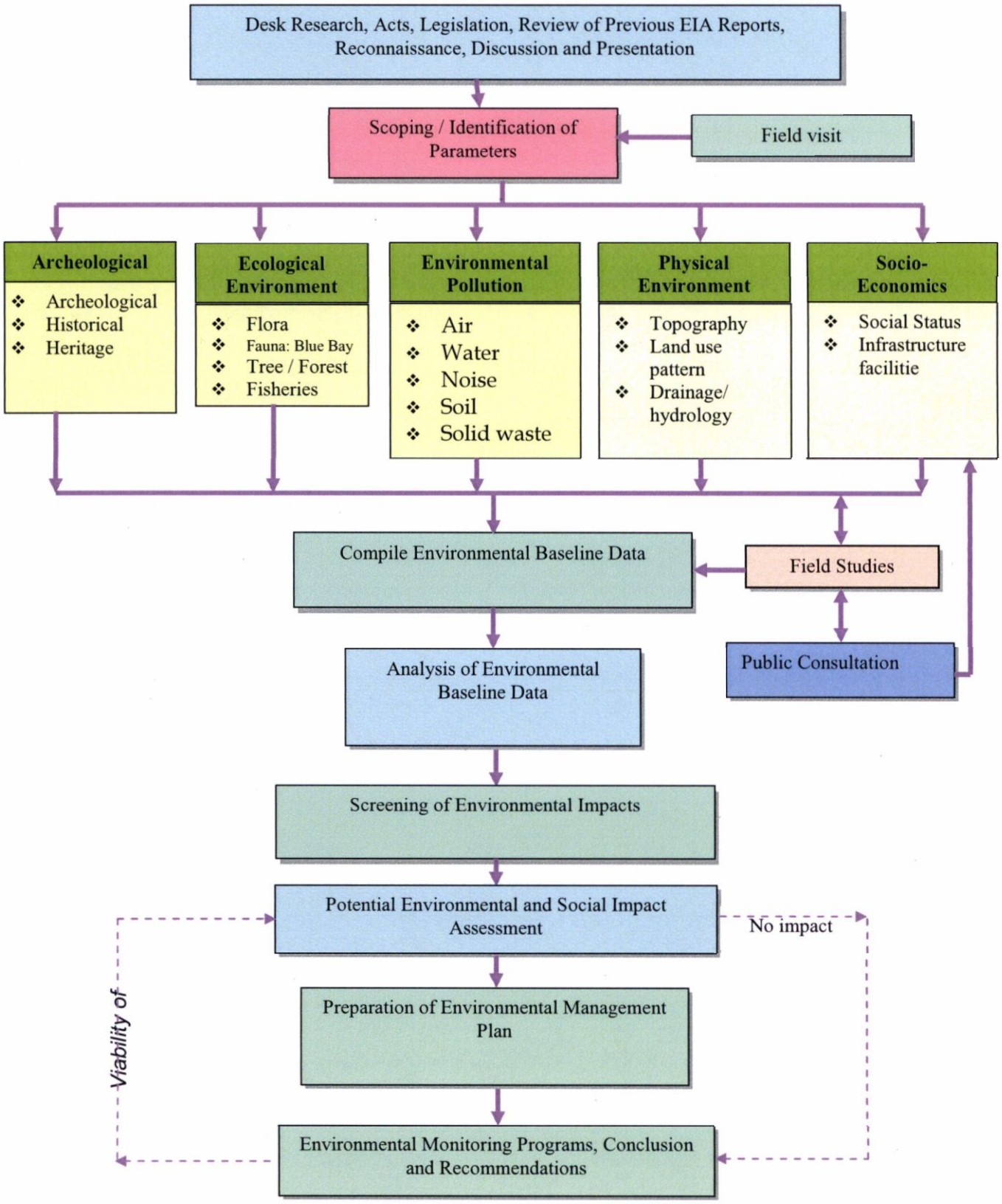
1.6 APPROACH AND METHODOLOGY

The LMRC has considered the different alternative. The final alternative was fixed based on Technical Feasibility, Socio-economic acceptability, and Environmental sustainability for Metro Corridors. The environmental study is carried out for the final alignment proposed by LMRC. The **approach** is to follow the sequence of steps adopted in an EIA study. The basic concept is to ascertain the existing baseline conditions and assess the impacts as a result of construction and operation of the project. The changes likely to occur in different components of the environment viz. physical, biological / ecological, environmental and socio-economic etc. have been studied, analyzed and quantified, wherever possible. The identification of parameters for data generation and impact assessment are important. The accurate analysis of assessment depends upon the reliable data generated/ available on environmental attributed. The baseline data for various parameters of physical (physiographic and soils), ecological (forestry, fisheries and wildlife), and environmental pollution (air, water, noise, and solid waste) are documented. The impacts are assessed for various phases of project cycle namely:

- Impacts due to project location,
- Impacts due to project design,
- Impacts due to project construction, and
- Impacts due to project operation.

The impacts are categorized as negative and positive. The cost of management and monitoring programs were estimated and budgeted for. The approach for the study is presented in **Figure-1.1.**

FIGURE 1.1
METHODOLOGY OF THE EIA STUDY



The standard **methodology** for the data collection, impact assessment and formulation of management plans is adopted. The National Acts, Legislation and Laws along with **EIB** guidelines were consulted with a view to ensuring compliance with various requirements. The consultant collected and compiled the environmental baseline data for environmental attributes from primary and secondary sources. The primary sources include site visits, visual inspection, field studies, monitoring and analysis. The secondary sources include the books, reports, maps and documents from various government and non-government organizations on subject matter. The methodology proposed to be adopted for data collection, impact analysis, preparation of environmental management and monitoring plans is highlighted in brief, in the following paragraphs. However, more elaborate methodology is present in the main text in the relevant sections.

1.6.1 Data Collection

The existing **land-use** pattern of the area has been identified manly as urban human settlements, roads, Trees and water bodies. The ***Soils*** parameters are studied from the field surveys conducted during this study.

Water Resources in the project were considered in terms of precipitation, surface run off; quantity and quality of water. These will facilitate to decide various uses such as drinking, irrigation etc.

Air and Noise quality is an important consideration during construction and operation phases. Ambient air quality and noise levels were monitored in an around project area to develop present baseline levels in the area.

Terrestrial **Ecology** was studied. The vegetation types were documented through the visual inspection, past research and filed investigations.

1.6.2 Environmental Impact Assessment

The objective of the study is to assess the impacts as a result of construction of the LMRC metro corridor along with depot and sub-stations. The changes likely to occur in different components of the environment were studied and analyzed. The core area of study is to be 200 m on either side of proposed alignment and 25 m for sensitive receptors. Based on project particulars and the existing environmental conditions, potential impacts were identified that are expected to be affected as a result of the proposed project and wherever possible, these are quantified. Both positive and negative impacts are evaluated to have an idea about resultant impacts. These impacts were assessed for various phases of project cycle namely, location, design, construction and operation. The standard methodology was adopted for impact prediction and assessment. Prediction is essentially a process to forecast the future environmental conditions in the

project area that might be expected to occur. The prediction of impacts can be through mathematical modeling, overlays/ super imposition of activity, or comparison of impacts observed. The environmental impact of the project includes changes in land use, soil, erosion, water quality, air quality and noise levels etc. The impact on soils due to disposal of waste water and erosion during storms were predicted. The impact on water quality in the water bodies was evaluated with the help of water quality analysis. The burning issues such as Green House Gases (GHGs) and Climate Change were also studied. More details on Environmental Impact Assessment are available in **Chapter 4.**

1.6.3 Environmental Management Plan

The project will provide higher living standard, better quality of life, less travel time, better connectivity and transport facilities. The management plans are essential to ensure that stress/ loads on the systems are within carrying capacity. The management plan aims at maintaining the environmental quality of project area at-least in pre-project stage. An environmental management strategy/ plans were developed to mitigate the adverse impacts. Efforts are made to enhance the quality of environmental attributes.

1.6.4 Environmental Monitoring

It is necessary to monitor during various phases of project cycles the environmental attributes. Monitoring would indicate any environmental problem, which has come up due to an ongoing activity. This will facilitate to assess the effectiveness of management / mitigation measures. The consultant has designed a post project environmental monitoring program for implementation. The cost estimates for environmental monitoring and management have been included in the project estimates.

1.6.5 Liaison with Authorities

For the preparation of this EIA, the project team and environmental experts have liaised with the LMRC, and Ministry of Environment and Forests in order to discuss the proposed scope of the EIA, available data in the specific area on environmental attributes and general comments / observations that these authorities may have on the project and its environs.

To coordinate all the activities related to LMRP with different departments, a committee has been constituted under the chairmanship of Chief Secretary, Govt. of Uttar Pradesh. The said committee holds a meeting every week to review the project status. Following information illustrates liaison with different departments:

- PWD for acquisition of area under roads
- District Magistrate for land acquisition
- Different Urban Local Bodies for utility diversion

1.7 FORMAT OF THE REPORT

The main elements of the study are as follows: In **Chapter-2** a concise documentation is given on current and planned activities and the expected main beneficiaries. **Chapter-3** summarises environmental baseline conditions including physical, biological and socio-economic parameters and pre-project environmental constraint such as air pollution, problems related to public health and traffic congestion. Potential negative and positive impacts are presented in **Chapters-4 and 5** respectively. These include issues such as loss of land, rehabilitation and resettlement, disposal of soil, loss of trees, noise and vibration, disruption of utilities/ facilities, socio-economic and other problems due to the development of proposed Mass Rapid Transport System in Lucknow. In addition the public consultation and its finding are also reported.

Based on the anticipated negative impacts, the project may bring about an environmental management strategy, which has been outlined in **Chapter-6. Chapter-7** includes post project environmental monitoring programmes. This programme aims at signalling any potential environmental problem during construction and operation of the project and timely implementation of corrective measures. Finally, a summary of the costs of the environmental management and monitoring programmes falling under the responsibility of the project is presented in **Chapter-8.**

CHAPTER – 2
PROJECT DESCRIPTION

2.1 EXISTING SYSTEMS NEED FOR THE PROJECT

As Lucknow is a vibrant city attracting a lot of people from several places particularly from West Bengal, Bihar and Eastern Parts of Uttar Pradesh. It is witnessing an economic boom and it became among the top 10 fastest growing Metro cities of India. It is the second largest city of Northern India after Delhi. Due to large population migration from all over the country and rapid growth rate of population coupled with high economic growth rate has resulted in an ever increasing demand for faster transport system instead of city's existing transport system. Multiple modes of public transport are available such as taxis, city buses, cycle rickshaws, auto rickshaws and compressed natural gas (CNG) low floor buses with and without air conditioning. The city is an important junction with links to all major cities of the state and country. The city has a total of fourteen railway stations and one Chaudhary Charan Singh International (CCS) Airport. Lucknow Metro Rail project is aimed at bringing about traffic revolution in Lucknow by creating traffic conveniences for the people of the city. It is expected that this developmental measure will not only be helpful for the city but will also bring about betterment of the people living in the city, district, region, state. So it is urgently needed to replace the existing transport system with a Metro rail project. The following are the benefits of Metro system over other modes of transportation:

- Reduction in vehicles on-road due to its high carrying capacity
- Reduction in consumption of fossil fuels
- Reduction in pollutants
- Reduction in travel time

2.2 ANALYSIS OF ALTERNATIVES

The proposed corridor was 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.

A comparison of scenario with and without the project has also been made. Advantages and disadvantages have been spelt out. The positive impacts of the chosen corridors are further elaborated in Chapter 5 which was the criteria for selecting the proposed corridor.

2.2.1 No Development Alternative

In case the Lucknow Metro is not constructed, the city will be deprived of the following benefits:

- Employment Opportunities,
- Enhancement of Economy,
- Mobility,
- Safety,
- Traffic Congestion Reduction, Reduction in Number of Buses,
- Reduced Fuel Consumption,
- Reduced Air Pollution,
- Carbon Dioxide and Green House Gases (GHG) Reduction,
- Saving in Road Infrastructure.

Since the positive impacts are more than a few negative impacts, consideration of 'no development alternative' is a non-starter and has thus not merited any further consideration.

2.2.2 Identified Corridors

A detailed technical feasibility of the proposed metro corridors was done through a traffic study and engineering alignment option study and was discussed with LDA several times. A group of second order corridors were also considered for evaluation as potential mass transit routes. The criteria of selection for most desirable option was ridership, accessibility & integration, ROW of major roads, type of metro (elevated and underground requirements), cost elements, acquisition of build up property, O&M depot locations and minimum disturbance/avoidance of heritage structures prevalent in these sections. The heritage structures are present on almost all the selected options and final decision on selection of final set of corridors was a challenging task.

The following corridors were considered before arriving on final Corridors:

i. NS: Amausi to Munshi Pulia via Kanpur Road and Faizabad Road (23 km)

ii. EW: Rajaji Puram to Gomtinagar crossing CBD and Hazazrat Ganj (18 km)

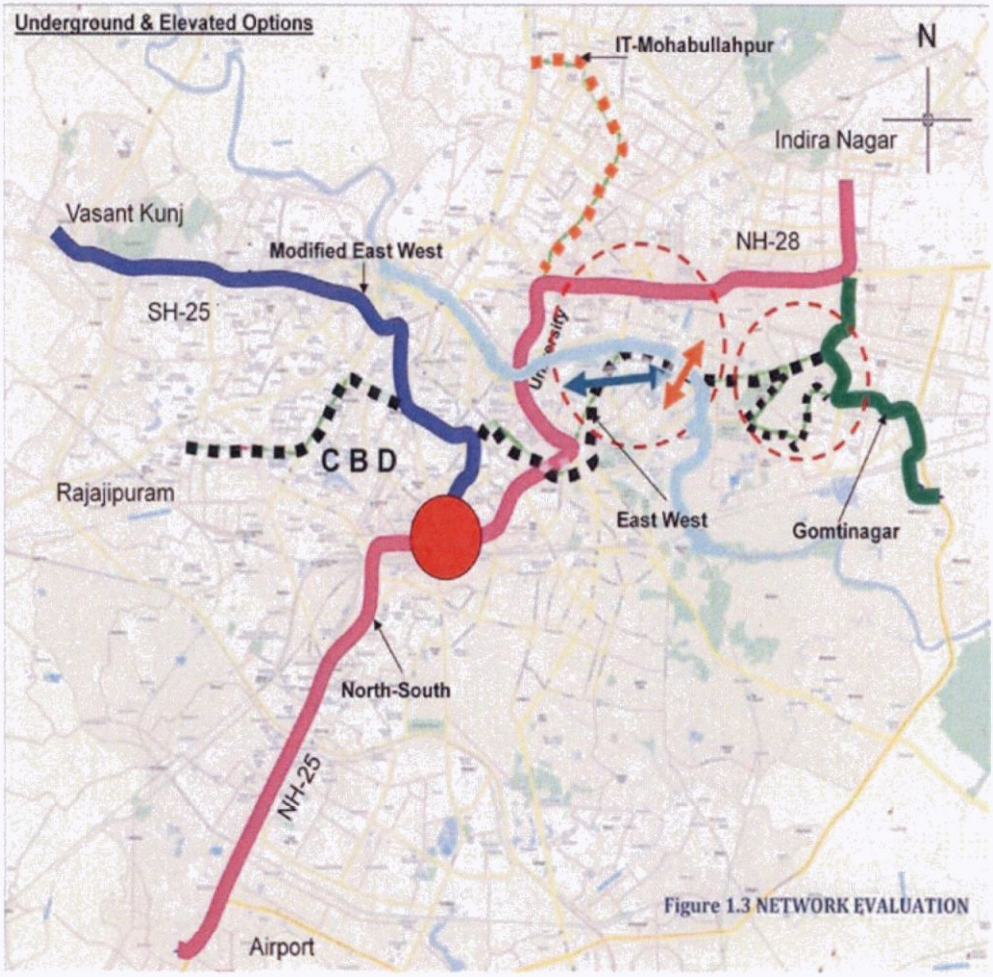
iii. Modified NS Corridor from Krishan Nagar to Muhibullahpur along Kanpur Road, Hazrat Ganj, MG Road, Hasan Ganj RS, crossing Gomti River near Bara Imambara along Sitapur NH-24 till Muhibullahpur / IET (20.5 km)

iv. Modified EW Corridor from Rajaipuram to Munshi Pulia via CBD, via Hazrat Ganj, Stadium, Parivartan Chk, IT Charaha along Faizabad Road till Munshi Pulia (18.6 km)

v. Modified EW Corridor from Lucknow Railway Station along Gautam Budha Marg via Aminabad, Pandey Ganj, City RS, Medical Crossing, Nawajganj and thereafter; along Hardoi Road up to Vasant Kunj (11.1 km)

Figure 2.1 shows the identified corridors of LMRP before finalizing the proposed corridors.

FIGURE 2.1
ROUTE MAP INDICATING IDENTIFIED CORRIDORS



The feasibility of these alternatives is discussed hereunder:

(i) NS: AMAUSI TO MUNSHI PULIA VIA KANPUR ROAD AND FAIZABAD ROAD

The following issues were studied in detail before finalising / freezing this corridor.

- The alignment was considered underground initially for a length of 5.1 km between Charbagh and KD Singh Babu Stadium. The location and positioning of ramp to cross river Gomti elevated was a major issue to be encountered. The road widths near Hazratganj market is barely 17m and the width of ramp to be provided was 10 m which would block the carriageway and sufficient width was not available for road traffic. As an alternative the ramp positioning near/opposite KD Singh Babu Stadium was also dropped in view of heritage structure at the Victoria Memorial site housed in the Begam Hazrat Mahal Park.
- Crossing of alignment across River Gomti underground was also dropped in view of complex geometry and availability of insufficient lengths for switch over between elevated to underground.

- To streamline these issues an elevated option was considered keeping in view the cost implications and complexity of construction of underground metro stations. There were no major obstacles for the alignment between Amausi and Mawaiya and the alignment was placed central along the Kanpur Road, which has sizeable ROW.
- The challenges posed by the elevated option were more near the existing BG Railway Line near Mawaiya Junction. In case the alignment has to cross the rail-lines elevated, the minimum metro rail level shall be 12 m above the broad gauge rail lines. To encounter this, extra dose bridge was envisaged to cross the railway lines elevated with span of about 80m.
- The issue of ramp positioning near KD Singh Babu Stadium could be avoided with the elevated option.
- The other constraints were on Faziabad Road between Mahangar and Lekhraj Market. The alignment has to surpass Indra Flyover before Mahanagar Junction and proposed ROB / Flyover planned across NH-28 crossing the rail lines near Kukrail Nala. The alignment has been planned double elevated at these locations.
- Finally, alignment has to turn at the Polytechnic Junction to terminate at Munshi Pulia. At this location the alignment has been planned to negotiate existing flyover at a safe distance.

(ii) EW: RAJAJI PURAM TO GOMTINAGAR CROSSING CBD AND HAZAZRAT GANJ

This corridor was envisaged to connect Gomti Nagar with Rajajipuram via central area, posed feasibility and ridership issues considering the following:

- The alignment was proposed to connect the Eastern part of Lucknow i.e. Gomti Nagar developing rapidly in terms of infrastructure facilities, education, medical facilities and Rajajipuram, the old established residential settlement in the west.
- The alignment was proposed to commence elevated from the Rajajipuram West near Auto stand. The alignment was to cross congested area of the Central Lucknow and was envisaged underground immediately after the proposed Rajajipuram West station.
- Crossing Aishbag Road the proposed connection with Hazratganj was aligned via crossing Subasha Marg, Aminabad, Kaiserbagh Junction reaching Vidhan-Sabha Marg. The alignment was then planned along the major banks road and approaching the Hazratganj Junction beneath Sarojni Nagar Road.
- From Hazratganj Junction, it followed underground via Ashoka Marg

reaching Shakti Bhawan

- The alignment was to cross Gomti River elevated. The switch over ramp had been proposed in the campus of the Botanical garden along the boundary wall. The alignment was planned to cross the Gomti River before the Cremation area, Baikunth Dham. Thereafter, alignment followed the road towards Fun Mall to reach Ram Manohar Lohiya Park towards Gomti Nagar.
- To reach Gomti Nagar, 2 elevated options were considered. Initially, the alignment was planned along Lohia Park Road turning at City Montessari School to reach Patrakar Puram. This would involve large scale property acquisition to provide adequate geometry and avoid the heritage Mutiny Ground.
- In the other option after Patrakarpuram the alignment was planned to cross the under-construction Flyover at a double height and reaching the terminating station Haneyman Chowk via Jaipuria School of management, Jaipuria School and Viraat Khand Market. The total length of the corridor was proposed to be 18.8 km and the underground section shall be about 8.5 km long. A total of 11 metro stations were planned on this corridor of which 6 stations were underground.
- The 4 km section between Botanical Garden and Sangeet Academy along the Butler Road did not attract significant ridership owing proximity to Butler Road flanked adjacent to riverbanks and therefore, no major station were planned. The positioning of elevated bridge across river Gomti was possible only the upstream side and would pose construction hazards. No other location was possible due presence of 3 existing bridges at this location.
- Since the metro connection to Gomti Nagar is vital, therefore, it was decided that a proposal for connecting proposed Indranagar metro station near Polytechnic Junction will be planned with an additional platform to aid possible metro connection via Wave Mall, Pickup Bhawan, Mashadipur and Patrakarpuram. This can then expanded in the Gomti Nagar area depending upon the future growth and potential of public transport demand.
- Similarly, the connectivity to Rajajipuram can be enhanced by integrating City railway station in the central area by a dedicated bus route.
- Therefore, this alignment was dropped.

(iii) MODIFIED NS CORRIDOR FROM KRISHAN NAGAR TO MUHIBULLAHPUR ALONG KANPUR ROAD, HAZRAT GANJ, MG ROAD, HASAN GANJ RS, CROSSING GOMTI RIVER NEAR JUNCTION OF MG ROAD & NH-24 ALONG SITAPUR ROAD TILL MUHIBULLAHPUR / IET (25 KM).

This alignment was tested as an alternative and was not considered due to presence of BG railway from Hasan Ganj towards Sitapur. A suitable sub-urban railway network can be planned along this corridor to cater to potential public transport demand.

(iv) MODIFIED EW CORRIDOR FROM RAJAJIPURAM TO MUNSHI PULIA VIA CENTRAL AREA CONNECTING HAZRAT GANJ, STADIUM, PARIVARTAN CHK, IT CHARAHA ALONG FAIZABAD ROAD TILL MUNSHI PULIA (17 KM)

This corridor did not attract significant traffic and there were many engineering constraints along this route and hence was not considered feasible.

(v) MODIFIED EAST WEST METRO CORRIDOR (LUCKNOW RS TO HARDOI ROAD) - 11 KM.

To cater to potential public mass transport demand in the central area a modified alignment (Lucknow Railway Station to Vasant Kunj on Hardoi Road) was tested as a viable alternative. The route between Lucknow RS via Gautam Budha Marg, Subash Marg to Hardoi Road via Chowk Chauraha is busy route and attracts considerable public transport trips throughout the day. The busy and commercial nature of Hardoi Road is poised for future growth and will need a mass transport facility in coming years. Many new residential and commercial establishments are proposed along this corridor till the Musabagh Forest. A six lane corridor gives access to newly planned residential settlement at Vasant Kunj. Hardoi Road has a planned ROW of over 30m and construction elevated metro is feasible.

The planning of alignment along this corridor was supplemented by connecting Lucknow RS with Gautam Budha Marg, Aminabad, Pandeyganj, Lucknow City RS at Wazirganj, Medical College connecting Hardoi Road besides Chota and Bara Imambara (maintaining a safe distance). The placement of station has been planned carefully in view of built-up nature and possible integration of proposed metro with other modes of traffic. A major bus terminal is also under construction near the Fish Mandi adjacent to proposed O&M Metro Depot location near Vasant Kunj. This will also integrate the metro corridor with road based bus system and cater to traveling needs.

The proposed alignment between Lucknow RS and Chowk Chauraha is planned underground in view dense mix of commercial cum residential landuse and thereafter, the alignment is proposed elevated along Hardoi Road till Vasant Kunj.

2.2.3 Environment and Social Considerations

The alignment of the proposed corridor was so selected that it will serve the maximum population, will entail less private land acquisition, least demolition of private and government structures, least tree cutting and will avoid impact on archaeological and historical structures. To achieve the above goals, the alignment suggested is mainly on the central verge of the road. In the highly densely populated areas the alignment is kept underground so as to lessen the social impacts that may have resulted from acquisition of property. The entire underground section will be constructed by tunneling through State of Art Tunnel Boring Machine (TBM).

2.3 PROPOSED METRO CORRIDOR

2.3.1 Details of Proposed Route

The recommended network for Phase I of MRTS in Lucknow City was finalized based on the above evaluation. The 2 corridors were finalized in Consultation with LDA and the preparation of DPR was taken for these 2 corridors. The NS and EW corridors will have a direct passenger interchange facilities at Lucknow Railway Station. Proposed depot locations have been planned at Amausi and Vasant Kunj on terminal ends on NS and EW corridors. Details of the proposed corridors are as follows:

a) North-South corridor starts at Chaudhary Charan Singh Airport and ends at Munshipulia via Sachivalaya, Hazaratganj, IT College Junction, Indira Nagar with a total length of 22.878 km having 22 stations (3 underground & 19 elevated).
b) East- West corridor (length = 11.098 km) starts at Lucknow Railway station and ends at Vasantkunj passing through Lucknow City Railway Station, Balaganj, Musabagh having 12 stations (7 underground & 5 elevated).

However, the current EIA study is restricted to North-South corridor (Chaudhary Charan Singh Airport to Munshipulia), including the 8.5 km priority section.

The proposed project is construction of metro corridor for N-S corridor (connecting Munshipulia to CCS International Airport) planned under Phase 1A. The relevant details of the proposed corridor were given below in **Tables 2.1 & 2.2**.

TABLE 2.1
DETAILS OF N-S CORRIDOR

Corridor Name	Elevated	Underground	Total length
N-S corridor: CCS Airport to Munshi Pulia	19.438 km	3.440 km	**22.878 km.**

(Source: LMRC DPR 2013)

TABLE 2.2
STATIONS ALONG N-S CORRIDOR

S. No.	Station Name	Category
1	CCS Airport	Elevated
2	Amausi	Elevated
3	Transport Nagar	Elevated
4	Krishna Nagar	Elevated
5	Singar Nagar	Elevated
6	Alambagh	Elevated
7	Alambagh Bus Station	Elevated
8	Mawaiya	Elevated
9	Durgapuri	Elevated
10	Charbagh	Elevated
11	Hussain Ganj	Underground
12	Sachivalaya	Underground
13	Hazratganj	Underground
14	K.D Singh Stadium	Elevated
15	Vishwavidyalaya	Elevated
16	IT Chauraha	Elevated
17	Mahanagar	Elevated
18	Badshahnagar	Elevated
19	Lekhraj Market	Elevated
20	R. S Mishra Nagar	Elevated
21	Indira Nagar	Elevated
22	Munshi Pulia	Elevated

(Source: LMRC DPR 2013)

The geographic area is within the jurisdiction of Lucknow Development Authority (LDA). The 22.878 km long corridor has been identified taking into consideration the issues regarding land acquisition, congestion issues and integration with other modes of transport. Therefore, stations are proposed in such a way so as to attract maximum demand from the traffic nodal points. The station locations are selected in such a way that it will entail minimal land acquisition apart from minimising inconvenience to the public. **Figure 2.2** provides the information of project location and **Figure 2.3** provides the details of N-S and E-W corridors. **Figure 2.4** represents the proposed corridor.

FIGURE 2.2
PROJECT LOCATION

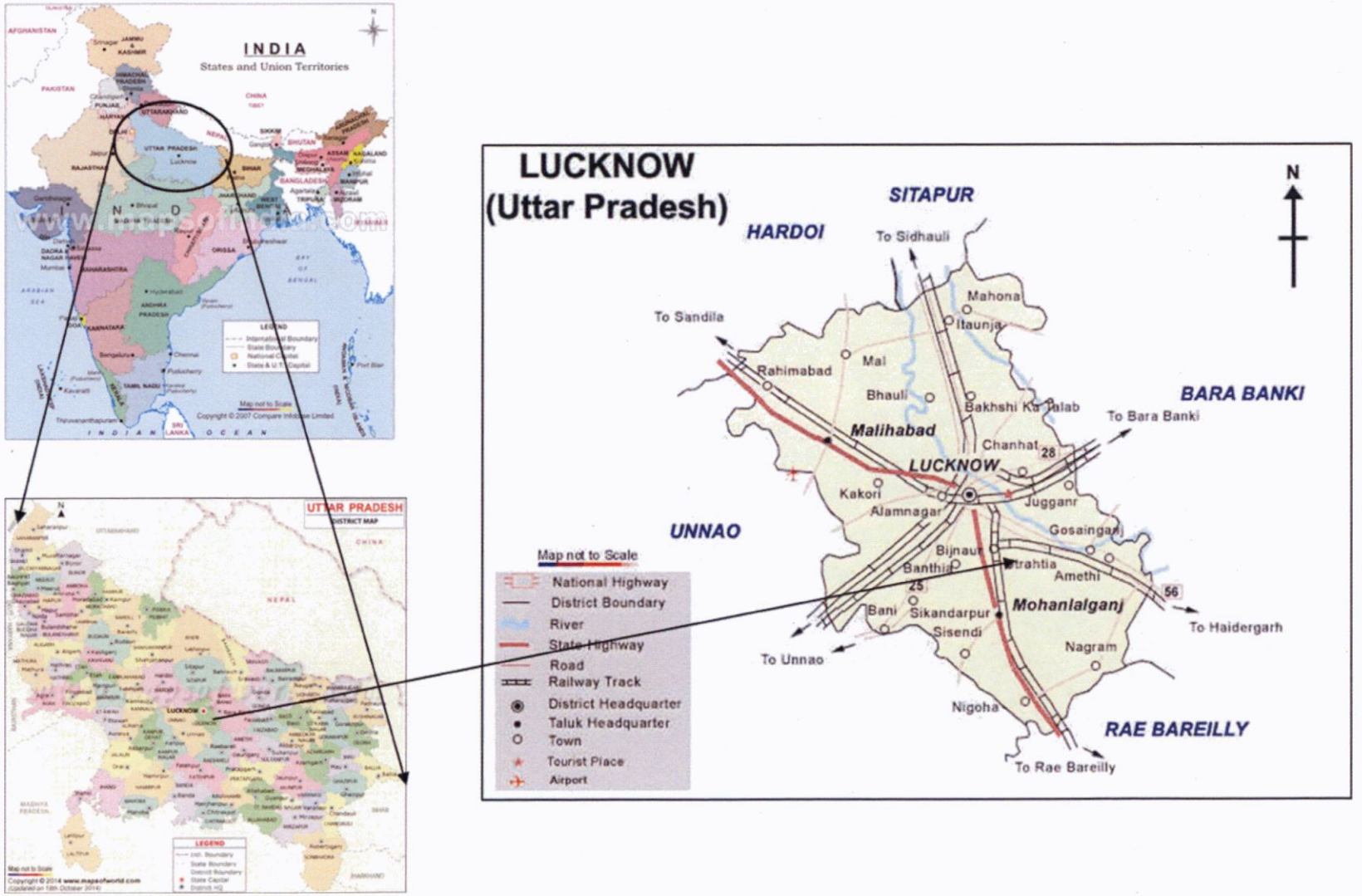
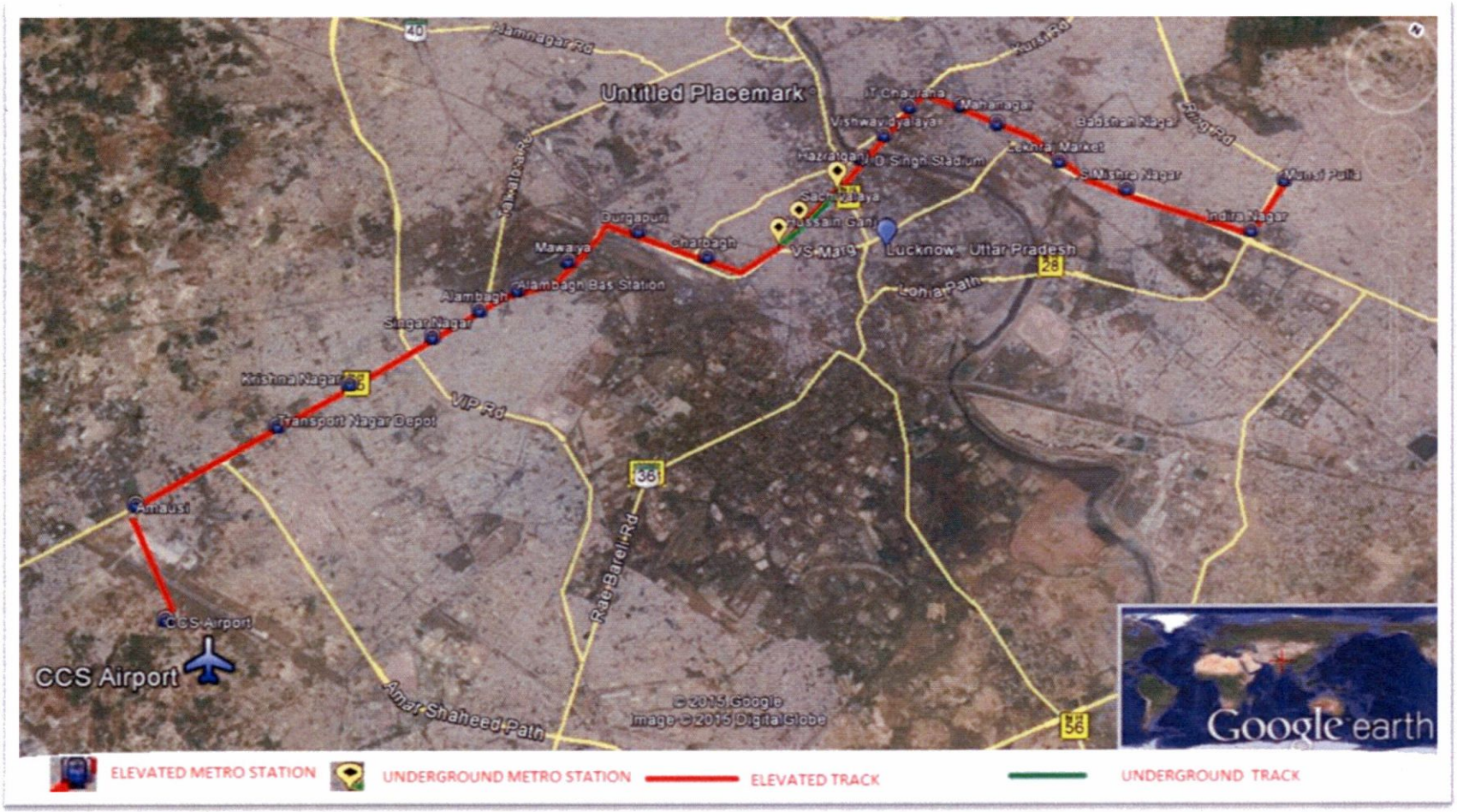


FIGURE 2.3
INDEX MAP FOR PROPOSED N-S AND E-W CORRIDORS

(Source: LMRC DPR 2013)

FIGURE 2.4
PROPOSED ALIGNMENT OF NORTH-SOUTH CORRIDOR



2.3.2 Ridership on North-South Corridor

The total ridership in the proposed North- South corridor in the year 2020 and 2041 was estimated to be 6.44 and 13.44 lakh passengers per day respectively. The maximum range of PHPDT (Peak Hour Peak Direction Traffic) on the North-South alignment in 2020 was estimated to be 20976 and by 2041 the maximum range of PHPDT is projected to be in the order of 44408. The estimated increase in daily ridership along the proposed corridor is shown in **Table 2.3**.

TABLE 2.3
ESTIMATED RIDERSHIP AT DIFFERENT HORIZON YEARS

Year	Corridor Length (km)	PHPDT	Daily Passenger km	Daily Ridership	Average Trip Length (km)
North-South Corridor : CCS Airport to Munshi Pulia					
2020	22.878	20976	4886515	644659	7.58
2025		25890	6132646	833240	7.36
2030		34955	7664688	1054290	7.27
2041		44408	9501868	1343970	7.07

(Source: LMRC DPR 2013)

2.3.3 Rolling Stock, Traction and Signalling

The salient features of proposals for Metro Corridor (underground and above ground) in respect of rolling stock, power supply, traction system and signalling are summarised in DPR and reproduced below:

- The required transport demand forecast is the governing factor for the choice of the Rolling Stock. The forecasted Peak Hour Peak Direction Traffic calls for an Medium Rail Transit System (MRTS).
- Variable voltage variable frequency (VVVF), light weight coaches, 3.2m wide with regenerative braking has been proposed for metro corridor
- Continuous Automatic Train Control (CATC) system, comprising cab signalling and automatic train protection system (ATP), along with automatic Train Operation (ATO) and automatic Train supervision (ATS) will be adopted. It will also have train describer-cum-passenger information system. Signalling and train control system will be capable of running trains at operation prescribed headway.

- The temperature and humidity of underground metro tunnels and stations are planned to be controlled at 29^{O}C and 70% respectively.
- The 25 kV electric traction has been proposed for Lucknow Metro. 25 kV AC traction has the economical advantages of minimal number of sub-stations and potential to carry large traffic (60,000-90,000 PHPDT). The system requires catenaries masts on surface/elevated section. In tunnel section 25 kV rigid overhead equipment OHE is proposed.
- Integrated system with Fibre Optics Cable, SCADA, Train radio, PA system will be provided for telecommunication.
- UIC -60 (60 kg/m) rail section has been adopted for the project. These rails are to be imported as these are not manufactured in India. The grade on main line will be 1080 Head Hardened. For the Depot lines, the grade of rails will be 880, which can be manufactures indigenously.
- Computer bases Automatic Fare Collection system (AFC) is proposed for the system. For multiple journey, the media shall be as utilised as Contactless Smart Token.

2.4 PASSENGER CARRYING CAPACITY

In order to maximise the passenger carrying capacity, longitudinal seating arrangement shall be adopted. Criteria for the calculation of standing passengers are 3 persons per square metre of floor area in normal state and 6 persons in crush state of peak hour. The carrying capacity for Standard Gauge is shown in **Table 2.4**.

TABLE 2.4
CARRYING CAPACITY OF TYPE 'A' STANDARD GAUGE CAR

Description	Driving Trailer car		Trailer car/ Motor car		6 car train	
	Normal	Crush	Normal	Crush	Normal	Crush
Seated	43	43	50	50	286	286
Standing	102	204	110	220	644	1288
Total	**145**	**247**	**160**	**270**	**930**	**1574**

(Source: LMRC DPR 2013)

2.5 MAINTENANCE DEPOTS

It is proposed to establish one depot–cum–workshop near Transport Nagar for North South Corridor. The area required for the proposed depot is 37.8 ha. This depot was selected based on the following criteria:

- Availability of large contiguous piece of land
- Located near to the alignment
- Minimum private land acquisition
- Land use not residential

2.6 SUB STATIONS

The high voltage power supply network of Lucknow city has 220kV and 132kV network to cater to various types of demand in vicinity of the proposed corridor. These sub stations are located along the alignment of corridor. Keeping in view the reliability requirements, two independent sources are considered. As per the sequence of construction, the revenue operation of elevated section will begin before the underground section is completed. To achieve the desired reliability, two Receiving Sub Stations (132 / 33 / 25 kV) are proposed to be set up for the proposed Corridor. Based on the discussions with Madhyanchal Vidyut Vitran Nigam Ltd., it is proposed to avail power supply for traction as well as auxiliary services from the following grid sub-stations at 220 kV voltage through cable feeders.

Electric Power requirement for the Corridor is likely to be 28 MVA approximately in year 2020 which is likely to increase to 48 MVA by the year 2041. Under normal conditions, this power will be equally shared between the two RSS feeding the corridor, while in case of failure of power supply from any one of the RSS; other RSS will feed the entire power requirement of the corridor. **Table 2.5** provides the details of sources of power supply.

Table 2.5

SUBSTATIONS

Corridor	Grid sub-station (with Input voltage)	Location of RSS of Metro Authority	Approx. length of cables
Corridor – 1 North – South Corridor (CCS Airport to Munshi Pulia)	Near Kanpur Road / Transport Nagar Sub Station at 220 kV	Amausi 220/33/25 kV RSS	2 to 3 km. 220kV cabling Double circuit
	Power Grid (PGCIL) 220 kV Sub Station at Kursi Road	Munshi Pulia 220/33/25 kV RSS	6 to 7 km. 220kV cabling Double circuit

(Source: LMRC DPR 2013)

2.7 CONSTRUCTION METHODOLOGY

It is proposed to provide precast Segmental Box Girder construction for elevated section and the underground section shall be done by "Cut and Cover", New Austrian Tunnelling Method (NATM), as well as by Tunnel Boring Machine (TBM).

2.8 COST ESTIMATES

The Lucknow Metro Project is proposed to be constructed with an estimated cost of Rs 5,590.00 Crore with central taxes and land cost. The length of the metro system and estimated cost at May-2013 price level without central taxes and with central taxes is placed in **Table 2.6**.

TABLE 2.6

ESTIMATED COST (RUPEES IN CRORES)

S. No.	Name of Corridor	Distance (km)	Estimated cost without taxes (Crore)	Estimated cost with Central taxes & land cost (Crore)
1	N-S Corridor (CCS Airport-Munshi Pulia)	22.878	4,992.00	5,590.00

(Source: LMRC DPR 2013)

CHAPTER – 3
ENVIRONMENTAL BASELINE DATA

3.1 ENVIRONMENTAL SCOPING

The information presented in this chapter stems from various sources. The objective of Environmental Impact Assessment (EIA) is to ascertain the baseline environmental conditions and then assess the impacts as a result of the proposed project during various phases of the project cycle. Identification of environmental parameters, data collection and impact predictions form the core of Environmental Impact Assessment process. Data on land environment has been collected and compiled from various reports and field surveys. The data on water quality, ground water hydrology, vegetation and fauna, air and noise quality was collected during field studies. Climatological data was collected from Indian meteorological Department. Efforts have been made to compile the available data from literature, books, maps and reports. The methodology adopted for data collection is highlighted wherever necessary. Environmental Attributes and Frequency of Baseline Survey is presented in **Table 3.1**. A scoping matrix has been formulated to identify the attributes likely to be affected due to the proposed project and summarized in **Table 3.2**.

TABLE 3.1
ENVIRONMENTAL ATTRIBUTES AND FREQUENCY OF MONITORING

S. No	Attribute	Parameter	Frequency	Source
LAND ENVIRONMENT				
1	Soil	Soil Characteristics	Once	Field studies and Detailed project report
2	Geology	Geological Status	---	Literature review
3	Seismology	Seismic Hazard	---	Literature review
WATER ENVIRONMENT				
4	Water Quality	Physical, Chemical and Biological parameters	Once	Field studies/literature review
AIR, NOISE AND METEOROLOGY				
5	Ambient Air Quality	$PM_{2.5}$, PM_{10}, SO_2,, NO_x, CO, HC	Two days	Field Studies/literature review
6	Meteorology	Temperature, Relative humidity, Rainfall, wind direction and speed	Data	India Meteorological Department/literature review
7	Noise	Noise levels in dB (A)	Once	Field monitoring
SCIO-ECONOMIC				
8	Socio-economic aspects	Socio-economic characteristic	Once	Field Studies, Literature review.
Ecology				
9	Trees	Number/species	Once	Filed Studies

TABLE 3.2
SCOPING MATRIX

No.	Impacts	Rating	Brief Description	Assumed mitigation measures	Survey for assessing impacts in this study
Social Environment					
1	Involuntary resettlement	A	Involuntary resettlement is required for construction of Phase III corridors.	- To provide proper compensation and rehabilitation. - To obtain consensus with the inhabitants.	Social condition of the area will be studied through interview of PAP/PAF's **(Social baseline survey)**
2	Local economy such as employment and livelihood, etc.	A	Local economy and livelihood in the land acquisition area will be affected since the people need to be relocated.	(same as No.1)	(same as No.1)
3	Land use and utilization of local resources	A	Private and government properties will be acquired for alignment and stations.	(same as No.1)	(same as No.1) Properties will be identified during topographical survey and route alignment.
4	Social institutions such as social infrastructure and local decision-making institutions	D	--	--	--
5	Existing social infrastructures and services	B B	Infrastructures such as water lines, sewer, storm water drains, telephone lines, gas pipelines, overhead electrical lines Traffic at the existing road may be affected during the construction work.	- The utility services will be maintained in working order during different stages of construction by temporary / permanent diversions or by supporting in position - The utilities will be restored to normal positions after construction - Diversion/ suggest alternative routes for smooth flow of traffic	Departments whose utilities bare being impacted will be identified. Existing condition of the road and road traffic will be observed through traffic survey.
6	The poor, indigenous and ethnic people	D	--	--	--
7	Misdistribution of benefit and damage	D	--	--	--
8	Cultural heritage	C	Few small religious structures may be affected.	(same as No.1)	Cultural heritages will be identified during survey.

No.	Impacts	Rating	Brief Description	Assumed mitigation measures	Survey for assessing impacts in this study
9	Local conflict of interests	D	--	--	--
10	Water Usage or Water Rights and Rights of Common	D	No impact is anticipated as water requirement will be met from separate tube wells for the project	--	--
11	Sanitation	B	Sanitation condition may deteriorate due to inflow of large number of construction workers.	Proper sanitation facilities will be provided (e.g. portable toilets) and ensure the proper management of waste.	Current sanitation condition at the project site will be ascertained.
12	Hazards (Risk) Infectious diseases such as HIV/AIDS	B	The risk of infectious diseases may increase due to inflow of large number of construction workers.	- To consider health care programs.	Information about diseases will be collected through the interview survey. **(Social baseline survey)**
Natural Environment					
13	Topography and Geographical features	D	No Impact on topography and geographical features is anticipated	--	--
14	Soil Erosion	B	Run off from unprotected excavated areas, and underground tunnel faces can result in excessive soil erosion	Careful planning, timing of cut and fill operations and revegetation	Soil condition will be assessed by taking soil sample and geotechnical study
15	Groundwater	B	Impact on ground water is expected as requirement of water for construction and operation of depot will met though tube well.	Rainwater harvesting will be done	Baseline data of ground water table and availability
16	Hydrological Situation	D	No impact on hydrological situation is anticipated.	--	--
17	Coastal Zone (Mangroves, Coral reefs, Tidal flats, etc.)	D	The project area is not in the coastal zone.	--	--
18	Flora, Fauna and Biodiversity	B D D	Trees will be cut which are falling along the alignment. No rare and endangered species are found . No impact on fauna is	- Compensatory afforestation will be carried out.	Tree survey will be carried out during the study

No.	Impacts	Rating	Brief Description	Assumed mitigation measures	Survey for assessing impacts in this study
			anticipated as the project is in urban area where there is no wildlife		
19	Meteorology	D	No impact on meteorology in anticipated	--	--
20	Landscape	D	There is no valuable landscape to be protected at the project site.	--	--
21	Global Warming	D	No activity which will cause the global warming is anticipated.	--	--
Pollution					
22	Air Pollution	B	Emission from construction equipments and vehicles will increase air pollutants.	- To use proper construction vehicles with good condition to minimize emission.	Air quality monitoring in project area
23	Water Pollution	C	Construction of bridge on Yamuna may create water pollution	- To select proper construction method. -	Water quality of the river will be surveyed by water sampling.
24	Soil Contamination	D	Oil spills, paints, solvents may cause soil contamination	To provide for oil trays and drip pans and provision of separate storage	Soil testing
25	Waste	B	Construction surplus soil will be generated.	- To select proper site to dispose the soil.	Quantity of surplus soil will be identified.
26	Noise and Vibration	B	Construction noise will be generated. Noise and vibration from metro operation may impact surrounding area.	- To restrict construction at night. - To install noise barriers if necessary	Noise quality monitoring in project area
27	Ground Subsidence	C	There will be possibility of subsidence.	- Detailed survey of condition of buildings/houses along proposed alignment will be conducted. - The details are discussed in Chapter 6, Section 6.2.9.	
28	Offensive Odor	D	No odour is anticipated	--	--
29	Bottom sediment	D	No Sedimentation is expected	--	--
30	Accidents	B	There are risks of accidents during construction. During operation	- To secure the safely control.	

No.	Impacts	Rating	Brief Description	Assumed mitigation measures	Survey for assessing impacts in this study
			accidents will be reduced		
A – Significant negative impact expected B – some negative impact expected C – extent of negative impact is unknown D – No negative impact expected					

3.2 LAND ENVIRONMENT

The Project area is situated in Lucknow, the Capital city of the state of Uttar Pradesh. The average elevation of Lucknow is 120 m above the sea level (a-MSL). Lucknow is located between 26.8° North latitude and 80.9° East Longitude. Parameters involved in land environment are, physiography, geology and soils, and seismicity. These are discussed in the following paragraphs.

3.2.1 Physiography

The Gomti River, Lucknow's chief geographical feature, meanders through the city and divides it into the Trans-Gomti and Cis-Gomti regions. Situated in the middle of the Indus-Gangetic Plain, the city is surrounded by rural towns and villages: the orchard town of Malihabad, Kakori, Mohanlal ganj, Gosainganj, Chinhat, and Itaunja. To the east lies Barabanki District, to the west Unnao District, to the south Raebareli District, while to the north lie the Sitapur and Hardoi Districts.

3.2.2 Geomorphology and Soils

The district forms a part of Ganga basin with flat alluvial terrain. General elevation varies from 103 m to 130 metres above mean sea level. The general slope of the district is south-east. Geomorphologically the district is divided into two geomorphic units (i) Older flood plains & (ii) Active flood plain. Older flood plain exists between elevation of 103 and 110 m above sea level. Both the terraces are developed on the either side of Gomti River. Erosional terrace is also developed along Sai Nadi. Active flood plains are restricted to present day bank line of the rivers. These are represented by land forms like point bars channel bars and lateral bars. Quaternary sediments have been divided upto older and newer alluvium. The older alluvium is comprised of grey to brown coloured silt clay and sand with or without Kankar of middle to late Pleistocene age. The Newer alluvium overlies the older alluvium and has been sub divided into terrace alluvium and channel alluvium & belongs to Holocene age. The newer alluvium comprises of light Khaki grey silt, clay and fine to medium and coarse grained grey sand which is micaceous in nature (Source: CGWB, Lucknow).

Soils in the district exhibit a wide variation in composition texture and appearance. The major position of the district is occupied by soils locally known as "Bhur" or "Silty Sand" on the ridges. "Matiyar" or "Clay Soils" occurs along topographic lows and "Dumat or Loamy soils" in the level lands. Clay is dominant in the areas where "Reh" (Usar) prevails.

In order to ascertain the quality and nature of soil within the vicinity of the project site, soil samples were collected. Soil samples at 30 cm depth were collected from three (3) locations (**Figure 3.1**) and were analyzed for 10 parameters. The results conclude that top soil is silt clay. These samples were collected about 0.3 m depth. The samples were tested for physical and chemical properties. The results of soil analysis are presented in **Table 3.3.**

TABLE 3.3
SOIL TEST RESULTS

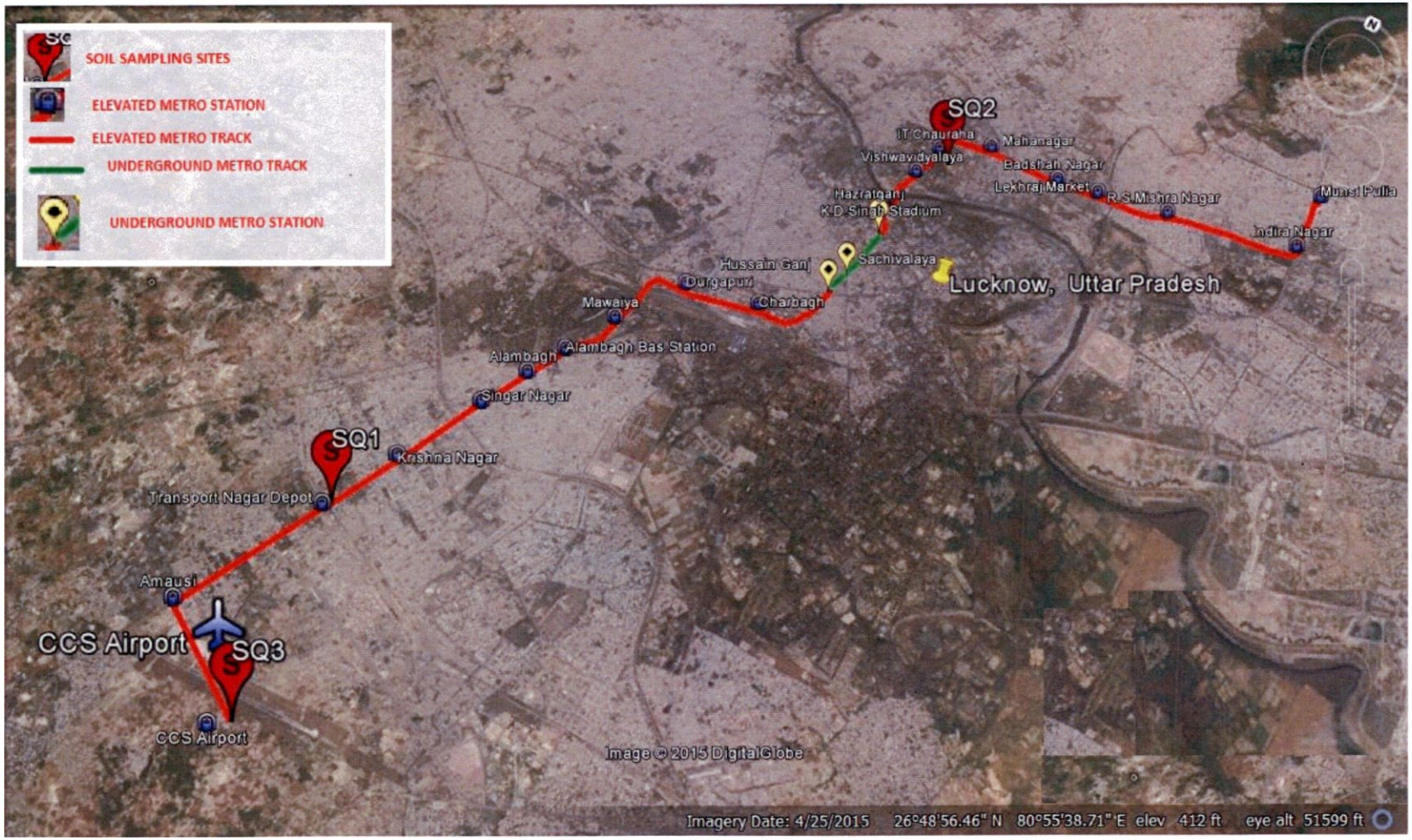
S.No.	Parameters	Units	Transport Nagar (SQ 1)	Lucknow University (SQ 2)	Airport (SQ 3)
1	**pH**	–	7.78	8.09	7.97
2	**Total Kjehldahl Nitrogen**	mg/kg	834.9	1503.80	1183.5
3	**Phosphorus (as P)**	mg/kg	80.30	119.2	167.5
4	**Potassium (as K)**	mg/kg	79.3	40.9	46.6
5	**Cyanide (CN)**	mg/kg	< 0.5	< 0.5	< 0.5
6	**Lead (as Pb)**	mg/kg	< 2.0	< 2.0	< 2.0
7	**Mercury (as Hg)**	mg/kg	< 1.0	< 1.0	< 1.0
8	**Cadmium (as Cd)**	mg/kg	< 2.0	< 2.0	< 2.0
9	**Arsenic (as As)**	mg/kg	< 5.0	< 5.0	< 5.0
10	**Total Chromium (as Cr)**	mg/kg	< 2.0	< 2.0	< 2.0
(Source: Field Studies) Month of Monitoring: May 2015					

Regional Scenario

- **pH:** This parameter is directly concerned with the acidity and alkalinity of the soil. The minimum value was found to be 7.78 which reach upto 8.09 in the study area.
- **Total Kjehldal Nitrogen:** Total Kjehldal Nitrogen (TKN) is the sum of organic nitrogen, ammonia (NH_3), and ammonium (NH_{4+}) in the chemical analysis of soil, water and wastewater. The value of TKN varies from 834.9 mg/kg to 1503.80 mg/kg.
- **Phosphorus (as P):** Phosphorus (P) is an essential element classified as a macronutrient because of the relatively large amounts of P required by plants. Phosphorus is one of the three nutrients generally added to soils in fertilizers. In present study concentration of Phosphorus in soil at particular sites were observed to be fluctuated in between 80.30 mg/kg to 167.5 mg/kg.
- **Potassium (as K):** Of the major nutrient elements, K is usually the most abundant in soils. Potassium exists in four forms in soils: solution, exchangeable, fixed or non exchangeable, and structural or mineral. The amount of Potassium at these sites fluctuated from 40.9 to 79.3 mg/kg.
- **Cyanide (CN):** Cyanide and cyanide compounds are present in soil and sediment due to both natural and anthropogenic sources. Soils represent the major potential pathway for cyanide contamination of groundwater. High concentrations of cyanide in landfill waste or industrial effluents present a hazard to both soil and groundwater. At all the sites value of Cyanide remains below the 0.5 mg/kg (≤0.5 mg/kg).
- **Lead (as Pb):** The contamination of urban soils by lead is a persistent source of risk to human health. The value of Lead in the present study was observed to be below 2.0 mg/kg.
- **Mercury (as Hg):** The concentration of Mercury remained below 1.0 mg/kg.
- **Cadmium (as Cd):** Of all the non-essential heavy metals, cadmium (Cd) is perhaps the metal which has attracted most attention in soil science and plant nutrition due to its potential toxicity to man, and the relative mobility in the soil-plant system. Cadmium remained below 2.0 mg/kg at all the sites.
- **Arsenic (as As):** The values for Arsenic was observed to be lesser than 5.0 mg/kg during the study.
- **Total Chromium (as Cr):** Hexavalent chromium [Cr (VI)] is a common environmental pollutant that is mobile in soils and is a known mutagen. The trivalent form [Cr (III)] has no known mutagenic properties and is highly insoluble and immobile above pH 5.5. The value remained constant and below 2.0 mg/kg at all the stations.

FIGURE 3.1

SOIL SAMPLE LOCATIONS

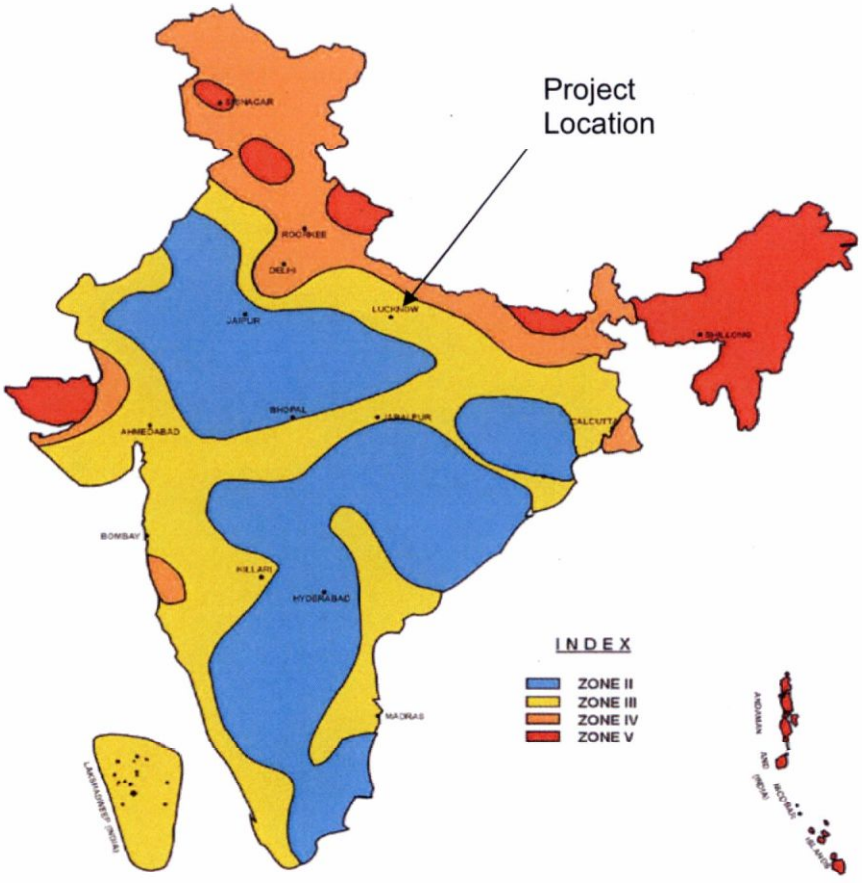


3.2.3 Seismicity

The country has been classified into different zones indicating the intensity of damage or frequency of earthquake occurrences. These zoning maps indicate broadly the seismic coefficient that could generally be adopted for design of buildings in different parts of the country. These maps are based on subjective estimates of intensity from available information on earthquake occurrence, geology and tectonics of the country.

Lucknow is located in Zone 3 of seismic zoning map of India (**Figure 3.2).** This zone is classified as Moderate Damage Risk Zone which is liable to MSK VII. The IS code assigns zone factor of 0.16 for Zone 3. MSK scale describes the impact as felt by most indoors and by many outdoors. A few persons may lose their balance. Many people are frightened and run outdoors. Small objects may fall and furniture may be shifted. Dishes and glassware may break. Comparing with Modified Mercalli intensity scale, Zone 3 can have earthquake of 5 to 5.9 Richter magnitudes near the epi-centre of the earthquake.

FIGURE 3.2
SEISMIC ZONING MAP OF INDIA



3.3 WATER ENVIRONMENT

Water environment consists of water resources and its quality. Its study is important from the point of view to assess the sufficiency of water resources for the needs of the project in its various stages of the project cycle and also to assess the impact of the project on water environment. In the proposed project, ground water is proposed to be used during construction as well as post construction period; hence its quality has been tested to evaluate its suitability for the intended purpose. Anticipated impacts of the proposed project on water environment have also been addressed.

3.3.1 Water Quality

Water quality is the physical, chemical and biological characteristics of water. It is most frequently used with reference to a set of standards against which compliance can be assessed. The most common standards used to assess water quality relate to drinking water, safety of human contact, and for health of ecosystems. An understanding of the various factors influencing water quality is thus very important as human health is largely dependent on the quality of water available for our use.

In order to collect baseline data on the existing water quality, Surface water and ground water samples were collected from different sources within the study area and some important physical and chemical parameters including heavy metals, for ground water, were considered for depicting the baseline status of the study area.

Ground water (Two locations) and surface water (Two samples) samples were collected from the study area to assess the water quality during the study period. The ground water samples were drawn from the bore wells. Surface water sampling was carried out from the Gomti River.

The test results when compared with the prescribed limits of various parameters as per IS 10500:1991 indicated that the total hardness and alkalinity of Indira Nagar wetre exceeding the desirable limits but within the permissible limits. The remaining parameters of the samples were within the desirable limits. The details of the sampling locations are given in **Table 3.4** and shown in **Figure 3.3**. The results of ground and surface water samples are provided in **Table 3.5 and 3.6**.

Table 3.4
WATER SAMPLING LOCATIONS

S.No.	Code	Name of the sampling Location
1	GW1	Indira Nagar
2	GW 2	Krishna Nagar
1	SW1	Gomti River (Upstream)
2	SW2	Gomti River (Down Stream)

FIGURE 3.3

WATER SAMPLE LOCATIONS

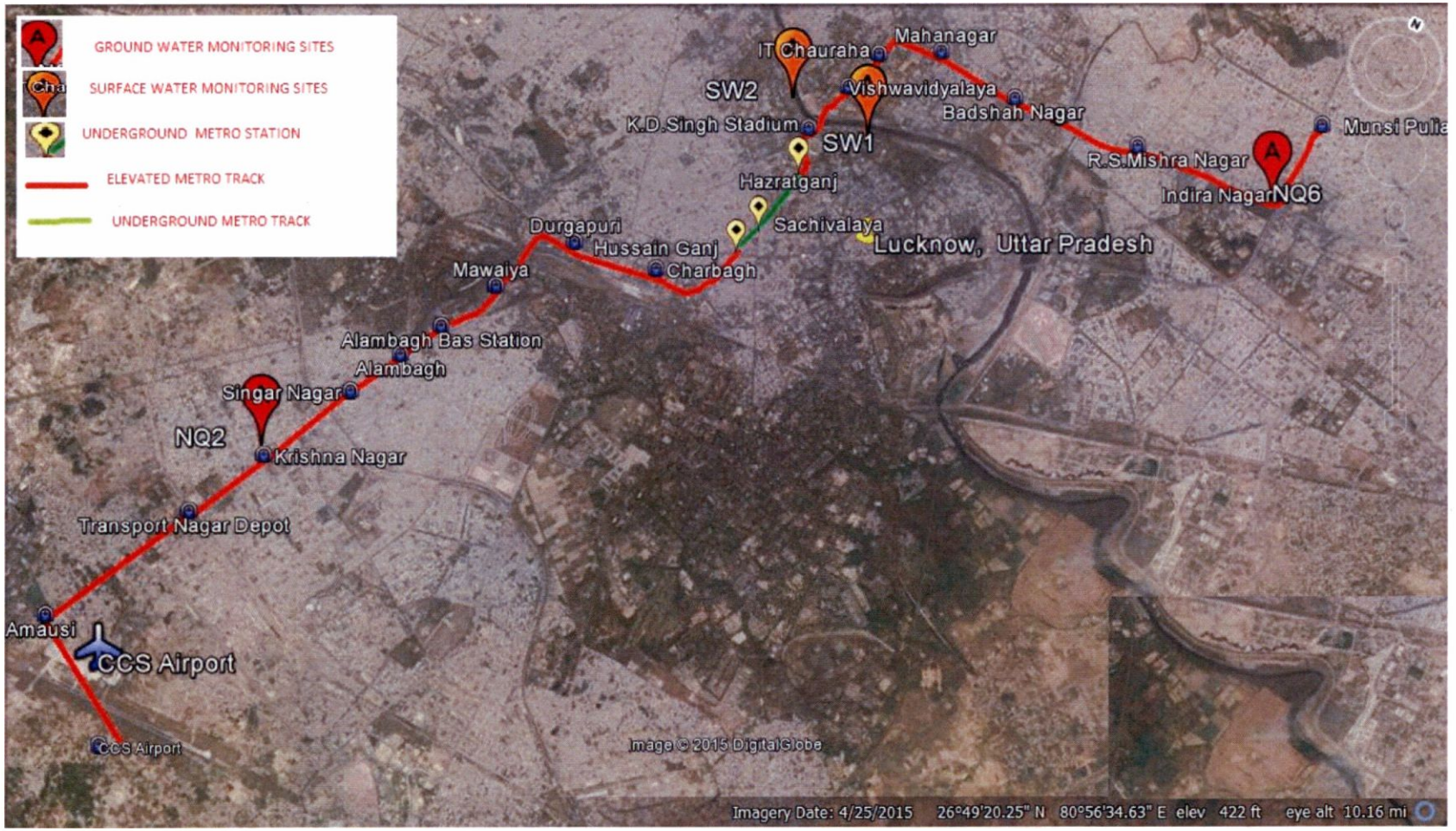


TABLE 3.5
GROUND WATER QUALITY AT BORE WELLS

Parameter	Unit	Indira Nagar	Krishna Nagar	Drinking Water Standard	
				Desirable	Permissible
pH Value	--	7.47	7.64	6.5	8.5
Total Hardness as $CaCO_3$	mg/l	399.36	276.48	300	600
Total Dissolve Solids	mg/l	460	434	500	2000
Alkalinity as $CaCO_3$	mg/l	253.44	372.48	200	600
Iron as Fe	mg/l	0.25	0.19	0.3	1.0
Chlorides as Cl	mg/l	103.66	30.59	250	-
Nitrate as NO_3	mg/l	18.8	4.0	45	-
Phosphate as PO_4	mg/l	0.15	0.20	-	-
Arsenic as As	mg/l	<0.01	<0.01	0.05	-
Lead as Pb	mg/l	<0.005	<0.005	0.05	-
Chromium as Cr+6	mg/l	<0.1	<0.1	0.05	-
(Source: Field Studies) Month of Monitoring: May 2015					

TABLE 3.6
SURFACE WATER QUALITY

Parameter	Unit	Gomti River Upstream	Gomti River Downstream
pH Value (at 28°C)	--	7.55	8.28
Temperature	^{0}C	32	32
Oil & Grease	mg/1	<1.4	<1.4
Total dissolve solid	mg/1	294	305
Total Suspended Solid	mg/l	31.4	17.2
Iron as Fe	mg/1	0.80	0.56
Chlorides as Cl	mg/1	29.7	25.5
Nitrate as NO3	mg/1	14.0	14.52
Phosphate as PO4	mg/1	0.60	0.53
Lead as Pb	mg/1	<0.005	<0.005
Chromium as Cr+6	mg/1	<0.1	<0.1
Chemical Oxygen Demand	mg/1	7.36	11.04
Biochemical Oxygen Demand, 3 days at 27°C	mg/1	<2.0	3.4
D.O. At 29°C	mg/1	4.08	4.1
Total Coliform	MPN/100ml	1600	1600

(Source: Field Studies) Month of Monitoring: May 2015

Regional Scenario

- The pH limit fixed for drinking water samples as per IS: 10500 is 6.5 to 8.5 beyond this range the water will affect the mucus membrane and or water supply system. As per the monitoring results, the pH was varying for ground water from 7.47 to 7.64 and in Surface water the pH was ranging from 7.55 to 8.28 which were found to be within the limits.

- The desirable limit for total dissolved solids as per IS: 10500 are 500 mg/l where as the permissible limits in absence of alternate source are 2000 mg/l, beyond this palatability decreases and may cause gastro intestinal irritation. In ground water samples collected from the study area, the total dissolved solids are varying from 276.48 mg/l to

399.36 mg/l. In surface water the total dissolved solids were varying from 294 mg/l to 305 mg/l. The TDS of all the samples were found to be within the desirable limits.

- The desirable limit for chloride is 250mg/l as per IS: 10500 where as the permissible limit of the same is 1000 mg/l beyond this limit taste, corrosion and palatability are affected. The Chloride levels in the ground water samples collected in the study area were varying between 30.59 mg/l to 103.66 mg/l; whereas, the chlorides in surface water were varying between 25.5 mg/l to 29.7 mg/l. the results are within the desirable limit.

- The desirable limit as per IS:10500 for hardness is 300 mg/l where as the permissible limit for the same is 600 mg/l beyond this limit encrustation in water supply structure and adverse effects on domestic use will be observed. In the ground water samples collected from the study area, the hardness is varying from 276.48 mg/l to 399.36 mg/l. The hardness of groundwater samples were within the permissible limits.

- Another important parameter concerned in ground water are heavy metals, mainly including them are Arsenic, Lead, Chromium. Even though the desirable and permissible standards are quite low as compared to others, their presence in small concentrations in drinking water can lead to serious health issues on prolong exposure. The ground water test performed at Indira Nagar and Krishna Nagar indicate these values well within permissible limits.

- Presence of anions in water in form of Nitrates, Chlorides levels are also analyzed as high concentration of nitrates in drinking water leads to methaemoglobinaemia, gastric cancer and cardiovascular diseases. The values observed at Indira Nagar and Krishna Nagar ground water samples and in Gomti River (surface water) sample is well within limits.

- In case of surface water, Dissolved oxygen is also analyzed to have knowledge of aquatic life support potential of river. The values at both entrance point and middle point are above minimum standard requirement of 4 mg/l. Simultaneously, MPN parameters are also checked for surface water sample. Value of 1600 indicates the presence of minimal fecal matter which might be possible due to entry of sewage at some location upstream of sample collection.

3.4 METEOROLOGY AND AIR ENVIRONMENT

Meteorology is an important parameter in an environmental impact assessment exercise. All air pollutants emitted by point and non-point sources are transported, dispersed or concentrated by meteorological and topographical conditions. The main parameters are: temperature, humidity, rainfall, winds and cloud cover. The meteorology and air environment of the area are discussed in subsequent sections.

3.4.1 Meteorology

Lucknow has a warm humid subtropical climate with cool, dry winters from December to February and dry hot summers from April to June. The rainy season is from mid- June to mid-September with an average rainfall of 966.24mm, mostly from the south-west monsoon winds. In winter the maximum temperature is around 21 degree Celsius and the minimum is in the 3 to 5 degree Celsius range. Fog is quite common from late December to late January. Summers can be quite hot with temperatures rising to the 40 to 45 degree Celsius range.

Records of mean maximum and mean minimum temperature of Lucknow obtained from Indian Meteorological Department, from 1952 to 2000 are given in **Table 3.7**.

TABLE 3.7
MONTHLY MEAN MAXIMUM & MINIMUM TEMPERATURE

Month	Mean temperature (°C)		
	Maximum	Minimum	
January	22.5	7.3	
February	25.9	9.7	**Station Name:** LUCKNOW (Amausi)
March	32.1	14.5	
April	38.0	20.4	
May	40.3	24.7	**Period:** 1952-2000
June	38.6	27.0	
July	33.8	26.1	**No. of Years:** 49
August	32.9	25.6	
September	33.0	24.3	
October	32.6	19.0	
November	29.0	12.3	
December	24.3	8.0	
(Source: Indian Meteorological Department)			

Rainfall

The average number of rainy days is 44. The normal rainfall of Lucknow district is 966.24 mm. The maximum rainfall occurs during the monsoon period i.e. June to September having normal value of 849.78 mm which is 87.9% of the annual rainfall. July is the wettest month having the normal rainfall of 289.56 mm followed by August with normal rainfall of 287.66 mm.

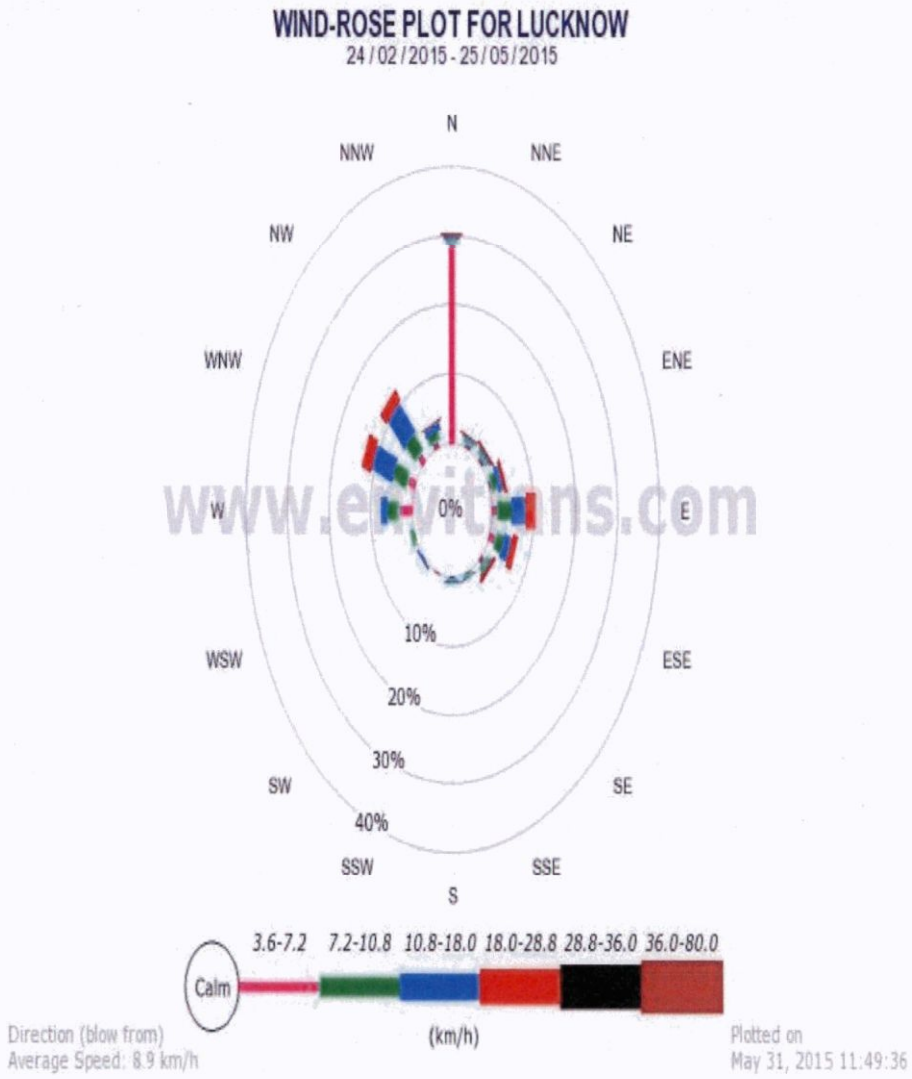
Humidity

The average relative humidity remains 25% in morning while in the evening it remains 68%. The annual normal potential evapotranspiration of the district is 1519 mm (source: CGWB study report, Lucknow).

Wind Speed

The average wind speed varies between 4 and 7.5 km/hr during winter and 9.9 and 11.7 km/hr during summer seasons. From wind rose diagrams it has been observed that the prominent wind direction in Lucknow area is north-to south direction i.e. Predominant wind direction is north (**Figure 3.4**).

FIGURE 3.4
WINDROSE BASED ON THE WIND SPEED AND DIRECTION IN LUCKNOW AREA



3.4.2 Air Quality

The atmospheric concentrations of air pollutants were monitored at 6 locations during May 2015 by setting up ambient air quality monitoring stations. The details of air monitoring stations are provided in **Table 3.8** and shown in **Figure 3.5.** Air Monitoring was carried out for $PM_{2.5}$, PM_{10}, NO_2, SO_2, and CO. Results of the air quality monitoring are presented in **Table 3.9.** These are compared with the standards prescribed by Central Pollution Control Board (CPCB).

TABLE 3.8
DETAILS OF AIR MONITORING LOCATIONS

Symbol	Monitoring Locations
AQ*1	Airport
AQ2	Transport Nagar
AQ3	D A V College
AQ4	Jain Hospital
AQ5	Lucknow University
AQ6	Indra Nagar
* AQ – Air Quality Monitoring Station	

TABLE 3.9
AMBIENT AIR QUALITY LEVELS IN THE STUDY AREA

Parameter / Monitoring Location		PM_{10} µg/m^3	$PM_{2.5}$ µg/m^3	SO_2 µg/m^3	NO_2 µg/m^3	CO µg/m^3
AQ1	I*	130.5	89.2	15.8	31.5	0.85
	II	132.9	85.3	15.3	33.6	0.89
AQ2	I	140.2	84.3	17.4	36.5	0.95
	II	136.7	86.9	16.2	38.4	0.98
AQ3	I	141.5	98.2	15.8	32.5	1.05
	II	143.8	95.8	16.8	30.4	1.09
AQ4	I	148.3	91.4	13.7	25.6	1.24
	II	151.7	93.8	14.6	28.7	1.22
AQ5	I	135.7	88.3	17.9	30.4	1.18
	II	138.9	92.9	17.3	29.4	1.14
AQ6	I	155.6	102.6	19.5	31.4	1.32
	II	159.7	98.3	18.7	32.8	1.28
Time weighted Average		24 Hours	24 Hours	24 Hours	24 Hours	1 Hour
NAAQ Standard		**100 µg/m^3**	**60 µg/m^3**	**80 µg/m^3**	**80 µg/m^3**	**2000 µg/m^3**

*** I – First day of monitoring**
II – Second day of monitoring
(Source: Field Studies) Month of Monitoring: May 2015

Regional Scenario
a) Particulate Matter <2.5µ & <10µ

Particulate Matter (PM) is the term used for a mixture of solid particles and liquid droplets suspended in the air. These particles originate from a variety of sources, such as power plants, industrial processes, and diesel trucks, and they are formed in the atmosphere by transformation of gaseous emissions. Their chemical and physical compositions depend on location, time, and weather. Particulate matter is composed of both coarse and fine particles.

Coarse particles (PM_{10}) have an aerodynamic diameter between 2.5µ and 10µ. They are formed by mechanical disruption (e.g. crushing, grinding, abrasion of surfaces) evaporation of sprays, and suspension of dust. PM_{10} is composed of alumiosilicate and other oxides of crustal elements, and major sources including fugitive dust from roads, industry, agriculture, construction and demolition, and fly ash from fossil fuel combustion. The lifetime of PM_{10} is from minutes to hours, and its travel distance varies from <1km to 10 km.

Fine particles have an aerodynamic diameter less than 2.5µ ($PM_{2.5}$). They differ from PM_{10} in origin and chemistry. These particles are formed from gas and condensation of high temperature vapors during combustion, and they are composed of various combinations of sulfate compounds, nitrate compounds, carbon compounds, ammonium, hydrogen ion, organic compounds, metals, and Particle bound water. The major sources of $PM_{2.5}$ are fossil fuel combustion, vegetation burning, and the smelting and processing of metals. Their lifetime is from days to weeks and travel distance ranges from 100km to >1000 km.

The minimum and maximum level of Particulate Matter <2.5µ recorded within the study area were in the range of 84.3 to 102.6 µg/m^3.

The minimum and maximum level of Particulate Matter <10µ recorded within the study area were in the range of 130.5 to 159.7 µg/m^3.

The 24 hourly average values of Particulate Matter <2.5µ & Particulate Matter <10µ were compared with the national ambient air quality standards and found that the monitoring results of all the sampling stations are exceeding the applicable standards.

b) Sulfur Dioxide

Sulfur dioxide gas is an inorganic gaseous pollutant. Sulfur dioxide emissions are expected to be emitted wherever combustion of any fuel containing sulfur takes place. The sulfur in the fuel will combine with oxygen to form sulfur dioxide. In general some of the important sources of sulfur dioxide are power stations, sulfuric acid plants, oil refining, boilers in utilities in any industry and domestic use of coal. Information in the literature

has indicated that the presence of sulfur dioxide in the photochemical smog reaction enhances the formation of visibility enhancing aerosols.

Sulfur dioxide is capable of producing illness and lung injury. Further it can combine with water in the air to form toxic acid aerosols that can corrode metal surfaces, fabrics and the leaves of plants. Sulfur dioxide is irritating to the eyes and respiratory system. Excessive exposure to sulfur dioxide causes bronchial asthma and other breathing related diseases as it affects the lungs.

The minimum and maximum level of SO_2 recorded within the study area was in the range of 13.7 $\mu g/m^3$ to 19.5 $\mu g/m^3$. These results were compared with the national ambient air quality standards and it was found that the monitoring results of all the sampling stations are much lower than the applicable limit of 80$\mu g/m^3$.

c) Nitrogen Dioxide

Nitrogen dioxide (NO_2) is one of the nitrogen oxides (NO_X), a group of air pollutants produced from combustion processes. In urban outdoor air, the presence of NO_2 is mainly due to traffic. Nitric oxide (NO), which is emitted by motor vehicles or other combustion processes, combines with oxygen in the atmosphere, producing NO_2. Long-term NO_2 exposure may decrease lung function and increase the risk of respiratory symptoms.

The minimum and maximum level of NO_2 recorded within the study area was in the range of 25.6 $\mu g/m^3$ to 38.4 $\mu g/m^3$.

The 24 hourly average values of NO_2 were compared with the national ambient air quality standards and it was found that the monitoring results of all the sampling stations are much lower than the applicable limit of 80$\mu g/m^3$.

d) Carbon Monoxide

Carbon monoxide is a gas and is found in air. High levels of carbon monoxide are poisonous to humans and, unfortunately, it cannot be detected by humans as it has no taste or smell and cannot be seen. Increased levels of carbon monoxide reduce the amount of oxygen carried by haemoglobin around the body in red blood cells. The result is that vital organs, such as the brain, nervous tissues and the heart, do not receive enough oxygen to work properly. The major man-made source of carbon monoxide is combustion of fossil fuels.

The one hour monitored levels in the study area were ranging from 0.85$\mu g/m^3$ to 1.32$\mu g/m^3$, which when compared with national ambient air quality standards, found to be within the prescribed limits.

FIGURE 3.5

AIR MONITORING LOCATIONS

3.5 NOISE ENVIRONMENT

Noise is responsible for adverse impact on physical and mental health of the people. The other impacts are:

- Physiological effects,
- Hearing impairment,
- Communication interference, and
- Sleep disruption

The assessment of impacts of noise sources on surrounding community depends on:

- Characteristics of noise sources (instantaneous, intermittent or continuous in nature).
- Time of day at which noise occurs, for example high noise levels at night in residential areas are not acceptable because of sleep disturbance.
- Location of noise source, with respect to noise sensitive land use, which determines the loudness and period of exposure.

Noise level survey was conducted along the alignment with an objective to establish the baseline noise levels and assess the impacts of total noise expected due to the proposed metro. Noise levels were measured at 6 locations as shown in **Figure 3.6**.

At random noise level measurement locations were identified for assessment of existing noise level status, keeping in view the land use pattern, residential areas, schools, bus stands, etc., the day levels of noise have been monitored during 6 AM to 10 PM and the night levels during 10 PM to 6 AM. The noise monitoring locations are shown in **Table 3.10** and the noise levels so obtained are summarized in **Table 3.11.**

TABLE 3.10
DETAILS OF NOISE MONITORING LOCATIONS

Symbol	Monitoring Locations
NQ*1	Airport
NQ2	Transport Nagar
NQ3	D A V College
NQ4	Jain Hospital
NQ5	Lucknow University
NQ6	Indra Nagar
* NQ – Noise Quality Monitoring Location	

FIGURE 3.6

NOISE QUALITY MONITORING LOCATIONS

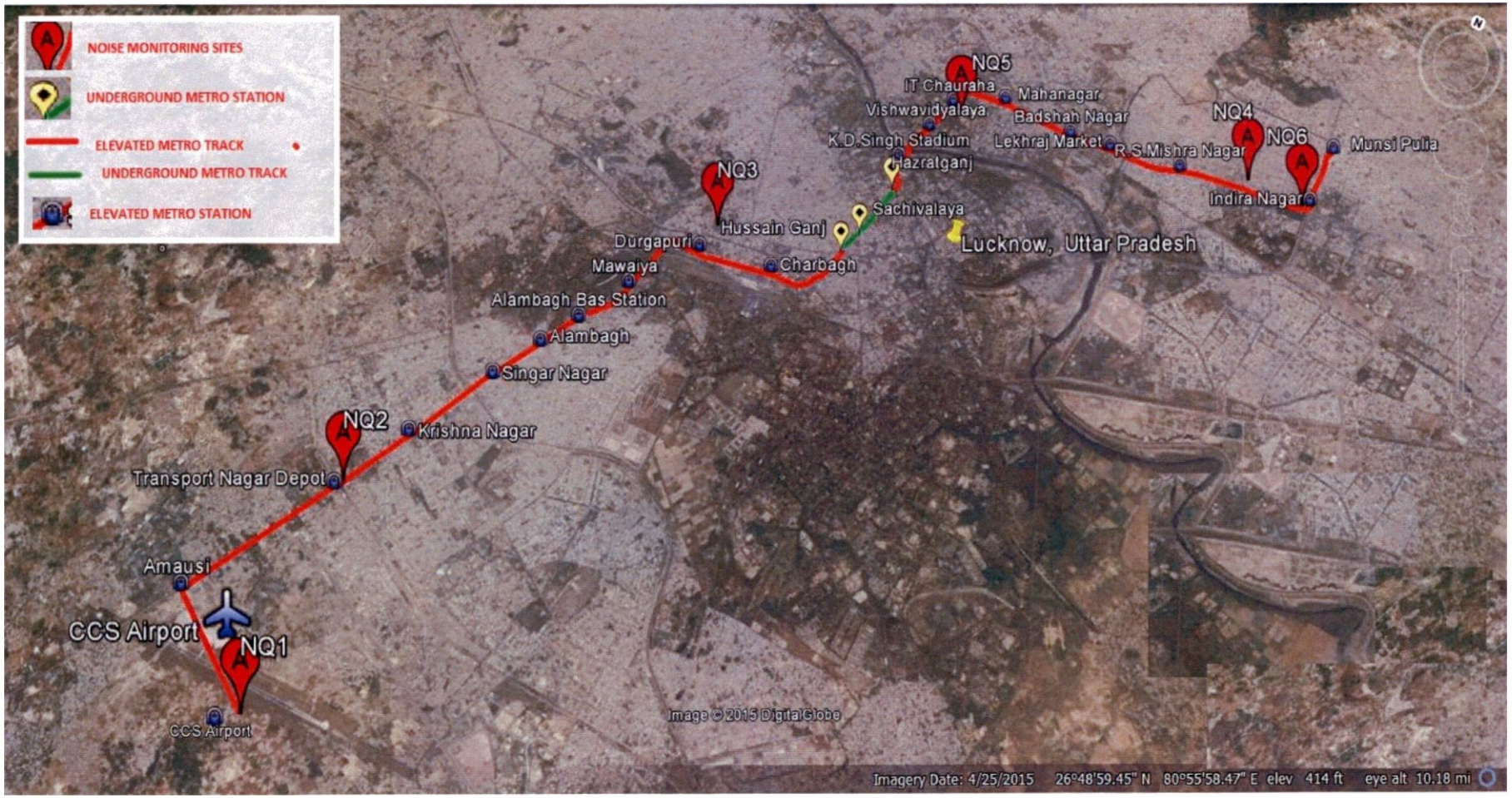


TABLE 3.11
NOISE MONITORING RESULTS

S.No.	Parameters	Airport		Transport Nagar		D A V College		Jain Hospital		Lucknow University		Indra Nagar	
		I	II	I	II	I	II	I	II	I	II	I	II
1	Leq (day) - dB(A)	71.6	70.9	74.2	74.6	62.4	62.9	60.3	61.4	65.4	64.8	66.7	67.1
2	Leq (Night) - dB(A)	56.2	55.4	58.6	59.7	47.2	48.3	48.1	50.4	52.9	51.4	53.2	52.1
3	Lmax - dB(A)	81.7	79.6	82.4	83.9	70.2	73.4	71.8	69.8	71.4	72.3	72.8	74.5
4	L min - dB(A)	48.6	50.7	52.9	53.4	40.8	41.7	42.3	41.9	45.6	46.2	47.2	45.8
5	L 90 - dB(A)	58.3	56.7	59.4	61.4	48.1	49.8	50.1	51.7	53.6	52.8	54.9	54.5
6	L 50 - dB(A)	64.8	63.7	67.2	68.3	55.3	56.4	55.3	56.3	60.8	59.6	61.4	60.9
7	L 10 - dB(A)	70.5	69.5	73.4	72.9	61.4	61.2	59.8	60.8	64.2	63.8	64.8	66.7

*** I – First day of monitoring**
II – Second day of monitoring

(Source: Field Studies) Month of Monitoring: May 2015

The results indicate that the city is like any typical Indian urban scenario, noise levels crossing the desirable limits primarily owing to vehicular traffic and other anthropogenic activities. The day equivalents during the study period are ranging between 60.3 dB(A) to 74.6 dB(A). Whereas, the night equivalents were in the range of 47.2 to 59.7 dB (A). From the results it can be seen that the Day equivalents and the Night equivalents were exceeding the Ambient Noise standards of residential areas.

3.6 VIBRATION SCENARIO

The sources of the vibration and noise induced by the metro trains are mainly the rolling stock, track and the interaction between them. The vibration induced by the train first causes the vibration of track structure as well as tunnel structure, and then, propagate through the strata to the surrounding environment. The vibration due to track structure occupies 35 percent of the total vibration.

In order to establish the existing/ambient vibration levels from traffic and other sources, vibration monitoring was conducted on the proposed underground stretch from Hussainganj to Hazaratganj of N-S Corridor. The monitoring was conducted at 12 locations with tri-axial sensors placed on the floor of the building. The results of the vibration monitoring are summarized in **Table 3.12**.

Since there are no Indian standards for vibration from transit sources, the results were compared with Federal Transit Administration (FTA), USA guidelines. The results show that the vibration levels are above the threshold of perception, however, within the threshold of annoyance.

It is important to mention that between Hussainganj and Sachivalaya (from chainage 10+700 to 11+000) for a length of 300 meters the alignment passes through very old residential buildings. Hence it is proposed to conduct detailed building condition survey before the start to tunneling work.

TABLE 3.12

VIBRATION MONITORING RESULTS

Sl.No	Location	Chainage	Depth of Rail level from ground level (in M)	Distance of the built up area from the nearest Track Line (Horizontal Distance) in M	Avg. vibration velocity at Residence/House, VdB RMS Ref: 2.54 X 10^5 mm/sec
1.	Burlington Square	10+980	20.118	0	69 VdB
2.	Burlington Mall	11+027	19.920	0	66 VdB
3.	Thakur Transport Building	9+900	17.215	0	66 VdB
4.	PCO Booth	9+993	16.500	0	70 VdB
5.	Tarachand Clinic	10+850	18.293	0	67 VdB
6.	House G+1	10+810	18.249	0	66 VdB
7.	House G+1	10+750	19.936	0	68 VdB
8.	House G+0	10+261	20.250	0	71 VdB
9.	House G+0	10+040	19.102	0	67 VdB
10.	Commercial Building	12+110	17.020	0	67 VdB
11.	Beside Masjid	12+050	17.551	0	64 VdB
12.	Pravin House	10+900	19.175	0	64 VdB
(Source: Field Studies) Month of Monitoring: May 2015					

3.7 ECOLOGY & ARCHAEOLOGY

An ecological study of the project area is essential to understand the impact due to project development activities on flora and fauna of the area. The project site is located in city area and it is free of any wildlife fauna. The construction activities whether on-site or off-site do not involve any loss of biomass, deforestation or any kind of disturbance to an ecological habitat.

3.7.1 Trees

Tree survey was carried out along the proposed alignment. As such no 'forest area' exists along the metro alignment or its corridors. Most of the trees were planted along the road. An inventory of trees likely to be lost has been prepared and summarized in **Table 3.13** and a list of local species available in the study area is provided as **Table 3.14**. No rare or endangered species of trees have been noticed during field survey.

TABLE 3.13
NUMBER OF TREES ALONG THE ALIGNMENT

S.no.	Description	No. of affected trees
1.	N-S Corridor	431
2.	Depot	750
Total		**1181**

From the table it is clear that a total of 1181 trees are expected to be effected for the entire N-S corridor. For the priority section (8.5 km) which is under construction, permission has been obtained to fell 968 trees. Out of this, 544 trees have been felled and 175 trees have been transplanted. Due to the additional measures taken by LMRC, 149 trees are expected to be saved

TABLE 3.14
DETAILS OF TREES IN THE STUDY AREA

S.No.	Local Name	English Name	Botanical Name	Family
1.	Aam	Mango	*Mangifera indica*	Anacardiaceae
2.	Jamun	Black plum	*Syzygium cuminii,*	Myrataceae
3.	Neem	Neem	*Azadirachta indica*	Meliaceae
4.	Babul	Acacia Nilotica	*Acacia Nilotica*	Fabaceae
5.	Eucalyptus	Eucalyptus	*Eucalyptus Globus*	Myrtaceae
6.	Simul	Silk Cotton Tree	*Bombax ceiba*	Malvaceae
7.	Seesam	Indian Rosewood	*Dalbergia sissoo*	Fabaceae
8.	Kadam	Kadam	*Neolamarckia cadamba*	Rubiaceae
9.	Khejur	Date Palm	*Phoenix dactylifera*	Arecaceae
10.	Singri	Khejari	*Prosopis cineraria*	Fabaceae
11.	Gular	Indian Fig Tree	*Ficus glomerata*	Moraceae
12.	Chatim	Not Defined	*Alstonia*	Apocynaceae
13.	Amla	Amla	*Emblica officinalis*	Phyllanthaceae

14.	Sajina	Drum Stick	*Moringa oleifera*	Moringaceae
15.	Bat	Banyan	Ficus benghalensis	Moraceae
16.	Sagwan	Teak	*Tectona grandis*	Lamiaceae
17.	Balamkhira	Kigelia	*Kigelia africana,*	Bignoniaceae
18.	Chilbil	Indian Elm	*Holoptelea integrifolia*	Ulmaceae
19.	Imli	Tamarind	*Tamarindus indica*	Fabaceae
20.	Pakur	Portia Tree	*Thespesia populnea*	Malvaceae
21.	Gulmohar	Royal Poinciana or Flamboyant	*Delonix regia*	Fabaceae
22.	Ashok	Ashoka tree	*Saraca asoca*	Fabaceae
23.	Debdar	Himalayan cedar	*Cedrus deodara*	Pinaceae
24.	Dhaicha	Not Defined	*Sesbania* bispinosa	Fabaceae
25.	Bottle brush	Not Defined	Callistemon	Myrtaceae
26.	Peepal	***Ficus eligiosa***	**sacred fig**	Moraceae
(Source: Field Studies)				

3.7.2 Archaeological Sites

Uttar Pradesh comprises a rich archaeological heritage characterized by a consistent continuity of human activity from the Paleolithic to modern times. This is evidenced by thousands of sites, remains, and monuments of archaeologically distinct periods in almost every part of the state. They represent various facets of history, art and architecture, language and trade, associated with those times. Statutorily only those sites and remains fall within the definition of ancient sites and remains which have been in existence for more than hundred years. They include the sites or remains of ancient monuments, such portions of land adjoining the site, which may be required for fencing or covering in order to preserve them and also the means of access to and convenient inspection of such monument. The responsibility for their protection and conservation is primarily vested with the Archaeological Survey of India (ASI) and State Archaeological Directorate.

The most significant sites and remains are declared protected under the provisions of **The Ancient Monuments and Archaeological Sites and Remains Act 1958** by the Central Government. Their protection, maintenance and conservation is the responsibility of Archaeological Survey of India which has branch offices to look after this work in U.P. Currently the number of sites, monuments and remains protected by the ASI in U.P. are 786.

Other ancient archaeological sites and remains are declared protected under the provisions of **The U.P. Ancient & Historical Monuments and Archaeological Sites & Remains Preservation Act, 1956** by the Government of U.P. Currently about 100 such sites and remains have been declared protected under this Act. These are being protected, conserved and maintained by the Directorate of Archaeology U.P. The list of State Protected Monuments is available in the website of the Archeological Survey of India.

There is no criticality to monuments due to the proposed alignment as all the monuments, except Alambagh gate, are located at more than 100m from the centre line of the alignment. The centre line of the proposed corridor is falling within 100 m from Alambagh Gate. The Alambagh gate has been declared to be of State Protected Monuments under ***Directorate of Archaeology, Uttar Pradesh***. The gate serves as an entrance way to the Chander Nagar and it is made up of bricks of that era. Special legal permission will be therefore required and construction work has to be done with very special arrangements. The legal issue will be settled before starting the construction work. Also, the construction methodology shall get by the State Archaeology department prior the start of construction near the Alambagh Gate.

As an additional protection measure, barricading of height of at least 3 m will be provided at the Alambagh Gate itself. Additionally, the following measures shall be adopted during construction near Archaeological monuments/structures:

- The pier location shall be at least 25 m away from the structure
- Vibration level (Peak Particle Velocity) at the monument shall not be more than 2.5 mm/sec
- No debris shall be stored in the vicinity of the monument
- During night time, the vicinity shall be properly lit
- Barricading shall be done at both construction and monument side

During the survey for Metro Rail Corridor it is found that 7 nos. of ASI identified monuments are near the proposed alignment as listed in **Table 3.15**.

TABLE 3.15
PROTECTED AND REGULATED ARCHAEOLOGICAL SITES ON N-S CORRIDOR

S. No.	Name of Protected monument/Site	Location	Dist. From Centre Line (m)	Chainage (km)
1	Alambagh Cemetery	26° 48.765' N 80° 54.261' E	202	5.620
2	Amzad Ali Shah's Mousoleum	26° 51.037' N 80° 56.882' E	160	12.523
3	Sapper's Tomb	26° 51.273' N 80° 56.062' E	200	13.180
4	Tomb of Mushir Zaidi	26° 51.260' N 80° 56.072' E	115	13.193
5	Tomb of Saadat Ali Khan	26° 51.271' N 80° 56.029' E	115	13.193
6	Victoria Memorial	26° 51.378' N 80° 56.053' E	102	13.428
7	Cementry on Faizabad Road	26° 52.274' N 80° 58.750' E	105	19.240
(Source: Field Studies)				

CHAPTER – 4
NEGATIVE ENVIRONMENTAL IMPACTS

4.1 GENERAL

The primary function of an environmental impact assessment study is to predict and quantify the magnitude of impacts, evaluate and assess the importance of the identified changes and formulate plans to monitor and mitigate the actual changes. Environmental impacts could be positive or negative, direct or indirect, local, regional or global, reversible or irreversible.

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

The main aim of the project is to decongest the road traffic. The project is designed keeping in view population growth, future traffic demands and environmental protection aspects. This project will not only reduce vehicles on road and vehicular pollution but also the pedestrians. The estimated reduction of air pollution in Lucknow is reported in **Chapter 5**.

The process began by identifying the development and operational activities resulting from the proposed project as contained in **Chapter-2**. **Chapter-3** was dedicated for providing information on the baseline environmental conditions for various parameters. This chapter discusses the potential impacts on environment. As far as possible, attempts have been made to quantitatively predict the impacts due to proposed project. For non-quantitative impacts, qualitative assessment has been made.

Negative impacts likely to result from the proposed development have been listed under the following headings:

- Impacts due to Project Location;
- Impacts due to Project Design;
- Impacts due to Construction; and
- Impacts due to Project Operation.

For each of these headings, potential impacts have been considered, while recommendations for mitigating measures have been stated in **Chapter –6.**

4.2 ENVIRONMENTAL IMPACTS

This section identifies and appraises the negative impacts on various aspects of the environment likely to result from the proposed development. It is pertinent to mention that the negative environmental impacts listed below are based on the assumption that no negative impact mitigation measure or benefit enhancements are adopted.

- Land Environment
- Water Environment
- Air Environment
- Noise Environment
- Biological Environment
- Socio-Economic Environment

The impacts on the above environmental components have been further assessed during various phases of project cycle namely project location, project design, construction and operation.

4.3 IMPACTS DUE TO PROJECT LOCATION

During this phase, those impacts, which are likely to take place due to the layout of the project, have been assessed. These impacts are:

- Project Affected People (PAPs)
- Change of Land use;
- Loss of trees/forest;
- Utility/Drainage Problems, and
- Impact on Historical and Cultural Monuments

4.3.1 Project Affected People (PAPs)

Rehabilitation and Resettlement (R&R) policy is defined in LMRC's "Resettlement Policy Framework" and the details of displaced (affected) families, budget, and timeframe are provided in LMRC's **"Resettlement Action Plan"**.

4.3.2 Change of Land Use

Under the present study, project layout maps were superimposed on land use maps to find out the change in land use. It is estimated that about 5.7 ha of private land, and 42.28 ha of Government land have to be acquired for the project. In addition to this, temporary land of about 3.67 ha of government land and 1.98 ha of private land maybe required for casting yards and for meeting the requirements of construction working space. The change of land use is presented in **Table 4.1.** From the data it

could be concluded that out of total permanent land required, about 11.9% land to be acquired is from private sector and 88.1% from Government. For the proposed N-S corridor, there will be two Resettlement Action Plans (RAP), one for the priority section (8.5 km) and another for the remaining section (14.37 km).

TABLE 4.1
CHANGE OF LAND USE

S.No.	Description	Land Requirement (ha)			
		Permanent		Temporary	
		Government	Private	Government	Private
1	Stations	1.83	2.02	2.94	1.73
2	Running Section	1.05	3.68	0.00	0.00
3	RSS/TSS	1.6	0.00	0.00	0.00
4	Depots	37.8	0.00	0.73	0.25
Total		**42.28**	**5.7**	**3.67**	**1.98**

(Source: LMRC DPR 2013)

4.3.3 Loss of Forests/Trees

The proposed metro line is in urban/city area and will not pass through any forests. Hence no loss to forest is anticipated due to the project. However, planted trees do exist throughout the corridors selected for the project.

A total of 1181 trees are expected to be effected for the entire N-S corridor. For the priority section (8.5 km) which is under construction, permission has been obtained to fell 968 trees. Out of this, 544 trees have been felled and 175 trees have been transplanted. Due to the additional measures taken by LMRC, 149 trees are expected to be saved. Hence, 857 trees along the alignment (**Refer Table 3.13)** are likely to be cut during construction.

Trees are major assets in purifications of urban air, which by utilizing CO_2 from atmosphere, release oxygen into the air. However, with removal of these trees, the process for CO_2 conversion will get effected and the losses are reported below:

i) Total number of Mature Trees : 857

ii) Decrease in CO_2 absorption @ 21.8 Kg/ year tree for 8 years : 149461 kg

iii) Oxygen production @ 49 kg/ year tree For 8 years : 335944 kg

The average consumption of oxygen for a person is about 182 kg/year. It means these trees will meet the requirement of about 230 people round the year. Trees help carbon sequestration acting a carbon sink. By removing the carbon and storing it as cellulose, trees release oxygen back into the air.

4.3.4 Utility/Drainage Problems

Metro lines are mostly planned to run through the urban area at grade, underground and above. The alignment will cross river systems, drains/nalas large number of sub-surface, surface and utility services, viz. sewer, water mains, storm water drains, telephone cables, overhead electrical transmission lines, electric pipes, traffic signals etc. These utilities/ services are essential and have to be maintained in working order during different stages of construction by temporary/permanent diversions or by supporting in position. In addition, cross drainage works such as bridges, culverts etc. will be required. Since these affect construction and project implementation time schedule/costs for which necessary planning/action needs to be initiated in advance.

4.3.5 Impact on Archaeological Sites

One cannot deny the importance of Historical/Archaeological and Cultural Monuments. During the survey for Metro Rail Corridor it is found that 8 nos. of archaeological sites are near the alignment. Alambagh Gate which is under the State Archaeology is located within 100 m from the centre line of the project corridor.

Utmost care needs be taken so that no significant impact is anticipated on the archeological structures due to any pollution arising from the project activities during construction and operation. Ancient Monuments and Archeological Sites and Remain (AMASR) Act 2010 prohibits any construction activity within 100 m on all sides of a protected monument. Construction will be started inside the regulated area (in between 100 m and 200 m) after obtaining necessary approvals from National Monument Authority.

There is no criticality to monuments due to the proposed alignment as all the monuments, except Alambagh gate, are located at more than 100m from the centre line of the alignment.

The centre line of the proposed corridor is falling within 100 m from Alambagh Gate. The Alambagh gate has been declared to be of State Protected Monuments under ***Directorate of Archaeology, Uttar Pradesh***. Special legal permission will be therefore required and construction work has to be done with very special arrangements. The legal issue will be settled before starting the construction work. Also, as an additional protection measure, barricading of height 3 m will be provided at the Alambagh Gate.

4.4 IMPACTS DUE TO PROJECT DESIGN

Considered impacts, due to project designs are:

- Platform inlets and outlets,
- Ventilation and lighting,
- Railway station refuse, and
- Seismological factors.

4.4.1 Platforms Inlets and Outlets

The platform level is about 13.6 m above the ground level for elevated and minimum 13 m below for underground stations. A typical elevated station is planned with two side platforms (each 4.5m wide). The concourse is concentrated in a length of about 72 m in the middle of the station with staircases leading from either side of the road. Maximum width of the station at concourse is about 33 m and at the narrowest part is 16.5 m. Minimum vertical clearance of 5.5 m has been provided under the concourse.

The typical underground station is a two level station with platforms at the lower level and concourse on the upper level. Concourse is provided at the ends in such a manner that the total depth of the underground station and cost is kept to the minimum. Two emergency staircases are also being planned in the traffic islands.

Provision has been made for escalators to connect concourse to platforms. On each platform one escalator has been proposed. In addition, two staircases, with a combined width of 4 m are provided on each platform connecting with the concourse. These stairs and escalators together provide an escape capacity to evacuate passengers in emergency, from platforms to place of safety, in 5.5 minutes. While calculating the waiting passengers on the platform in emergency, 2 missed headways are assumed. One lift has been provided on either platform to provide access for elderly and disabled. Additional staircases have been provided for the fire escape at the two ends of each platform. These stairs of combined width of 8 m lead directly to the footpaths below or open spaces near the station depending upon the ground situation. For emergency evacuation purposes, it is assumed that the waiting passengers at the station along with the section load will have to be evacuated from the platforms within 5.5 minutes.

The station planning standards are listed in **Table 4.2**. From this table it can be concluded that all stations have necessary provision for space at inlet, outlet, elevators and platforms to accommodate people in normal as well as in emergency situation. Hence no hazard is anticipated due to the proposed sizes of inlets and outlets.

TABLE 4.2
STATION PLANNING STANDARDS

a.	Design passenger flow/2 min	5% of peak hour flow
b.	Escalators carrying capacity 2/min (1.11m width 30° slope) up & down	267 passengers
c.	Unidirectional staircase/m/s min. Up & Down	126, 140 passengers.
d.	Unidirectional staircase/m/s min. Up & Down	177 Passengers
e.	Ticket issuing machines/2 min	20 passengers
f.	Turnstile gates /2 min.	60 passengers
g.	Side platform	2.5 persons/sq.m
h.	Island platform	1.5 persons/sq.m
i.	Concourse	2.5 persons/sq.m
j.	Platform during emergency	5 persons/sq.m (including safety zone)
k.	Safety zone	0.65 m train side 0.25 m wall side
l.	Min. Platform widths	Island 8m : Side 6 m
m.	Emergency evacuation time	5.5 min
n.	Maximum travel distance in emergency	60 m
o.	Walking speed for passengers	1 m/sec.
p.	Escalator carrying capacity in emergency/2 min	240 passengers
q.	Stair case carrying capacity in emergency/2 min	114 passengers
r.	Time taken for reversing escalators	1 min.
s.	No. of passengers in 6 coach train with dense crush loading	2000 Nos.

4.4.2 Ventilation and Lighting

The platforms, concourse, staircase and escalator areas both for underground and elevated stations will have adequate and uniform fluorescent lighting to provide pleasant and cheerful environment. The details of illumination proposed at different locations are reported in **Table 4.3**.

TABLE 4.3
ILLUMINATION AT DIFFERENT LOCATIONS

LOCATION/PREMISES	ILLUMINATION (LUX)
Entrance to stations from the road	250
Booking/Concourse	200
Platforms	150
Passenger staircase and escalator areas	250
Toilets	100
Offices	200
Tunnels	100
Sub-ways	250
Emergency lighting of stations, platforms, passages, escalators & public utilities.	50

4.4.3 Railway Station Refuse

The collection and removal of refuse from railway stations in a sanitary manner is of great importance for effective vector control, nuisance abatement, aesthetic improvement and fire protection. The refuse from railway station includes;

- Garbage,
- Rubbish, and
- Floor Sweepings.

It is estimated that the solid waste generation will be around 4 – 6 kg/day at elevated stations and 6 - 8 kg/day at underground stations.

At elevated stations, the solid waste generation is more due to PD (Property Development) area and airborne dust. Thus, about 76 m^3 of solid waste will be generated from elevated stations and 18 kg from underground stations from the proposed corridor. Thus a total of about 94 kg of solid waste per day will be generated from all metro stations. The maintenance of adequate sanitary facilities for temporarily storing refuse on the premises is considered a responsibility of the LMRC project authorities. The storage containers for this purpose will be specially designed. To avoid odour and the accumulation of fly-supporting materials, garbage containers will be washed at frequent intervals.

4.4.4 Risk Due to Earthquake

The project area lies in Zone III of Bureau of Indian Standards (BIS) Seismic Zoning Map. Zone 3 can have earthquake of 5 to 5.9 Richter magnitudes near the epi-centre of the earthquake. Seismic factor proposed by India Meteorological Department (IMD) for the purpose of design of Civil Engineering structures shall be incorporated suitably while designing the structures. It is understood that such measures have already been taken in construction of earlier phases.

4.5 IMPACT DUE TO PROJECT CONSTRUCTION

Although environmental hazards related to construction works are mostly of temporary nature, it does not mean that these should not be considered. Appropriate measures are included in the work plan and budgeted for. The most likely negative impacts related to the construction works are:

- Soil erosion, pollution and health risk at construction site,
- Traffic diversion and risk of existing building,
- Excavated soil disposal problems,
- Dust Generation
- Increased water demand
- Impact due to Supply of Construction Material

- Impact due to Construction near Archaeological Structures
- Noise Pollution

4.5.1 Soil Erosion, Pollution and Health Risk at Construction Site

Run off from unprotected excavated areas, and underground tunnel faces can result in excessive soil erosion, especially when the erodability of soil is high. Mitigation measures include careful planning, timing of cut and fill operations and revegetation. In general, construction works are stopped during monsoon season.
Problems could arise from dumping of construction spoils (Concrete, bricks) waste materials (from contractor camps) etc. causing surface and ground water pollution. However, it is proposed to have mix concrete directly from batching plant for use at site. Batching plants will be located away from the site and from human settlement. The other construction material such as steel, bricks, etc. will be housed in a fenced stored yard. The balance material from these yards will be removed for use/disposal.

Health risks include disease hazards due to lack of sanitation facilities (water supply and human waste disposal) and insect vector disease hazards of local workers and disease hazards to the local population. Mitigation measures include proper water supply, sanitation, drainage, health care and human waste disposal facilities. In addition to these, efforts need to be made to avoid water spills, adopt disease control measures and employment of local labour. Problems could arise due to difference in customs of workers from outside and local residents. These risks could be reduced by providing adequate facilities in worker's camps, raising awareness amongst workers and by employment of preferably local labour.

Taking into consideration the safety issues of risks of HIV/AIDS during the project period, a specialized NGO will be hired by LMRC to undertake appropriate activities to deal with them in the labour camps. It is presumed that labour working in the project may not be aware with the hazards of the disease. The major activities of such NGO will include awareness generation, information dissemination and mobilization to act on the issues towards safer behavior.

4.5.2 Traffic Diversions and Risk to Existing Buildings

During construction period, complete/partial traffic diversions on road will be required, as most of the construction activities are on the road but most of the roads are double lane. Hence, wherever possible, rather than completely blocking the roads it is considered to make these roads as one way to allow for operation of traffic together with construction activities. Moreover, on both sides of the roads, a clear passage of 8 m will be maintained for smooth operation of traffic, emergency and local movements. Advance traffic updates/information on communication systems will be an advantage to users of affected roads. The rail corridor does not pose any

serious risk to existing buildings. However, the situation in the underground corridor is not the same as it passes under the road/buildings of some congested areas. Sufficient care has to be taken while designing the system underground. Still it will be appropriate to carry out stability and ground settlement analysis for proceeding further during construction.

4.5.3 Problems of Excavated Soil Disposal

The metro route is both elevated and underground. The underground portion is 3.440 km. The construction activity involves cut and cover, tunnel (bored and rock), foundation, fill and embankment. Owing to paucity of space in busy cites and for safety reasons, elaborate measures need to be adopted for collection, storage, transfer and disposal of soil.

About 2.1 million cubic meter of soil is estimated to be excavated from the proposed corridor. Some quantity of soil will be utilized in backfilling at stations and Depot. The balance shall be disposed off in environmental friendly manner. Disposal of excess soil is permitted in low lying areas after obtaining necessary permissions and in Nagar Nigam authorized dumping ground. It will be ensured by LMRC that the excavated soil is not disposed in the banks of river Gomti or any other water bodies.

4.5.4 Dust Generation

Transportation of earth and establishment of the material will involve use of heavy machinery like compactors, rollers, water tankers, and dumpers. This activity is machinery intensive resulting in dust generation. However, this activity will be only short-term. Protective measures shall be undertaken during construction phase.

4.5.5 Increased Water Demand

The water demand will increase during construction phase. Sufficient water for construction purpose is made available by digging borehole / borewell within the vicinity of the project site during the construction phase. Hence proper care shall be taken while deciding the location of these activities or drawing water from public facilities. Water requirement for construction of Metro will be met through the tube-wells bored specially for the purpose of metro construction after taking approval from competent authority. Hence, there will be no negative impact on the residents living in the vicinity of tube wells whose water demand is, in any case, met by municipal water.

4.5.6 Impact due to Supply of Construction Material

Metro construction is a material intensive activity. Different types of construction material will be required for construction of metro corridor. A summary of approximate construction material required for the proposed corridor is given in **Table 4.4**.

Quarry operations are independently regulated activities and outside the purview of the project proponent. It is nonetheless, appropriate to give consideration to the environmental implications in selection of quarry sources since poorly run operations create dust problems, contribute noise pollution, ignore safety of their employees, or cause the loss of natural resources.

About 10-15% of the construction material such as waste material from contractor camps is left behind by the contractor as construction waste/spoils. Dumping of construction waste/spoil in a haphazard manner may cause surface and ground water pollution near the construction sites.

TABLE 4.4
CONSTRUCTION MATERIAL REQUIREMENT

Material	Unit	Total Qty
Tunnel		
Steel	MT	7529.8
Cement OPC 53 G Ultratech	MT	5387.8
Sand Pathankot	MT	9474.7
Aggregates	MT	16005.8
RO Water	KL	1930.4
Microsilica Corniche	MT	289.1
Admixture BASF sky 777	MT	29.7
Under Ground Station		
Steel	MT	8400
Cement OPC 53 G Ultratech	MT	18044.91
Sand Pathankot	MT	31306.82
Aggregates	MT	50308.33
RO Water	KL	6826.627
Admixture BASF sky 777	MT	86.9634
Elevated Station		
Steel	MT	26042.16
Cement OPC 53 G Ultratech	MT	77420.45
Sand Pathankot	MT	134319.8
Aggregates	MT	215844.5
RO Water	KL	29289.18
Admixture BASF sky 777	MT	373.1106
Viaduct		

Steel	MT	17166.0
Cement OPC 53 G Ultratech	MT	55255.5
Sand Pathankot	MT	97139.0
Aggregates	MT	151527.8
RO Water	KL	20649.1
Microsilica Corniche	MT	719.3
Admixture BASF sky 777	MT	300.9

4.5.7 Loss of Historical and Cultural Monuments

No historical/cultural monuments will be lost as a result of the proposed development.

4.5.8 Impact due to Construction near Archaeological Structures

There are eight archaeological sites near the project corridor falling within the prohibited or regulated zone. The construction works can have adverse impact on these sites because of vibration, air pollution and other pollutants. But necessary precautionary measures will be taken during the construction activities, so as to mitigate any adverse effect.

4.5.9 Noise Pollution

Construction noise in the community may not pose a health risk or damage to peoples' hearing, but it can adversely affect peoples' quality of life. To some degree, construction noise can be a contributing factor to the degradation of someone's health in that it can cause people to be irritated and stressed and can interrupt their ability to sleep - all of which may lead to higher blood pressure, anxiety, and feelings of animosity toward the people or agencies responsible for producing the noise. Construction noise may disturb people at home, in office buildings or retail businesses, in public institutional buildings, at locations of religious services depending upon their vicinity to construction site. Construction noise is unwelcome during nighttime in residential areas during sleep; it can be equally unwelcome during the daytime in commercial areas if it interferes with peoples' ability to conduct business.

The major sources of noise pollution during construction are movement of vehicles for transportation of construction material to the construction site and the noise generating activity at the construction site itself. The Metro construction is equipment intensive. A noise prediction is carried out for Lmax and Leq for different combinations of construction equipments working simultaneously at a site. While predicting the noise levels, average day time noise level is taken as 67.9dB(A), average evening time noise level as 67.8 dB(A) and night time average noise level as 51.9 dB(A). These assumed values are average of the noise level monitoring carried

out for this project at different locations. The Result of the noise prediction is presented in **Table 4.5** and shown graphically in **Figure 4.1** through **Figure 4.3.**

TABLE 4.5
NOISE LEVEL PREDICTION DURING CONSTRUCTION

	Concrete Batch Plant + Concrete Mixer Truck		Auger Drill Rig +Dump Truck + Generator + Slurry Plant		Dump Truck + Excavator + Pneumatic Tools	
Distance	Lmax	Leq	Lmax	Leq	Lmax	Leq
5	103	97.8	104.4	102.9	105.2	103.6
10	97	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	85.8	92.3	90.8	93.1	91.6
25	89	83.8	90.4	88.9	91.2	89.6
30	87.4	82.2	88.8	87.3	89.6	88
35	86.1	80.9	87.5	86	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	77.8	84.4	82.9	85.2	83.6
55	82.2	77	83.5	82	84.4	82.8
60	81.4	76.2	82.8	81.3	83.6	82
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
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
100	77	71.8	78.3	76.8	79.2	77.6

FIGURE 4.1
NOISE LEVELS dB(A) DUE TO CONCRETE BATCH PLANT + CONCRETE MIXER TRUCK

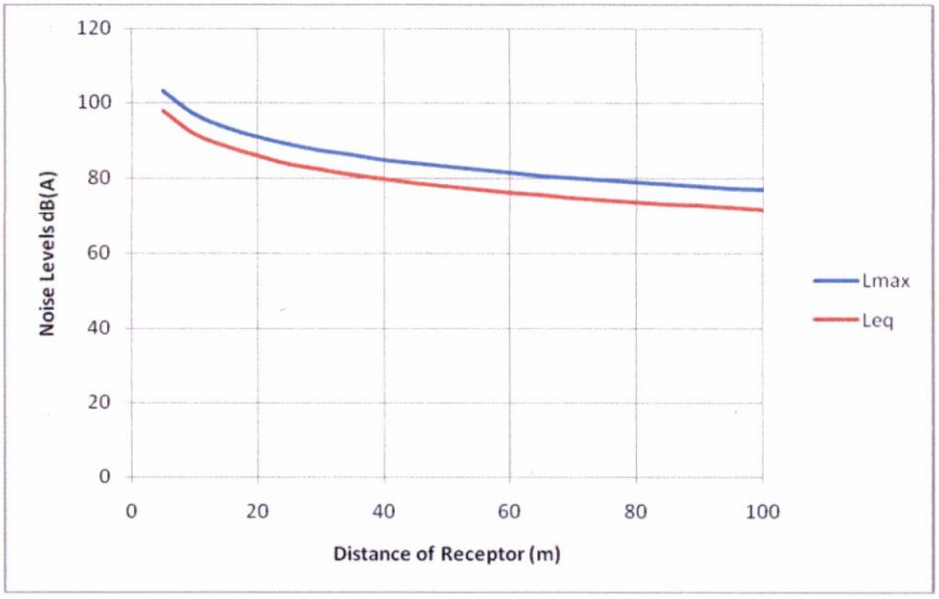


FIGURE 4.2
NOISE LEVELS dB(A)DUE TO AUGER DRILL RIG + DUMP TRUCK + GENERATOR + SLURRY PLANT

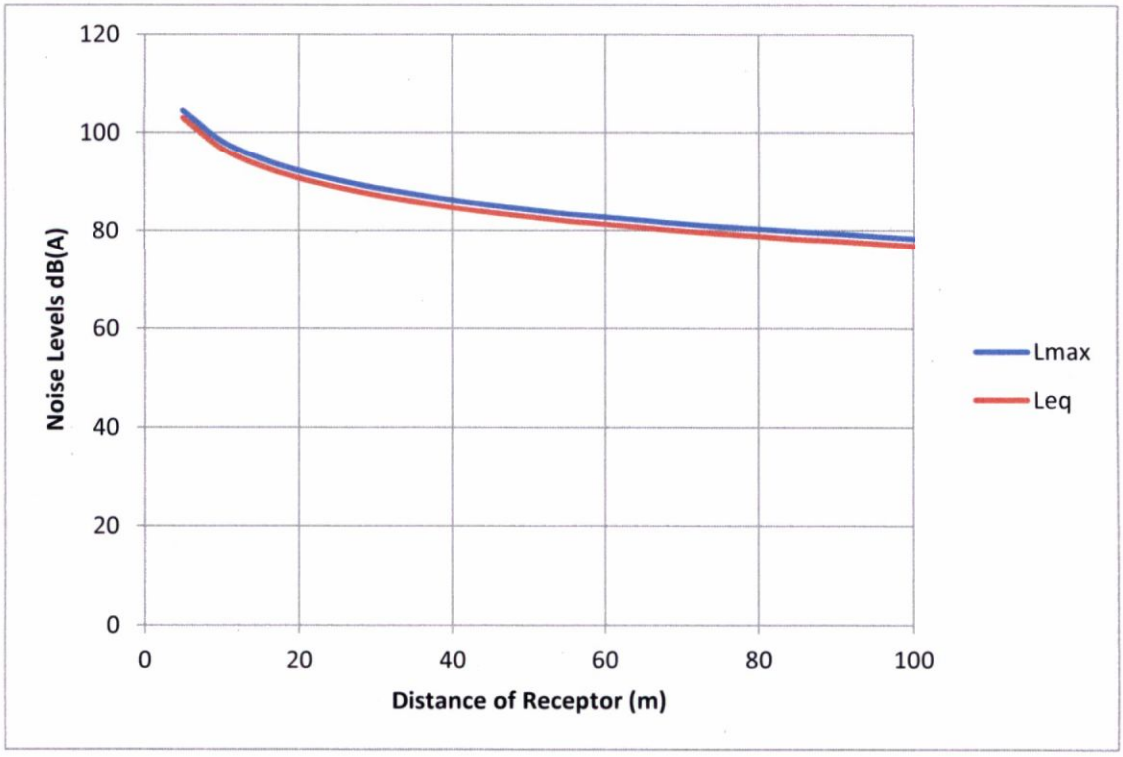
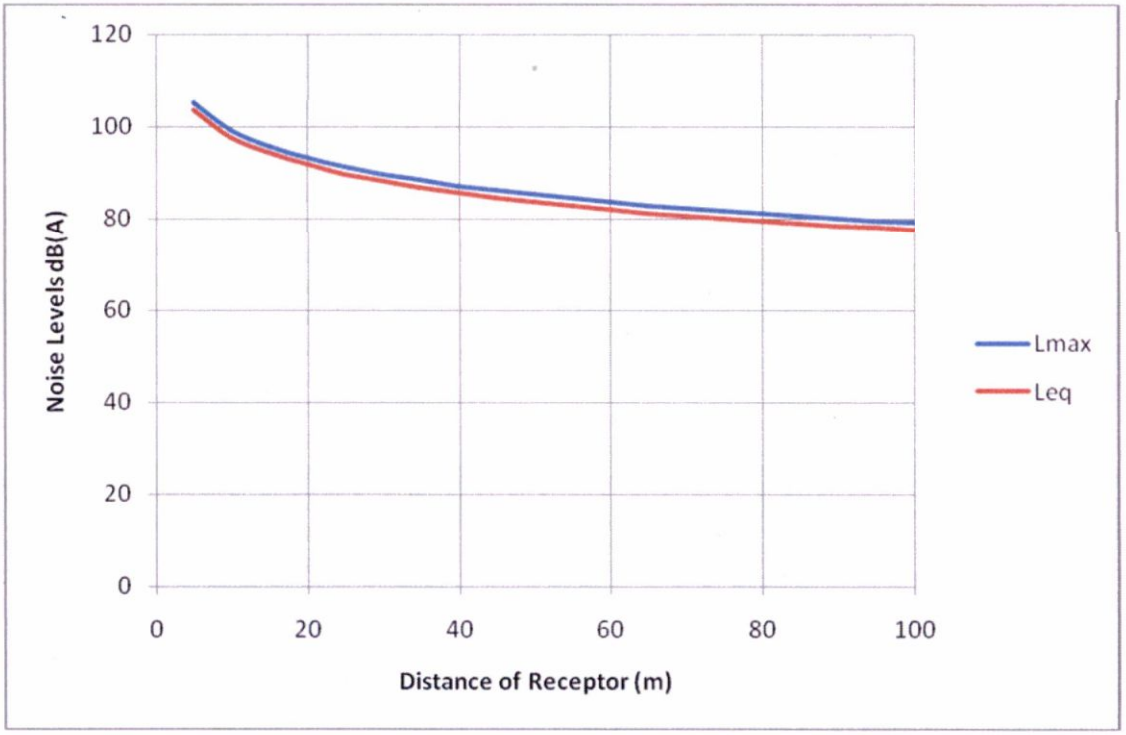


FIGURE 4.3
NOISE LEVELS dB(A)DUE TO DUMP TRUCK + EXCAVATOR + PNEUMATIC TOOLS



4.6 IMPACTS DUE TO PROJECT OPERATION

Along with many positive impacts, (Refer **Chapter 5**) the project may cause the following negative impacts during operation of the project due to the increase in the number of passengers and trains at the stations:

- Noise pollution,
- Water supply and sanitation at Stations,
- Refuse disposal and sanitation, and
- Pedestrainisation and visual issues

4.6.1 Noise Pollution

During the operation phase the main source of noise will be from running of metro trains. Noise radiated from train operations and track structures generally constitute the major noise sources. Airborne noise is radiated from elevated structures, while ground-borne noise and vibration are of primary concern in underground operations.

Basic Sources of wayside airborne noise are:

i) Wheel / Rail Noise : Due to wheel /rail roughness
ii) Propulsion Equipment: Traction motors, cooling fans for TM, reduction gears etc.

iii) Auxiliary Equipment: Compressors, motor generators, brakes, ventilation systems, other car mounted equipment

iv) Elevated Structure Noise
- At low speed(<15 km/h) auxiliary equipment may predominate
- At speeds up to approx. 50 km/h, W/R noise predominates
- At speeds greater than 50 km/h, the propulsion equipment noise predominates
- For light weight steel elevated structures, the structure noise can predominate at all speeds above 15 km/h

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:

i) **Train** speed **(V):** Car interior noise levels vary from 15 $\log_{10} V$ to 40 $\log_{10} V$.

ii) **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.

iii) **Sound Insulations of car body** : Single leaf or Sandwich construction.

iv) **Type & Design of Mechanical Equipment:** Propulsion system & Auxiliary Equipment (A/c system ,compressors and motor generator sets).

v) **Wheel and Rail conditions**: Rail corrugations and wheel flats can increase the noise levels by 10-15 dB(A)

A study was carried out by National Physical Laboratory for Delhi metro noise levels in elevated and underground metro stations for various operations. These results can be similar for LMRC as well. The noise levels are presented in **Table 4.6** and **Table 4.7.** Wayside Noise Level at 15 m from track Centre Line and at 25 km/h =71.5± 2.0

TABLE 4.6

EXTERIOR NOISE LEVELS IN METRO STATIONS

S. No	DESCRIPTION	AVERAGE NOISE LEVELS (dB)A	
		EL	UG
1	Background Noise Level	64.0± 1.5	56.0± 0.5
2	Train entering the PF (Max)	84.0± 1.5	87.5± 1.5
3	Train leaving the PF (Max)	84.0± 0.5	87.5± 1.5
4	Train stopping in PF	79.0± 0.0	79.5± 1.0
5	Train stationary in PF	76.0± 0.5	76.0± 2.0
6	Train starting from PF	78.5± 1.0	80.5± 2.0
7	Train braking	86.0± 0.0	86.0± 2.0

8	Announcement	74.0± 0.5	70.5± 0.0
	Overall	**76.0± 7.0**	**75.0± 10.0**

TABLE 4.7
INTERIOR NOISE LEVELS IN METRO TRAINS

S. No	DESCRIPTION	AVERAGE NOISE LEVELS (dB)A	
		EL	UG
1	Train stationary	62.0± 1.0	68.0± 0.5
2	Train starting	62.0± 1.0	69.5± 0.5
3	Train motoring	70.0± 2.5	77.0± 2.0
4	Train coasting	72.0± 2.0	85.0± 3.0
5	Train at max. speed	78.0± 1.0	90.0± 1.0
6	Train decelerating	69.0± 0.5	79.0± 2.0
7	Train stopping	64.4± 1.0	74.0± 2.0
8	Train braking	74.5± 1.0	84.0± 4.0
9	W/R Noise	75.0± 1.5	86.5± 2.0
10	Door operations (max.)	-	75.0± 0.0
	Overall	**69.0± 5.0**	**78.0± 8.0**

4.6.2 Water Supply and Sanitation

Public Health facilities such as water supply, sanitation and wash rooms are very much needed at the stations. The water demands will be on station for drinking, toilet, cleaning and also for other purpose like AC, chiller and other purposes. Water shall be treated before use, upto WHO drinking water standards. Ground water shall be used for this purpose. The water requirement for the stations will be met through the public water supply system after taking necessary approvals. However as an environmental conservation measure, rainwater harvesting will be also carried out at stations.

4.6.3 Pedestrian Issues

There is an expectation that MRTS will increase the pedestrianisation in Central Business Districts (CBD). As has been demonstrated in several countries, notably in Western Europe and North America, pedestrian station of certain localities is a desirable change in CBDs of the city. While initial reactions of the residents or commercial establishments are sometimes unfavourable to the concept, in no case has dissatisfaction been expressed, or a reversal of Pedestrainisation instituted, once an area has been so developed. The benefits are seen to outweigh any disadvantages of increased movements for access etc. The main aim of MRTS system is to decongest the road traffic in Central Business Districts. The connections will further reduce the pedestrian number, which are available now on the roads.

4.6.4 Visual Impacts

The introduction of MRTS implies a change in streets through which it will operate. An architecturally well designed elevated section can be pleasing to the eyes of beholders. Recent MRTS projects have attempted to incorporate this objective in their designs, as in the case of Singapore. Same has been incorporated in Delhi MRTS also. Since a low profile would cause the least intrusion, the basic elevated section has been optimised at this stage itself.

4.7 IMPACTS DUE TO DEPOT

One depot is planned for the proposed N-S metro corridor. This Depot is planned to be constructed in an area of 37.8 Ha at Transport Nagar. The area here is barren and with no habitation. In order to develop existing area as depot, it will need substantial filling by earth brought from outside. The depot will have following facilities:

- Washing Lines,
- Operation and Maintenance Lines,
- Workshop, and
- Offices.

These facilities will could generate water and noise issues. Problems anticipated at depot sites are:

- Water supply,
- Oil Pollution,
- Cutting of trees
- Sanitation,
- Effluent Pollution,
- Noise Pollution,
- Loss of livelihood,

4.7.1 Water Supply

Water supply will be required for different purposes in the depot. The water requirement for train washing purpose will be 3000 litre per day per train and 40,000 litres per day for other requirements (Drinking, Horticulture, Canteen, Toilets, etc.). This water will be obtained through bore wells after taking approval from competent authority.

The water after conventional treatment can be processed through Reverse Osmosis (RO) technology for specific use such as drinking/ cooking and final washing of equipment/ trains.

4.7.2 Oil Pollution

Oil spillage during change of lubricants, cleaning and repair processes, in the maintenance Depot cum workshop for maintenance of rolling stock, is very common. The spilled oil shall be trapped in oil and grease trap. The collected oil would be disposed off to authorised collectors, so as to avoid any underground/ surface water contamination.

4.7.3 Noise Pollution

The main source of noise from depot is the operation of workshop. The roughnesses of the contact surfaces of rail and wheel and train speed are the factors, which influence the magnitude of rail - wheel noise. The vibration of concrete structures also radiates noise. Due to less activity, no impact on the ambient noise is anticipated.

4.7.4 Solid Waste

Solid waste generated from the Depot will be taken by the cleaning contractor weekly and disposed to the local municipality waste disposal sheds. Sludge is expected to be generated from each ETP/STP that will be stored in leak proof containers and disposed off as per State Pollution Control Board guidelines. Oil and grease will be produced from Depot which will be disposed off through approved re-cyclers. The iron turning of the PWL for the wheel profiling will also be generated from the metro Depots

4.8 EPILOGUE

Based on above negative impacts, a checklist of impacts has been prepared along with positive impacts in **Chapter-5.** The net resultant impacts without management plans are also summarised. The management plans to mitigate the negative impacts are reported in **Chapter-6.**

CHAPTER - 5
POSITIVE ENVIRONMENTAL IMPACTS

5.1 POSITIVE ENVIRONMENTAL IMPACTS

Based on project particulars **(Chapter - 2)** and existing environmental conditions **(Chapter - 3)**, potential impacts that are likely to result from the proposed LMRC development have been identified and wherever possible these have been quantified. This chapter deals with the positive impacts of the project. The introduction of LMRC metro corridor will also yield benefits from non-tangible parameters such as saving due to equivalent reduction in road construction and maintenance, vehicle operating costs, less atmospheric air pollution and socio-economic benefits of travel time, better accessibility, better comfort and quality of life. However, all benefits cannot be evaluated in financial terms due to non-availability of universally accepted norms. The parameters such as economic growth, improvement in quality of life, reduction in public health problems due to reduction in pollution, etc have not been quantified.

Various positive impacts have been listed under the following headings:

- Employment Opportunities,
- Enhancement of Economy,
- Mobility,
- Safety,
- Traffic Congestion Reduction,
- Reduced Fuel Consumption,
- Reduced Air Pollution,
- Carbon Dioxide and Green House Gases (GHG) Reduction,
- Reduction in Number of Buses, and
- Saving in Road Infrastructure.

5.1.1 Employment Opportunities

The project is likely to be completed in a period of about 24-36 months. During this period manpower will be needed to take part in various activities. About 10,000 persons are likely to work during peak period of activity. In operation phase, 35 persons per kilo meter length of the corridor will be employed for operation and maintenance of the proposed system. Thus the project would provide substantial direct employment; besides, more people would be indirectly employed in allied activities and trades.

5.1.2 Enhancement of Economy

Whenever any developmental project is implemented enhancement of economy is bound to come. It is estimated that Lucknow have population 45,89,838 in 2011, out of these about 33.79% live in rural area and rest 66.21% live in urban areas of Lucknow. With the development of the proposed corridor, it is likely that more people will be involved in trade, commerce and allied services.

5.1.3 Mobility

The total ridership in the proposed North- South corridor in the year 2020 is estimated to be 6.4 lakh passengers per day. The maximum PHPDT on any section is estimated to be more than 20,976 by 2020. The proposed development will reduce journey time to an extent as indicated in the **Table 5.1**.

TABLE 5.1
ESTIMATED REDUCTION IN JOURNEY TIME

Quantified Benefits in Horizon Years	2019	2020	2021	2022	2023
Annual Time Saved by Metro Passengers in Crore Hour.	5.57	6.07	6.43	6.82	7.23

(Source: LMRC DPR 2013)

5.1.4 Reduction in Road Accidents

Reduction in Road accidents is a positive impact of Lucknow Metro Rail Project implementation. Reduction in Road accidents also found after metro introduction in other cities of India. Road accident was a very common phenomenon in previous years but due to metro there were very fewer cases of accidents found and it will be continued in the coming years as well.

TABLE 5.2
ESTIMATED REDUCTION IN ACCIDENTS

Quantified Benefits in Horizon Years	2019	2020	2021	2022	2023
Reduced No of Fatal Accidents in Year	20.73	22.48	23.75	25.08	26.49
Reduced No of Other Accidents in year	186.56	202.35	213.72	225.74	238.45

(Source: LMRC DPR 2013)

5.1.5 Traffic Congestion Reduction

To meet the forecast transport demand in the year 2026, it is estimated that the number of buses will have to be more by 4%. During this period personalised vehicles may also

grow by 4%. Together, they will compound the existing problems of congestion and delay. The proposed development will reduce journey time and hence congestion and delay.

5.1.6 Reduced Fuel Consumption

On implementation of the project, it is estimated that both petrol and diesel consumption will get reduced. The saving will be due to two factors namely Reduction in vehicles and decongestion on roads.

The estimated reduction in the number of passengers and vehicles and in fuel consumption is reported in **Table 5.3** & **Table 5.4**.

Table 5.3
ESTIMATED REDUCTION IN PASSENGERS AND VEHICLES

Vehicles	% PASSENGER	% Vehicle
BUS	14.53%	0.80%
MINI BUS	3.63%	0.42%
CAR	1.54%	1.02%
TAXI	0.17%	0.10%
2WH	75.85%	94.09%
AUTO	4.27%	3.56%

(Source: LMRC DPR 2013)

Table 5.4
ESTIMATED REDUCTION IN FUEL CONSUMPTION

Quantified Benefits in Horizon Years	2019	2020	2021	2022	2023
Annual Fuel Saved by Metro Passengers in thousand Tons.	33.72	37.17	39.91	42.86	46.04

(Source: LMRC DPR 2013)

5.1.7 Reduced Air Pollution

It is expected that air quality of the city will improve and people will depend on Metro service and there will be less usage of cars and buses, which in turn lead to reduction in the contribution of air pollutants. As Metro operation will not locally generate air emission, ambient air quality will be better in future. The major pollutants that define the ambient air quality are: particulate matter, Sulphur dioxide, Nitrogen oxides, and Carbon monoxide. The sources of these pollutants vary from domestic fuel burning to industrial and vehicular emissions. In addition to the above pollutants, un-burnt products like aldehydes, formaldehydes, acrolein, acetaldehyde and smoke are by products of vehicular

emissions. The predicted reduction in emissions of air pollution with Lucknow Metro is summarised in **Table 5.5**.

TABLE 5.5
ESTIMATED REDUCTION IN AMBIENT AIR QUALITY LEVELS

Tons/Year	2019	2020	2021	2022	2023
CO	1498.35	1634.55	1736.38	1844.60	1959.59
HC	1011.42	1103.36	1172.10	1245.14	1322.76
NOX	281.71	307.32	326.46	346.81	368.43
PM	56.37	61.49	65.33	69.40	73.72
SO2	3.75	4.10	4.35	4.62	4.91
CO2	38579	42085	44707	47493	50454
Total Emission Saved	41430	45196	48012	51004	54184

(Source: LMRC DPR 2013)

5.1.8 Saving in Road Infrastructure

The metro corridors will bring savings in investment in road infrastructure due to shifting of passengers to metro rail and withdrawal of vehicles in the project area.

5.2 CHECKLIST OF IMPACTS

The impact evaluation determines whether a project development alternative is in compliance with existing standards and regulations. It uses acceptable procedures and attempts to develop a numeric value for total environmental impact. A transformation of the review of multiple environmental objectives into a single value or a ranking or projects is the final step in impact assessment. There are about hundred methods for carrying out impact assessment, which can be grouped into the following categories:

- Ad – hoc method,
- Checklist,
- Matrix,
- Network,
- Overlays,
- Environmental Index and
- Cost Benefit analysis.

Each of the methods is subjective in nature and none of these is applicable in every case. Of the 7 methods listed above, checklist has been used and presented.

Checklist is a list of environmental parameters or impact indicators which encourages the environmentalist to consider and identify the potential impacts. A typical checklist identifying anticipated environmental impacts is shown in **Table 5.6**.

TABLE 5.6

CHECKLIST OF IMPACTS

S. No.	Parameter	Negative Impact	No Impact	Positive Impact
A.	**Impacts due to Project Location**			
i.	Displacement of People	*		
ii.	Change of Land use and Ecology	*		
iii.	Loss of Cultural and Religious Structures	*		
iv.	Drainage & Utilities Problems	*		
B.	**Impact due to Project Design**			
i.	Platforms - Inlets and Outlets		*	
ii.	Ventilation and Lighting		*	
iii.	Railway Station Refuse	*		
iv.	Risk due to Earthquakes		*	
C.	**Impact due to Project Construction**			
i.	Soil Erosion, Pollution and Health risk	*		
ii.	Traffic Diversions and Risk to Existing Buildings	*		
iii.	Problems of Soil Disposal and Seepage Risk	*		
D.	**Impact due to Project Operation**			
i.	Oil Pollution	*		
ii.	Noise	*		
iii.	Water Demands	*		
iv.	Pedestrian Issues		*	
v.	Visual Impacts		*	
vi.	Employment Opportunities			*
vii.	Enhancement of Economy			*
viii.	Mobility			*
ix.	Safety			*
x.	Traffic Congestion Reduction			*
xi.	Less fuel Consumption			*
xii.	Less Air Pollution			*
xiii.	Carbon dioxide Reduction			*
xiv.	Reduction in Buses			*
xv.	Reduction in Infrastructure			*

5.3 STAKEHOLDER ENGAGEMENT AND PUBLIC CONSULTATION

LMRC's information disclosure strategy includes wide dissemination of project related information, in print and electronic media regarding significant project details. The details of such dissemination are as follows:

Purpose:

Any construction activity will result in environmental and social impacts, this is particularly true for a Metro construction project like LMRP. These problems may be reduced to a great extent if people are properly informed and consulted about the project and allowed to make meaningful choices or preferences.

This serves to reduce the insecurity and opposition to the project which otherwise are likely to occur during project implementation. A public consultation program was conducted to bridge the gap between the project proponent and the stakeholders.

Scope of the Meeting:

The scope of the consultation program was to minimize negative impact in the project corridors and to make people aware of the project. Keeping in mind the significance of consultation and participation of the people likely to be affected or displaced due to the proposed project, discussions were conducted with stakeholders. In this meeting, both environmental and social issues pertaining to the project were discussed.

The first public consultation program for Lucknow Metro Rail Project was conducted on 7th August' 2015 at Lucknow Polytechnic College, Krishna Nagar, Lucknow. For the public consultation, all relevant Stakeholders including affected people, residential Welfare Associations (RWAs), trade organizations and general public were invited through notice.

The meeting was chaired by Shri. A.K.Agnihotri (SDM) along with official of LMRC. The meeting was attended by more than 70 people from all walks of life including representatives from affected families, trade organizations, RWA, teachers etc.
The meeting started with a brief presentation on LMRP covering the project details, salient features, and the associated positive and negative impacts. The proposed mitigation measures were also explained during the presentation. In addition to the environmental aspects, social aspects were also highlighted covering compensation and Resettlement and Rehabilitation benefits.

Soon after the presentation, the public was given opportunity to express their views, concerns, and suggestions about the project. The LMRC team replied to their queries and the summary of the discussion is tabulated in **Table 5.7.**

Table 5.7

ISSUES DISCUSSED DURING PUBLIC CONSULTATION

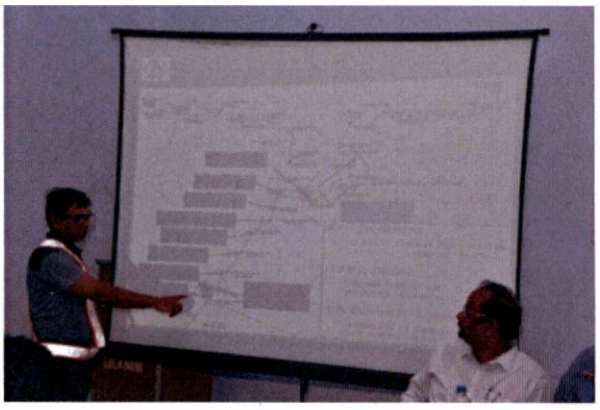
Sl.No	Issues discussed	Important opinions and views	LMRC reply
1.	Overall project	Advantages & disadvantages of this project	• Associated Environmental (positive & adverse) impacts with this project were explained in detail. • R & R plan and Employment opportunity was explained in detail.
2.	Environment	Increase in dust generation & noise pollution	Assurance was given that mitigation measures to contain dust and noise pollution during construction are being implemented.
		Tree cutting was done in several area	• It was informed that the tree cutting will be as minimum as possible. • Tree transplantation is being done wherever possible. • Plantation of new trees will be done in association with the forest department.
3.	Barricading/traffic diversion	Traffic diversions and traffic jams due to construction of metro.	Traffic jams are temporary and requested to cooperate with the project.
		Shop Owners raised concern on erection of barricades in front of their shops which is resulting in loss of business.	• LMRC said that barricading is done for safety purpose for workers as well as for general public. • Barricading will be removed once the construction of a certain area is finished. • Assurance was given that all efforts are being made to expeditiously complete the construction work. • It was also highlighted that once the metro becomes operational, this will enhance the revenue.
4.	Land	What is the basis of compensation of land?	Compensation for land is calculated on the basis of **circle rate.** In addition to the circle rate, 100% solatium will also be paid.
5.	Land acquisition	Why notice was not	One public notice was issued on

		issued to land owners from LMRC.	19th May 2015 for acquisition of land for the construction activity. Shortly individual notice will be issued to pvt. Land owners.
		Land acquisition at Mawaiya	• LMRC assured that the land is being acquired temporarily. • No squatters will be directly affected by the project. The land is being temporarily acquired for safety reasons. • Sufficient time will be given for vacating the premises. • LMRC will provide rent to the affected families for the acquisition period. The amount is being worked out and will be informed shortly.
6.	Compensation	What will be the compensation for acquisition of buildings.	Cost of Building is based on **valuation**. In addition, 100% solatium will also be paid.

Major suggestions/objections in the feedback form

1. After the completion of construction activity, the displaced people should be allowed to move back to Mawaiya
2. Instead of giving rent, it was suggested that LMRC should explore possibility of providing accommodation in the case of temporary acquisition.
3. The Compensation package should be based on the replacement value.
4. New house/shop should be provided against the demolition of house/shop
5. Employment for the affected people.
6. During operation, the facilities like public toilet & drinking water must be placed at the unpaid area of the station.
7. Plantation of trees should be more that the trees that were felled.

Photographs





CHAPTER – 6
ENVIRONMENTAL MANAGEMENT PLAN

6.1 MANAGEMENT PLANS

The Lucknow Metro Rail Corporation will provide employment opportunity, quick mobility service and safety, traffic congestion reduction, less fuel consumption and air pollution on one hand and problems of muck disposal, traffic diversion, utility dislocation etc. on the other hand.

Protection, preservation and conservation of environment has always been a primary consideration in Indian ethos, culture and traditions. Management of Environment by provision of necessary safeguards in planning of the project itself can lead to reduction of adverse impacts due to a project. This chapter, therefore, spells out the set of measures that will be taken during project construction and operation to mitigate or bring down the adverse environmental impacts to acceptable levels based on the planned Environmental Management Plan (EMP).

The most reliable way to ensure that the plan will be integrated into the overall project planning and implementation is to establish the plan as a component of the project. This will ensure that it receives funding and supervision along with the other investment components. For optimal integration of EMP into the project, there shall be investment links for:

- Funding,
- Management and training, and
- Monitoring.

The purpose of the first link is to ensure that planned actions are adequately financed. The second link helps in embedding training, technical assistance, staffing and other institutional strengthening items in the mitigation measures to implement the overall management plan. The third link provides a critical path for implementation and enables sponsors and the funding agency to evaluate the success of mitigation measures as part of project supervision, and as a means to improve future projects. This chapter has been divided into three sections:

- Mitigation measures during Construction
- Mitigation measures during Operation
- Disaster management, and
- Emergency measures.

For every issue discussed for above measures, the implementing agency as well as staffing, equipment, phasing and budgeting have been presented as far as possible. All required funds will be channeled through the project authority. The Environmental Management Plans have been prepared and discussed in subsequent sections.

6.2 MITIGATION MEASURES DURING CONSTRUCTION

The main aim of mitigation measures is to protect and enhance the existing environment of the project during construction. This section includes measures for:

- Compensatory Afforestation,
- Construction Material Management,
- Labour Camp,
- Energy Management
- Hazardous Waste Management
- Housekeeping,
- Utility Plan,
- Archaeological and Historical Preservation
- Air Pollution Control Measures,
- Noise Control Measures,
- Vibration Control Measures,
- Traffic Diversion/Management,
- Soil Erosion Control,
- Muck Disposal,
- Draining of Water from Tunnel,
- Water and Solid Waste management,
- Rain water harvesting
- Depot, and
- Training and Extension.

6.2.1 Compensatory Afforestation

The objective of the afforestation programme shall be to develop natural areas in which ecological functions could be maintained on a sustainable basis. The Department of Forests is responsible for the conservation and management of trees/forests in the project area. According to the results of the present study, it is found that about 431 trees are likely to be lost due to the proposed N-S corridor and 750 trees due to depot. As per the Forest Conservation Rules (2003), two saplings will be planted for cutting a single tree.

6.2.2 Construction Material Management

The major construction material to be used for construction of Metro are coarse aggregates, cement, coarse sand, reinforcement steel, structural steel, water supply, drainage and sanitary fittings etc. The material will be loaded and unloaded by engaging labour at both the locations by the contractor.

The duties of the contractor will include monitoring all aspects of construction activities, commencing with the storing, loading of construction materials and equipment in order to maintain the quality. During the construction period, the construction material storage site is to be regularly inspected for the presence of uncontrolled construction waste. Close liaison with the LMRC officers and the head of the construction crew will be required to address any environmental issues and to set up procedures for mitigating impacts. The scheduling of material procurement and transport shall be linked with construction schedule of the project. The Contractor will be responsible for management of such construction material during entire construction period of the project. The contractor will test all the materials in the Government labs or Government approved labs in order to ensure the quality of materials before construction.

6.2.3 Labor Camp

The Contractor during the progress of work will provide, erect and maintain necessary (temporary) living accommodation and ancillary facilities for labour to standards and scales approved by the LMRC. All temporary accommodation will be constructed and maintained in such a fashion that uncontaminated water is available for drinking, cooking and washing. Safe drinking water will be provided to the dwellers of the construction camps. Construction camps will be the responsibility of the concerned contractors and these will not be allowed in the construction areas but sited away. Adequate health care will be provided for the work force.

Sanitation Facilities: Construction camps will be provided with sanitary latrines and urinals. Sewerage drains will be provided for the flow of used water outside the camp. Drains and ditches will be treated with bleaching powder on a regular basis. The sewage system for the camp will be properly designed, built and operated so that no health hazard occurs and no pollution to the air, ground or adjacent watercourses takes place. Compliance with the relevant legislation will be strictly adhered to. Garbage bins will be provided in the camp and regularly emptied and the garbage disposed off in a hygienic manner.

Shelter at Workplace: At every workplace, shelter shall be provided free of cost, separately for use of men and women labourers. The height of shelter shall not be less than 3m from floor level to lowest part of the roof.

Canteen Facilities: A cooked food canteen on a moderate scale shall be provided for the benefit of workers wherever it is considered necessary. The contractor shall conform generally to sanitary requirements of local medical, health and municipal authorities and at all times adopt such precautions as may be necessary to prevent soil pollution of the site.

First aid facilities: At every workplace, a readily available first-aid unit including an adequate supply of sterilized dressing materials and appliances will be provided. Suitable transport will be provided to facilitate taking injured and ill persons to the nearest hospital.

Day Crèche Facilities: At every construction site, provision of a day crèche shall be worked out so as to enable women to leave behind their children. At construction sites where 20 or more women are ordinarily employed, there shall be provided at least a hut for use of children under the age of 6 years belonging to such women. Huts shall not be constructed to a standard lower than that of thatched roof, mud walls and floor with wooden planks spread over mud floor and covered with matting. Huts shall be provided with suitable and sufficient openings for light and ventilation. There shall be adequate provision of sweepers to keep the places clean. There shall be two maidservants (or aayas) in the satisfaction of local medical, health, municipal or cantonment authorities. Where the number of women workers is more than 25 but less than 50, the contractor shall provide with at least one hut and one maidservant to look after the children of women workers. Size of crèches shall vary according to the number of women workers employed.

6.2.4 Energy Management

The contractor shall use and maintain equipment so as to conserve energy and shall be able to produce demonstrable evidence of the same upon LMRC request.

Measures to conserve energy during construction include but not limited to the following:

- Use of energy efficient motors and pumps,
- Use of energy efficient lighting, which uses energy efficient luminaries,
- Adequate and uniform illumination level at construction sites suitable for the task,
- Proper size and length of cables and wires to match the rating of equipment, and
- Use of energy efficient air conditioner.

The contractor shall design site offices maximum daylight and minimum heat gain. The rooms shall be well insulated to enhance the efficiency of air conditioners and the use of solar films on windows may be used where feasible.

6.2.5 Hazardous Waste Management

The contractor shall identify the nature and quantity of hazardous waste generated as a result of his activities and shall file a 'Request for Authorization' with Pollution Control Board along with a map showing the location of storage area. Outside the storage area, the contractor shall place a 'display board', which will display quantity and nature of hazardous waste, on date. Hazardous Waste will be stored in a secure place. It shall be the responsibility of the contractor to ensure that hazardous wastes are stored, based on the composition, in a manner suitable for handling, storage and transport. The labeling and packaging is required to be easily visible and be able to withstand physical conditions and climatic factors. The contractor shall approach only Authorized Recyclers for disposal of Hazardous Waste, under intimation to the LMRC.

6.2.6 Environmental Sanitation

Environmental sanitation also referred to as Housekeeping, is the act of keeping the working environment cleared of all unnecessary waste, thereby providing a first-line of defense against accidents and injuries. Contractor shall understand and accept that improper environmental sanitation is the primary hazard in any construction site and ensure that a high degree of environmental sanitation is always maintained. Environmental sanitation is the responsibility of all site personnel, and line management commitment shall be demonstrated by the continued efforts of supervising staff towards this activity.

General environmental sanitation shall be carried out by the contractor and ensured at all times at Work Site, Construction Depot, Batching Plant, Labour Camp, Stores, Offices and toilets/urinals. Towards this the Contractor shall constitute a special group of environmental sanitation personnel. This group shall ensure daily cleaning at work sites and surrounding areas and maintain a register as per the approved format by the LMRC. Team of environmental sanitation squad shall carry out:

- Full height fence, barriers, barricades etc. shall be erected around the site in order to prevent the surrounding area from excavated soil, rubbish etc, which may cause inconvenience to and endanger the public. The barricade especially those exposed to public shall be aesthetically maintained by regular cleaning and painting as directed by the Employer. These shall be maintained in one line and level.
- The structure dimension of the barricade, material and composition, its colour scheme, LMRC logo and other details.
- All stairways, passageways and gangways shall be maintained without any blockages or obstructions. All emergency exits passageways, exits fire doors,

break-glass alarm points, fire-fighting equipment, first aid stations, and other emergency stations shall be kept clean, unobstructed and in good working order.

- All surplus earth and debris are removed/disposed off from the working areas to officially designated dumpsites. Trucks carrying sand, earth and any pulverized materials etc. in order to avoid dust or odour impact shall be covered while moving.
- No parking of trucks/trolleys, cranes and trailers etc. shall be allowed on roads, which may obstruct the traffic movement.
- Roads shall be kept clear and materials like: pipes, steel, sand boulders, concrete, chips and brick etc. shall not be allowed on the roads to obstruct free movement of road traffic.
- Water logging or bentonite spillage on roads shall not be allowed.
- Proper and safe stacking of material are of paramount importance at yards, stores and such locations where material would be unloaded for future use. The storage area shall be well laid out with easy access and material stored / stacked in an orderly and safe manner.
- Flammable chemicals / compressed gas cylinders shall be safely stored.
- Unused/surplus cables, steel items and steel scrap lying scattered at different places within the working areas shall be removed to identified locations(s).
- All wooden scrap, empty wooden cable drums and other combustible packing materials, shall be removed from work place to identified location(s).
- Empty cement bags and other packaging material shall be properly stacked and removed.

The Contractor shall ensure that all his sub-contractors maintain the site reasonably clean through provisions related to environmental sanitation (housekeeping).

6.2.7 Utility Plan

The proposed Metro corridor runs along major arterial roads of the city, which serve institutional, commercial and residential areas. Large number of sub-surface, surface and overhead utility services, viz. sewers, water mains, storm water drains, telephone cables, electrical transmission lines, electric poles, traffic signals etc. already exist along the proposed alignment. These utility services are essential and have to be maintained in working order during different stages of construction by temporary / permanent diversions or by supporting in position. As such, these may affect construction and project implementation time schedule /costs, for which necessary planning / action will be initiated in advance.

Prior to the actual execution of work at site, detailed investigation of all utilities and location will be undertaken well in advance by making trench pit to avoid damage to any utility.

While planning for diversion of underground utility services e.g. sewer lines, water pipe lines, cables etc., during construction of Metro alignment, the following guidelines would be adopted:

- Utility services shall be kept operational during the entire construction period and after completion of project. All proposals shall therefore, ensure their uninterrupted functioning.
- The elevated viaduct does not pose any serious difficulty in negotiating the underground utility services, especially those running across the alignment. In such situation, the spanning arrangement of the viaduct may be suitably adjusted to ensure that no foundation need be constructed at the location, where utility is crossing the proposed Metro alignment. In case of utility services running along the alignment either below or at very close distance, the layout of piles in the foundations shall be suitably modified such that the utility service is either encased within the foundation piles or remains clear of them.

6.2.8 Archaeological and Historical Preservation

No damage to Archeological and Historical Monuments is anticipated. However, during the construction period, archaeological or historic resources may be affected by direct or indirect construction activity. Prior to the initiation of construction, LMRC intends to review without objection a resources protection plan for historic structures where it appears they may be affected by the project. This plan will be develop by the contractor in consultation with the Archaeological Survey of India (ASI) and other parties. This plan will identify the sensitive resources as well as specify the construction monitoring requirement. These requirements may include ground vibration monitoring and recording any component inadvertently subjected to impact.

In the proposed alignment, the tunnel for the metro network is being constructed by using the state of the art technology i.e. Tunnel Boring Machine which gives negligible vibration and does not affect the surrounding structure. The stations are being constructed by cut and cover method which is widely accepted and the safest technique being adopted by metros in India and abroad.

6.2.9 Ground Settlement

Ground movement associated with the construction of underground railway tunnels is inevitable. As the tunnelling progresses forward, the lack of support for the overburden

causes the ground above the tunnel to subside. Although there are a number of measures to control subsidence that includes compensation grouting and earth pressure balance tunnel boring machines that will be employed in the Project, they cannot fully negate subsidence during and after the tunnelling process.

The contractor will ensure that no inadvertent damage is incurred. As ground settlement cannot be avoided in tunnelling works due to the loss of volume loss. Tilt meters will be installed at key positions to ensure the 2/1000 design value is observed with trigger and allowable values of 1.4/1000 and 1.7/1000, respectively. 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 ensure that no structural damage is incurred and cosmetic damages are repaired under the supervision and control of LMRC. The contractor will immediately cease all operation if any of the trigger values are breached. LMRC will advise mitigation measures to the contractor to control settlement, tilt, and, crack to include but not limited to structural reinforcement and operation parameters of the TBM. Permeation grouting or "the introduction of grout into soil pores without any essential change in the original soil volume and structure to stabilize the shell or crown for the Tunnel Boring Machine (TBM) to pass underneath and minimize water flow through the tunnel alignment.

6.2.10 Air Pollution Control Measures

During the construction period, the impact on air quality will be mainly due to increase in Particulate Matter (PM) along haul roads and emission from vehicles and construction machinery. Though the estimation of air quality during construction shows insignificant impact on ambient air quality, nevertheless certain mitigation measures which shall be adopted to reduce the air pollution are presented below:

- The Contractor shall take all necessary precautions to minimize fugitive dust emissions from operations involving excavation, grading, and clearing of land and disposal of waste. He shall not allow emissions of fugitive dust from any transport, handling, construction or storage activity to remain visible in atmosphere beyond the property line of emission source for any prolonged period of time without notification to the Employer.
- The Contractor shall use construction equipment to minimise or control of air pollution. He shall maintain evidence of such design and equipment and make these available for inspection by Employer.
- Contractor's transport vehicles and other equipment shall conform to emission standards fixed by Statutory Agencies of Government of India or the State Government from time to time. The Contractor shall carry out periodical checks and undertake remedial measures including replacement, if required, so as to operate within permissible norms.

- The Contractor shall cover loads of dust generating materials like debris and soil being transported from construction sites. All trucks carrying loose material shall be covered and loaded with sufficient free - board to avoid spills through the tailboard or sideboards.
- The temporary dumping areas shall be maintained by the Contractor at all times until the excavate is re-utilised for backfilling or as directed by Employer. Dust control activities shall continue even during any work stoppage.
- The Contractor shall place material in a manner that will minimize dust production. Material shall be minimized each day and wetted, to minimize dust production. During dry weather, dust control methods will be used daily especially on windy, dry days to prevent any dust from blowing across the site perimeter.
- The Contractor shall water down construction sites as required to suppress dust, during handling of excavation soil or debris or during demolition. The Contractor will make water sprinklers, water supply and water delivering equipment available at any time that it is required for dust control use. Dust screens will be used, as feasible when additional dust control measures are needed specially where the work is near sensitive receptors.
- The Contractor shall provide a wash pit or a wheel washing and/or vehicle cleaning facility at the exits from work sites such as construction depots and batching plants. At such facility, high-pressure water jets will be directed at the wheels of vehicles to remove all spoil and dirt.
- The Contractor shall design and implement his blasting techniques so as to minimize dust, noise, and vibration generation and prevention fly rock.
- Blasting technique shall be consistent not only with nature and quaintly of rock to be blasted but also the location of blasting.

6.2.11 Noise Control Measures

There will be an increase in noise level in the tunnel and nearby ambient air due to construction of the Metro corridor. The exposure of workers to high noise levels especially need to be minimized. This could be achieved by:

- Job rotation,
- Automation of machinery
- Construction of temporary noise barriers
- Use hydraulic tools instead of pneumatic tools,
- Acoustic enclosures shall be provided for individual noise generating construction equipment like DG sets,
- Scheduling truck loading, unloading and hauling operation,

- Schedule work to avoid simultaneous activities that both generated high noise levels,
- Anti drumming floor and noise absorption material,
- Low speed compressor, blower and air conditioner,
- Mounting of under frame equipments on anti-vibration pad,

The workers employed in high noise level area could be employed in low noise level areas and vice-versa from time to time. Automation of equipment and machineries, wherever possible, shall be done to avoid continuous exposure of workers to noise. At work places, where automation of machineries is not possible or feasible, the workers exposed to noise shall be provided with protective devices. Special acoustic enclosures shall be provided for individual noise generating equipments, wherever possible.

During construction, there may be high noise levels due to pile driving, use of compressors and drilling machinery. Effective measures shall be taken during the construction phase to reduce the noise from various sources. The noise from air compressor can be reduced by fitting exhaust and intake mufflers.

The pile driving operation can produce noise levels up to 100 dB (A) at a distance of 25-m from site. Suitable noise barriers can reduce the noise levels to 70 dB (A) at a distance of 15m from the piles. A safety precaution as stipulated in IS: 5121 (1969) '*Safety Code for Piling and other Deep Foundation'* need to be adopted.

Noise level from loading and unloading of construction materials can be reduced by usage of various types of cranes and placing materials on sand or sandy bag beds.

6.2.12 Vibration Control Measures

In locations where the alignment is close to historical / heritage and sensitive structures, the contractor shall prepare a monitoring scheme prior to construction at such locations. This scheme shall include:

- Monitoring requirements for vibrations at regular intervals throughout the construction period.
- Pre-construction structural integrity inspections of historic and sensitive structures in project activity.
- Information dissemination about the construction method, probable effects, quality control measures and precautions to be used.

6.2.13 Traffic Diversion/ Management

During such construction, traffic is most likely to be affected. Hence Traffic Diversion Plans are required in order to look for options and remedial measures so as to mitigate any traffic congestion situations arising out due to acquisition of road space during Metro construction. Any reduction of road space during Metro construction results in constrained traffic flow. In order to retain satisfactory levels of traffic flow during the construction period; traffic management and engineering measures need to be taken. They can be road widening exercises, traffic segregation, one-way movements, traffic diversions on influence area roads, acquisition of service lanes, etc.

Various construction technologies are in place to ensure that traffic impedance is done at the minimum. They are:

- 'Cut-and-Cover' method is planned for construction of the underground segment. This means that the stretch between two points will have to be blocked during construction. However, temporary decking may be provided by blocking the road carriageway partially to permit traffic movement along the same stretch. Construction of switch-over-ramp also requires some road space.
- For elevated section wherever it is passing along the road, the requirement would be mainly along the central verge.
- As regards to the alignment cutting across a major traffic corridor, 'Continuous Cantilevered Construction Technology' would be applied to prevent traffic hold-ups or diversions of any kind.
- Wherever the stations are isolated, areas available around it shall be utilized for road diversion purposes such as lay-byes and service roads.

Only temporary diversion plans will be required during construction of the Metro. At the onset, all encroachments from road ROW will have to be removed. These encroachments vary from 'on-street' parking to informal activities. During the construction, it is planned that temporary decking may be provided by blocking the road carriageway partially to permit 'through' as well as right-turning traffic movements. Total blockage of traffic along the underground section is not recommended due to non-availability of reasonably good alternate road network.

Keeping in view the future traffic growth and reduction of carriageway due to Metro construction, implementation of traffic management/diversion plans shall become inevitable for ensuring smooth traffic movement and similar traffic diversion plans shall be formulated and followed during the execution stage.

Traffic Management Guidelines: The basic objective of the following guidelines is to lay down procedures to be adopted by contractor to ensure the safe and efficient movement of traffic and also to ensure the safety of workmen at construction sites.

- All construction workers shall be provided with high visibility jackets with reflective tapes as most of viaduct /tunneling and station works or either above or under right-of-way. The conspicuity of workmen at all times shall be increased so as to protect from speeding vehicular traffic.
- Warn the road user clearly and sufficiently in advance.
- Provide safe and clearly marked lanes for guiding road users.
- Provide safe and clearly marked buffer and work zones
- Provide adequate measures that control driver behavior through construction zones.
- The primary traffic control devices used in work zones shall include signs, delineators, barricades, cones, pylons, pavement markings and flashing lights.

The contractor will hire a transportation consultant that carryout the traffic survey and suggest alternative routes for smooth flow of traffic.

6.2.14 Soil Erosion Control

Prior to the start of the relevant construction, the Contractor shall submit to the LMRC for approval, his schedules for carrying out temporary and permanent erosion/sedimentation control works as are applicable for the items of clearing and grubbing, roadway and drainage excavation, embankment/sub-grade construction, bridges and other structures across water courses, pavement courses and shoulders. He shall also submit for approval his proposed method of erosion/sedimentation control on service road and his plan for disposal of waste materials. Work shall not be started until the erosion/sedimentation control schedules and methods of operations for the applicable construction have been approved by the LMRC.

The surface area of erodible earth material exposed by clearing and grubbing, excavation shall be limited to the extent practicable. The Contractor may be directed to provide immediate control measures to prevent soil erosion and sedimentation that will adversely affect construction operations, damage adjacent properties, or cause contamination of nearby streams or other watercourses. Such work may involve the construction of temporary berms, dikes, sediment basins, slope drains and use of temporary mulches, fabrics, mats, seeding, or other control devices or methods as necessary to control erosion and sedimentation.

The Contractor shall be required to incorporate all permanent erosion and sedimentation control features into the project at the earliest practicable time as outlined in his accepted

schedule to minimize the need for temporary erosion and sedimentation control measures. Under no conditions shall a large surface area of credible earth material be exposed at one time by clearing and grubbing or excavation without prior approval of the LMRC.

The LMRC may limit the area of excavation, borrow and embankment operations in progress, commensurate with the Contractor's capability and progress in keeping the finish grading, mulching, seeding and other such permanent erosion, sedimentation and pollution control measures, in accordance with the accepted schedule.

Temporary erosion is sometimes caused due to the Contractor's negligence, carelessness or failure to install permanent controls. Sedimentation and pollution control measures then become necessary as a part of the work as scheduled or ordered by the LMRC, and these shall be carried out at the Contractor's own expense. Temporary erosion, sedimentation and pollution control work required, which is not attributed to the Contractor's negligence, carelessness or failure to install permanent controls, will be performed as ordered by the LMRC.

6.2.15 Muck Disposal

Construction of underground metro projects is a specialised and complex task. Owing to paucity of space in the busy cities and for safety reasons, elaborate measures need to be adopted for collection, transfer, storage and disposal of excavated muck. Muck collection, transportation, disposal and its treatment need to be carried out in a systematic manner. Muck collection shall be in containers from the dredging sites / places. These containers shall be such that muck shall not spill during movement to disposal site. The excavated muck will be first collected at dumping ground and then transferred to disposal sites. Dumping areas are essential to store the excavated earth temporarily for back filling at later date and final disposal.

The transfer and disposal of surplus soil may create air pollution and leached water problem. To mitigate these problems following mitigation measures are planned to be adopted:

1. The disposal sites will be cleaned and then treated so that leached water does not contaminate the ground water.
2. Material will be stabilised each day by watering or other accepted dust suppression techniques.
3. The height from which soil will be dropped shall be minimum practical height to limit the dust generation.
4. The stockpiling of earth in the designated locations with suitable slopes.
5. During dry weather, dust control methods such as water sprinkling will be used daily especially on windy, dry day to prevent any dust from blowing.

6. Sufficient equipment, water and personnel shall be available on dumping sites at all times to minimise dust suppression.
7. Dust control activities shall continue even during work stoppages.
8. The muck shall be filled in the dumping site in layers and compacted mechanically. Dumping sites on sloping ground shall be protected adequately against any possible slide/slope failure through engineering measures.

It is desirable to first clean the disposal area site for vegetation biomass exists over it. The faces and top shall be treated/ vegetated to avoid erosion. Once the filling is complete, the entire muck disposal area shall be provided with a layer of good earth on the top, dressed neatly, and covered with vegetation.

6.2.16 Draining of Water from Tunnel

Problems of water flow associated with tunneling are bound to take place. In cut and cover type construction continuous pumping is an economical alternative. The well point system is recommended for dewatering as the volume of water to be pumped out is not large at stations. A recharge pit will be provided where the water table has to be lowered during tunneling.

A suitable piezometer is installed to monitor the water table constantly and to see how much lowering has been effectively done. The dewatering shall not be stopped unless it is ensured from design calculations that the load of the constructed box component has reached a stage where it will be able to counter act the hydrostatic pressure from below.

The dewatering can be achieved by:

- Leading the ground water to a sump by drains and pump out the water from the sump to the recharge pit. To prevent loss of fines, inverted filter may have to be used.
- The construction of diaphragm walls of concrete along the side of channels, before the commencement of excavation will be required. The concrete walls are taken down to rest on bed rock or impervious strata or, in their absence, deep enough below the bottom of excavation, to serve as an effective cut off for the inflow of ground water into the proposed excavation. The trenches are made in lengths of 2.5 to 5m and kept continuously filled with a thiotropic material like Bentonite slurry, which has the effect of 14tabilizing the trench and preventing any subsidence. As the excavation proceeds, concrete wall can be strutted mutually or anchored with surrounding rocks or soil with long tie rods.

6.2.17 Water and Solid Waste Management

During construction there will be excessive usage of ground water. To avoid excess usage of water during construction following measures will be taken to reduce water consumption.

1. Recycle of water consumed in wheel washing.
2. Discarded water from the R/O plant at Batching Plants shall be used for re-charge of ground water.
3. Water from dewatering will also be used for groundwater re- charge.

Local municipality identifies the waste disposal sites and communicates to LMRC. LMRC will ensure that the waste disposed off only at such sites.

It is the responsibility of the contractor to identify the type of waste being generated at site and its appropriate disposal management as per the identified disposal sites and report the same to LMRC in its monthly report as per the format mentioned in **Table 6.1**.

Table 6.1

FORMAT FOR WASTE GENERATION AND DISPOSAL

Waste type	Cumulative quantity generated	Quantity generated this month	Method & frequency of disposal	Remarks (Qty. send to agency)
Construction & Demolition waste				
a. Concrete waste				
b. Demolition waste				
c. Bentonite/Polymer mixed soil				
d. Good earth				
Hazardous waste				
a. Waste oil, oil filters, air filters, used cartridges etc				
Recyclable waste				
a. Paper, Plastic, wood, bottles, rubber etc				
Bio-degradable waste				
a. Food waste, vegetable waste etc				
Bio-Medical waste				
a. Used cottons, bandages, shredded needles, syringes etc				
Metal scrap				
E-Waste				
Miscellaneous (any other)				

6.2.18 Rain water harvesting

To conserve and augment the storage of groundwater, rainwater harvesting structures shall be installed at batching plants and casting yards of suitable capacity.

6.2.19 Depot

About 750 trees will be affected due to the construction of Depot at Transport Nagar. Options will be explored to transplant the trees as far as possible and avoid cutting of trees.

The land required for the proposed depot is 37.8 ha. Although it is not a low-lying area, some quantity of earth work is required to make the surface even. The excavated soil from underground stations and tunnel works will be used for depot.

6.2.20 Training and Extension

The training for engineers and managers is imparted by LMRC on regular basis to implement the environmental protection clauses of the tender document and to implement the best environmental practices during the construction phase. The course content draws heavily from past experiences. These training programs are imparted through regular training workshops in which presentations are made on a variety of issues pertaining to environmental management so as to sensitize the participants and raise their awareness on environmental issues in general and conditions of contract on environment, in particular. These programmes could be extended for the local population for their active participation in the project implementation. Apart from training, such programme shall include guidelines for safety, methods of disaster prevention, action required in case of emergency, fire protection, environmental risk analysis etc. The cost involved for such programme is presented in **Table 6.2.**

TABLE 6.2
COST OF TRAINING PROGRAMME

S. NO	ITEM	COST (Rupees)
1.	Curriculum Development and course preparation 2 months Rs.30000/month	60,000
2.	2 Extension Officers (1year) Rs.25, 000/ month	6, 00,000
3.	Instructor 20 sessions of 10 days each	5, 00,000
4.	Demonstration/Presentation Aids	50,000
5.	Material etc	1,00,000
	Total	**13,10,000**

6.3 MITIGATION MEASURES DURING OPERATION

The main aim of mitigation measures is to ensure that the activities related to Metro operation do not harm the environment. This section includes measures for:

- Energy Management
- Air Pollution
- Noise Control Measures,
- Vibration Control Measures,
- Rain water harvesting and Seepage water from Tunnel
- Water Supply and Sanitation
- Solid Waste management
- Management Plans for Depot

6.3.1 Energy Management

LMRC will adopt the following energy conservation measures during design stage:

In Traction

(i) Use of regenerative braking resulting in energy saving of about 30-40% of Traction Energy.

(ii) Design of coaches:-
   a) Reduction in Tare weight of coach by use of stainless steel and,
   b) Increased passenger capacity per coach
   c) Variable Voltage Variable Frequency drives

(iii) Selection of 25 kV ac traction, which resulted in reduction in equipment sizing, lower losses in the equipment and in turn more efficient system

In Station Auxiliary Equipment

i) Maintaining Power Factor near Unity.

ii) Selection of closed system, where the conditioned air gets re-circulated

iii) Choice of Acceptable conditions inside coaches and stations areas using Relative Warmth Index.

iv) Selection of Energy Efficient VAC Equipment

v) Provision of solar PV at proposed Singaar Nagar metro station

6.3.2 Air Pollution

Metro operation will cause no air pollution in the city, additionally, reduce congestion on the roads there by contributing to improvement in the overall pollution levels in the city.

6.3.3 Noise Control Measures

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, and other car mounted equipment.

There will be an increase in noise level during operation of the Metro. However, noise levels in the core city are expected to go down. The increase in levels is marginal; hence local population will not be adversely affected. However measures shall be adopted to mitigate the noise levels at source. This could be achieved by:

- 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, and
- Sound proof compartments control rooms etc.
- Special acoustic enclosures shall be provided for individual noise generating equipments, wherever possible.

The ballast-less track is supported on two layers of rubber pads to reduce track noise and ground vibrations. The concept of a "low-noise" electric locomotive will be adopted at a very early state of planning and will be followed up with detailed work throughout the project execution and operation. In addition, baffle walls as parapets will be constructed at up to the rail level so as to reduce sound levels.

In addition, it is recommended to provide skirting of coach shell covering the wheel which will screen any noise coming from the rail wheel interaction as of propagating beyond the viaduct. In sensitive areas, track can be suitably designed so as to avoid propagation of noise to adjacent structures. In the operational stage, there may be issues of noise at sensitive receptors near the elevated track.

6.3.4 Vibration Control Measures

Vibration emanates from rail - wheel interaction and the same can be reduced by minimizing surface irregularities of wheel and rail, improving track geometry, providing elastic fastenings, and separation of rail seat assembly from the concrete plinth with insertion of resilient and shock absorbing pad.

While designing the track structure for Mass Rapid Transit System all the above points have been taken into consideration in the following ways:

- To prevent development of surface irregularities on the rail, a fairly heavy rail section of 60 kg/m, 90 UTS rail, supported at every 60 cms has been planned further rail grinding at regular intervals by rail grinding machine and also lubrication of rail by vehicle mounted lubricator.
- Rails will be continuously welded and also will be laid to fine tolerances so that any noise/vibration on account of track geometry could be reduced.
- The vibration generated from rail-wheel interaction will be greatly absorbed by the elastic fastening system planned to be used.

The lower vibration has been achieved by providing of bolster less type bogies having secondary air spring.

6.3.5 Rainwater Harvesting and Seepage Water from Tunnel

During operation phase, seepage water will be collected in a sump, located at the lowest point of the station, along the side of walls (retaining). Proper drainage system has been incorporated in design for the collection of water. The collected water from the sump will be pumped into the drains regularly. The possibility of reusing the seepage water, after initial treatment, for station operations will be explored in later stages.

LMRC will install rainwater harvesting facilities at stations in compliance to the Mandatory Roof Top Rain Harvesting regulations. Every station will be provided with two rainwater harvesting pits to recharge rainwater runoff. In exceptional cases, if rainwater enters into station or on the track, proper drainage system is included in design to divert the water into the above mentioned sump.

6.3.6 Water Supply and Sanitation

The Metro operation will require substantial amount of water which shall be sourced from groundwater after obtaining necessary permissions. All stations will employ a cooling water recirculation system for air-conditioning.

The public health facilities, such as water supply, sanitation and toilets are much needed at the stations. Water will be treated before use up to WHO drinking water standards. Proper drainage system shall be provided for sewage disposal. Recycled water will be used for facility cleaning and landscape irrigation. All toilets will be equipped with low-flow fixtures.

6.3.7 Solid Waste Management

Solid waste generated at underground station and elevated station is estimated to be about 6 – 8 Kg/Day and 4 - 6 Kg/Day respectively. The maintenance of adequate sanitary facilities for temporarily storing refuse on the premises is considered a responsibility of the LMRC project authorities. The storage containers for this purpose need to be designed. However it is suggested that the capacity of these containers shall not exceed 50 litres and these shall be equipped with side handles to facilitate handling. To avoid odor and the accumulation of fly-supporting materials, garbage containers shall be washed at frequent intervals. This shall be collected and transported to local municipal bins for onward disposal to disposal site by municipality.

6.3.8 Management Plans for Depot

A depot is planned at Tilak Nagar for the proposed metro corridor. The management plans for depot include:

- Water Supply,
- Oil Pollution Control,
- Sewage/Effluent Pollution Control,
- Surface Drainage,
- Green belt development,
- Rain water harvesting, and
- Recycling of treated waste water.

Water supply: The water supply could be either collected from Municipal Corporation or through boring tube well into the ground. The ground water will need treatment depending upon its use. Domestic and some of the industrial application, a reverse Osmosis (RO) plant of 8 liter/ minute capacity will be appropriate. The water treatment plant flow chart is given in **Figure 6.1**. The estimated cost of water supply plant is about 12.05 million per plant.

Oil Pollution Control: The oil tends to form scum in sedimentation chambers, clog fine screens, interfere with filtration and reduce the efficiency of treatment plants. Hence oil and grease removal tank has to be installed at initial stage of effluent treatments. Such tanks usually employ compressed air to coagulate the oil and grease and cause it to rise promptly to the surface. Compressed air may be applied through porous plates located in

bottom of the tank. The tank may be designed for a detention period of 5 to 15 minutes. **Figure 6.2** explains the mechanism of Oil separator.

Sewage/Effluent Pollution Control: The sewage could be treated up to the level so that it could be used for horticulture purpose in the campus and can also be discharged into the stream a process flow chart is presented in **Figure 6.3.**

Effluent is likely to be generated at depot and this will have oil, grease and, detergent as main pollutants. This has to be treated as per requirement of regulatory pollution control agency of the state. Process flow chart of effluent treatment plant is shown in **Figure 6.4.**

Surface Drainage: The area shall have proper drainage. The Storm water of the depot will be collected through the drain. Rain water harvesting pits at different locations in the drains and for surplus storm water, the drainage system is connected to a nearby disposal site. The drainage costs have been included in project cost.

Green belt development: The greenbelt development / plantation in the depot area not only functions as landscape features resulting in harmonizing and amalgamating the physical structures of proposed buildings with surrounding environment but also acts as pollution sink / noise barrier. In addition to augmenting present vegetation, it will also check soil erosion, make the ecosystem more diversified and functionally more stable, make the climate more conducive and restore balance.

Rain water harvesting: To conserve and augment the storage of groundwater, it has been planned to construct roof top rainwater harvesting structure of suitable capacity in the depot.

FIGURE 6.1
FLOW CHART FOR WATER TREATMENT PLANT

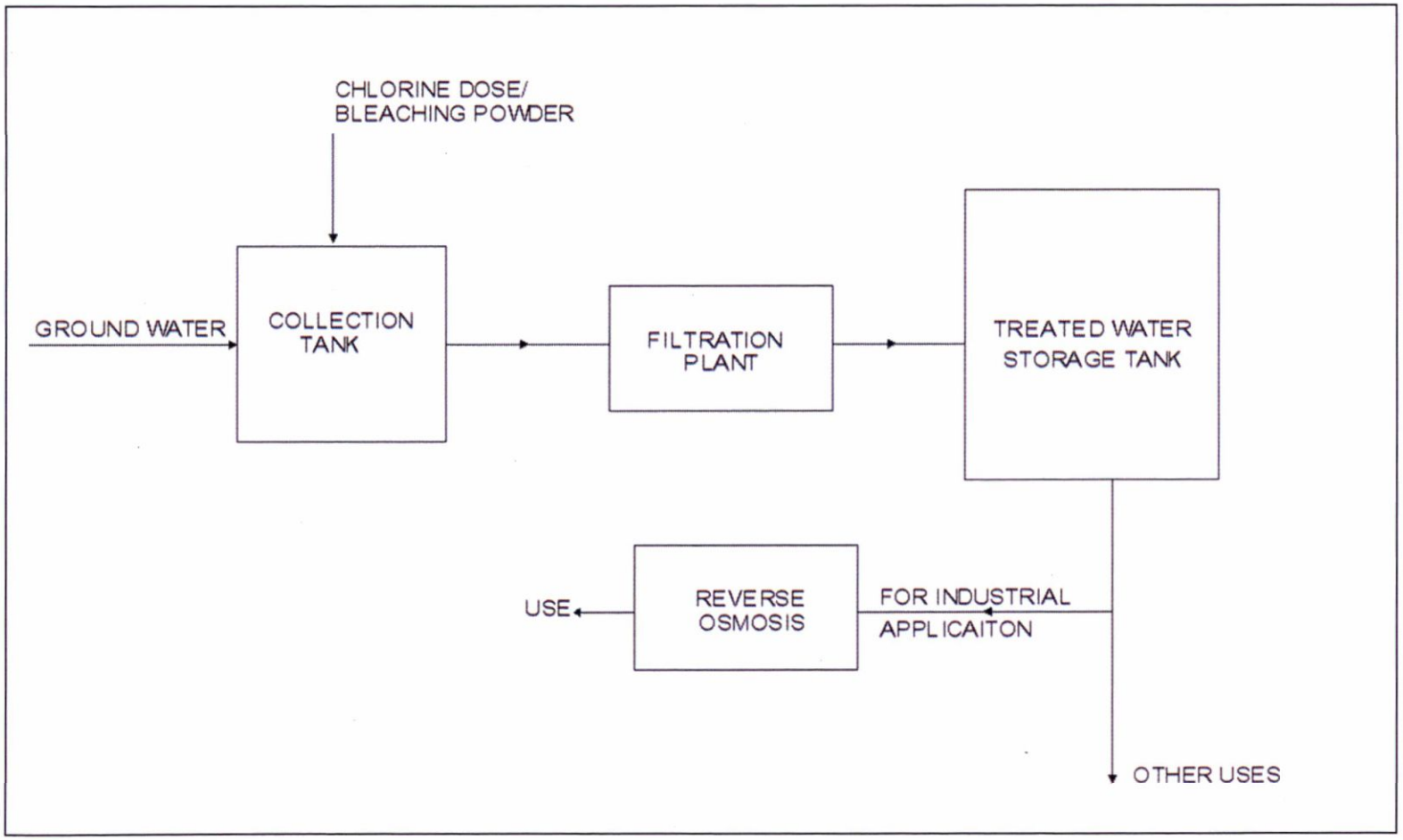


FIGURE 6.2
OIL SEPERATOR

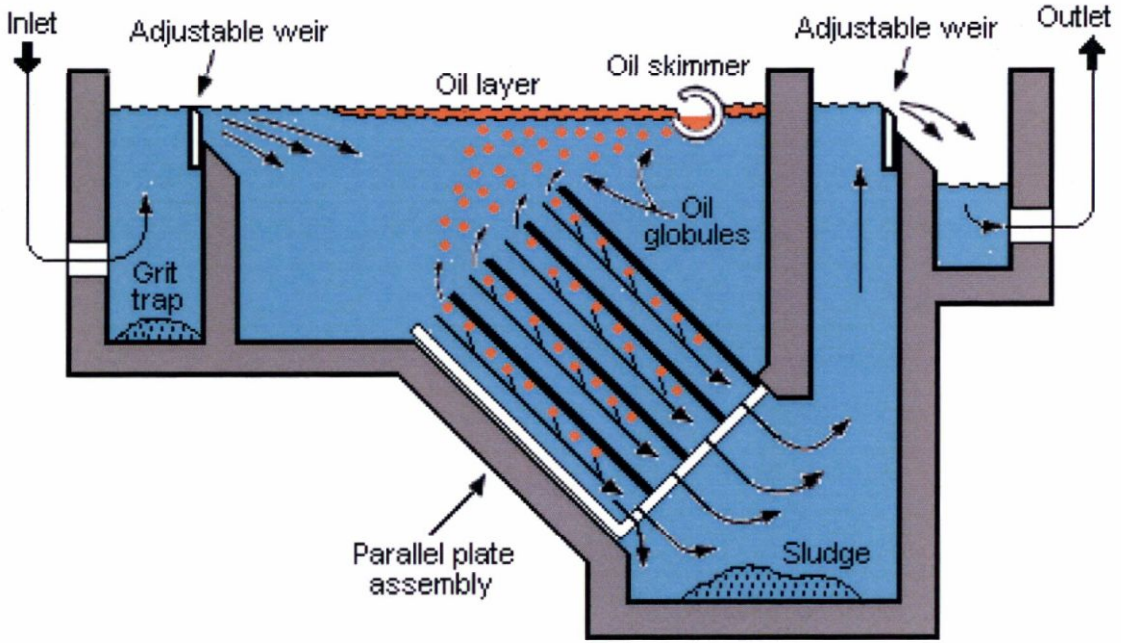


FIGURE 6.3
FLOW CHART FOR SEWAGE TREATMENT PLANT

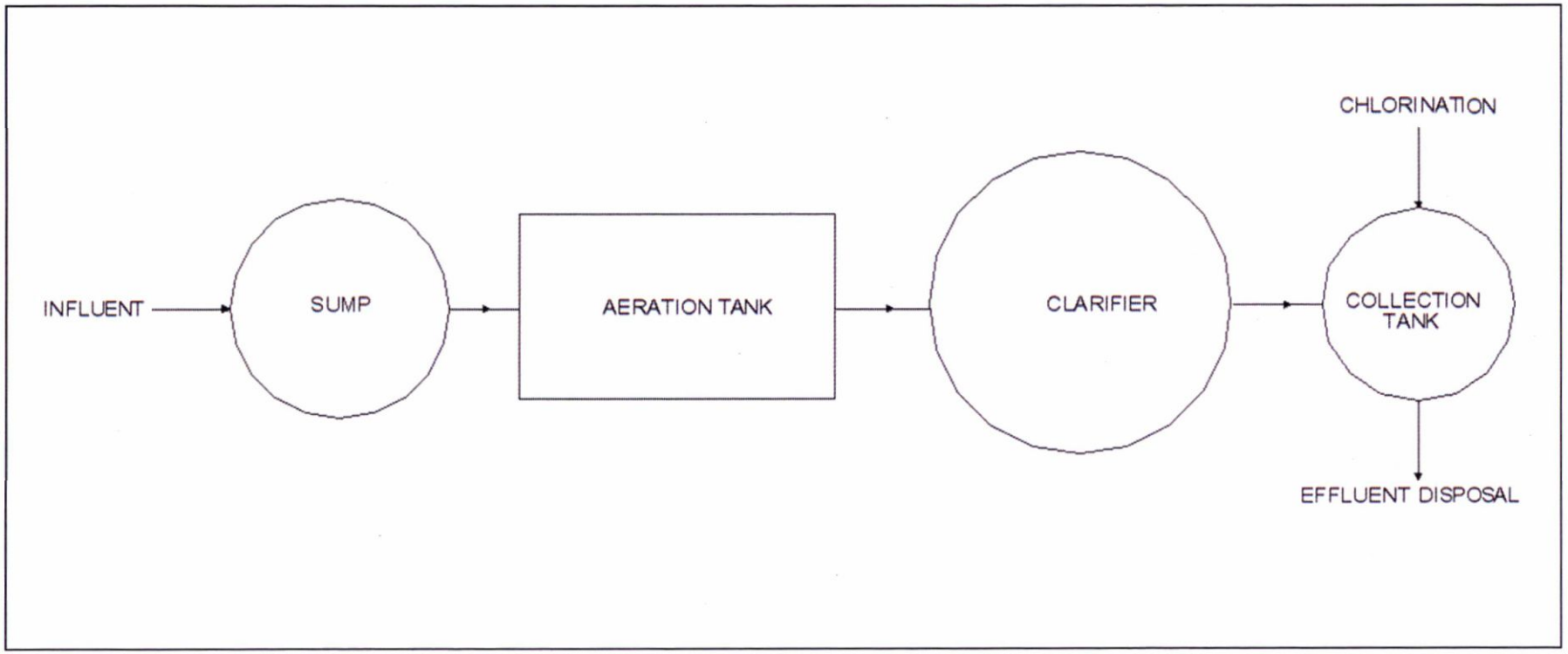
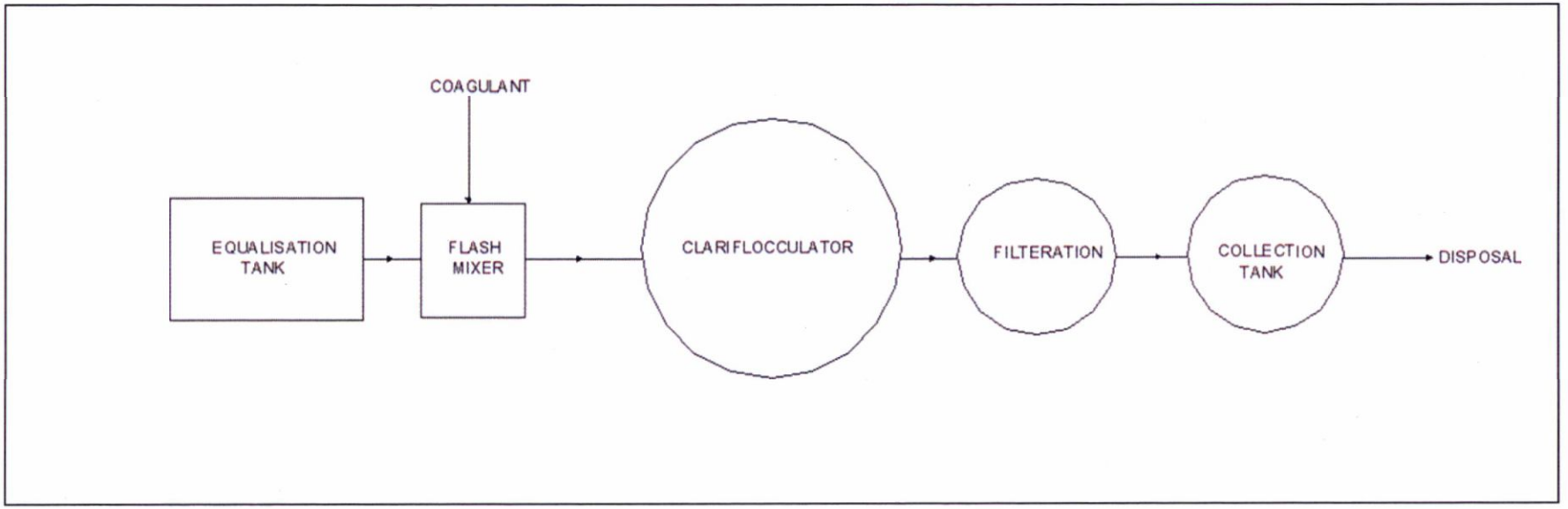


FIGURE 6.4
FLOW CHART FOR EFFLUENT TREATMENT PLANT



6.4 DISASTER MANAGEMENT

Disaster is an unexpected event due to sudden failure of the system, external threats, internal disturbances, earthquakes, fire and accidents. The first step is to identify the causes which develop/ pose unexpected danger to the structural integrity of Metro tunnel or overhead rail. The potential causes are excessive load, cracks, failure and malfunctioning of sensing instruments, accident, etc. These need to be looked into with care.

Under section 18 and 19 of the Disaster Management Act, 2005 the State Disaster Management Authority (SDMA) has powers to oversee the sudden failures of the system.

6.4.1 Preventive Action

Once the likelihood of a disaster is suspected, action has to be initiated to prevent a failure. Engineers responsible for preventive action shall identify sources of repair equipments, materials, labour and expertise for use during emergency.

6.4.2 Reporting Procedures

The level at which a situation will be termed a disaster shall be specified. This shall include the stage at which the surveillance requirements shall be increased both in frequency and details.

The Engineer-in-Chief shall notify the officer for the following information:

- Exit points for the public,
- Safety areas in the tunnel/overhead rail, and
- Nearest medical facilities.

6.4.3 Communication System

An efficient communication system is absolutely essential for the success of any disaster management plan. This has to be worked out in consultation with local authorities. More often, the entire communication system gets disrupted when a disaster occurs. The damage areas need to be clearly identified and provided with temporary and full proof communication system.

6.4.4 Emergency Action Committee

To ensure coordinates action, an Emergency Action Committee shall be constituted. The civic administrator may be the Chairman of this Committee. The committee may comprise of:

- Station Master concerned,
- Police Officer of the area,
- Home Guard representative,
- Fire Brigade representative,
- Health Department representative,
- Department of Information and Publicity, and
- Non-Governmental Organization of the area.

Emergency Action Committee will prepare the evacuation plan and procedures for implementation based on local needs and facilities available. The plan shall include:

- Demarcation of the areas to be evacuated with priorities,
- Safe route to be used, adequacy of transport for evacuation, and traffic control,
- Safe area and shelters,
- Security of property left behind in the evacuated areas,
- Functions and responsibilities of various members of evacuation teams, and
- Setting up of joint control room.

All personnel involved in the Emergency Action Plan shall be thoroughly familiar with all the elements of the plan and their responsibilities. They shall be trained through drills for the Emergency Action Plan. The staff at the site shall be trained for problem detection, evaluation and emergency remedial measures. Individual responsibility to handle the segments in emergency plan will be allotted.

Success of an emergency plan depends on public participation, their response to warning notifications and timely action. Public has to be educated on the hazards and key role in disaster mitigation by helping in the planned evacuation and rescue operations.

It is essential to communicate by whom and how a declared emergency will be terminated. There shall be proper notification to the public on de-alert signals regarding termination of the emergency. The notification shall be clear so that the evacuees know precisely what to do when re-entering or approaching the affected areas.

6.5 EMERGENCY MEASURES

The emergency measures are adopted to avoid any failure in the system such as lights, fire, means of escape, ventilation shafts etc. The aim of Emergency Action Plan is to identify areas, population and structures likely to be affected due to a catastrophic event of accident. The action plan shall also include preventive action, notification, warning procedures and co-ordination among various relief authorities. These are discussed in following sections.

6.5.1 Emergency Lighting

The emergency lights operated on battery power shall be provided at each station. The battery system shall supply power to at least 25% of the lights at the station, platforms, tunnels/viaducts for a period of 2 hours. The underground station shall have transformer at each end of the platform. Both the transformers need to be kept energized and shall feed independently alternate rows of lights so that in case of failure of one transformer, there will not be complete darkness. The tunnels need to be provided with fluorescent incandescent lamps at a spacing of 20 m.

6.5.2 Fire Protection

The building materials shall be of appropriate fire resistance standard. For underground structures the fire resistance period shall be at least 4 hours, and 2 hours for surface or over head structures. Wood shall not be used for any purpose, excluding artificial wood products, which are flame resistant. The materials which have zero surface burning characteristics need to be used. The electrical systems shall be provided with automatic circuit breakers activated by the rise of current as well as activated by over current. The design of a station will include provision for the following:

- Fire prevention measures,
- Fire control measures,
- Fire detection systems,
- Means of escape,
- Access for fireman, and
- Means of fire fighting.

Accumulations of refuse of any inflammable material like paper, plastic cartons constitute a major fire hazards and shall not be permitted. Smoking shall be strictly prohibited at all locations of Metro System.

All aspects of fire prevention and control will be dealt in close collaboration with the city fire fighting authority. Smoke control will be achieved by the following means:

- Downstand bulkheads of a minimum depth of 600 mm to provide smoke containment. These will be provided around openings for escalators, lifts and stairs in underground stations,
- In underground stations the ventilation system will be designed to extract smoke in the event of fire, and
- In enclosed public areas of above ground stations (e.g. a concourse located below a platform) arrangement for smoke extraction will be provided.

A minimum of 30 minutes supply of water is to be assured in the case of fire. The pumps/overhead tanks shall have the capacity to discharge the water at the rate of 1100 litres per minute at a head of 21 m at nozzle mouth.

The storage capacity in an underground or overhead tank may be divided into two parts i.e. dead storage and running storage. Fire fighting pumps shall be provided with a diesel pump as a standby arrangement, in case of power failure.

Fire of electrical origin, water cannot be used until the electric system has been made dead and earthened. For electrical fires, non-aqueous agents like ABC Power Chloro Bromo Methane or CO_2 gas are utilized for fire fighting. Fire extinguishers with these agents shall be liberally provided at static installations and on the rolling stock.

Generally there are often more casualties from smoke inhalation than from burning. Smoke need to be transported away from the site of the fire. In order to achieve this, both fresh air has to be introduced into the underground section and exhaust gases shall be sucked out from other section.

Openings, including ducts and passages, between Metro property and any adjoining structures which allow free access into the Metro property will be protected by fire doors, fire shutters, fire dampers etc. as appropriate. Fire detection and alarm systems will be provided as per the prevailing state of art technology.

A. Fire Prevention and Safety Measures

Fire prevention measures will be designed and implemented to minimize the risk of outbreak of fire by appropriate choice, location and installation of various materials and equipment. In stations planning, potential sources of fire can be reduced by:

i. Fire Prevention

- Use of non-combustible or smoke retardant materials where possible,
- Rolling stock is provided with fire retarding materials, low smoke zero halogen type electric cable is also provide,
- Provision of layout which permits ease of maintenance for equipment and cleaning of the station premises,
- Provision of special storage spaces for combustible materials such as paint and oil,
- Prohibition of smoking in fire prone areas,
- Provision of cigarette and litter bins, and
- Good housekeeping.

ii. Safety

Following provisions will be required from fire safety point of view:

- Automatic sprinkler/detection system to be provided if floor area exceeds 750 sq.m
- One wet riser-cum-down comer per 1000 sqm floor area with static underground storage tank, overhead tanks and pumps of suitable capacity with hydrants, first-aid reel, etc.
- Portable fire non-aqueous extinguishers of Carbon di Oxide, chemical dry powder etc. at suitable places.
- Automatic smokes venting facilities.
- Two separate means of exit shall be provided, if more than 10 persons are working and the area exceeds 1400 sq.m
- Fire resisting doors shall be provided at appropriate places along the escape routes to prevent spread of fire and smoke.
- The travel distance for fire escape shall not exceed 20 m where escape is available in more than one direction; the distance could be upto 40 m.

B. Fire Alarm and Detection System

A complete fire detection system with equipment complying with the requirements of Fire Services shall be provided through out each station and ancillary buildings including entrance passageways, subways and adits etc. to give visual and audible indication of alarm conditions actuated by the operation of break glass contact or fire sensors e.g. detector heads, linear heat detecting cables etc. The system shall be operated from 24 V DC Power sources.

Manually operated call points shall be provided at every hydrant and nose reel points, station head wall, tail wall and other locations. Alarm bells shall be installed in each plant room complex at both platform and concourse level and shall be clearly audible at all points in the room/area.

Beam detector or heat detector shall be installed at roof level, ceiling and floor cavity, whilst linear detecting cables shall be installed in under platform cable ducts and cable shafts.

Smoke probe units shall be installed in rooms/compartments. When an alarm point is operated, the fire pump shall start to operate automatically. A station fire control and indicating panel shall be provided an installed in the station controllers room, for the control, indication and monitoring of the whole detection and fire fighting systems.

C. Fire Control Measures

Control of the spread of fire and smoke will be achieved by partition of fire risk areas, planning for smoke extraction, and arrangement for smoke containment. Partition is aimed at limiting the extent of a fire. The openings will be capable of being sealed in the event of fire. With the exception of station public areas, a fire compartment will not exceed 1500 m^2. Partition of the public areas in stations is not practicable for operational reasons. The fire resistance period of this separated area shall be about 3 hours.

D. Access for Fireman

A secondary access to the station, not used by passengers for evacuation, shall be available to fireman shall the need arise. The entry point shall be easily accessible from the road. Access shall be available to all levels of the station. The minimum width of the stairs is 1.0 m and maximum height shall not exceed 60 cm.

6.5.3 Ventilation Shafts

The Environmental Control system for underground stations requires ventilation openings between various plants, plant rooms and the atmosphere. Five independent shafts are required for exhaust air, fresh air intake and draft relief. The minimum cross-sectional area of each shaft will be 12 m^2. Total length of each ventilation shaft from the station box to the atmosphere shall not exceed 60m.

6.5.4 Emergency Door

The rolling stock is provided with emergency doors at both ends of the cab to ensure directed evacuation of passengers in case of any emergency including fire in the train.

6.6 SUMMARY OF ENVIRONMENTAL MANAGEMENT PLAN (EMP)

The environmental impacts stemming out of the proposed project can be mitigated with simple set of measures, dealing with careful planning and designing of the metro alignment and structures. Adequate provision of environmental clauses in work contracts and efficient contract management will eliminate or reduce significantly all possible problems. A common problem encountered during implementation of environmental management plans of such projects is lack of environmental awareness among engineers and managers concerned with day to day construction activities, which can be solved through regular environmental training programs. A set of preliminary EMP is presented in **Table 6.2,** which defines actions to be undertaken during the design stage, pre-construction, construction and operation stage of the project. The effectiveness of environmental considerations will, however, depend on appropriate inclusion of these in the work contracts.

The major concern during the construction stage is that the contractors, due to lack of enforcement, would not practice good environmental sanitation (housekeeping), may intend to get unauthorized use of the easily available natural resources and other available infrastructure like roads and water resources. This would result in degradation of ambient air quality, water resources and land environment around the construction sites and workers camp. Improper management of earthwork and bridge construction activities would disrupt the natural drainage and increase soil erosion. Improper management may result in spillage of explosives into the hands of unsocial elements. Finally the implementation of the mitigation actions requires that the project implementation unit would record an end-of-construction mitigation checklist, before releasing the final payment of any work contract.

In addition to that, LMRC shall prepare and establish Environmental and Health Policy and Procedures that shall become an integral part of contract document. Conditions of contract on Environment Health and Safety (EHS), which is part of LMRC tender, will be provided to the contractor. This document is prepared on lines of DMRC's similar document.

Operational phase mitigation would involve good environmental sanitation (housekeeping) practice at metro establishments including effective solid waste collection and disposal, wastewater disposal, upbringing of plantations and green area. Protection of earth slopes in landslide prone area would be a very important task. During the operation period, the metro operating unit will be required to confirm receipt of the construction period mitigation report through the environment department and prepare a follow on timetable of actions.

TABLE 6.3
ENVIRONMENTAL MANAGEMENT ACTION PLAN (EMAP)

Environmental Impact	Mitigation Measures Taken or To Be Taken	Time Frame	Implementing Organization	Responsible Organization
DESIGN PHASE				
Metro Alignment	The proposed corridor alignment was selected to minimise the land disturbance to avoid archaeological sites, temples and other environmentally sensitive areas in least.	During Design	DPR and design consultant	LMRC
Cultural Heritage	Avoided by adjustment of alignment.	During Design	DPR and design consultant	LMRC
Flood	Bridges shall be well designed	During Design	DPR and design consultant	LMRC
Loss of Water Bodies	Utmost care taken to avoid alignment crossing water bodies	During Design	DPR and design consultant	LMRC
Inadequate design provision for safety against seismological hazard	Make sure that design provides for safety of structures against worst combination of forces in the probability of an earthquake likely to occur in seismic zone-III.	DPR and detailed design stage	DPR and design consultant	LMRC
PRE –CONSTRUCTION STAGE				
Water requirement	The requirement of water shall be for construction purpose etc., shall be planned and shall be arranged in order to avoid digging of Tube wells.	Pre construction stage	Contractor	LMRC/EMP implementing agency
Disposal of final treated effluent from treatment plat	Options for final disposal shall be studied and the suitable disposal route shall be decided carefully to minimize the impact of receiving bodies. As far as possible zero discharge rules may be adopted.	During design stage / and pre construction of treatment plant	Contractor	LMRC/EMP implementing agency
CONSTRUCTION PHASE				
Environmental Management and Monitoring	This will include institutional requirements, training, environmental management and monitoring	During and after construction	Contractor	LMRC/EMP implementing agency
Dust	Water shall be sprayed during construction phase, wherever it is required to avid dust. Vehicles delivering materials shall be covered to reduce spills and dust blowing off the load.	During construction	Contractor	LMRC/EMP implementing agency
Air Pollution	Vehicles and machinery are to be regularly maintained so that emissions conform to National and State AAQ Standards.	Beginning with and continuing throughout construction	Contractor	LMRC/EMP implementing agency

Environmental Impact	Mitigation Measures Taken or To Be Taken	Time Frame	Implementing Organization	Responsible Organization
Equipment Selection maintenance and operation	Construction plants and equipment will meet recognized international standards for emissions and will be maintained and operated in a manner that ensures relevant air, noise, and discharge regulations are met.	During construction	Contractor	LMRC/EMP implementing agency
Noise	Noise standard at processing sites, will be strictly enforced as per GOI noise standards. Workers in vicinity of strong noise will wear earplugs and their working time shall be limited as a safety measure. At construction sites within 150m of sensitive receptors construction will be stopped from 22:00 to 06:00. Machinery of noise barriers (Stone walls and plantation) for silence zones including schools and hospitals.	Beginning and through construction	Contractor	LMRC/EMP implementing agency
Vibration	The vibration level limits at work sites adjacent to the alignment shall conform to the permitted values of peak p velocity as given in article project SHE Manual	Beginning and through construction	Contractor	LMRC/EMP implementing agency
WATER				
Contamination from Wastes	All justifiable measures will be taken to prevent the wastewater produced in construction from entering directly into rivers and irrigation system	Throughout construction period	Contractor	LMRC/EMP implementing agency
Wastage of water	Measures shall be taken to avoid misuse of water. Construction agency shall be instructed accordingly to follow strict procedures while using the water for construction and drinking purpose.	Beginning with and continuing throughout construction	Contractor	LMRC/EMP implementing agency
Sewerage disposal during construction at Service Centres	A minimum distance of any sewage or toilet facility from water sources shall be 200 meters	Throughout construction period	Contractor	LMRC/EMP implementing agency
Sanitation and Waste Disposal in Construction Camps	Sufficient measures will be taken in the construction camps, i.e. provision of garbage tank and sanitation facilities. Waste in septic tanks will be cleared periodically. Drinking water will meet Indian National Standards.	Before and during building of construction camps	Contractor	LMRC/EMP implementing agency

Environmental Impact	Mitigation Measures Taken or To Be Taken	Time Frame	Implementing Organization	Responsible Organization
	Garbage will be collected in a tank and disposed of daily. Special attention shall be paid to the sanitary condition of camps. Camps will be located at a minimum distance of 200 m from water sources.			
SOIL				
Quarrying	Quarrying will be carried out at approved and licensed quarries only.	During construction	Contractor	LMRC/EMP implementing agency
FLORA AND FAUNA				
Loss of trees and Avenue Plantation	Areas of tree plantation cleared will be replaced according to Compensatory afforestation Policy under the Forest Conservation Act. Trees will be planted against every tree cut as per norms.	After completion of construction activities	Forest Department	Forest Department
SOCIAL				
Loss of Access	Temporary access shall be built at the interchange and other roads.	During construction	Contractor	LMRC/ Traffic department
Traffic jams and congestion	If there are traffic jams during construction, measures shall be taken to relieve the congestion with the co-ordination of transportation and traffic police department	During construction	Contractor	LMRC/ Traffic department
Safety with vehicles, people and livestock and signage	• Safety education and fines. • Allow for adequate traffic flow around construction areas • Provide adequate signage, barriers and flag persons for safety precautions. • Communicate to the public through radio, TV & newspaper announcements regarding the scope and timeframe of projects, as well as certain construction activities causing disruptions or access restrictions	During construction	Contractor	LMRC/ Traffic department
Increase in disease Water-borne Insect-borne Communicable diseases	• Make certain that there is good drainage at all construction areas, to avoid creation of stagnant water bodies. • Provide adequate sanitation and waste disposal at construction camps. • Provide adequate health care for workers	During construction At start-up Throughout	Contractor	LMRC/EMP implementing agency

Environmental Impact	Mitigation Measures Taken or To Be Taken	Time Frame	Implementing Organization	Responsible Organization
	and locate camps away from vulnerable groups	construction		
Location of camps depots and storage areas	Location of camps depots and storage areas shall be as per the contract specifications.	Throughout construction	Contractor	LMRC/EMP implementing agency
OPERATION PHASE				
Noise and Vibration	Suitable measures shall be considered where warranted. The public shall be educated about the regulations of noise and vibration pollution and its implications.	After completion of construction	LMRC/EMP implementing agency	LMRC/EMP implementing agency
WATER				
Oil pollution	Suitable treatment shall be taken for treatment oil before discharging the wastewater specially in depot areas.	During operation of the treatment plant	LMRC/EMP implementing agency	LMRC/EMP implementing agency
Maintenance of Storm Water Drainage System	The urban drainage systems will be periodically checked and cleared so as to ensure adequate storm water flow.	Beginning and end of monsoon	LMRC/EMP implementing agency	LMRC/EMP implementing agency
Disposal of final treated effluent from treatment plat	Options for final disposal shall be studied and the suitable disposal route shall be decided carefully to minimize the impact of receiving bodies. As far as possible zero discharge rules may be adopted.	During operation of the treatment plant	LMRC/EMP implementing agency	LMRC/EMP implementing agency
SOCIAL				
Safety and noise disturbances	New buildings shall be prohibited within 50 m of the edge of carriageway. No new schools and hospitals shall be allowed within 200 m of carriageway.	Throughout and after project development period.	Planning Department /LMRC	LMRC/EMP implementing agency

CHAPTER - 7
ENVIRONMENTAL MONITORING PLAN

7.1 PRE-CONSTRUCTION PHASE

The environmental monitoring programme is a vital process of any Environmental Management Plan (EMP) of development project for review of indicators and for taking immediate preventive action. This helps in signalling the potential problems resulting from the proposed project activities and will allow for prompt implementation of corrective measures. Environmental monitoring has to be an integral part of Metro for better environmental management of air, noise, vibration, water quality etc both during construction and in operation. Generation of dust and noise are two main issues during any large construction activity. Degradation of water quality is another. The parameters are monitored in pre- construction, construction and operation phase and are based on the need to evaluate the deviation of environmental conditions from baseline environmental conditions due to construction and operation of the Metro. The environmental monitoring will be required during both construction and operational phases. The following parameters are planned to be monitored:

- Water Quality,
- Air Quality,
- Noise and Vibration,
- Environmental Sanitation and Waste Disposal
- Ecological Monitoring and Afforestation,
- Workers Health and Safety

Environmental monitoring during pre-construction phase is important to know the baseline data and to predict the adverse impacts during construction and operation phases. Pre-construction phase monitoring has been done for the proposed project for air, noise, water, soil quality and ecology. The results so obtained are documented in **Chapter 3**.

7.2 CONSTRUCTION PHASE

During construction stage environmental monitoring will be carried out for air quality, noise levels, vibrations, water quality, and ecology. At this stage it is not possible to visualize the exact number of locations where environmental monitoring will be carried out. However, it is advisable to conduct monitoring at all construction sites in addition to the sensitive locations along the alignment. The frequency of monitoring for each parameter is summarized in **Table 7.1**

7.2.1 Water Quality

Since water contamination leads to various water related diseases, the project authorities shall establish a procedure for water quality surveillance and ensure safe water for the consumers. The water quality parameters are to be monitored during the entire period of project construction. Monitoring shall be carried out by NABL certified private or Government agency. Water quality shall be analyzed following the procedures given in the standard methods. Parameters for monitoring will be as per BIS: 10500. The monitoring points could be ground and surface water.

7.2.2 Air Quality

In addition to these, air quality shall be monitored at the locations of baseline monitoring as reported in Chapter 3. The parameter recommended is Particulate Matter (PM_{10}). The contractor will be responsible for carrying out air monitoring during the entire construction phase under the supervision of LMRC.

7.2.3 Noise and Vibration

The noise will be monitored at construction sites for entire phase of construction by the site contractor and under the supervision of LMRC.

7.2.4 Ecological Monitoring

The project authority in coordination with the Department of Forest shall monitor the status of ecology/trees along the project corridor at least 4 times in a year during construction phase in order to maintain the ecological environment.

7.2.5 WORKERS HEALTH AND SAFETY

Monitoring of health risk issues that might arise throughout the project life time will be done. Epidemiological studies at construction sites and workers camp will be performed to monitor the potential spread of diseases. Regular inspection and medical checkups shall be carried out to workers health and safety monitoring. Any reoccurring incidents such as irritations, rashes, respiratory problems etc shall be recorded and appropriate mitigation measures shall be taken. Contractor will be the responsible person to take care health and safety of workers during the entire period of the construction and project proponent is responsible to review/audit the health and safety measures/plans. The monitoring frequency for Water Air, noise, vibration, and water are presented in **Table 7.1**

TABLE 7.1
CONSTRUCTION STAGE MONITORING SCHEDULE

Parameter	Frequency
Air (PM10)	2 x 24 hours, twice a month
Noise	24 hours, once a week
Vibration	24 hours, once a week
Water	Once in 6 months

7.3 OPERATION PHASE

Even though the environmental hazards during the operation phase of the project are minimal, the environmental monitoring will be carried out for air, noise, vibration, water, waste water, solid waste and ecology during operation phase of the project. The parameters that will be monitored during operation will be PM_{10} for air, heavy metals for solid waste, pH, TSS, BOD, COD, oil and grease for wastewater. However, water quality parameters that will be monitored will be as per BIS 10500.

The monitoring schedule is presented in **Table 7.2**. The monitoring program shall be conducted by an external agency certified by NABL under the supervision of LMRC. Project proponent (LMRC) is responsible for successful environmental monitoring of the proposed project during operation phase.

The results of Air quality, water quality, wastewater, vibration will be submitted to management quarterly during construction phase and semi annually during operation phase.

During operation, various kinds of waste are expected to be generated from metro. It is important to monitor the type and quantity of waste being generated to identify proper/authorized disposal methods. **Figure 7.1 & 7.2** provide the details of type of waste expected to be generated at depot and station.

For better environmental performance, LMRC shall monitor the following components:

- Electricity/Energy consumption
- Water consumption & wastewater generation
- Possibility of Solar Energy use
- Solid Waste generation and Disposal

TABLE 7.2
OPERATION STAGE MONITORING FREQUENCY

Parameter	Frequency
Air (PM_{10})	2x24 Hour, once in a month
Noise	24 hours once a year
Vibration	24 hours once a year
Water	Once a year
Waste Water	Once in 4 months
Solid Waste	Once a year

FIGURE 7.1
WASTE GENERATED IN DEPOT

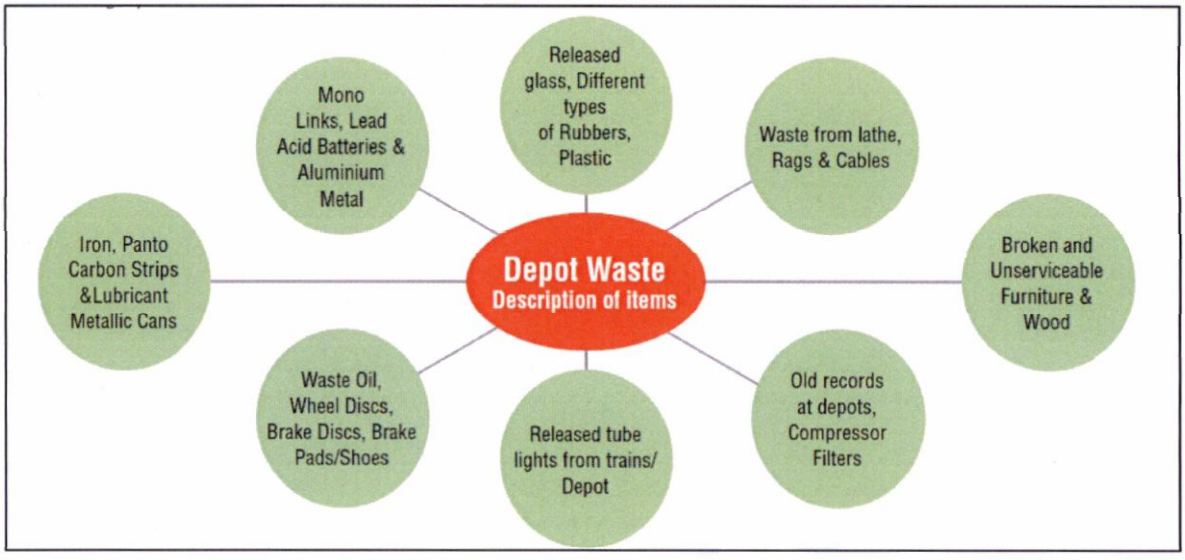
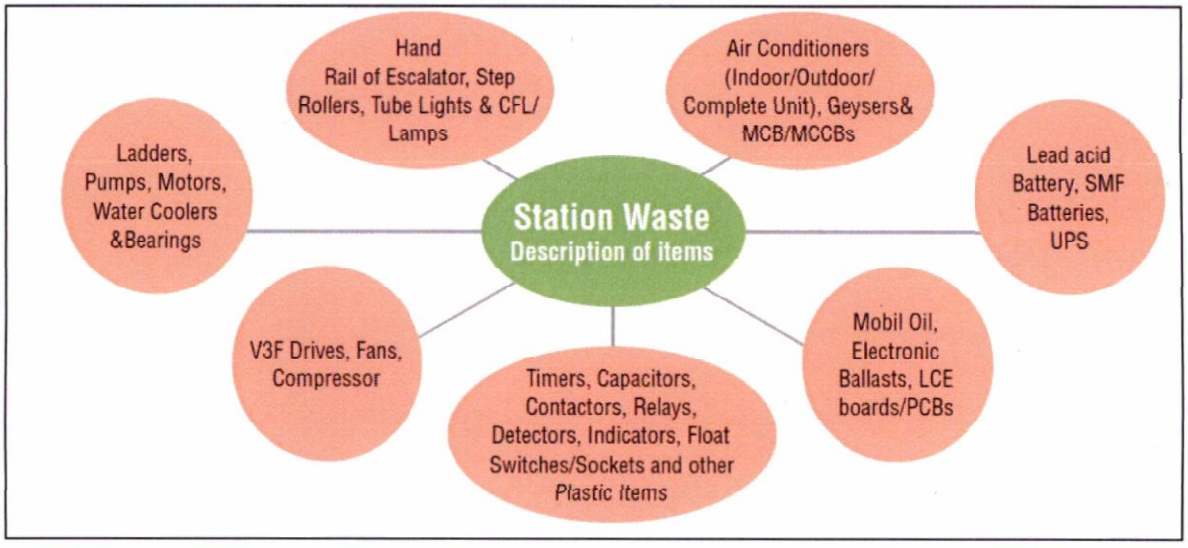


FIGURE 7.2
WASTE GENERATED IN STATION



7.4 ESTABLISHMENT OF AN ENVIRONMENTAL DIVISION

LMRC shall establish an Environment Division at the initial stage of the project itself. The division shall be staffed with an Environmental Engineer/Officer and a Technical Assistant (environment background). The task of the division would be to supervise and coordinate studies, environmental monitoring and implementation of environmental mitigation measures, and it shall reported directly to Chief Engineer (Planning) of the project authority. Organizational setups for Environmental Monitoring during construction and operation phase are shown in **Figure 7.3 and 7.4**. Progress of the division shall be reviewed by an Environmental Advisor once in a year. The environmental Advisor shall be an experienced expert familiar with environmental management in similar projects. Costs for the first ten years (including 10% annual increase has been) given **Table 7.3**.

TABLE 7.3
COST FOR ENVIRONMENTAL DIVISION

S. No	Particulars	In Rupees
Per Year		
1.	Environmental Engineer (1No.)	12,00,000
2.	Technical Assistant (1No.)	6,00,000
3.	Miscellaneous Expenditure	2,00,000
	Total Cost per One Year	**20,00,000**
	Total Cost for Ten Years with 10% annual increase	**318,74,849**

FIGURE 7.3
ORGANIZATIONAL SETUP DURING CONSTRUCTION PHASE

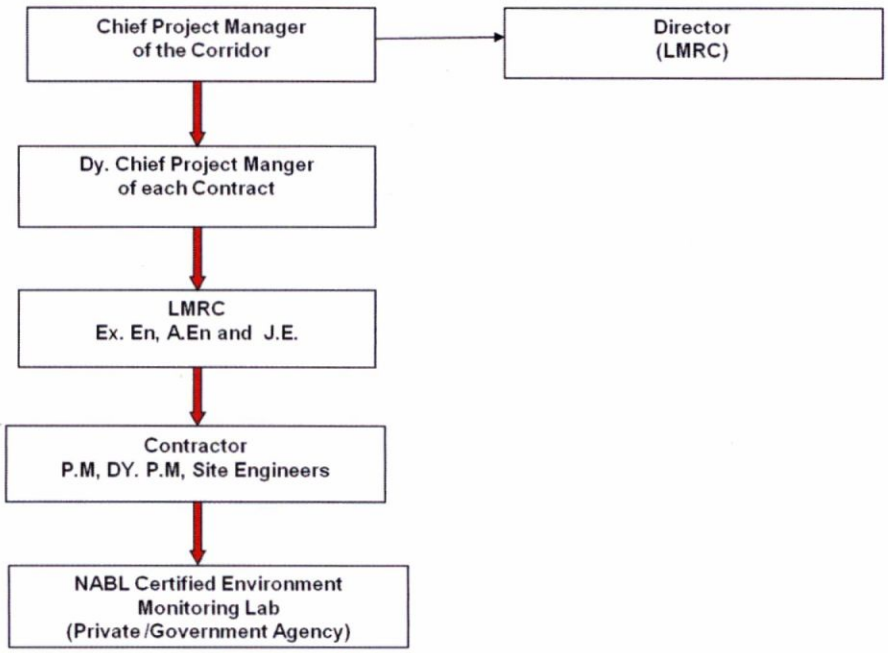
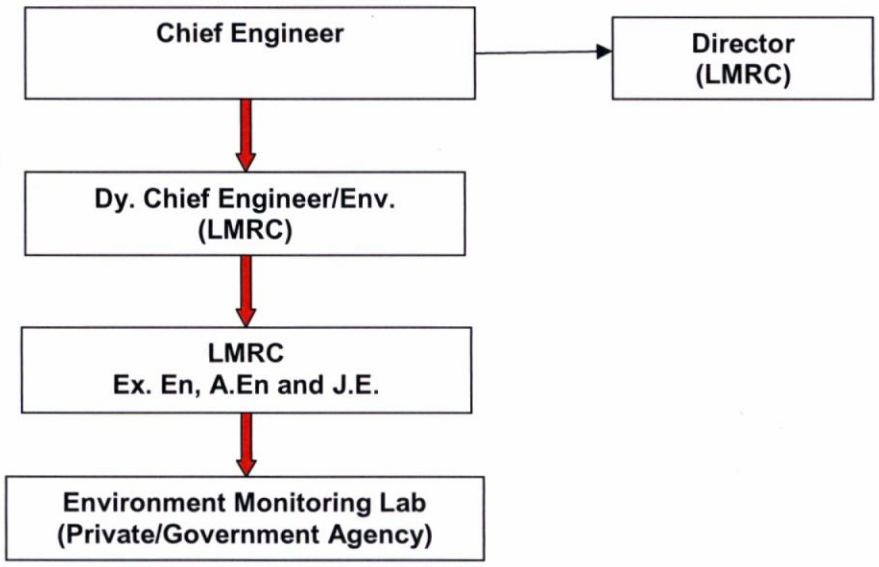


FIGURE 7.4
ORGANIZATIONAL SETUP DURING OPERATION PHASE



CHAPTER-8
COST ESTIMATES

8.1 SUMMARY OF COSTS

A summary of approximate costs involved in Environmental mitigation, management, and monitoring of the proposed Metro Project is presented in **Table 8.1.**

TABLE 8.1
ENVIRONMENTAL COSTS

S. No.	ITEM	COST Rs.Million
1.	Water Supply Treatment	36.15
2.	Sewage Effluent Treatment	23.4
3.	Drainage	18.0
4.	Rain Water Harvesting In Depot Area	2.55
5.	Green Belt Development	12.0
6.	Recycling of treated waste water	12.3
7.	Air, Noise, vibration, Water, Waste Water, Solid waste, during construction and operation	48.38
8.	Ecological monitoring	10.00
9.	Establishment of Environment Division	31.87
10.	Training And Extension	1.31
	Total	**195.96**

The Environmental management plan shall be implemented in phases so that optimum benefit could be achieved and shall be synchronized with the construction schedules.

Annexure 1.1

DRINKING WATER QUALITY STANDARDS FOR SOME OF THE IMPORTANT PARAMETERS (IS 10500:2012)

S.No.	PARAMETER	UNIT	LIMITS AS PER (IS:10500-2012)	
			ACCEPTABLE	PERMISSIBLE
1	Colour	Hazen	5.0	15.0
2	Odour	–	Agreeable	Agreeable
3	Taste	–	Agreeable	Agreeable
4	Turbidity	NTU	1.0	5.0
5	pH	–	6.5-8.5	No relaxation
6	Total Hardness (as $CaCO_3$)	mg/L	200.0	600.0
7	Total Dissolved Solids	mg/L	500.0	1000.0
8	Calcium (as Ca)	mg/L	75.0	200.0
9	Iron (as Fe)	mg/L	0.3	No relaxation
10	Chloride (as Cl)	mg/L	250.0	1000.0
11	Residual Free Chlorine	mg/L	0.2	1.0
12	Fluoride (as F)	mg/L	1.0	1.5
13	Total Dissolved Solids	mg/L	500.0	2000.0
14	Magnesium (as Mg)	mg/L	30.0	100.0
15	Copper (as Cu)	mg/L	0.05	1.5
16	Manganese (as Mn)	mg/L	0.1	0.3
17	Sulphate (as SO_4)	mg/L	200.0	400.0
18	Nitrate (as NO_3)	mg/L	45.0	No relaxation
19	Phenolic Compounds (as C6H5OH)	mg/L	0.001	0.002
20	Mercury (as Hg)	mg/l	0.001	No relaxation
21	Selenium (as Se)	mg/L	0.01	No relaxation
22	Total Arsenic (as As)	mg/L	0.01	0.05
23	Cyanide (as CN)	mg/L	0.05	No relaxation
24	Lead (as Pb)	mg/L	0.01	No relaxation
25	Total Chromium (as Cr^{+6})	mg/L	0.05	No relaxation
26	Alkalinity (as $CaCO_3$)	mg/L	200.0	600.0
27	Aluminium (as Al)	mg/L	0.03	0.2
28	Boron (as B)	mg/L	0.5	1.0
29	Cadmium (as Cd)	mg/L	0.003	No relaxation
30	Anionic Detergents (as MBAS)	mg/L	0.2	1.0

Annexure 1.2

EFFLUENT DISCHARGE STANDARDS (INLAND SURFACE WATER)

S.No.	Parameter	Unit	Standards
1	Colour & Odor	--	All efforts should be made to remove colour and unpleasant odor as far as practicable.
2	Suspended Solids Max.	mg/l	100
3	Particle size of Suspended Solids	--	Shall pass 850 micron IS Sieve
4	pH value	--	5.5 to 9.0
5	Temperature, Max.	°C	Shall not exceed 5°C above the receiving water temperature
6	Oil and grease, Max.	mg/l	10
7	Total residual Chlorine, Max.	mg/l	1.0
8	Ammonical Nitrogen (as N), Max.	mg/l	50
9	Total Kjeldah Nitrogen (as N), Max.	mg/l	100
10	Free Ammonia (as NH_3), Max.	mg/l	5
11	Biochemical Oxygen Demand (5 days at 20°C), Max.	mg/l	30
12	Chemical Oxygen Demand Max.	mg/l	250
13	Arsenic (as As), Max.	mg/l	0.2
14	Mercury (as Hg), Max.	mg/l	0.01
15	Lead (as Pb), Max.	mg/l	0.1
16	Cadmium (as Cd), Max.	mg/l	2.0
17	Hexavalent Chromium (as Cr^{+6}), Max.	mg/l	0.1
18	Total Chromium (as Cr) Max.	mg/l	2.0
19	Copper (as Cu), Max.	mg/l	3.0
20	Zinc (as Zn), Max.	mg/l	5.0
21	Selenium (as Se), Max.	mg/l	0.05
22	Nickel (as Ni), Max.	mg/l	3.0
23	Cyanide (as CN), Max.	mg/l	0.2
24	Fluorides (as F), Max.	mg/l	2.0
25	Dissolved phosphates (as P), Max.	mg/l	5.0
26	Sulphides (as S), Max.	mg/l	2.0

S.No.	Parameter	Unit	Standards
27	Phenolic compounds (as C_6H_5OH), Max.	mg/l	1.0
28	Radioactive Materials α Emitters, μcurie/ml, Max. β Emitters, μcurie/ml, Max.	mg/l	 10^{-7} 10^{-6}
29	Bio-assay test	mg/l	90% survival of fish after 96 hours in 100% effluent
30	Manganese (as Mn)	mg/l	2.0
31	Iron (as Fe)	mg/l	3.0
32	Vanadium (as V)	mg/l	0.2
33	Nitrate Nitrogen	mg/l	10.0

Annexure 1.3

TOLERANCE LIMITS FOR INLAND SURFACE WATER QUALITY

Characteristic	Designated Use Class of Inland Waters				
	A	B	C	D	E
pH value	6.5 to 8.5	6.5 to 8.5	6.5 to 8.5	6.5 to 8.5	6.0 to 8.5
Dissolved Oxygen, mg/l, Min.	6	5	4	4	-
Biochemical Oxygen Demand (5 days at 20^0C), mg/l	2	3	3	-	-
Total coliform organisms, MPN/100 ml. Max.	50	500	5000	-	-
Colour Hazen units	10	300	300	-	-
Chlorides (as Cl), mg/l Max.	250	-	600	-	600
Sodium Adsorption ratio Max.	-	-	-	-	26
Boron (as B), mg/l. Max.	-	-	-	-	2
Sulphates (as SO_4), mg/ l	400	-	400	-	1000
Nitrates (as NO), mg/l Max.	20	-	50	-	-
Free Ammonia (as NH_3), mg/l	-	-	-	1.2	-
Conductivity at 25° C microhm / cm Max.	-	-	-	1000	2250
Arsenic (as As), mg/l. Max.	0.05	0.2	0.2	-	-
Iron (as Fe), mg/l	0.3	-	50	-	-
Fluorides (as F), mg/l	1.5	1.5	1.5	-	-
Lead (as Pb), mg/l. Max.	0.1	-	0.1	-	-
Copper (as Cu), mg/l	1.5	-	1.5	-	-
Zinc (as Zn) mg/l/ Max.	1.5	-	1.5	-	-
Manganese (as Mn), mg/l	0.5	-	-	-	-
Total Dissolved Solids, mg/l	500	-	1500	-	2100
Total Hardness ($CaCO_3$), mg/l	300	-	-	-	-
Magnesium (as Mg), mg/l	100	-	-	-	-
Chlorides (as Cl), mg/l	250	600	-	-	600
Cyanides (as CN), mg/l	0.05	0.05	0.05	-	-

A: Drinking Water Source without conventional treatment but after disinfections;
B: Outdoor bathing organized;
C: drinking water source with conventional treatment followed by disinfections;
D: propagation of wildlife and fisheries;
E: irrigation, industrial cooling, controlled waste disposal.
Source: Central Pollution Control Board

Annexure 1.4

NATIONAL AMBIENT AIR QUALITY STANDARDS

Pollutant	Time Weighted Average	Industrial, Residential, Rural & Other Area	Ecologically Sensitive Area (notified by Central Government
Sulphur Dioxide (SO_2), □m^3	Annual 24 Hours**	50 80	20 80
Nitrogen Dioxide as NO_2, □m^3	Annual 24 Hours**	40 80	30 80
Particulate Matter (size less than 10□m) or PM_{10} □m^3	Annual 24 Hours**	60 100	60 100
Particulate Matter (size less than 2.5□m) or PM2.5 □m^3	Annual * 24 Hours**	40 60	40 60
Ozone (O3)□□m^3	8 hours** 24 Hours**	100 180	100 180
Lead (Pb)□□m^3	Annual * 24 Hours**	0.50 1.0	0.50 1.0
Carbon Monoxide (CO) mg/m^3	8 Hours** 1 Hour**	02 04	02 04
Ammonia (NH_3)□□m^3	Annual * 24 Hours**	100 400	100 400
Benzene (C_6H_6)□□m^3	Annual *	05	05
Benzo (a) pyrene (BaP)particulate phase only nm^3	Annual *	01	01
Arsenic (AS)□□nm^3	Annual *	06	06
Nickle (Ni) nm^3	Annual *	20	20

Source: Central Pollution Control Board Notification dated 18th November 2009

** Annual arithmetic mean of minimum 104 measurements in a year at a particular site taken twice a week hourly at uniform intervals*

*** 24 hourly or 08 hourly or 01 hourly monitored values, as applicable, shall be complied with 98% of the time in a year. 2% of the time, they may exceed the limits but not on two consecutive days of monitoring.*

Annexure 1.5

NATIONAL AMBIENT NOISE STANDARDS

Category of Zones	Leq in dB (A)	
	Day *	Night
Industrial	75	70
Commercial	65	55
Residential	55	45
Silence Zone **	50	40

Source: Central Pollution Control Board

* *Day Time is from 6.00 AM to 9.00 PM.*

** ***Silence Zone*** *is defined as an area up to 100m around premises of Hospitals, Educational Institutions and Courts. Use of vehicle horn, loudspeaker and bursting of crackers is banned in these zones.*

Annexure 1.6

FTA GUIDELINES FOR GROUND BORNE VIBRATION

Land Use Category	GBV Impact Levels (VdB re 1 micro-inch /sec)			GBN Impact Levels (dB re 20 micro Pascals)		
	Frequent Events[1]	Occasional Events[2]	Infrequent Events[3]	Frequent Events[1]	Occasional Events[2]	Infrequent Events[3]
Category 1: Buildings where vibration would interfere with interior operations.	65 VdB[4]	65 VdB[4]	65 VdB[4]	N/A[4]	N/A[4]	N/A[4]
Category 2: Residences and buildings where people normally sleep.	72 VdB	75 VdB	80 VdB	35 dBA	38 dBA	43 dBA
Category 3: Institutional land uses with primarily daytime use.	75 VdB	78 VdB	83 VdB	40 dBA	43 dBA	48 dBA

Notes:

1. "Frequent Events" is defined as more than 70 vibration events of the same source per day. Most rapid transit projects fall into this category.
2. "Occasional Events" is defined as between 30 and 70 vibration events of the same source per day. Most commuter trunk lines have this many operations.
3. "Infrequent Events" is defined as fewer than 30 vibration events of the same kind per day. This category includes most commuter rail branch lines.
4. This criterion limit is based on levels that are acceptable for most moderately sensitive equipment such as optical microscopes. Vibration-sensitive manufacturing or research will require detailed evaluation to define the acceptable vibration levels. Ensuring lower vibration levels in a building often requires special design of the HVAC systems and stiffened floors.
5. Vibration-sensitive equipment is generally not sensitive to ground-borne noise.