दिल्ली मेट्रो रेल कॉरपोरेशन लिमिटेड
DELHI METRO RAIL CORPORATION LTD.

ENVIRONMENTAL IMPACT ASSESSMENT
OF
DANAPUR - MITHAPUR- KHEMNI CHAK
AND
PATNA STATION-NEW ISBT
CORRIDORS OF PATNA METRO (UPDATED)




JULY 2020

DELHI METRO RAIL CORPORATION

Metro Bhawan, Fire Brigade Lane,

Barakhamba Road, New Delhi-110001

cerd

CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ANNEXURES

EXECUTIVE SUMMARY

E.1.1 Introduction

M/s RITES has prepared the Detailed Project Report (DPR) for Metro corridors in Patna city. The details of corridors in Patna Metro are as follows:

S. No	Corridor	Corridor Details	Length of corridor	Number of stations
1.	Danapur- Khemni Chak	Corridor 1	17.933 Km	14
2.	Patna Station - New ISBT	Corridor 2	14.564 Km	12

Two interchange stations, viz., Patna Station and Khemni Chak have been proposed, one on each corridor. The project involves construction of twin tunnels, viaduct, stations - both elevated and underground, sub stations and one depot located near New ISBT. The present study has been carried out for assessing the Environmental Impacts for both Danapur - Khemni Chak and Patna Station-New ISBT corridors. The report is prepared on the basis of primary data collected at site, in addition to secondary data. The environmental study is carried out for the alignment prepared by DMRC.

E.1.2 Legal, Policy and Regulatory Framework

The Government of India has laid down various policy guidelines, regulations, acts and legislations pertaining to sustenance and protection of environment and its various components. Following Environmental laws are applicable to this Metro:

S. No.	Act/Regulation	Objectives	Implementing / Responsible Agency
1.	Air (Prevention and Control of Pollution) Act, 1981 amended 1987	To control and monitor air pollution as per prescribed limits set by CPCB.	Bihar State Pollution Control Board
2.	The Water (Prevention and Control of Pollution) Act, 1974 amended 1988	To control and monitor water pollution as per prescribed limits	Bihar State Pollution Control Board
3.	The Forest Conservation Act, 1980 amended 1988	To check deforestation by restricting conversion of forested areas into non-	➢ Forest Department, Govt. of Bihar - up to 5 Ha and less than 40 %

S. No.	Act/Regulation	Objectives	Implementing / Responsible Agency
		forested areas	canopy closure) ➢ Regional Chief Conservator of Forest - 5 - 20 Ha. ➢ MoEF -Above 20 Ha and more than 40 % canopy closure)
4.	Ancient Monuments and Archaeological Sites and Remains Act, 1958 amended 2010	Preservation of culture and historical remains.	Archeological Survey of India (ASI), State Archeological Department
5.	Indian Motor Vehicles Act, 1988 (1989)	To check vehicular air and noise pollution	Motor Vehicles Department, Govt. of Bihar
6.	Right to Fair Compensation and Transparency in Land Acquisition, Rehabilitation and Resettlement Act, 2013	Rules for acquisition of land by Government	Department of Settlement and Land Records, Revenue Departments of State Governments.
7.	Noise Pollution Rules 2000 amended 2002, 2006 and 2010	Regulation regarding control and management of Noise	CPCB, Bihar State Pollution Control Board
8.	The Building and other construction Workers Act, 1996	Employing Labour and Workers	Labour Commissioner
9.	Municipal Solid Waste Management Rules 2016	Managing the solid wastes generated at the project	Local Authorities
10.	C& D Waste Management Rules, 2016	C & D Waste generated during construction	Local Authority
11.	Hazardous and Other Wastes (Management and Transboundary Movement) Rules, 2016	Hazardous waste generated during construction and operation.	Bihar State Pollution Control Board
12.	E waste Management Rules, 2016	Handling of e-waste generated during construction and operation	Bihar State Pollution Control Board

S. No.	Act/Regulation	Objectives	Implementing / Responsible Agency
13.	Fly ash Notification, 1999	Use of flyash in construction	Bihar State Pollution Control Board
14.	CGWA Guidelines	Construction of Rainwater harvesting system	CGWA
15.	EIA Notification (January 1994 and New EIA Notification dated 14th September, 2006	For all Development Projects	Bihar State Pollution Control Board/ SEIAA
16.	Environment Protection Act, 1986	Protection of Environment.	MoEFCC

E.1.3 Various Environment Permissions Required

As per EIA notification of 2006, Railway Projects are not listed in the schedule which lists projects that require to seek prior Environmental Clearance from MoEFCC/ SEIAA. Still, various local level permissions related to environment are required to be taken for this project during Preconstruction, Construction and Operation phase. The key permissions required for the project are listed below:

Key Environmental Clearances Required

Permission/ Clearance / Permit	Acts/Rules	Concerned Agency	Stage
Consent to Establish and Consent to Operate for Batching plant	The Water (Prevention and Control of Pollution) Act, 1974, amended 1988 and The Air (Prevention and Control of Pollution) Act 1981, amended 1987	Bihar State Pollution Control Board	Pre-Construction
Consent to establish and operate STP and ETP	The Water (Prevention and Control of Pollution) Act, 1974, amended 1988	Bihar State Pollution Control Board	Operation
Generation, handling, storage and transportation of hazardous waste	Hazardous and Other wastes (Management & Transboundary Movement) Rules, 2016	Bihar State Pollution Control Board	Construction and Operation

Permission for extraction of ground water	Environment (Protection) Act, 1986	CGWA (Local Unit)	Pre-constrcution as well as for operation
Permission for felling trees	Tree Preservation Act	Forest Department/ Municpal Authorities	Pre-construction
C&D Waste Management Plan	C&D Waste Management Rules, 2016	Local Authority	Pre-construction

E.1.4 Approach and Methodology

DMRC has fixed the alignment based on Technical Feasibility, Socio-Economic acceptability and Environmental Sustainability for metro corridors. This environmental study is carried out for the final alignment proposed by DMRC. The approach has been to ascertain the existing baseline conditions and assess the impacts as a result of construction and operation of the project. Changes that are 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. Baseline data for various parameters of physical (physiographic and soils), ecological, and environmental pollution (air, water, noise, and solid waste) has been 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 further categorized as negative and positive. The cost of Rs.640.19 Lakh for management and monitoring programs has been estimated and budgeted.

E.2 Project Description

E.2.1 Transport Demand and Forecast

Traffic studies and forecasting the transport demand for Danapur - Mithapur – Khemni Chak and Patna Station - New ISBT Metro corridor have been carried out. Station wise boarding at different horizon years has been worked out.

E.2.2 Proposed Metro Corridor

In view of increasing demand for mass transport, Bihar State Govt. and Patna authorities desired that the metro corridor shall be developed in the city.

E.2.2.1 Route Alignment

The metro corridors have been proposed between Danapur – Khemni Chak and Patna Station - New ISBT.

E.2.2.2 Route Length and Stations

The length of the alignment under study is about 17.933 Km between Danapur and Khemni Chak and 14.564 Km between Patna Station and New ISBT, totalling 32.497 km. The alignment between Danapur and Khemni Chak will have 14 stations including interchange station at Patna station and Khemni Chak. On Patna Station to New ISBT corridor, 12 stations are proposed. Additionally, a depot is proposed near New ISBT. There are 6 underground stations on Danapur- Khemni chak corridor and 7 underground stations on Patna station to New ISBT corridor. Elevated stations are 8 on Danapur Khemni chak corridor and 5 stations on Patna station- New ISBT corridor. The length of underground corridor is 10.54 Km and 7.926 Km on Danapur- Khemnichak and Patna Station- New ISBT corridors respectively. The length of elevated section is 7.393 km and 6.638 km on corridor 1 and 2 respectively. The area proposed for depot is around 19.2 ha and is devoid of any habitation.

E.2.2.3 System Requirement

The proposed corridors will be implemented with track on Standard Gauge (SG) 1435 mm. To meet the projected traffic demand on Danapur- Khemni Chak corridor, the possibility of running trains with composition of 3 Car trains/ 6 Car trains with different headway has been examined. 18 trains per hour are required to meet the projected PHPDT demand for the year 2031. On Patna Station- New ISBT corridor, 3 car trains with different headway have been examined and 17 trains per hour are required for meeting the projected demand

in 2031. A design speed of 85 kmph and schedule speed of 35 kmph has been adopted.

E.3 Environmental Baseline Data

E.3.1 Environmental Scoping

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.

E.3.2 Land Environment

The Project area is located in Patna city. The average elevation of the project area is in range of 48-63 m above the Mean Sea Level (a-MSL).

Geology and Soils:

Patna is situated on the southern bank of river Ganges. The city also straddles the rivers Sone, Gandak and Punpun. The city is approximately 35 kilometres long and 16 to 18 kilometres wide. Patna is located in Indo-Gangetic plain and so natural fertile soil is one major asset of the state. Thus Indo-Gangetic plain's soil is the backbone of agricultural and industrial development. The Indo-Gangetic plain in Patna consists of a thick alluvial mantle of drift origin overlying in most part, the Siwalik and older tertiary rocks. The soil is mainly little young loam rejuvenated every year by constant deposition of silt, clay and sand brought by streams but mainly by floods. This soil is deficient in phosphoric acid, nitrogen and humus, but potash and lime are usually present in sufficient quantity.

The most common soil in Patna is Gangetic alluvium of Indo-Gangetic plain region. Patna is having a vast stretch of very fertile flat land. It is drained by the Ganges River, including northern tributaries of other rivers. The river Ganges flows through the middle of the city from west to east.

Seismicity: According to the Bureau of Indian Standards, the city falls under seismic zone-IV, in a scale of II to V (in order of increasing proneness to earthquakes).

E.3.3 Water Environment

Water environment consists of water resources and its quality.

E.3.3.1 Water Resources

Patna is unique in having four large rivers in its vicinity. The topography of Patna city is saucer shaped as per Patna City Development Plan prepared in 2006. Ground water fulfills the basic need of the people administered by Patna Jal Parishad under Patna Municipal Corporation. The public water supply system comprises 98 tube wells that pump water directly to the distribution mains.

E.3.3.2 Ground Water

The Patna district area is underlain by Quaternary alluvial formation comprising various grades of clay, silt, sand with occasional and gravel. From the groundwater potential point of view the entire district falls under good to very good category. The presence of kankar (nodules of CaCO3) and fine sand at places render the top clay zone semi-pervious in nature, where ground water occurs under phreatic condition. The deeper aquifers are made up of medium to coarse grained sand with occasional gravels.

E.3.3.3 Water Quality

Water quality implies the physical, chemical and biological characteristics of water. The groundwater quality in Patna city is within permissible limits as per IS: 10500:2012. However, total dissolved solids, hardness, nitrate and flouride are a little higher than the acceptable limits but within permissible limits.

E.3.4 Meteorology

Patna has a humid subtropical climate under the Köppen climate classification: (Cwa) with extremely hot summers from late March to early June, the monsoon season from late June to late September and chilly winter nights and foggy or sunny days from November to February. The highest temperature ever recorded was 46.6 °C, in the year 1966, the lowest ever was 0.0 °C, on 9 January 2013, and highest recorded rainfall was 204.5 mm (8.05 in), in the year 1997.

E.3.5 Air Environment

Patna city has multiple factors comtributing to air pollution in the city area. These mainly include emissions from vehicular traffic, road dust and emission

from industries. To have an estimate of existing PM_{10} and $PM_{2.5}$ levels in the city, air monitoring has been carried out at a few locations and results have been reported in Baseline Section of this report. PM_{10}, $PM_{2.5}$ and SO_2 levels are higher than permissible limits.

E.3.6 Noise Environment

Just like in air pollution, the city has multiple factors that contribute to Noise pollution in city area. These primarily include vehicular noise on road, honking and industual noise. To estimate existing noise levels in the city, noise monitoring has been carried out at some locations. Values so obtained have been reported in Baseline Section of this report. Noise level is higher than permissible limits at all locations.

E.3.7 Trees

There are 551 trees in Danapur - Khemni Chak corridor and 360 trees in Patna Station – New ISBT corridor. There is no tree in Depot area. Thus, a total of 911 trees along the corridor and in station area are required to be felled. These trees are of common species like Pipal, Neem, and Babool etc.

E.3.8 Socio- Economic Conditions

According to 2011 census data, Patna city had a population of 16, 83,200 (before expansion of the city limits) within the corporation limits, with 8, 94,158 men and 7, 89,042 women. This was an increase of 22.2 percent compared to the 2001 figures. The overall literacy rate is 83.37%, with the male literacy rate being 87.35% and the female literacy rate being 79.89%. The sex ratio of Patna is 885 females per 1,000 males.

E.3.9 Socio-Economic Survey

A socio-economic survey was undertaken for the proposed corridor in Feb 2020 to assess the socio-economic conditions of project-affected families/people and to examine the impacts of the proposed metro alignment on their conditions. There can be two types of impacts on the PAPs. One is the displacement of residential house and another is displacement of commercial establishments. The survey has been undertaken on the corridors using structured questionnaire. This figure of affected PAPs and PAFs will be worked out in detailed SIA which is being carried out separately.

E.3.10 Archaeological Sites

There are many heritage sites in Patna district but the proposed alignment of Patna metro does not pass through any of the Archaeological monument or heritage sites. The closest heritage site Golghar is more than 300m from Corridor 2.

E.4.0 Negative Environmental Impacts

E.4.1 General

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.

E.4.2 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:

- Change of Land use- The total land required is 40.001 ha out of which 36.444 ha permanently and about 3.557 ha temporarily. Out of this, private land is 32.471 ha and the rest 7.530 ha land is Govt. land.
- Loss of trees: 911 trees are likely to be felled leading to loss of CO_2 absorption 158.88 tonnes and Oxygen generation of 357.11 tonnes in 8 years.
- Utility/Drainage Problems - The alignment will cross drains/ nalas, large number of sub-surfaces, surface and utility services, viz. sewer, water mains, storm water drains, telephone cables, overhead electrical transmission lines, electric pipes, roads, traffic signals etc.
- Impact on Historical and Cultural Monuments- There is no affect on such monuments.

E.4.3 Impacts Due to Project Design

- Platform inlets and outlets: No hazard is anticipated due to the proposed sizes of inlets, outlets and platform utilities.
- Ventilation and lighting: Care has been taken at design stage itself to avoid illuminating the stations which could attract birds during night. Maximum illumination level proposed is 200Lux which provides normal lighting.
- Risk Due to Earthquake: The project area lies in Zone IV of Bureau of Indian Standards (BIS) Seismic Zoning Map.

E.4.4 Impacts Due to Project Construction

The most likely negative impacts related to the construction works are: -

- During construction period, complete/partial traffic diversions on road will be required. There is adequate safe distance between buildings and proposed corridor. However, at some places buildings are too close and will be affected and acquired for the project.
- The metro route is elevated as well as underground and thus the excavation would be for tunnels and underground stationsl and boring of piles and construction of pile caps and piers.
- The water demand will increase during construction phase for meeting out drinking and domestic water requirement of workers. Water requirement for construction of Metro stations will also be required to be met.
- C&D waste such as concrete, stones and dirt generated during construction will require proper disposal.
- Batching Plant and Casting Yard should be located in an area alloted by PMRC away from habitation. Consent to Establish and Operate and Authorization for hazardous waste is required from Bihar State Pollution Control Board (BSPCB).
- 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.

E.4.5 Impacts Due to Project Operation

Along with many positive impacts, 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 radiated from train operations and track structures generally constitute the major noise sources. Airborne noise is radiated from elevated structures.
- The water demand will be created at station for drinking, toilet, cleaning and also for other purpose like AC, chiller and other purposes.
- The refuse from station includes Garbage, Rubbish, and Floor Sweepings. As per the available data from other Metros the solid waste generation is about 0.8 – 1.2 cum/day at elevated stations.
- The introduction of metro implies a change in aesthetics of the streets through which it will operate. An architecturally well-designed elevated section can be pleasing to the eyes of beholders.

E.4.6 Impacts Due to Depot

One depot is proposed near New ISBT. The management plans for depot site includes:

Water supply: Significant quantity of water will be required for operation and functioning of depot. Water could be arranged either from water supplying authority or through boring tube well after taking permission from Central Ground Water Authority. The ground water will need treatment depending upon its quality and end use envisaged.

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 have to be installed at initial stage of effluent treatment.

Sewage/Effluent Pollution Control: Sewage will be generated at depot. The sewage could be treated up to the required level so that it could be used for

horticulture purpose in the campus and remaining can be discharged into the stream.

Effluent will be generated at Depot. The effluent 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 Bihar State Pollution Control Board (BSPCB).

Surface Drainage: The area should have proper drainage. The Storm water of the depot will be collected through the drain.

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.

Rainwater harvesting: To conserve and augment the storage of groundwater, it has been proposed to construct roof top rainwater harvesting structure of suitable capacity for storage in the depot where ground water level is more than 5 m.

E.5 Positive Environmental Impacts

The introduction of this alignment 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. About 4000 persons are likely to work during peak period of activity. In operation phase of the project about 35 persons per kilo meter length of the corridor i.e. approx. 1125 persons will be employed for operation and maintenance of the proposed system. In a nutshell, positive impacts include:

- Employment Opportunities.
- Enhancement of Economy
- Mobility, Safety and Reduced Accidents.
- Traffic Congestion Reduction.
- Reduced Noise levels.

- Reduced Fuel Consumption.
- Reduced Air Pollution.
- Reduction in Number of Buses/ Auto Rickshaws.

E.6 Environmental Management Plan

E.6.1 Management Plans

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.

E.6.2 Mitigation Measures

Mitigation measures have to be adopted during construction at all the construction sites including Batching Plant and Casting Yards on all the aspects.

Compensatory Afforestation: According to the results of the present study, it is found that 911 trees are likely to be lost due to the project. About 3644 sapplings would be planted and maintained for three years. Compensatory afforestation program will be finalized in consultation with Tree Authority.

Construction Material Management: The scheduling of material procurement and transport shall be linked with construction schedule of the project. Care shall be taken to avoid spillage of material during construction.

Labour Camp: All temporary accommodation must be constructed and maintained in such a fashion that safe, hospitable and hygienic conditions achieved. Uncontaminated water should be made available for drinking, cooking and washing.

Energy Management: Use of energy efficient motors and pumps and use of energy efficient lighting, which uses energy efficient luminaries, have been recommended.

Hazardous Waste Management: Outside such storage area, the contractor shall place a ‘display board’, which will display quantity and nature of hazardous waste, on date. Hazardous Waste needs to be stored in a secure place. It has to be disposed off through authorized agents only.

Environmental Sanitation: 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.

Utility Plan: Utility services shall be kept operational during the entire construction period and after completion of project.

Air Pollution Control Measures: The Contractor shall take all necessary precautions to minimise fugitive dust emissions from operations involving excavation, grading, and clearing of land and disposal of waste. The Contractor shall use construction equipment so as to minimize or control of air pollution. Contractor's transport vehicles and other equipment shall conform to emission standards fixed by Statutory Agencies. The Contractor shall carry out periodical checks and undertake remedial measures including replacement so as to operate within permissible norms.

Construction and Demolition Waste: Opportunities for reducing C&D waste focus on three approaches, typically expressed as **Reduce-Reuse-Recycle**. Efforts shall be made to recover embedded energy and to recycle the maximum quantity of C & D Waste to manufacture tiles, curb stones, paver block etc. There shall be no disposal of any waste along river, storm water drains, nallahs or any other water body or depression. Rather C & D waste shall be collected and sent to an authorized waste recycling facility or to dispose in low lying areas with the consent of the owner of land.

Noise Control Measures: During construction the exposure of workers to high noise levels especially near the machinery needs to be minimized. This could be achieved by: Job rotation; Automation; Construction of permanent and temporary noise barriers; Use electric instead of diesel powered equipment; Use hydraulic tools instead of pneumatic tools; Acoustic enclosures should be provided for individual noise generating construction equipment like DG sets,

Traffic Diversion/Management: In order to retain satisfactory levels of traffic flow during the construction period; traffic management and engineering measures need to be taken. They can be traffic segregation, one-way movements, traffic diversions on influence area roads, acquisition of one lane,

etc. Maintenance of diverted roads in good working condition to avoid slow down and congestion shall be a prerequisite during construction period.

Soil Erosion Control: The surface area of erodible earth material exposed by clearing and grubbing, excavation shall be limited to the extent practicable. Immediate control measures would be provided to prevent soil erosion and sedimentation that will adversely affect construction operations, damage adjacent properties, or cause contamination of nearby streams or other watercourses.

Solid Waste Management: Solid Waste Management and Handling Rules shall be applicable. Solid waste will be generated at station which is about 0.8 – 1.2 m3/Day. The option of establishment of Organic Waste composter which converts Municipal Solid Waste into manure to be used for plantation pupose shall be seriously explored at stations and Depot. Use of plastics shall be minimized and eliminated and wood packings shall be reutilized.

The maintenance of adequate sanitary facilities for temporarily storing refuse on the premises is considered a responsibility of the project authority

During Construction

The public health facilities, such as water supply, sanitation and bio-toilets are much needed at the stations. Water should be treated before use up to drinking water standards. The sewerage disposal systems should be adopted for sewage disposal. The water for domestic consumption shall be sourced from Patna Municipal Corporation supply or alternatively designated borewells may be installed with due permission from (CGWA), statuatory authority prior to installation of borewell as per CGWA guidelines of 2015 and 2019.

Solid waste shall be stacked at designated place and when sufficient quantity accumulates it shall be disposed off through covered trucks to land fill site designated and authorized by Patna Authority.

During Operations

Practically, public facilities at stations may be designated to any NGO who may provide public conveniences at metro stations. The NGO shall be responsible for upkeep and management of the utilities.

Solid waste will be generated at station to the tune of 0.8 – 1.2 m^3/Day. Covered storage containers for this purpose and capacity need to be made available.

Rainwater harvesting: it has been proposed to construct roof top rainwater harvesting structure of suitable capacity in the alignment, stations and depot area where ground water level is more than 5 m.

Training and Extension: The training for engineers and managers is to be imparted by PMRC on regular basis to implement the environmental protection clauses of the tender document and to implement the best environmental practices during the construction phase.

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

Fire Protection

The building materials should be of appropriate fire resistance standard. The fire resistance period should be at least 2 hours for surface or over head structures as per fire rules. 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.

Flood Control Plan: Excessive rainfall during monsoon can lead to situation of water logging, particularly in underground station and in structures in low lying areas during construction. In situation like flood, a flood control plan shall be prepared

Communication System: An efficient communication system is absolutely essential for the success of any disaster management plan. The damage areas need to be clearly identified and provided with temporary and fool proof communication system.

Emergency Measures: The emergency measures are adopted to avoid any failure in the system such as lights, fire, means of escape etc.

E.7.0 Environmental Monitoring Plan

E.7.1 Construction Phase

Item	Parameter	Frequency and Duration	Locations
Air	$PM_{10,}$ $PM_{2.5}$	2×24hours Twice/month During entire civil construction stage or even later, if directed by DMRC	25 locations (at all station and depot construction locations)
Water	Ground-water quality (IS 10500:2012)	Once / 6months During entire civil construction stage	2 locations
Noise	Noise Level (Leq and Lmax)	24hours Once/ week During entire civil construction stage or even later, if directed by DMRC	25 locations
Vibration	VPeak, Vrms, VdB	2 hours as per requirement during Construction along UG section	5 locations as per requirement

E.7.2 Operation Stage Monitoring Schedule

Item	Parameter	Frequency and Duration	Locations
Air	PM_{10}, $PM_{2.5}$	24 hours twice a month for 3 years	7 locations
Waste Water	wastewater quality	Once a year for 3 years	Depot
Noise	Noise Level	24 hours Once ayear	15 locations (Sensitive Receptors along the

	(Leq)	for 3 years	elevated section)
Vibration	VPeak, Vrms, VdB	2 hours for 3 years	15 locations as per requirement

E.7.3 Establishment of an Environmental Division

PMRC is required to setup an Environmental Management Division. However, during construction and few years after operation DMRC's Envionment Division may assist PMRC in these tasks.

E.8.0 Summary of Costs

A provision of Rs. 640.19 Lakh has been suggested towards the cost of environment management. The compensation for loss of land, fire control, information systems and contractor's obligations has been incorporated in project costs. The Environmental management plan should be implemented in phases so that optimum benefit could be achieved and should be synchronized with the construction schedules.

CHAPTER 1

INTRODUCTION

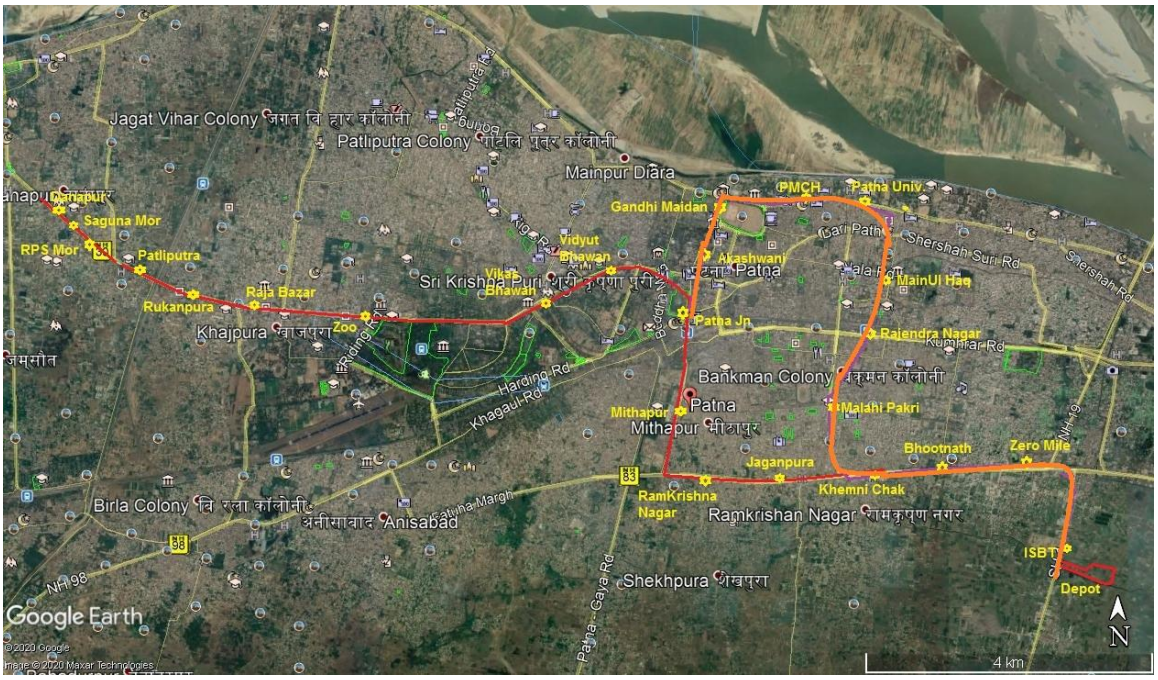
1.1 Project Proposal

High population growth rate of Patna coupled with high economic growth has resulted in an ever-increasing demand for transport creating excessive pressure on the city's existing road transport system, which comprises mainly the public buses, private vehicles, autos and Taxis.

Detailed Project Report (DPR) for Metro on two different corridors viz one from Danapur to Khemni Chak and second from Patna Station - New ISBT has been prepared.

Delhi Metro Rail Corporation will execute the Corridor 1 (Danapur to Khemnichak) and Corridor 2 (Patna Rly station to New ISBT) of Patna Metro projects. Proposed alignment has been depicted in **Figure 1.1.**

Figure1.1 Proposed Alignment



Details of alignment excluding stations are given in Table 1.1.

Table 1.1Details of Alignment of Patna Metro

S. No.	Corridor	Type	Lentgh (Km)	Stations
1	Corridor 1 (Danapur to Khemni chak)	UG	10.54	6
		Elevated	7.393	8
		Total	17.933	14
2	Corridor 2 Patna Station to New ISBT)	UG	7.926	7
		Elevated	6.638	5
		Total	14.564	12

Two stations viz., Patna station and Khenichak are interchange stations.

1.2 Scope of Work

The present study is Environmental Impact Assessment (EIA), which has been carried out for Danapur- Khemni Chak and Patna Station- New ISBT corridors of Patna Metro.

The objective of the EIA study is to identify potential environmental impacts of the proposed rail-based Mass Rapid Transit System (MRTS) and formulate strategies to avoid / mitigate the same. The scope of work to accomplish the above objective, comprise the following.

- To conduct literature review and to collect data relevant to the study area;
- Reconnaissance survey, field visits and study of toposheets of Survey of India for selection of sampling and monitoring locations for various environmental components;
- Analysis of alternatives;
- Understanding the baseline environmental conditions of the project area;
- Identifying the potential environmental impacts of the project proposal;
- Recommending appropriate mitigation measures to avoid / minimise the environmental impacts; and
- Preparing an environmental management plan for implementation.

The environmental studies have been confined to the situation around the deemed areas of direct influence caused by constructional and operational

facilities along the proposed new alignment. The EIA was conducted on the approved route alignment from Danapur to Khemnichak and Patna Rly station to New ISBT of Patna Metro. ROW was demarcated on the General Alignment Drawing and the study has been carried out accordingly. The report is prepared on the basis of collection of primary data at site, in addition to secondary data.

1.3 Legal, Regulatory and Institutional Framework

This section reviews the policies, regulations and administrative framework within which the project is to be implemented. The review includes sector specific Environmental Policies & Regulations of the Government of India and the institutional profile of various agencies such as MoEFCC, PCB and other bodies associated with the project.

1.3.1 Environmental Policies and Regulations

The Government of India has laid down various policy guidelines, regulations, acts and legislations pertaining for sustenance and protection of environment and its various components. **Table 1.2** shows the details of relevant environmental legislations and implementing agencies.

Government of India (GoI), Bihar State Government and other regulatory agencies have laid down various Acts and Regulations on Environmental Management which are fairly extensive and take care of most of the aspects involved and the laws pertaining to them are quite stringent. To oversee the implementation of rules in projects, there is a need for a monitoring agency to take care of the environment during the construction and operation phases projects in the country. The environmental policies and regulations reviewed are broadly categorised into the following categories:

- Environmental Policy and Regulatory frameworks in India
- Regulatory Framework at the State level

1.3.2 Policy and Regulatory Framework of Government of India

The Government of India has laid down various policy guidelines, regulations, acts and legislations pertaining to sustenance and protection of environment and its various components.

Constitutional Provisions of Government of India on Environment

The Constitution of India in its Article 48 provides for the protection and preservation of the environment and states "the state shall endeavor to protect and improve the environment and to safeguard forests and wild life of the country." Further Article 51-A (g) on fundamental duties emphasises that, "It shall be the duty of every citizen of India to protect and improve the natural environment including forests, lakes, rivers and wildlife and to have compassion for living creatures." These two provisions of the constitution are the guiding principles for various environmental legislations in the country and to safeguard the environment. Simutaneously there is provision of Right to life and clean environment as per Article 21 of the constitution of India.

Water (Prevention and Control of Pollution) Act, 1974

Water Act is the first environmental regulation that was introduced at the State and Centre levels, Pollution Control Boards to control / regulate environmental pollution in India. The Act was amended twice in the year 1978 and 1988. The Act vests regulatory authority on State Pollution Control Boards and empowers them to establish and enforce effluent standards for industries and local authorities discharging effluents. This provides for the prevention and control of water pollution besides maintaining and restoring of the wholesomeness of water. 'Pollution' means such contamination of water or such alteration of the physical, chemical or biological properties of water or such discharge of any sewage or trade effluent or of any other liquid, gaseous or solid substance into water (whether directly or indirectly) as may, or is likely to, create a nuisance on health or safety, or to domestic, commercial, industrial, agricultural or other legitimate uses, or to the life and health of animals or plants or of aquatic organisms.

The Act resulted in the establishment of the Central and State level Pollution Control Boards whose responsibilities include managing water quality and effluent standards, as well as monitoring water quality, prosecuting offenders and issuing licenses for construction and operation of certain facilities.

Air (Prevention and Control of Pollution) Act, 1981

Similar to Water Act, the Air Act vests regulatory authority on the State Pollution Control Boards and empowers them to enforce air quality standards to prevent air pollution in the country. This Act provides for prevention, control and abatement of air pollution. 'Air Pollution' means the presence in the atmosphere of any 'air pollutant', which means any solid, liquid or gaseous substance (including noise) in the atmosphere in such concentration as may be or tend to be injurious to human beings or other living creatures or plants or property or environment. The SPCB is empowered to set air quality standards, monitor, and prosecute offenders under The Air (Prevention and Control of Pollution) Act, 1981. Section 21 of the Act requires an application to be made to the State Board to establish or operate any industrial operation.

The Environment (Protection) Act, 1986

The Environment (Protection) Act, popularly known as EP Act, is an umbrella legislation that supplements existing environmental regulations. Empowered by the EP Act, the Ministry of Environment Forests (MoEF), Government of India has issued the following notifications regulating sitting of industry and operations, procuring clearance to establish industries and development of projects with appropriate EIA studies, coastal zone regulations and other aspects of environment care:

- Empowers the Government of India (section 6) to make rules to regulate environmental pollution by stipulating standards and maximum allowable limits toprevent air, water, noise, soil and other environmental pollutants.
- Prohibits operations that emit pollutants in excess of standards (section 7).
- Regulates handling of hazardous substances and identifies persons responsible fordischarges and pollution prevention (section 9).
- Section 1 7 deals with offences committed by Government Departments.
- Formulated Hazardous waste and management rules, E-waste rules, C&D waste rules etc. in accordance with the sections 6, 8 and 25 of EP Act.

EIA Notification, 1994 & 2006

The EIA notification dated 27th January, 1994 imposes restrictions & prohibitions on the expansion & modernization of any activity or new projects listed in the Schedule I of the notification unless Environmental Clearance has been accorded by the MoEF.

Subsequent to it, EIA notification was published on 14th September, 2006 for imposing certain restrictions and prohibitions on new projects or activities, or on the expansion or modernisation of existing projects or activities based on their potential environmental impacts as indicated in the schedule to the notification, being undertaken in any part of India, unless prior environmental clearance has been accorded in accordance with the objectives of National Environment Policy as approved by the Union Cabinet on 18th May, 2006 and the procedure specified in the notification, by the Central Government or the State or Union territory Level Environment Impact Assessment Authority (SEIAA).

The notification has listed out the Projects or activities requiring prior environmental clearance under Category "A" and "B" based on the spatial extent of potential impacts and potential impacts on human health and natural and manmade resources. Category "A" projects require prior environmental clearance from MoEF on the recommendations of an Expert Appraisal Committee (EAC) and Category "B" projects require prior environmental clearance from State or Union territory Level Environment Impact Assessment Authority (SEIAA) on the recommendations of a State or Union territory Level Expert Appraisal Committee (SEAC). In the absence of a duly constituted SEIAA or SEAC, a category "B" project shall be treated as a Category "A" project.

The railways and metro rail projects are not included in the schedule of the EIA notification 2006 which lists projects that require prior enviornnmental clearance.

The Indian Forest Act, 1927

- Section 5 states that after declaring a particular land as reserved forest, no fresh clearings for any purpose shall be made, except in accordance with such rules as made by the state Government.
- As per Section 26 of Indian Forest Act, 1927 a number of activities are

prohibited in forest areas and prior approval is required from the central government to use forest land for non-forest purposes.

- Sections 30, 32 furnish power to the State government to regulate certain acts (clearing for cultivation, building or any other purpose) in such forests as specified in the section.
- Section 35 furnishes power to the State Government to prohibit certain acts (clearing of vegetation etc) in lands not being the property of the Government.

Forest (Conservation) Act, 1980 (as amended in 1988)

The Forest (Conservation) Act, 1980 prohibits large-scale diversion of forestland for non-forest use. As amended in 1988, no State Government or authority shall make such diversions except with the prior approval of the Central Government. Salient features of the act are summarized below:

- Section 2 of the Act restricts the state Government on the de-reservation of forests or use of forest land for non-forest purposes.
- The Forest (Conservation) Act, 1980 pertains to the cases of diversion of forest area and felling of roadside plantation. Depending on the size of the tract to be cleared, clearances are applied for at the following levels of Government.
- If the area of forests to be cleared or diverted exceeds 20ha (or, 10ha in hilly area) then prior permission of Central Government is required;
- If the area of forest to be cleared or diverted is between 5 to 20ha, the Regional Office of Chief Conservator of Forests is empowered to approve;
- If the area of forest to be cleared or diverted is below or equal to 5Ha, the State Government can give permission; and
- If the area to be clear-felled has a forest density of more than 40%, permission to undertake any work is needed from the Central Government, irrespective of the area to be cleared.

The Forest (Conservation) Rules, 1981

- The Rule 4 of the Act lays down the procedure for State Governments to make a proposal seeking prior approval in case of Reserved Forest (RF) is involved to de-reserve a forest for non-forest purposes (section 2 of Forest Act, 1980),

provided all proposals involving clearing of naturally grown trees in forest land or portion thereof, for the purpose of using it for afforestation, shall be sent in the form of a working plan / management plan.

The Motor Vehicles Act, 1988

In 1988, the Indian Motor Vehicles Act empowered the State Transport Authority (usually the Road Transport Office) to enforce standards for vehicular pollution and prevention control. The authority also checks emission standards of registered vehicles, collects road taxes, and issues licenses. In August 1997, the Pollution under Control Certificate (PUC) program was launched in an attempt to crackdown the vehicular emissions in the States. Since this Act is applicable for all states, this will be applicable for this project also.

The Ancient Monuments and Archaeological Sites and Remains Act, 1958

According to this Act, an area within the radius of 100 m and 300 m from the "protected property" is designated as "protected area" and "controlled area" respectively. No development activity (including building, mining, excavating, blasting) is permitted in the "protected area" and development activities likely to damage the protected property are not permitted in the "controlled area" without prior permission of the Archaeological Survey of India (ASI) if the site / remains / monuments are protected by ASI or the State Directorate of Archaeology, if these are protected by the State.

1.3.3 Policy and Regulatory Framework at state level

The Bihar State Pollution Control Board enforces environmental regulations and policies in the state of Bihar. The Board and Committee follow the standards and regulations prescribed by Central Pollution Control Board and various Acts promulgated by the Ministry of Environment & Forests, Government of India.

1.3.4 Summary of Applicable Environmental Regulations

Following table gives summary of relevant environmental laws applicable to the project. However, as per notifications Railways Projects are not required to seek prior Environmental Clearance from MoEF&CC.

Table 1.2 Environmental Legislations Applicable to the Project

S. No.	Act/Regulation	Objectives	Implementing /Responsible Agency
1.	Air (Prevention and Control of Pollution) Act, 1981 amended 1987	To control and monitor air pollution as per prescribed limits set by CPCB.	Bihar State Pollution Control Board.
2.	The Water (Prevention and Control of Pollution) Act, 1974 amended 1988	To control and monitor water pollution as per prescribed limits	Bihar State Pollution Control Board
3.	The Forest Conservation Act, 1980 amended 1988	To check deforestation by restricting conversion of forested areas into non-forested areas	• Forest Department, Govt. of Bihar - up to 5 Ha and less than 40 % canopy closure) • Regional Chief Conservator of Forest - 5 - 20 Ha. • MoEF - Above 20 Ha and more than 40 % canopy closure)
4.	National Forest Policy, 1988	To preserve and restore biological diversity	Forest Department, GoI and Government of Bihar.
5.	Hazardous and Other Wastes (Management and Transboundary Movement Rules, 2016	Handling of Hazardous wastes generated in the project during construction and operations	Bihar State Pollution Control Board.
6.	National Environmental Appellate Authority Act, 1997	For grievance redressal	Ministry of Environment and Forests
7.	Ancient Monuments and Archaeological Sites and Remains Act, 1958 amended 2010	Preservation of culture and historical remains.	Archeological Survey of India (ASI), State Archeological Department
8.	The National Environment Tribunal Act, 1992	Liability for damages due to any accident while handling hazardous substances	Chairman, National Environmental Tribunal
9.	The Explosives Act (&	Regulations regarding	Bihar State Revenue

	Rules), 1884 (revised in 1983). Other relevant codes of BIS and National Building Codes. issued in 1983)	the use of explosives and precautionary measures while blasting and quarrying	Department
10.	The Public Liability Insurance Act & Rules, 1991	Imposes liability on the owner to provide immediate relief in respect of death/injury or damage to any person/property arising out of accident/activity implementation	All project proponents including the State Public Works Departments
11.	Indian Motor Vehicles Act, 1988 (1989)	To check vehicular air and noise pollution	Motor Vehicles Department, Govt. of Bihar
12.	Right to Fair Compensation and Transparency in Land Acquisition, Rehabilitation and Resettlement Act, 2013	Rules for acquisition of land by Government	Department of Settlement and Land Records, Revenue Departments of State Government.
13.	Noise Pollution Rules 2000 amended 2002 & 2006	Regulation regarding control and management of Noise	CPCB and Bihar State Pollution Control Board.
14.	Municipal Solid Waste Management Rules 2016	Managing the solid wastes generated at the project	Local Authorities
15.	C & D Waste Management Rules, 2016	C & D Waste generated during construction	Bihar State Pollution Control Board/ Municipal Corporation
16.	Fly ash Notification, 2016	Use of flyash in construction	Bihar State Pollution Control Board.
17.	CGWA Guidelines, 2015 and 2019	Tubewell Permission / Construction of Rain water harvesting system	CGWA
18.	EIA Notification (January 1994 and New EIA Notification dated 14th September, 2006	For all Development Projects	Bihar State Pollution Control Board.
19.	Environment Protection Act , 1986	Protection of Environment.	MoEF&CC

1.3.5 Various Environment Permissions Required

References to EIA notification, Railway Projects are not covered to seek prior Environmental Clearance from MoEFCC/ SEIAA. Various permissions related to environment required for the project during Preconstruction, Construction and Operation phase of the project. The key permissions required for the project are listed below:

Table 1.3 Key Environmental Clearances Required

S. No.	Permissions/ Clearances	Acts / Rules / Notifications / Guidelines	Concerned Agency	Stage
1	Permission for felling of trees	Forest Conservation Act (1980), Procedural Guidelines developed by the Department of Environment, GoM; Tree removal will be guided as per state government rules.	District Collecto/State Forest Department	Pre-construction
2	Consent to operate, batching plant – (Ready mix concrete plant)	Air (Prevention and Control of Pollution) Act 1981 and water act 1974.	Bihar State Pollution Control Board	Construction
3	Permission for withdrawal of ground water	Environment (Protection) Act, 1986	Central Ground Water Authority	Construction and Operation
4	Authorization for Disposal of Hazardous Waste	Hazardous Waste (Management and Handling) Rules 2016	Bihar State Pollution Control Board	Construction and Operations
5	Disposal of E-waste	E- Waste Management Rules 2016	Bihat State Pollution Control Board	Operation
6	Pollution Under Control Certificate	Central Motor and Vehicle Act 1988	Department of Transport, Govt. of Bihar authorised testing centres	Construction

If sand and aggregartes are sourced from the minies owned by contractor permission will be required from mining department and clearance from BSPCB and State SEIAA.

1.4 Institutional Framework

Department of Environment, Govt. of Bihar will be the regulatory authority for implementation of Environmental rules applicable to this project. The Ministry of Environment, Forests and Climate Change (MoEF&CC) is the nodal agency in the administrative structure of the central government for planning, promotion, co-ordination and overseeing the implementation of India's environmental and forestry policies and programs. The major responsibilities of MoEF&CC 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.
- Forest clearance.

In addition to above, Patna Municipal Corporation is responsible for cleaning and maintenance of the City. It will regulate the collection and disposal of Municipal Solid Wastes, C& D wastes, arrange water supplies and disposal of sewage and sanitation.

1.4.1 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.

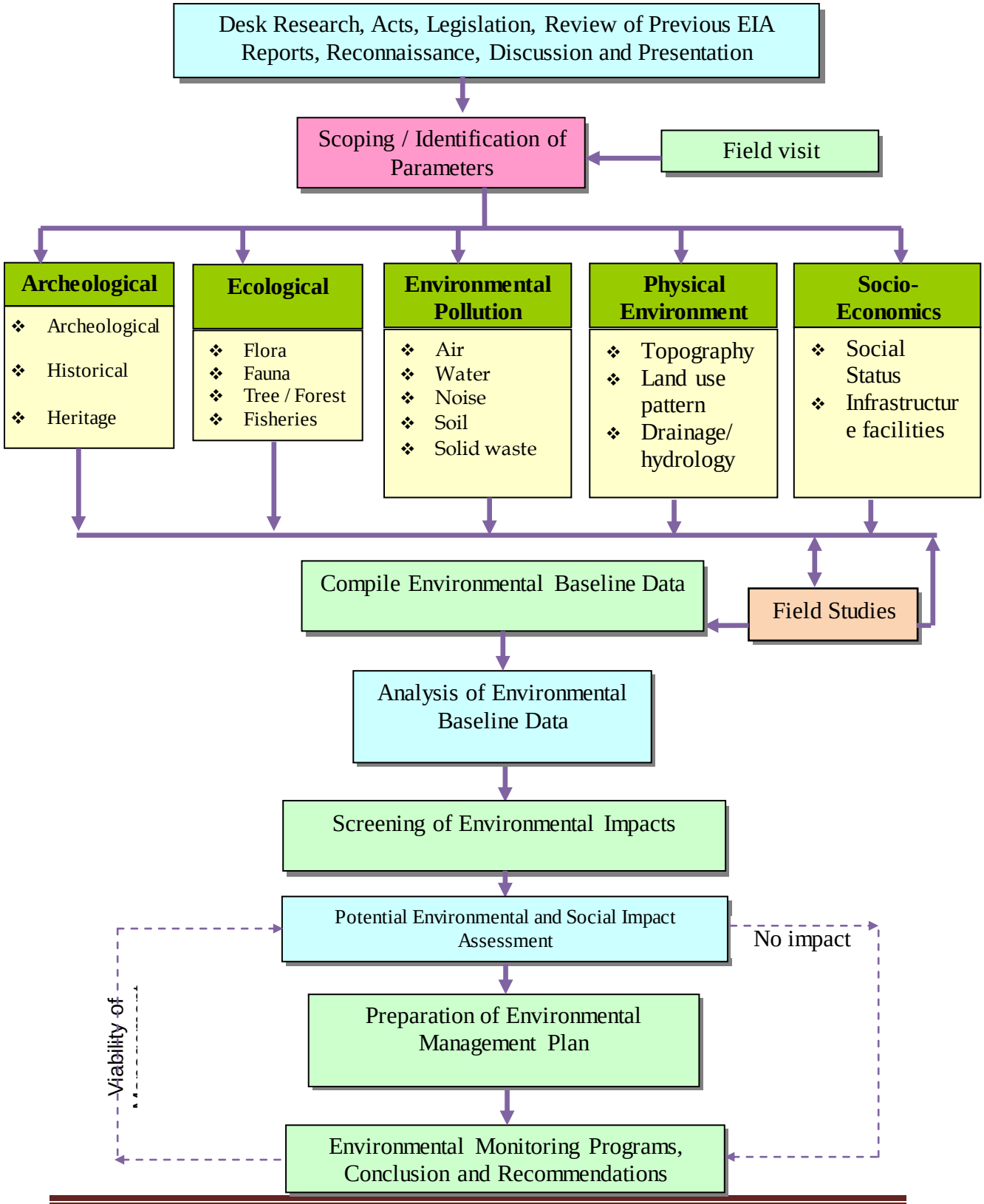
1.5 Approach and Methodology

The alignment was fixed based on technical feasibility, socio-economic acceptability, and environmental sustainability for Metro Corridors. The environmental study is carried out for the alignment proposed by DMRC. 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 analysis of assessment depends upon the reliable data generated/ available on environmental attributed. This study has documented the baseline data for various parameters of physical, ecological and environmental pollution (air, water, noise and vibration). 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 1.2.**

FIGURE 1.2 METHODOLOGY FOR 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 guidelines were consulted with a view to ensuring compliance with various requirements. Environmental baseline data for environmental attributes from primary and secondary sources were collected and compiled. 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 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.

1.5.1 Data Collection

The existing land-use pattern of the area has been identified mainly as urban human settlements, roads, trees and water bodies. **Water Resources** in the project were considered in terms of precipitation, surface run off; quantity and quality of water. **Air and Noise** quality is an important consideration during construction and operation phases. Ambient air quality and noise levels were monitored in project area to develop present baseline levels in the area.

1.5.2 Environmental Impact Assessment

The objective of the study is to assess the impacts as a result of construction of the proposed Patna Metro corridors. The changes likely to occur in different components of the environment were studied and analyzed.

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 get an idea about resultant impacts. The environmental impact of the project includes changes in land use, soil, erosion, water quality, air quality and noise levels etc. The impact on soil due to disposal of wastewater and erosion during construction has been predicted. The project will provide higher

living standard, better quality of life, less travel time, better connectivity and transport facilities.

1.5.3 Environmental Management Plan

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 with respect to pre-project stage. An environmental management strategy/ plan has been developed to mitigate the adverse impacts. Efforts are made to enhance the quality of environmental attributes.

1.5.4 Environmental Monitoring

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.

1.6 Purpose of The report

The present study has been carried out for assessing the Environmental Impacts for the proposed Metro corridors viz., Danapur to Khemni Chak and Patna Station to New ISBT. The report is prepared on the basis of primary data collection at site, in addition to secondary data. The environmental study is carried out for the alignment proposed by DMRC.

1.7 Format of the Report

The main elements of the study are as follows: In **Chapter-2** a concise documentation is given on project activities. **Chapter-3** summarises environmental baseline conditions including physical, biological and socio-economic parameters and pre-project environmental constraint. Potential negative and positive impacts are presented in **Chapter-4**. 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 Patna Metro corridor 1 & 2. The positive impacts included employment opportunities, mobility, traffic congetion reduction, fuel savings, reduced air pollution etc.

Chapter-5 includes Environment Management Plan. **Chapter 6** included Analysis of alternatives. These include the various alternatives disussed for the project alignment and how the present alternative is selected. **Chapter 7** presents post project environmental monitoring programmes. This programme aims at signalling any potential environmental problem during construction and operation of the project and it should allow for timely implementation of corrective measures. **Chapter 8** includes how the different stakeholders were consulted and their apprehensions were resolved. Finally, a summary of the costs of the environmental management and monitoring programmes falling under the responsibility of the project is presented in **Chapter-9.**

CHAPTER 2

PROJECT DESCRIPTION

2.0 Patna City

Patna is the capital and largest city of the state of Bihar in India. Patna is the second-largest city in Eastern India after Kolkata. It had an estimated city population of 1.68 million in 2011, making it the 19th largest city in India. With over 2 million people, its urban agglomeration is the 18th largest in India. Patna also serves as the seat of Patna High Court. One of the oldest continuously inhabited places in the world, Patna was founded in 490 BCE by the king of Magadha.

2.1 Project Description

Two metro corridors have been proposed in Patna to cater the requirement of the city viz corridor 1 between Danapur and Khemni Chak via Mithapur which is 17.933 km in length and Corridor 2 between Patna Station and New ISBT which is 14.564 km in length. Corridor 1 will be elevated between Danapur and Patliputra and Mithapur to Khemni Chak. It will be underground after Patliputra up to Mithapur. The corridor 2 will be underground from Patna Station to Rajender Nagar. It will be elevated between Malai Pakri to New ISBT. Total length of elevated portion is 7.393 Km in Corridor 1 and 6.638 Km in Corridor 2 totalling to 14.031 km of elevated corridor. The length of underground section is 10.54 Km in Corridor 1 and 7.926 Km in Corridor 2 totalling to 18.466 Km of underground section. Standard Gauge of 1435 mm has been adopted for these corridors.

2.2 Need of the Project

The Patna City has been growing rapidly due to large scale urbanization and economic activities. A number of initiatives have been taken in recent years to improve the Transport Infrastructure in the City and to provide better public transport facilities to the commuters. However, the growing needs of commuters and city have led city planning agencies to plan and create additional infrastructure facilities to serve the future needs. The sharing of limited right of way by a variety of modes and other utility services has resulted in traffic congestion, accidents, and inadequate parking area and environment deterioration. A Comprehensive Mobility Plan (CMP) has been prepared in 2018 adhering to MoHUA guidelines. It identifies

various short, medium and long-term measures of transport infrastructure in the City. CMP recommends mass transport systems along major travel corridors. The Government of Bihar has decided to introduce efficient, safe and high capacity public transport system in Patna. Based on the proposals from CMP, an Alternatives Analysis has been carried out by NIT Patna in 2018 to find the most viable mass transit system along two identified priority corridors. Alternatives Analysis Report recommends to implement a Metro Rail system on the two priority corridors in Patna

2.3 Location of Stations

A total of 14 stations in corridor 1 (Danapur to Khemnichak) and 12 stations in Corridor 2 (between Patna station-New ISBT Corridor) and a Depot are proposed in the Patna Metro. Index Map is shown in **Figure 2.1.** The details of corridor wise stations are given in **Table 2.1** and **Table 2.2** respectively for Corridor 1 and 2**. Layout map of stations is attached as Annexure-7.**

Figure 2.1: Location of the proposed Corridors and Depot of Patna Metro

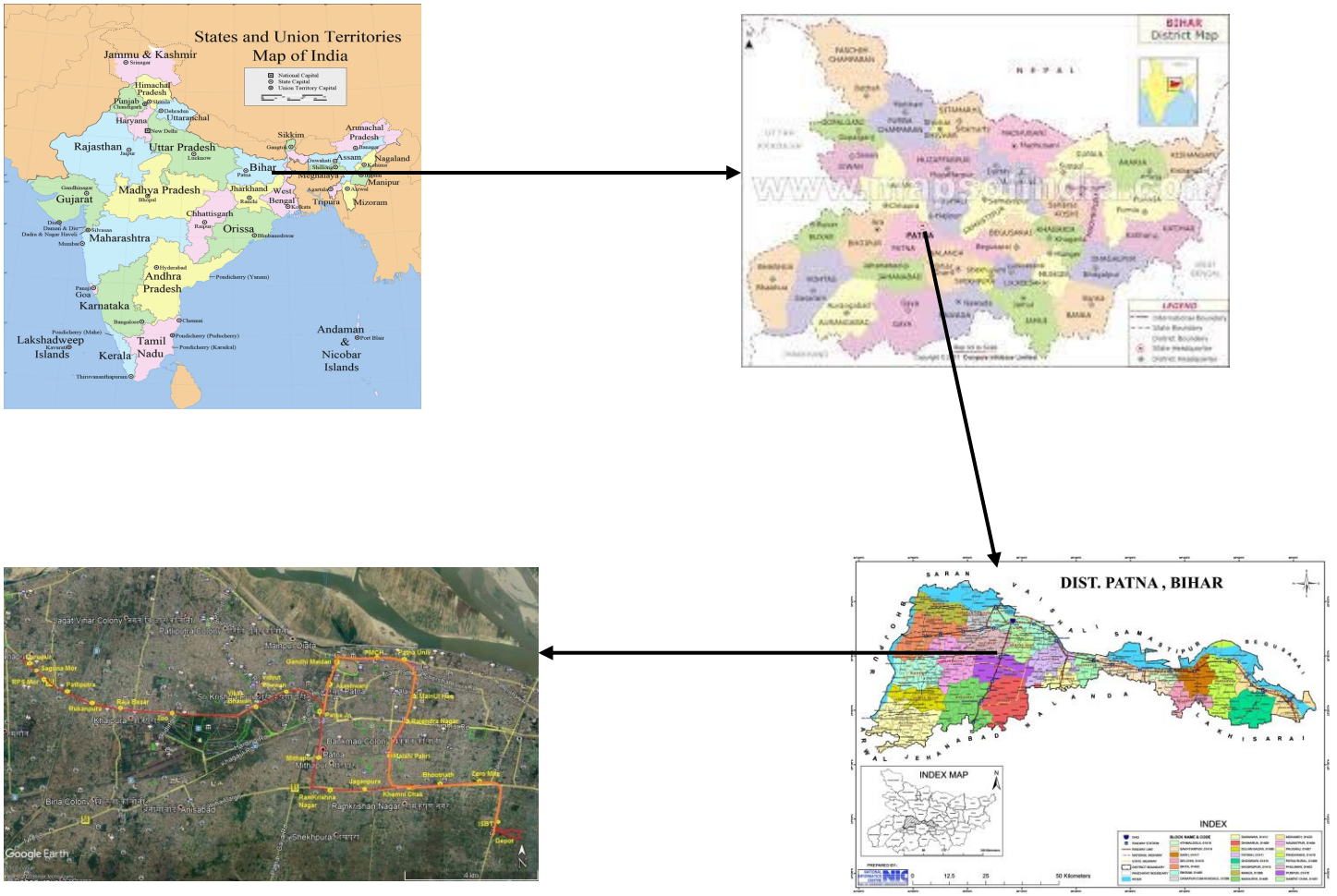


Table 2.1. Details of Stations of Danapur- Khemni Chak Corridor

S.No.	Station/ Location Name	Chainage Centre	Inter Station Distance(M)	Remarks
0	Dead End	0.00		
1	Danapur	349.57		Elevated
2	Saguna Mor	1288.73	939.16	Elevated
3	RPS Mor	2141.88	853.15	Elevated
4	Patliputra	2905.29	763.41	Elevated
5	Rukanpura	4784.85	1879.56	Underground
6	Raja Bazar	5703.36	918.51	Underground
7	Zoo	7933.43	2230.07	Underground
8	Vikas Bhawan	8932.15	998.72	Underground
9	Vidyut Bhawan	10400.12	1467.97	Underground
10	Patna Station	11048.77	648.6	Underground
11	Mithapur	14006.66	2957.89	Elevated
12	Ramkrishna Nagar	15234.39	1227.73	Elevated
13	Jaganpura	16217.42	983.03	Elevated
14	Khemni Chak	17330.00	1112.58	Elevated
	Dead End	17848.00		

Table2.2 Stations of Patna Station – New ISBT

S.No.	Station/ Location Name	Chainage Centre	Inter Station Distance(M)	Remarks
0	Dead End	0.00		
1	Patna Station	126.36		Underground
2	Akashwani	939.79	813.43	Underground
3	Gandhi Maidan	2169.23	1229.44	Underground
4	PMCH	3356.42	1187.19	Underground
5	Patna University	4638.96	1282.54	Underground
6	Main Ul Haq	6320.38	1681.42	Underground
7	Rajendra Nagar	7214.09	893.71	Underground
8	Malahi Pakri	8494.86	1280.77	Elevated
9	Khemni Chak	9991.47	1496.61	Elevated
10	Bhootnath	11006.69	1015.22	Elevated
11	Zero Mile	12324.44	1317.75	Elevated
12	New ISBT	13746.86	1422.42	Elevated
	Dead End	14232.00		Elevated
	Depot			

All stations will be two level stations with the station facilities on concourse and the platforms.

2.4 Construction Methodology

The geometrical design norms are based on international practices adopted for similar metro systems with standard gauge on the assumption that the maximum permissible speed on the section is limited to 85 kmph.

The elevated tracks will be carried on Twin-U/ I girders supported on single circular piers, generally spaced at 28-m center to center and located on the median or on the space available between main carriageway and service road to the extent possible. The horizontal alignment and vertical alignment are, therefore, dictated to a large extent by the geometry of the road and ground levels followed by the alignment.

The superstructure of a large part of the viaduct comprises of simply supported spans. It is proposed to provide box girders/U-girder/I-girder as superstructure for the viaduct. However, at major crossings over or along existing bridges special steel or continuous unit will be provided. The pier segment will be finalized based on simply supported span of 31.0 m and the same will be kept for all standard spans of simply supported. For major crossings having span of more than 31.0 m, special continuous units of normally 3m span construction or steel girders are envisaged.

Underground alignment will be constructed by means of tunnels made through Tunnel Boring Machine/ open cut and cover method. Underground stations will be constructed by means of cut and cover method or TBM. There is no soft ground which may lead to slope failures. Since the groundwater is high it is envisaged that top-down construction methodology will be adopted. In top-down method diaphragm wall will be constructed along the pheriphery of the station box. Earth retaining structures like diaphragm walls, sheet piles, secant piles etc will be used during construction.

2.5 System Requirement

The corridors will be mix of elevated and underground sections. The proposed corridors will be implemented with track on Standard Gauge (SG) 1435mm. To meet the projected traffic demand on Danapur- Khemni Chak corridor, the

possibility of running trains with composition of 3 Car trains/ 6 Car trains with different headway has been examined. 18 trains/ hour are required to meet the projected PHPDT demand for the year 2031. On Patna Jn- New ISBT corridor 3 car trains with different headway have been examined and 17 trains / hour are required for projected demand in 2031. The system is designed for a speed of 85 kmph and schedule speed of 35 kmph.

2.6 Station wise Boarding and Alighting

The daily ridership on the proposed corridor will have an important impact on the feasibility of the project since the revenue generation will depend mostly on the number of people using the facility; this has been forecast by detailed model development and calibration.

Trafic projections for different horizon years have been worked out in the DPR. The projections have been summarized in **Table 2.3 and Table 2.4.**

Table 2.3 Daily Trips on Metro System in Year 2024, 2031, 2041 & 2051

S.No.	Corridor Name	Daily Trips			
		2024	2031	2041	2051
1	East- West Corridor: Danapur-Mithapur via Patna Railway Station	543022	889674	993623	1231631
2	North-South Corridor (Patna Railway Station - New ISBT via Gandhi Maidan)	331460	535844	590850	688481
Total Daily Trips		**874482**	**1425518**	**1584473**	**1920112**

Table 2.4 Daily Boarding for Danapur – Khemni Chak and Patna Station - New ISBT Metro corridors

S.No.	Corridor Name	Daily Boardings			
		2024	2031	2041	2051
1	East- West Corridor:Danapur-Mithapur- Khemni Chak	585023	941935	1065218	1316282
2	North-South Corridor (Patna Station - New ISBT	373460	588104	662445	773133
Total Daily Boardings		**958483**	**1530039**	**1727663**	**2089415**

2.7 Depot

Depot for Danapur – Khemni Chak and Patna Station - New ISBT Metro corridors has been proposed in land identified near New ISBT site. An area of about 19.2 ha has been identified and location of depot is just beyond the New ISBT station. The depot-cum-workshop will be established with following functions:

(i) Major overhauls of all the trains.

(ii) All minor schedules and repairs.

(iii) Lifting for replacement of heavy equipment and testing thereafter.

(iv) Repair of heavy equipments

CHAPTER 3

EXISTING ENVIRONMENTAL SCENARIO

3.1 Existing Environment

In order to assess the impacts of the proposed project, field visits were made to understand the environmental profile of the project influence area. This involved field inspections at all the locations, collection of secondary information for all the environmental components and discussions with the officials and local people. The profile presented below comprises of the following: -

- Physical Environmental Components such as Meteorology, Geology, Topography, Air Quality, and Water quality
- Land Environment such as soil quality
- Biological Environmental Components such as flora and fauna,

3.2 Physical Environment

The components of physical environment discussed in this section includes,

- Meteorological parameters such as Climate, temperature, rainfall,
- Geology and Seismicity;
- Topography;
- Ambient Air Quality;
- Water Quality;
- Ambient noise levels.

For all the parameters, information was collected from field study, the Indian Meteorological Department, various Government Departments and discussions with the officials.

3.3 Climate, Temperature and Rainfall

Patna has a humid subtropical climate under the Koppen climate classification: (Cwa) with extremely hot summers from late March to early June, the monsoon season from late June to late September and chilly winter nights and foggy or sunny days from November to February. Highest temperature ever

recorded was 46.6 °C, in the year 1966, the lowest ever was 0.0 °C, on 9 January 2013, and highest rainfall was 204.5 mm, in the year 1997.

Temperature

The temperature data for Patna has been taken. The month-wise minimum & maximum temperatures have been given in Table. 3.1.

Table 3.1 Temperature at Patna (30 years Average upto 2010)

Month	Record high °C	Average high °C	Average low °C	Record low °C
January	30	22.4	9.3	1.1
February	35.1	26	12.1	3.4
March	41.4	32.2	16.7	8.2
April	44.6	37	22.1	13.3
May	45.6	37.4	25.1	17.7
June	46.6	36.4	26.7	19.3
July	41.2	33	26.3	21.1
August	39.7	32.9	26.3	20.5
September	37.5	32.5	25.5	19
October	37.2	31.9	21.5	12
November	34.1	29	15.1	7.7
December	30.5	24.5	10.5	2.2
Year	46.6	31.3	19.8	1.1

Source: IMD

The detail of rainfall at Patna is shown in **Table 3.2.**

Table 3.2 Average Monthly Rainfall at Patna

Year	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec	Annual
2014	25.2	27.4	19.9	0.0	71.3	105.8	172.8	448.9	183.1	35.7	0.0	0.1	1090.2
2015	11.8	0.0	18.2	8.0	1.4	74.5	251.0	172.7	61.8	9.4	0.0	0.0	608.8
2016	2.6	0.0	2.4	0.0	80.3	75.9	289.5	110.5	383.7	52.3	0.0	0.0	997.2
2017	0.0	0.0	8.3	9.0	35.7	68.4	299.2	181.1	109.4	19.4	0.0	0.0	730.5
2018	0.0	0.0	0.7	7.6	17.0	42.0	260.3	224.6	96.8	1.4	0.0	1.1	651.5

Source: IMD

3.4 Geology and Siesmicity

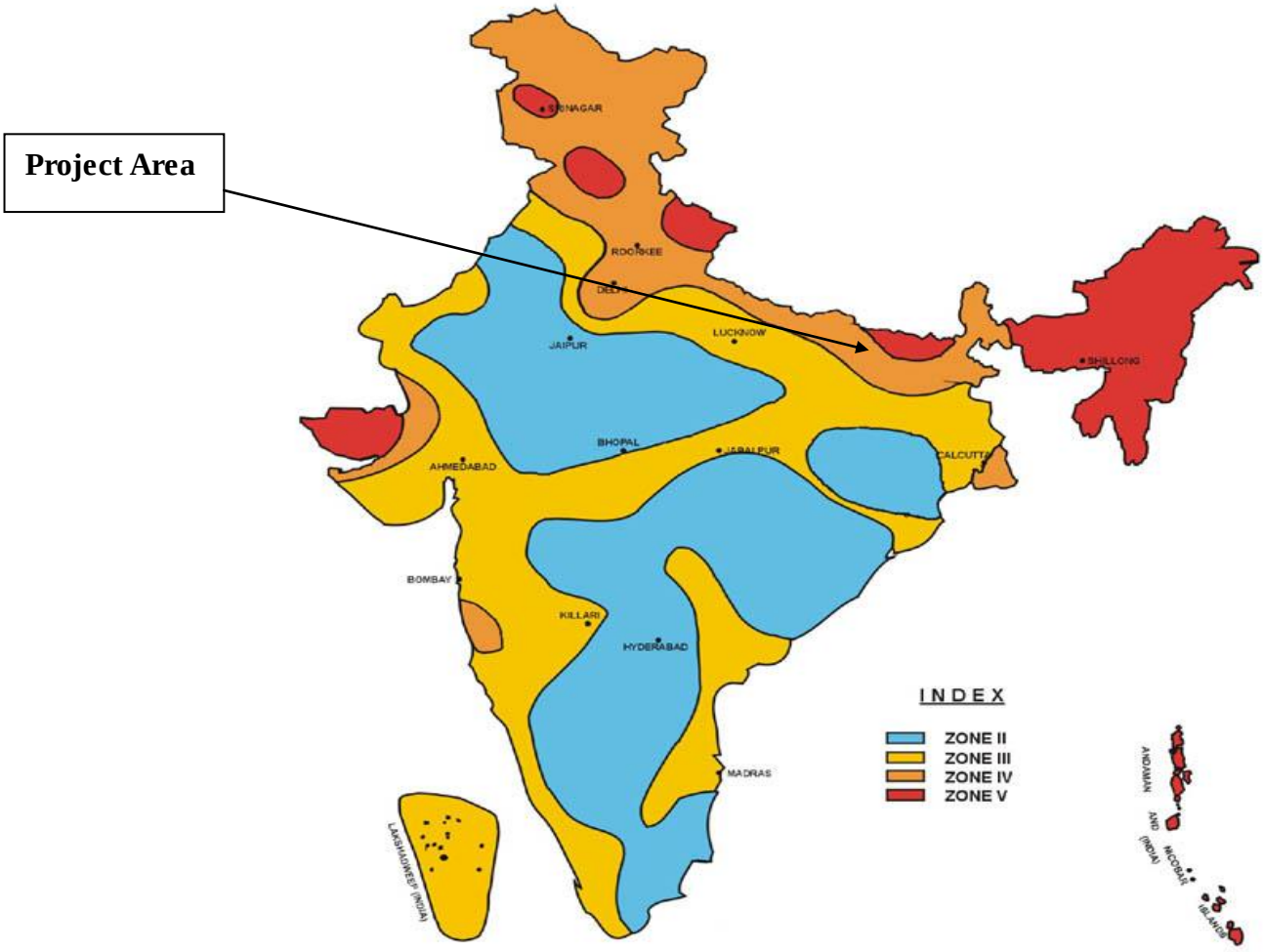
3.4.1 Geology of Patna

Patna is situated on the southern bank of river Ganges. The city also straddles the rivers Sone, Gandak and Punpun. The city is approximately 35 kilometres in length and 16 to 18 kilometres wide. Patna is located in Indo-Gangetic plain so naturally fertile soil is one asset of the state. Thus Indo-Gangetic plain's soil is the backbone of agricultural and industrial development. The Indo-Gangetic plain in Patna consists of a thick alluvial mantle of drift origin overlying in most part, the Siwalik and older tertiary rocks. The soil is mainly little young loam rejuvenated every year by constant deposition of silt, clay and sand brought by streams but mainly by floods. This soil is deficient in phosphoric acid, nitrogen and humus, but potash and lime are usually present in sufficient quantity.

The most common soil in Patna is Gangetic alluvium of Indo-Gangetic plain region. Patna is blessed with a vast stretch of very fertile flat land. It is drained by the Ganges River, including northern tributaries of other river. The river Ganges flows through the middle of the city from west to east.

3.4.2 Seismicity of Project Area

The country has been classified into different zones indicating the intensity of damage or frequency of earthquake occurrences. According to the Bureau of Indian Standards, the city falls under seismic zone-IV, in a scale of II to V (in order of increasing proneness to earthquakes).



3.4.3 Topography/ Physiography

The terrain of Patna city is mostly flat. The average height of ground surface is in the range of 48-63m above the mean sea level (MSL).

3.5 Environmental Monitoring

Environmental Monitoring has been carried out at site for the following parameters:

1. Ambient Air Quality;
2. Ground and Surface Water Quality;
3. Ambient Noise Levels;
4. Vibrations at critical ocations in the vicinity of Underground section;
5. Soil Quality.

3.6 Ambient Air Quality

Air Quality data has been generated, compiled and collated for the specified parameters as per the norms and procedures specified by various notifications and standard methods prescribed by Central Pollution Control Board (CPCB) and Ministry of Environment and Forests, Government of India.

Monitoring stations have been set up at different locations in the vicinity of proposed stations. The basic criteria for selecting sampling locations had been the location of stations where there would be movement of people and vehicles and location of receptor. The sampling/ monitoring sites have been selected for monitoring Ambient Air Quality.Major pollutants, namely Particulate Matter PM_{10}, $PM_{2.5}$, Sulphur Dioxide (SO_2), Nitrogen Oxides (NO_x), Carbon mono-oxide (CO) were measured at the monitoring stations.

The sampling locations for environmental monitoring were as given in the following **Table 3.3**.

Table 3.3: Sampling Locations for Ambient Air Quality Monitoring

S. No.	Location	Monitoring Code
1.	Danapur	A 1
2.	Raja Bazar	A 2
3	Zoo	A 3
4.	Mithapur	A 4
5.	Patna Station	A 5
6	PMCH	A 6
7.	Patna University	A 7
8.	Khemni Chak	A 8
9.	New ISBT	A 9

The locations for monitoring of Ambient Air Quality have been shown in **Figure 3.1.**

Figure 3.1 Air Quality Monitoring locations

The Air quality was monitored round-the-clock in accordance with the guidelines issued by the Ministry of Environment and Forests / Central Pollution Control Board under National Ambient Air Quality Standards as per National Ambient Air Quality Standards (NAAQS 2009) issued on 18th November 2009 by Ministry of Environment and Forests, Govt. of India. The monitoring has been carried out in January 2020. RPM data were collected on 24-hourly basis at above mentioned location. The gaseous samples were collected on eight-hourly basis. Analyses wes carried out according to the Indian Standards, such as IS 5182: Part IV (1973) for Suspended Particulate Matter (PM10), Part II (1969) for Sulphur Di-oxide (SO2), Part VI (1975) for Oxides of Nitrogen (NOx) and Part X (1976) for Carbon Monoxide (CO).

Observed Air Quality

The values of all the parameters as observed during the field monitoring are given in **Table 3.4** for different monitoring stations. Data given in the Table shows the observed level of pollutants at the monitoring stations. National **Ambient Air Quality Standards (NAAQS),** as specified by the Central Pollution Control Board (CPCB), Ministry of Environment and Forests, are given in **Annexure 4.**

Table 3.4: Ambient Air Quality along Danapur- Khemni Chak and Patna Station – New ISBT corridors

(January 2020) (Values are in μg/m^3)

S. No	Location	PM_{10}	$PM_{2.5}$	NOx	SO_2	CO
	Regulatory Standards	**100**	**60.0**	**80**	**80**	**2000**
1	Danapur	124	96	11.3	73.2	0.77
2	Raja Bazar	137	101	11.9	79.8	0.83
3	Zoo	146	113	13.8	87.4	1.23
4	Patna Station	259	156	17.2	119.3	1.39
5	Mithapur	217	143	15.4	105.3	1.27
6	PMCH	216	137	9.7	57.1	1.19
7	Patna Unversity	253	171	10.4	64.5	1.14
8	Khemni Chak	312	168	15.6	94.1	1.41
9	New ISBT	281	141	14.2	88.2	1.37

Source: Observed Values

It is to be noted that the particulate levels, both PM_{10} as well as $PM_{2.5}$, are higher than prescribed limits at all locations. This may be because of heavy traffic movement on roads and location of industries in the vicinity of alignment. The gaseous parameters are within permissible limits but are on higher side showing ambient air quality all along the alignment is of low quality.

3.7 Water Resources and Quality

Water Resources in Patna

Patna is unique in having four large rivers in its vicinity. It is the largest riverine city in the world. The topography of Patna city is saucer shaped as per Patna City Development Plan prepared in 2006. Ground water fulfills the basic need of the people administered by Patna Jal Parishad under Patna Municipal Corporation. The public water supply system comprises tube wells that pump water directly to the distribution mains.

Water environment consists of water resources and its quality. Its study is important from the point of view of assessing 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 operations to meet out domestic water requirements of the project in case water is not made available by Patna Municipal Corporation (PMC). 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.

Hydrogeology

The Patna district area is underlain by Quaternary alluvial formation comprising various grades of clay, silt, sand with occasional and gravel. From the groundwater potential point of view the entire district falls under good to very good category. The presence of kankar (nodules of $CaCO_3$) and fine sand at places render the top clay zone semi-pervious in nature, where ground water occurs under phreatic condition. The deeper aquifers are made up of medium to coarse grained sand with occasional gravels. A notable geomorphic feature is the strong natural levee formation or upland all along the southern bank of the Ganga which acts as a natural barrier thereby causing many of the streams flowing from south to run parallel to the course of Ganga before finally joining it further east of the district boundary. Soils are divided into three groups viz. (i) Recent alluvium (ii) Tal and (iii) Older alluvium. The soils of the district have developed on alluvial deposits transported from relatively younger geological formations where physical weathering is predominant and the soils developed in them are generally coarser in texture.

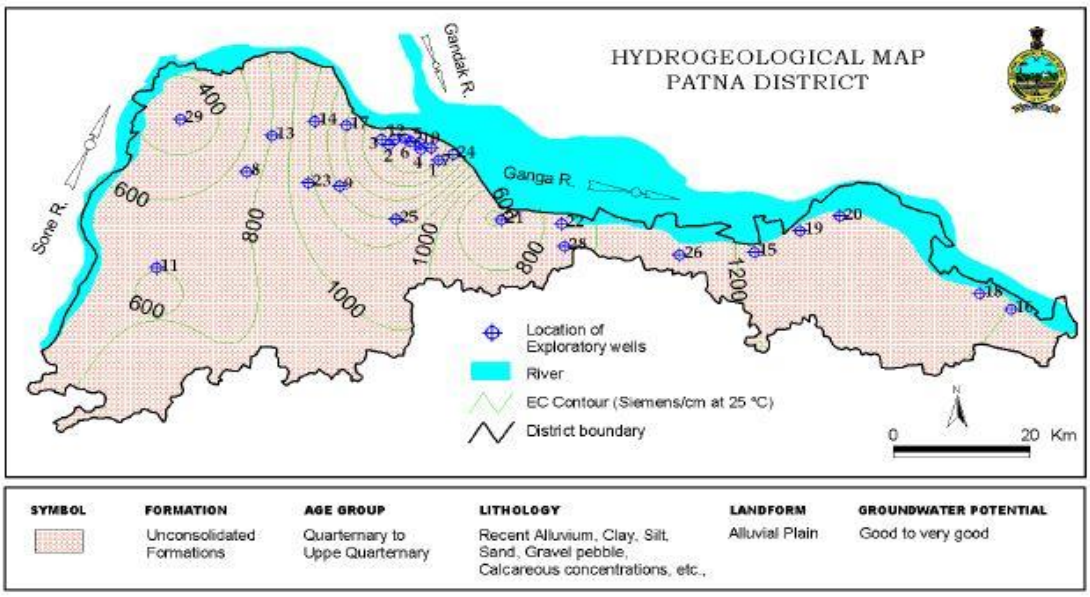
Water Levels

Central Ground Water Board monitors water levels in 43 Ground Water Monitoring wells (GWMW) in the district. These GWMW are measured four times in a year Viz. January (Rabi Season), May (Pre-monsoon), August (Monsoon) and November (Post-Monsoon).

During pre-monsoon season, the minimum and maximum water levels were observed as 3.64 and 10.09 m below ground level respectively. About 20 % of the

wells have the water level in the range of 2 – 5 m below ground level. In majority of the wells (70 %), the water levels remain in the range of 5 – 10 m below ground level.

Figure 3.2 Hydrogeological Map of Patna



The spatial distribution of water levels during premonsoon season reveals that the south-west and central parts of the district are observed with a depth range from 2 to 5 m below ground level while in the eastern part the depth to water level are > 10 m below ground level (Fig. 3.3). The water level measurement during post-monsoon season ranges from 1.40 to as deep as 7.12 m below ground level. There are each 45.45 % of wells observed in depth range of 0 – 2 and 2 – 5 m below ground level whereas about 18.18 % of wells observed in 5 – 10 m below ground level depth range. Spatial distribution of water level shows that maximum area is covered with the range of 2 to 5 m below ground level. In the southern, central & eastern part of the area water level is > 10 m below ground level (Figure. 3.4).

Figure 3.3 Premonsoon Depth to Water Level

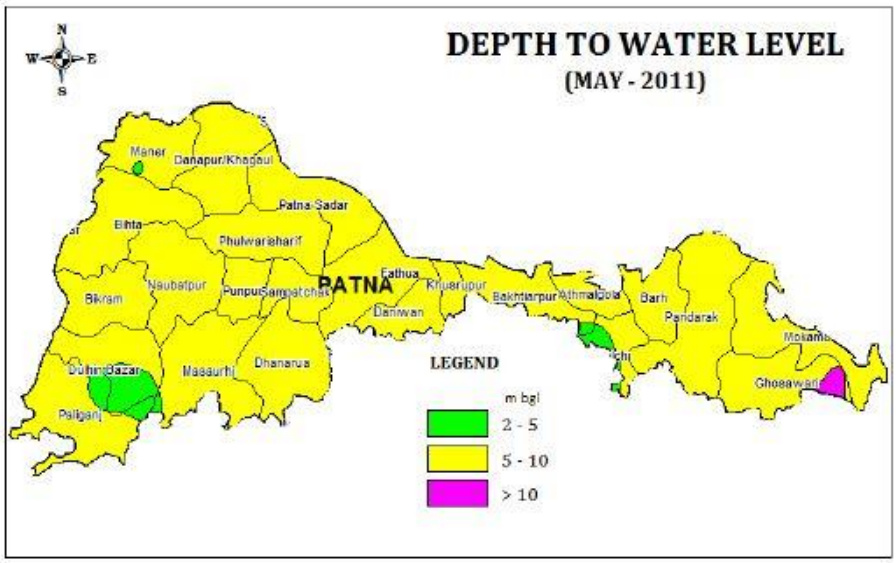
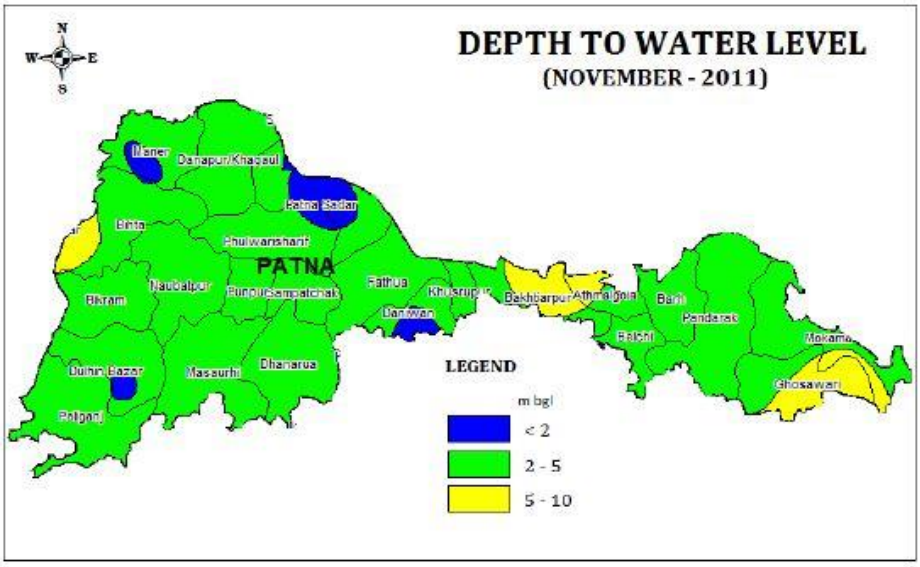


Figure 3.4 Post Monsoon Depth to Water Level



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 are related 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. Water sampling has been done on 25th January 2020. Water sampling Sites have been given in Table 3.5 and shown in **Figure 3.5**. Water quality has been given in **Table 3.6**

Groundwater quality is quite good. However, total dissolved solids, hardness, nitrates and flouride are a little higher than the desirable limits but within permissible limits. All other parameters are well within the desirable limits.

Table 3.5 Sampling Locations for Water Quality Monitoring

S. No.	Location	Monitoring Code
Ground Water		
1.	Danapur ,IOC Petrol Pump Saguna More,	GW 1
2.	Raja Bazar,PNB Bank	GW 2
3	Zoo, Parking Toilet	GW 3
4.	Mithapur , Bikaneri Bala G Sweets	GW 4
5.	Patna Station, Shiva Temple	GW 5
6.	New ISBT , Family Restaurant	GW 6
7.	Kemni Chak, Gyan Ganga Trade Center	GW 7
8.	Patna University, Science College	GW 8
9.	PMCH, Dr V P Choudhary Residence	GW 9

Figure 3.5 Water Sampling / Monitoring Sites

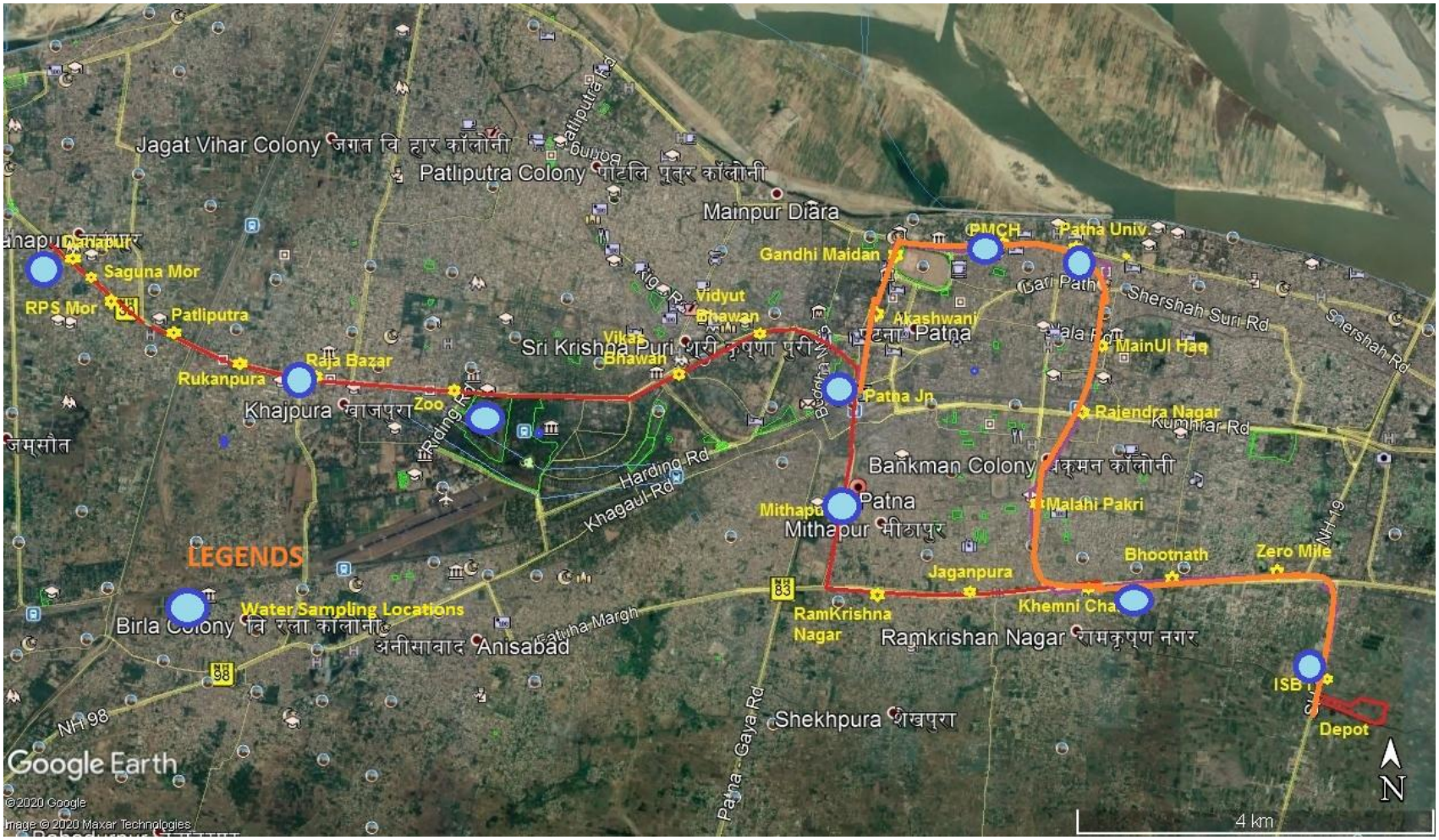


Table 3.6: Ground Water Quality for Metro Corridor between Danapur to Khemni Chak

Parameter Location	Danapur, IOC Petrol Pump Saguna More	Raja Bazar,PNB Bank	Zoo, Parking Toilet	Mithapur , Bikaneri Bala G Sweets	Permissile Limits
Colour, Hazen	Colourless	Colourless	Colourless	Colourless	5 (15) Max
Odour	Unobjectionable	Unobjectionable	Unobjectionable	Unobjectionable	Agreeable
Taste	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable
Turbidity, NTU	3.5	2.3	3.7	2.6	1 (5) Max
pH at $25^{o}C$	7.86	7.74	7.82	7.72	6.5-8.5 Max
Total Hardness as $CaCO_3$, Mg/l	246	258	217	182	200 (600) Max
Chloride as Cl, Mg/l	89	67	92	87	250 (1000) Max
Total Iron as Fe, Mg/l	0.05	0.09	0.17	0.11	0.3 Max
Total Dissolved Solids, Mg/l	1497	1388	1635	1402	500 (2000) Max
Sulphates as SO_4, Mg/l	124	129	105	114	200 (400) Max
Nitrates as NO_3, Mg/l	51	57	58.1	51	45 Max
Fluorides as F, Mg/l	3.28	2.74	3.87	3.31	1.0 (1.5) Max
Lead as Pb, Mg/l	BDL	BDL	BDL	BDL	0.01 Max
Copper as Cu,Mg/l	BDL	BDL	BDL	BDL	0.05 (1.5) Max
Manganese as Mn,Mg/l	BDL	BDL	BDL	BDL	0.1 (0.3) Max

Phenolic Compound as C6H5OH,Mg/l	BDL	BDL	BDL	BDL	0.001 (0.002) Max
Mercury as Hg,Mg/l	BDL	BDL	BDL	BDL	0.001
Cadmium as Cd,Mg/l	BDL	BDL	BDL	BDL	0.003
Selenium as Se, Mg/l	BDL	BDL	BDL	BDL	0.01
Arsenic as As,Mg/l	BDL	BDL	BDL	BDL	0.01 (0.05)
Cyanide as Cn,Mg/l	BDL	BDL	BDL	BDL	0.05
Zinc as Zn, Mg/l	2.07	1.84	1.04	1.65	5 (15)
Detergent as MBAS, Mg/l	BDL	BDL	BDL	BDL	0.02 (1.0)
Chromium as Cr^{+6} ,Mg/l	BDL	BDL	BDL	BDL	0.05
Total Alkalinity as $CaCO_3$, Mg/l	127	124	146	138	200 (600)
Aluminum as Al,Mg/l	BDL	BDL	BDL	BDL	0.03 (0.2)
Boron as B, Mg/l	BDL	BDL	BDL	BDL	0.5 (1.0)
Bacteriological Analysis					
Coliform,MPN/100ml	Nil	Nil	Nil	Nil	-
E-Coli/ml	Negative	Negative	Negative	Negative	-

Table 3.7: Ground Water Quality for Metro Corridor between Patna stations to New ISBT and Danapur to Khemni Chak

Parameter Location	Patna Station, Shiva Temple	PMCH, Dr V P Choudhary Residence	Patna University, Science College	Khemni Chak, Gyan Ganga Trade Center	Patna University, Science College	*Standard*
Colour, Hazen	Colourless	Colourless	Colourless	Colourless	Colourless	5 (15) Max
Odour	Unobjectionable	Unobjectionable	Unobjectionable	Unobjectionable	Unobjectionable	Unobjectionable
Taste	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable
Turbidity, NTU	4.1	3.6	3.2	2.7	3.2	1 (5) Max
pH at 25^{o}C	7.65	7.75	7.69	7.83	7.69	6.5-8.5 Max
Total Hardness as $CaCO_3$, Mg/l	315	224	216	253	216	200 (600) Max
Chloride as Cl, Mg/l	142	94	73	129	73	250 (1000) Max
Total Iron as Fe, Mg/l	0.28	0.16	0.12	0.27	0.12	0.3 Max
Total Dissolved Solids, Mg/l	2147	1671	1237	1924	1237	500 (2000) Max
Sulphates as SO_4, Mg/l	168	117	91	108	91	200 (400) Max
Nitrates as NO_3, Mg/l	76	78	49	71	49	45 Max
Fluorides as F, Mg/l	2.58	2.97	2.69	4.32	2.69	1.0 (1.5) Max
Lead as Pb, Mg/l	BDL	BDL	BDL	BDL	BDL	0.01 Max
Copper as Cu,Mg/l	BDL	BDL	BDL	BDL	BDL	0.05 (1.5) Max
Manganese as Mn,Mg/l	BDL	BDL	BDL	BDL	BDL	0.1 (0.3) Max
Phenolic Compound as C6H5OH,Mg/l	BDL	BDL	BDL	BDL	BDL	0.001 (0.002) Max
Mercury as Hg,Mg/l	BDL	BDL	BDL	BDL	BDL	0.001 Max
Cadmium as Cd,Mg/l	BDL	BDL	BDL	BDL	BDL	0.01 Max

Selenium as Se, Mg/l	BDL	BDL	BDL	BDL	BDL	0.01 Max
Arsenic as As,Mg/l	BDL	BDL	BDL	BDL	BDL	0.05 Max
Cyanide as Cn,Mg/l	BDL	BDL	BDL	BDL	BDL	0.05 Max
Zinc as Zn, Mg/l	2.31	2.41	1.09	1.61	1.09	5 (15) Max
Detergent as MBAS, Mg/l	BDL	BDL	BDL	BDL	BDL	0.2 (1.0) Max
Chromium as Cr^{+6} ,Mg/l	BDL	BDL	BDL	BDL	BDL	0.05 Max
Total Alkalinity as $CaCO_3$, Mg/l	159	163	135	156	135	200 (600) Max
Aluminum as Al,Mg/l	BDL	BDL	BDL	BDL	BDL	0.03(2) Max
Boron as B, Mg/l	BDL	BDL	BDL	BDL	BDL	0.5(1) Max
Bacteriological Analysis						
Coliform,MPN/100Ml	Nil	Nil	Nil	Nil	Nil	-
E-Coli/Ml	Negative	Negative	Negative	Negative	Negative	-

Source: Monitored results

3.8 Noise Levels

Noise levels have been monitored at sampling locations using digital sound level meter. Leq noise levels have been recorded as dB (A) and reported in the report. Noise sampling Locations are given in **Table 3.8.** Noise level monitoring have been carried out between 9th and 12th February 2020. The monitoring locations are shown in **Figure 3.6.**

Table 3.8: Sampling Locations for Noise Level Monitoring

S. No.	Location	Monitoring Code
1.	Danapur near IOCL Petrol Pump	N 1
2.	Raja Bazar Near PNB Bank	N 2
3	Front of Zoo Gate Facing Road	N 3
4.	Mithapur Near Bikaner Bala G Sweets	N 4
5.	New ISBT, RPS School Campus near guard Room	N 5
6.	Patna Station front of Spyker Show room opposite Budha Park	N 6
7.	Kemni Chak balcony of Ganga Trade Centre	N 7
8.	Patna University from of union bank ATM	N 8
9.	PMCH , front of Dr. V P Choudhary Residence	N 9

Ambient Noise level measurements have been carried out to know the existing noise level along the proposed corridor of metro and its vicinity that could be affected due to the proposed project. The observed hourly Leq values of noise levels are given in **Table 3.9.** The allowable limits are given in **Table 3.10.**

A few photographs of Noise Monitoring at sites are given below:

Figure: 3.6 Noise Level Monitoring Locations

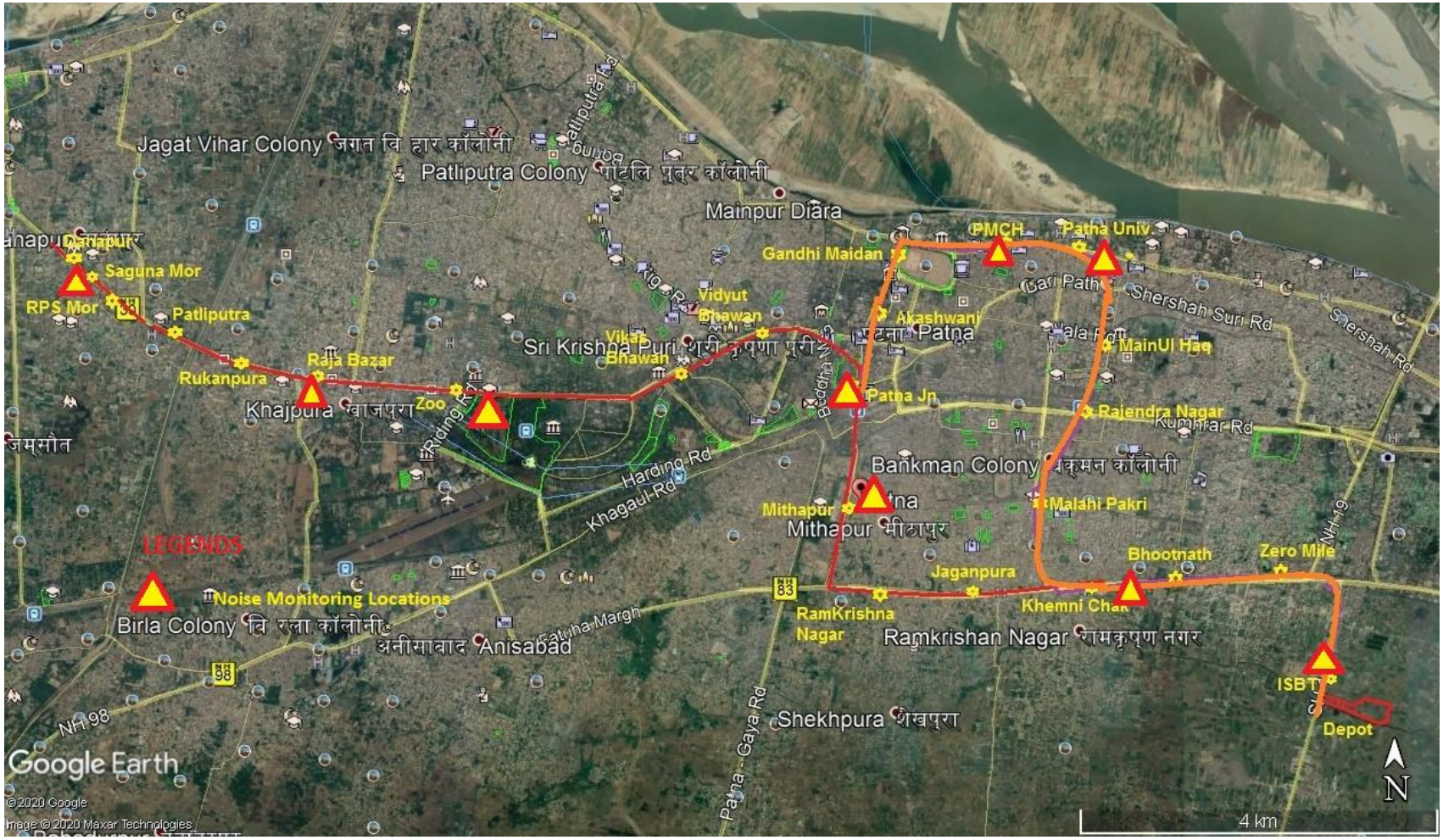


Table 3.9 Measure Noise Levels dB (A)

Day Time (6:00 Am-10:00 PM), dB(A)							Night Time (10:00 PM-6:00AM), dB(A)					
Location Name & Land Mark	**Lmax**	**Lmin**	**Leq**	**L10**	**L50**	**L90**	**Lmax**	**Lmin**	**Leq**	**L10**	**L50**	**L90**
Danapur near IOCL Petrol Pump	86.5	59.3	70.4	73.8	69.8	66.7	79.6	47.4	59.8	62.6	55.8	51.4
Raja Bazar Near PNB Bank	78.2	58.7	68.7	72.5	66.1	63.2	73.7	48.9	60.2	68.4	56.8	52.9
Front of Zoo Gate Facing Road	81.1	56.5	67.4	70.1	64.1	60.1	76.2	45.3	57.7	67.1	54.2	49.4
Mithapur Near Bikaner Bala G Sweets	86.7	61.5	73.2	79.8	70.5	68.1	77.1	51.8	62.3	73.8	56.1	50.4
Patna Station front of Spyker Show room opposite Budha Park	104.8	67.9	76.3	69.2	76.2	71.9	80.8	46.3	67.5	66.5	63.8	51.5
New ISBT, RPS School Campus near guard Room	76.2	51.1	58.2	60.7	55.7	54.3	68.9	43.4	50.5	58.1	47.3	45.7
Kemni Chonk balcony of Ganga Trade Centre	80.9	49.6	63.8	76.1	56.2	51.8	76.2	46.1	54.1	66.0	50.3	49.4
Patna University from of union bank ATM	83.1	56.5	66.2	70.3	63.4	60.6	78.6	45.8	50.9	58.2	54.8	51.3
PMCH, front of Dr. V P Choudhary Residence	79.4	51.0	60.8	71.9	61.1	56.7	77.9	42.6	51.4	65.1	48.3	45.9

Table 3.10 Allowable Noise Levels dB (A)

Category of Area/Zone	Day Time	Night Time	
Industrial Area	75	70	EPA-1986, Noise pollution (Regulation Control), Rule-2000, PCLS/02/1992, IVth Edition.
Commercial Area	65	55	
Residential Area	55	45	
Silence Area	50	40	

*Day Time (6:00 AM-10:00 PM); Night Time (10:00 PM-6:00AM)

Observed Noise levels were found to exceed the permissible noise limits at all locations. The noise levels are higher both during day time as well as night time. This is due to regular movement of heavy traffic along the alignment.

3.9 Vibration

Vibration consists of rapidly fluctuating motions with an average motion of zero. During vibration the oscillatory waves propagate from the source through the ground to adjacent buildings. Vibration from construction projects is caused by general equipment operations and is usually highest during pile driving, soil compacting, jack hammering and construction related demolition activities. Although the vibration is sometimes noticeable outdoors, it is almost exclusively an indoor problem.

Vibration energy spreads out as it travels through the ground, losing its strength the further it goes. High frequency vibrations dissipate much quicker than low frequency vibrations, which can travel further. Construction equipment usually operates in the mid- to upper- frequency, which has less potential to damage structures. Earthquakes produce vibrations at very low frequencies, resulting in a higher potential for structural damage.

The primary concern is that the vibration can be intrusive and annoying to building occupants. Buildings founded on the soil in the vicinity of the construction site respond to these vibrations, with varying results ranging from no perceptible effects at the lowest levels, low rumbling sounds and feelable vibrations at moderate levels and slight damage at the highest levels. Ground vibrations from

construction activities very rarely reach the levels that can damage structures but can achieve the audible and feelable ranges in buildings very close to the site.

Vibration monitoring was carried in at 5 locations from 10th and 11th February 2020 for 2 hours. The locations are depicted in **Figure 3.7** and the observed values are given in **Table 3.11**.

Table 3.11: Vibration Monitoring Locations, monitoring schedule and observed Vibration Levels

Sl No	Name of Location	Max Value			Mean Value		
		Vpeak	Vrms	VdB	Vpeak	Vrms	VdB
1	Raja Bazar, at Paras Hospital	0.15	0.11	72	0.06	0.04	64
2	Patna Station at Spyker Show Room	0.22	0.16	76	0.10	0.07	69
3	Jeevak Heart Hospital between Rajender Nagar and Malahi Pakri	0.18	0.13	74	0.08	0.06	67
4	Zoo, at Residence of Neeraj Kumar Minister of Inf & Pub Rel. B 3/3	0.27	0.19	78	0.12	0.08	70
5	Chief Justice Residence between Akashwani and Gandhi Maidan	0.07	0.05	66	0.04	0.03	61

The sampled data with peak amplitude values of particle velocity was recorded. The vibration monitoring was conducted for 02 hours at each site. Reconstruction of waveforms is obtained and peak values are taken accordingly.

Figure 3.7 Vibration Monitoring Sites

3.10 Land Environment

3.10.1 Soil Quality

Soil samples have been collected from the sampling locations in Jan 2020 so as to assess its physio-chemical parameters for the purpose of assessing its suitability for plantation and vegetation support characteristics. Soil samples have been collected from surface up to a depth of 30 cm. The samples have been tested using standard methods of lab analysis.

Soil samples have been collected at eight locations in January 2020, to assess the quality for physico chemical parameters

Soil sampling Locations are given in **Table 3.12. and depicted in Figure 3.8.**

Table 3.12 Sampling Locations for Soil Quality Monitoring

S. No.	Location	Monitoring Code
1.	Danapur	S 1
2.	Raja Bazar	S 2
3	Zoo	S 3
4.	Patna Station	S 4
5.	PMCH	S 5
6.	Patna University	S 6
7.	Khemni Chak	S 7
8.	New ISBT	S 8

The results of analysis are given in the **Table.3.13.**

Figure 3.8 Soil Sampling / Monitoring Sites

Table 3.13 Soil Quality at Sampling Sites along Metro Corridor

Sl. No.	Parameter	Station Name			
		Kemni Chak	Patna University	PMCH	ZOO
1	pH	**7.76**	7.67	7.81	7.59
2	Electrical Conductivity	**1369**	2136	2057	1837
3	Lead as Pb, PPM	ND	ND	ND	ND
4	Mercury as Hg, PPM	ND	ND	ND	ND
5	Cadmium as Cd, PPM	ND	ND	ND	ND
6	Arsenic as As, PPM	ND	ND	ND	ND
7	Cyanide as Cn, PPM	ND	ND	ND	ND
8	Chromium as Cr+6 , PPM	ND	ND	ND	ND

Note: ND refers Not Detected

Sl. No.	Parameter	Station Name			
		Danapur	Raja Bazar	Patna Station	New ISBT
1	pH	**7.72**	7.79	7.63	7.82
2	Electrical Conductivity	**1145**	1453	1786	1954
3	Lead as Pb, PPM	ND	ND	ND	ND
4	Mercury as Hg, PPM	ND	ND	ND	ND
5	Cadmium as Cd, PPM	ND	ND	ND	ND
6	Arsenic as As, PPM	ND	ND	ND	ND
7	Cyanide as Cn, PPM	ND	ND	ND	ND
8	Chromium as Cr+6 , PPM	ND	ND	ND	ND

Note: ND refers Not Detected

These results are compared with the standard soil classification given in Handbook of Agriculture. It has been observed that during the study period, the pH of the soil ranged from 7.59 – 7.82 indicating that the soils are slightly to moderately basic in nature.

3.11 Biological Environment

Tree survey has been carried out along the proposed alignment. Tree with Girth at Breast Height (GBH) 30 cm have been counted. The alignment does not pass through any forest area. There is no tree in Depot area.

The total number of trees found in the proposed metro corridor are as follows:

A. Danapaur- Khemni Chak : 551 trees

B. Patna Satation – New ISBT: 360 trees.

No endangered species of trees have been noticed during field survey. Trees have been found of indigenous and common species like Euclyptus, Pipal, Jamun, Neem, Palm, Babool, Ber, Gulmohar and other planted trees. These species are those that are suitable for the climatic conditions of this place. The details are given in Table 3.14

Table 3.14 Flora of Patna

Common Name	Scientific Name	Family
A. FLORA		
Amba	Mangifera indica	Anacardiaceae
Sitaphal	Annona squamosa L.	Annonaceae
Ashok	Polyalthia longifolia	Annonaceae
Saptaparni	Alstonia scholaris	Apocynaceae
Kaner	Nerium indicum	Apocynaceae
Sadaphuli	Vinca rosea	Apocynaceae
Tad	Borassus fabellifer	Arecaceae
Sal	Shorea robusta	
Kendu	Diospyros melanoxylon	
Salai	Boswellia serrata	
Asan	Terminalia tomentosa	
Bahera	Terminalia bellirica	
Paisar	Pterocarpus marsupium	
Mahua	Madhuca indica	
Rui	Calotropis gigantea	Asclepiadaceae
Dagadipala	Tridax procumbens	Asteraceae
Neel Gulmohor	Jacaranda mimosefolia	Bignoniaceae
Shalmali	Bombax ceiba	Bombacaceae
Bahava	Cassia fistula	Caesalpiniaceae
Cassia	Cassia javanica	Caesalpiniaceae
Cassia	Cassia siamea	Caesalpiniaceae
Takla	Cassia tora	Caesalpiniaceae
Gulmohar	Delonix regia	Caesalpiniaceae
Copper pod	Peltophorum ferruginium	Caesalpiniaceae

Chinch	Tamarindus indica	Caesalpiniaceae
Motha	Cyperus spp.	Cyperaceae
Palash	Butea monosperma	Fabaceae
Gokarna	Clitoria ternatea	Fabaceae
Shisham	Dalbergia sisso	Fabaceae
Karanj	Pongamia pinnata	Fabaceae
Mehndi	Lawsonia inermis	Lythraceae
Jaswand	Hibiscus rosasinensis	Malvaceae
Bakan neem	Melia azedarach	Meliaceae
Kala shirish	Albizia lebbeck	Mimosaceae
Vad	Ficus benghalensis	Moraceae
Umbar	Ficus glomerata	Moraceae
Pipal	Ficus religiosa	Moraceae
Shevga	Moringa oleifera	Moringaceae
Nilgiri	Eucalyptus globulus	Myrtaceae
Jambhul	Eugenia jambolana	Myrtaceae
Boganvel	Bouganvillea spectabilis	Nyctaginaceae
Surwal	Andropogan contortus	Poaceae
Rohis	Andropogon martinii	Poaceae
Dub	Cynodon dactylon	Poaceae
Bordi	Zizyphus jujuba	Rhamnaceae
Bor	Zizyphus mauritiana	Rhamnaceae
Bakul	Mimusops elengi	Sapotaceae
Rukhdo	Ailanthus excelsa	Simaroubaceae
Pankanis	Typha angustata	Typhaceae
Kathal	Artocarpus heterpphyllus	Moraceae

3.12 Socio- Economic Conditions

With an estimated population of 1.68 million in 2011, Patna is the 19th most populous city in India and with over 2 million people, its urban agglomeration is the 18th largest in India. Residents of Patna are referred to by the demonym Patnaite. According to 2011 census data, Patna city had a population of 1,683,200 (before expansion of the city limits) within the corporation limits, with 894,158 men and

789,042 women. This was an increase of 22.2 percent compared to the 2001 figures. 11.32 per cent of the population was under six years of age, with 102,208 boys while 88,288 are girls. The overall literacy rate is 83.37%, with the male literacy rate being 87.35% and the female literacy rate being 79.89%. The sex ratio of Patna is 885 females per 1,000 males. Child sex ratio of girls is 877 per 1000 boys. The urban agglomeration had a population of 2,046,652 of which 1,087,864 are males and 958,788 are females with 82.73% literacy. Patna metropolitan region constitutes the second largest metropolitan region in eastern India.

According to the 2011 census, Patna's major religion is Hinduism with 86.39% followers. Islam is second most popular religion in Patna with approx. 12.27% following it. Christianity, Jainism, Sikhism and Buddhism are also practised in Patna. During last census report, around 0.01 % stated other religion and app. 0.49% stated no particular religion. Roughly 0.25% of Patna's population lives in slums which makes Patna, the city with the lowest percentage of people living in slum in India. Like other fast-growing cities in the developing world, Patna suffers from major urbanisation problems including unemployment, poor public health and poor civic and educational standards for a large section of the population. In 2015, the National Sample Survey Organisation revealed that, for females, Patna had highest unemployment rate 34.6% and for males it was the second highest with a rate of 8% in 2011–12.

Patna has long been a major agricultural hub and centre of trade. Its most active exports are grain, sugarcane, sesame, and medium-grained Patna rice. There are several sugar mills in and around Patna. It is an important business and luxury brand centre of eastern India.

The economy of Patna has seen sustained economic growth since 2005. The economy has been spurred by growth in the Fast-Moving Consumer Goods industry, the service sector, along with Green revolution and businesses. In 2009, the World Bank stated Patna as the second best city in India to start up a business. As of 2015, GDP per capita of Patna was ₹1,06,000 ($1581) and its GDP growth rate is 7.29 per cent. Patna is the 21st fastest growing city in the world and the fifth fastest growing city in India, and is expected to grow at an average annual rate of 3.72%.

3.13 Socio-Economic Survey

A socio-economic survey was undertaken for the proposed corridors to assess the socio-economic conditions of project-affected families/ people and to examine the impacts of the proposed metro alignment on their conditions. There can be two types of impacts on the PAPs. One is the displacement of residential house and another is displacement of commercial establishments. The survey has been undertaken on the corridors using structured questionnaire in February 2020. The socioeconomic impacts have been assessed in the Social Impact Assessment study separately. The R & R compensation has to be worked out on the basis of RTFCLARRA 2013 or through mutual negotiations.

3.14 Archaeological Sites and Sensitive Receptors

The proposed alignment does not pass through any of the Archaeological monuments or heritage sites. However, there are a few heritage sites and archaeological structures in Patna City, which are as follows:

1. Supposed site of the Palace of Ashoka, Kumrahar, Patna
2. The grove known as “Bulandibagh”, Bulandipur, Patna.
3. The mound or stupa known as “Choti Pahari”, Chhotipahari
4. Mound known as the five stupas or “Panch Pahari”, Paharidih
5. Remains of wooden foundations and ancient Mauryan walls, Sandalpur
6. Mir Ashraf’s Jama Mosque.

As per the provisions of Ancient Monuments and Archaeological Sites and Remains (Amendment and Validation) Act, 2010, construction activities around the centrally protected monuments and sites are regulated as Prohibited area (Section 20A) upto 100m from boundary in all directions and Regulated Area (Section 20B) up to 300 m. Since the alignment in no where near these limits hence no permissions from ASI is required.

Regarding sensitive receptors there are a few hospitals and schools which are in the vicinity of the alignment. The details are given in Table 3.15.

Table 3.15 Details of Sensitive Receptors along metro Alignment

S.No.	Receptor	Type of Alignment	Chainage m	Side LHS/RHS
	HOSPITALS			
A	**Danapur- Khemni Chak**			
1.	Bimal Hospital	Elevated	1300	RHS
2.	Royal Hospital	UG	5000	LHS
3.	Paras HMRIHospital	UG	5700	LHS
4	Shekhar Hospital	UG	6600	LHS
5	Patna Central Hospital	UG	15100	LHS
6	Vatsalya Advance Children Hospital	Elevated	15460	LHS
7	Apex Hospital	Elevated	16350	LHS
8	Pulse Emergency Hospital	Elevated	16410	LHS
	SCHOOLS			
1	Kendriya Vidyalaya Danapur	Elevated	350	LHS
2	JD Womens Colege	UG	7100	LHS
3.	Dr. Zakir Hussain Institute	UG	10000	LHS
4.	Patna Womens College	UG	10350	LHS
5.	National Institute of Fashion Technolgy	UG	13600	LHS
6	Aryabhatta Knowledge University	Elevated	13800	LHS
	RELIGIOUS			
1	Panchmukhi Hanuman Mandir	UG	8100	RHS
2	Hanuman Mandir Patna Stn	UG	12200	LHS
B	**Patna Station- New ISBT**			
1	PMCH	Elevated	3350	LHS

2	Patna Boneand Spine Hospital	UG	7500	RHS
3	Jeevak Heart Hospital	UG	7550	Center
4	Bihar Cancer Surgical	Elevated	7950	LHS
5	Jaiguru Dev Hospital	Elevated	8800	LHS
6	Ford Hospital	Elevated	10000	RHS
7	Rachita Trauma Hospital	Elevated	10200	RHS
8	New Paramount Hospital	Elevated	10500	LHS
9	Earth Hospital	Elevated	12000	LHS
	SCHOOLS			
1	Amity Global Business School	UG	600	RHS
2	Dental College	UG	3050	LHS
3	Public Health Institute	UG	3200	LHS
4	PMCH	UG	3356	LHS
5	Patna University	UG	4100	LHS
6	RPS Public School	Elevated	14050	RHS
	RELIGIOUS			
1	Shiv Temple	UG	290	RHS
2	Hanuman Mandir	UG	480	RHS
3	Radha Krishna Mandir	UG	3800	RHS

CHAPTER 4

ENVIRONMENTAL IMPACT ASSESSMENT

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. 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 –5.**

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:

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

The construction and operational phases of the proposed development shall comprise of various activities, each of which may have an impact on the environmental parameters. The environmental attributes have been studied to evaluate impacts on the environment during the construction and operation phases of both the metro Corridor. Due to the proposed construction of metro Corridor, the water environment, air environment, noise, soil, land environment, ecological environment and socio-economic factors are identified as the significant environmental components likely to be

affected. The potential impacts due to location, during construction and operational phases of the metro Corridor on various environmental components are predicted quantitatively/qualitatively and discussed in the following sections.

4.3.1 Impact on Physiography and Topography

The Danapur- Khemni Chak and Patna Station – New ISBT metro alignment pases through the flat terrain. The alignment is elevated at Danapur with elevated station at Danapur and remains elevated upto Patliputra. Thereafter, near Raja Bazar it is underground upto Patna Station. The underground corridor has stations viz Raja Bazar, Rukan pura, Zoo, Vlkas Bhawan, Vidyut Bhawan and Patna Station. Thereafter the alignment is elevated upto Khemni chak.

Another alignment takes off from New ISBT station. The alignment is elevated and remains elevated upto Malai Pakri. Thereafter, it is underground upto Patna University. After Patna University, two stations are planned to be elevated viz Patna Medical College & Hospital and Gandhi Maidan. After Gandhi Maidan, the corridor is again underground and terminates at Patna Station.

The alignment mostly passes through plain area. The project site is level plain and requires cutting at certain locations during construction phase. However, impact on the physiography and topography of the area would be insignificant during construction and operation phase of the project. Cut and cover technology will be used for constructing underground stations (Top down/Bottom up).

Therefore, impact on the physiography and topography of the area would be insignificant during construction and operation phase of the project, except at location when entry/ exit shafts for TBM are proposed during construction. The Location of entry exit shafts for Tunnel Boring Machine

4.3.2 Change of Land use pattern

The alignment is both elevated as well as underground. The land requirement is kept as minimual hence the change of land use is minimum. Construction work in the area will not bring any significant changes in the land use pattern, since the proposed alignment is planned mostly in areas which are not occupied by any major existing infrastructure. The development of station buildings will not have any significant impact on the future land use. The station buildings shall enhance the aesthetics in the region

as these buildings shall be built based on the modern architecture, green design i.e, energy efficiency measures as per the present-day building norms and also shall include the pleasing aesthetics providing adequate level of greenery outside the buildings.

Table 4.1: Change in Land Use for Corriodor 1 and Corridor 2 (in ha)

Sr. No	Item	Unit	Corridor 1	Corridor 2	Total
1	**Government Land**				
1.1	Permanent	ha	2.311	1.662	3.973
1.2	Temporary	ha	1.068	2.489	3.557
1.3	**Total Government Land**	ha	**3.379**	**4.151**	**7.53**
2	**Private Land**				
2.1	Permanent	ha	0.940	31.531	**32.471**
2.2	Temporary	ha	0	0	0
2.3	**Total Private Land**	ha	**0.940**	**31.531**	**32.471**
3	**Total Land Requirement**	**ha**	**4.319**	**35.682**	**40.001#**
4	**Total Permanent Land**	**ha**	**3.251**	**33.193**	**36.444**
5	**Total Temporary Land**	**ha**	**1.068**	**2.489**	**3.557**

Total Land includes 11.3 ha land for PD area

4.3.3 Loss of Cultural and Historical Monuments

No historical/ cultural monument will be affected as a result of the proposed development of project. This is because the limits of 100m and 300m as given in Ärchaeological Sites and Remains (Amendment and Validation) Act 2010 are not infringed. Hence no prior permission from ASI is envisaged.

4.3.4 Loss of Vegetation / Trees

A total 911 trees are located in the Right of Way (ROW) of corridors. An attempt will be made to minimize the tree felling by cutting only those trees which will be essentially required for the working.

Trees are assets in purification 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 Trees : 911

ii) Decrease in CO_2 absorption @ 21.8 Kg/year/ tree for 8 years: : 158.88Tonnes

iii) Oxygen production @ 49 Kg/year per tree for 8 years : 357.11 Tonnes

The average consumption of oxygen for a person is about 182 kg/ year. It means these trees will meet the requirement of about 1945 people round the year. There will be plantation of four times of felled trees as compensatory afforestation which will exceed the generation of oxygen and absorption of carbon dioxide over time.

4.3.5 Utility/ Drainage Problems

The alignment is a combination of underground, and elevated on both corridors. The alignment will cross drains and large number of utility services, viz. water mains, sewer, storm water drains, telephone cables, overhead electrical transmission lines, electric pipes, traffic signals etc. It is essential to maintain these utilities/ services in working condition during the construction stage by temporary/permanent diversions or by supporting in position. In addition, cross drainage works such as bridges, culverts etc. may be required. Since these affect construction and project implementation time schedule / costs for which necessary planning / action shall be accounted for well in advance. The details on affected utilities are available in DPR. The drainage system along the route alignment may not be adequate to cater to construction run off. Hence as a precautionary measure during construction, care shall be taken by the contractors to ensure that the construction debris and silt do not move into the existing drains leading to its blockage.

4.3.6 Socio-Economic Impact on PAPs

Socio-Economic Impact on Project affected People have been assessed by identifying them on the basis of Right of Way (ROW) of 11 m and Station block

area of 250m x 25 m. The socio-economic impact aspect has been dealt with in details separately in Social Impact Assessment.

4.4 Impacts Due To Project Design

Considered impacts, due to project designs are:

- Lighting,
- Risk Due to Earthquake.

4.4.1 Lighting

The platforms, concourse, staircase and escalator areas both for underground and elevated stations will be provided adequate and uniform LED lighting to provide pleasant and cheerful environment. Maximum illumination level proposed is 200Lux which provides normal lighting.

4.4.2 Risk Due to Earthquake

The project area falls under seismic zone IV as per the Seismic Zoning Map of India (IS 1893, Part-I, 2002). Necessary seismic factors suggested by Indian Meteorology Department (IMD) shall be incorporated suitably while designing the structures to safeguard against earthquake risks.

4.5 Impacts Due to Project Construction

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

- Topsoil erosion, pollution and health risk at construction site,
- Traffic diversion and risk of existing building,
- Excavated soil disposal problems,
- Impact on Air Quality and Dust Generation,
- Increased water demand and Dewatering,
- Waste Water and Sewage
- Impact due to Supply of Construction Material,

- Disposal of Construction and Demolition Waste,
- Impacts due to batching plant and casting yard,
- Noise Pollution.
- Vibrations
- Subsidence
- Ecology
- Socioeconomic impacts
- Loss of Archeological Monuments

4.5.1 Topsoil Erosion, Pollution and Health Risk at Construction Site

The construction activity will involve clearing of the site. An effort shall be made to minimize alteration of topography by avoiding unnecessary cuttings and excavations. The terrain is almost flat. Every care has to be taken to avoid damage to the topsoil. It has to be preserved and utilized.

Problems could arise from dumping of construction spoils (Concrete, bricks) waste materials (from contractor camps) etc. causing pollution. However, it is proposed to have mix concrete directly from batching plant for use at site. It would minimize the pollution at construction site.

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

Employment of local labour shall be preferred. Problems could arise due to difference in customs of workers from outside and local residents.

4.5.2 Traffic Diversions and Risk to Existing Buildings

During construction period, partial traffic diversions on road will be required, as most of the construction activities are along the road. Hence, wherever possible, rather than completely blocking the roads it will be advisable 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 shall 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 elevated rail corridor does not pose any serious risk to existing buildings since there is safe distance between buildings and proposed corridor.

4.5.3 Impact on Topsoil:

The soil all along the alignment varies between clay to sandy. The topsoil removed during the leveling will be stacked separately and will be used during the greenbelt development. Vegetation and topsoil will be removed prior to commencement of bulk earthwork. The construction activities will result in loss of topsoil to some extent in the area. Apart from localized constructional impacts no significant adverse impact on the soil in the surrounding area is anticipated.

4.5.4 Problems of Excavated Earth

Excavated Earth: Along the elevated alignment, the excavation would be carried out for piers and their piling, construction of ramp, underground station and launching and reteival shaft. Excavated earth will be stacked properly at a maximum slope of 45^{o}. Adequate measures will be taken to prevent slope failures or land slides during execution. The soil would be used for refilling at various sites. If there would be some residual soil, it would be utilized by Project Authority for internal use for refilling low lying areas/ sites and, if surplus, it would be disposed off at designated locations as per Development Authority directions.

Huge quantity of earthwork would be excavated for which a large number of excavators and dumper trucks would be required to excavate and transport the soil to earmarked areas of disposal. Alternatively, users of excavated earth may also be explored in the city.

Underground sections are proposed between Rukan Pura to beyond Patna Junction for a length of 10355 m in Corriodor 1 and Patna Junction to Rajender Nagar for a length of 8115 m in Corridor 2 where the Tunneling is planned. This activity can lead to run off from unprotected excavated areas and can result in soil erosion, especially in the areas where the soil is prone to high erodability.

There will be generation of approx. 2.0 million m^3 of muck. This will have to be disposed off at the designated sites allotted by local Authorities viz., Patna Development Authority/ Patna Municipal Corporation with the approval of State Pollution Control Board and Land-owning Agency. Presently the site has not been identified but it shall be identified and allocated before start of construction activities.

Care will be taken not to allow any flow into the drainage system or any water body/stream. The topsoil shall also be disturbed during the construction stage due to excavation and movement of vehicles and equipments. Exposure of loose soil to rain water can increase turbidity in the run-off for a very short duration; however, this impact is limited to the excavated surfaces during the rainy season. After completion of the construction activity in depots, all the open areas shall be paved, which will reduce the risk of soil erosion.

4.5.5 Impact on Air Quality and Dust Generation

Impact of construction activity on air quality is a cause for concern mainly in the dry months due to settling of dust particles. The main sources of emission during the construction period are the movement of equipment at site and dust emitted during the leveling, grading, earthworks, foundation works, and other construction related activities. The dust emitted during the above-mentioned activities depend upon the type of soil being excavated and the ambient humidity levels. The impact is likely to be for short duration and confined locally to the construction site itself. The composition of dust in this kind of operation is however mostly coarse particles, inorganic and non-toxic in nature. These are not expected to travel long distance before settling. Exhaust emissions from vehicles and equipment deployed during the construction phase also result in marginal increase in the levels of SO_2, NOx, Particulates, CO and unburnt hydrocarbons. It may, therefore, be concluded that construction activities may cause changes in the particulate matter levels as well

as gaseous pollutants in some of the localised areas. The impact will be confined within the project boundary and is expected to be negligible outside the project boundaries. Proper upkeep and maintenance of vehicles, sprinkling of water at construction site, providing sufficient vegetation etc. are some of the proposed measures that would greatly reduce the impact on the air quality during the construction phase of the project. The impact will, therefore be reversible, marginal, and temporary in nature. Measures to control air pollution and dust are given in the EMP.

4.5.6 Increased Water Demand and Dewatering

During the construction phase, water will be required for construction purposes (for concrtete batching and curing) in the period of construction, which is expected to be about 4 years. In addition to this water will also be required for dust suppression and for meeting domestic water requirement of work foirce including drinking water. The water requirement during construction phase would be temporary and widely variable in nature. Possibility of availability of water, other than groundwater may also be explored for contruction phase. The source of water could be surface water from river Ganges, if permitted by Irrigation department. It is also proposed to adopt the techniques and equipments, which will further help in reduction of water demand during construction (Use of low water closets and cisterns, water saving showers & spray taps and adopting dry cleaning methods as far as practicable). Therefore, the impact on the water resources during the construction phase would be temporary and variable in nature.

Dewatering: The project corridors involve construction of underground portion in substantial length of 10.54 Km in Line 1 between Danapur and Khemni chak corridor and 7.926 Km in Line 2 between Patna station and New ISBT. Groundwater table is quite shallow and there will be requirement of dewatering of huge quantity of groundwater during construction. It is anticipated that there will not be any depletion of groundwater table due to continous dewatering in the area due to abundance of water along the underground corridors. Moreover, there is no possibility of any subsidence due to dewatering in the area along the proposed tunnels.

The identification of the potential users of dewatered groundwater shall be explored by PMRC at the time of construction. Simultaneously, this water may be used for construction activities of the project. The possibility of tying up with water supply department to use the dewatered water after primary treatment may also be explored.

4.5.7 Waste Water and Sewage

Impact on water quality during construction phase may be due to sewage generated from the construction work force stationed at the site. Temporary sanitation facilities like Bio-toilets will be set up for disposal of sanitary sewage generated by the work force as per the prevailing labour laws. Since, most of the construction work force will constitute of floating population, the demand of water and sanitation facilities will be very less and shall be managed by providing drinking water and sanitation facilities at the site during construction phase. Therefore, the overall impact on water quality during construction phase of proposed project is likely to be short term and insignificant and reversible.

4.5.8 Impact due to Supply of Construction Material

Metro construction is a material intensive activity. Huge quantity of different construction materials will be required for construction of metro corridor. Approximate Material Consumption in both the corridorsis as tabulated below:

S.No	Construction Material	Unit	Per Elevated Station	Per Underground Station	Per Km of Viaduct	Per Km of UG tunnel
1.	Concrete	Cum	13583	41288.7	16917.1	12133
2.	Cement (for concreting work)	MT	5172.5	13937.4	5249	3764.6
3	Steel (Structural and Non-Structural)	MT	1751.5	10657.9	2239.3	2836.2

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. It shall be ensured by contractors that source mine/ quarry shall be a legally registered mining lease having environmental clearance as per law. The materials shall be sourced from nearest mines to minimize the global warmng impacts. Primarly GHG emission reduction on account of modal shift from the project is being calculated. However, GHG emission reduction on account of energy efficiency in newer Metro stations has also been attempted.

4.5.9 Generation of Construction and Demolition Waste

Construction and demolition (C&D) debris is defined as that part of the solid waste stream that results from land clearing and excavation, and the construction, demolition, remodeling and repair of structures, roads and utilities. C&D waste includes concrete, stones and dirt generated during excavation (sometimes collectively referred to as "fill material" or rubble). C& D Waste may be generated from Pile caps, residual cement bags, residual steel scrap, excess construction material stacked at site etc.

It is estimated that C& D Waste will be generated to the extent of 9456 tonnes from viaduct, 1767 tonnes from tunnels, 9844 tonnes from elevated stations and 25846 tonnes from underground stations totaling to 46913 tonnes app.

Soil generated from construction works will be given to other agencies for land filling purposes. It is proposed to utilize the C&D waste at construction site. The waste shall be utilized in development of low-lying areas. Further, it is suggested that C&D waste processing facility shall be developed to recycle the waste generated and consequently recycled products can be uttilised in future construction works.

Inert waste such as cured mortar, bricks, tiles waste concrete, and mortar, left over aggregate and debris etc. generated during the construction phase shall be recycled and reused to the maximum extent possible. Alternatively, C & D waste may be used for back filling of low-lying areas as directed by authorities, leaving no significant impact on environment. C& D Waste Board shall be displayed on site as part of C & D waste management.

4.5.10 Impacts due to Casting Yard and Batching Plant

Batching plant and casting yards are required for casting of girders and segments to be used in construction of metro corridors. During construction phase there would be establishment and operation of Batching Plant and Casting Yard which would be located in an area designated and allotted by Local Develpment Authorities. Number of batching plant and casting yards is anticipated to be ten. There would be requirement to get NOC (Consent to Establish) and (Consent to Operate) under Water and Air Acts from Bihar State Pollution Control Board. Simultaneously, there would be requirement to get the authorization for storage and handling of hazardous chemicals to store and handle used oils and other such materials.

There would be significant movement of men, material and machinery in batching plant and casting yard. Major water requirement will be at Batching plant and casting yard. It is expected that both batching plant and casting yard would be located at same complex. Huge quantity of Cement, aggregates and other construction materials would be used in each batching plant and casting yard. There would be generation of dust, noise, flue gases and other contaminants from the working of heavy machinery for handling and transporting the construction materials. The mitigation measures have been elaborated in EMP.

4.5.11 Noise Pollution

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. Heavy construction traffic for loading and unloading, fabrication and handling of equipment and construction materials are likely to cause an increase in the ambient noise levels. The areas affected are those close to the site. At the peak of the construction, marginal increase in noise levels is expected to occur locally at the construction site. The activities, which produce periodic noise, are as follows:

- Foundation, pillars and Viaducts construction;
- Infrastructure such as Station Buildings and Yards construction; and
- Tunnelling construction for underground part.

The typical noise levels of some construction equipments are given in **Table 4.2.**

Table 4.2: Typical Noise Levels of Construction Equipments

Particulars	Noise Levels dB(A)
Earth Movers	
Front End Loaders	72-84
Backhoes	72-93
Tractors	76-96
Scrapers, Graders	80-93
Pavers	86-88
Trucks	82-94
Material Handlers	
Concrete mixers	75-88
Concrete pumps	81-88
Cranes (movable)	75-86
Cranes (derrick)	86-88
Stationary Equipment	
Pumps	69-71
Generators	71-82
Compressors	74-86

The peak noise levels from continuous construction activity may be about 85-90 dB (A). At places where the alignment is passing through the populated areas there the noise levels shall have some impact whereas the locations where the alignment is passing through the fields etc there the impact of noise shall be insignificant.

There are many middle and highrise buildings in vicinity of elevated corridor between Khemni chak and Zero-mile stations on line 2 between Patna station and New ISBT which may experience some noise disturbance but these structures are commercial structures. Care shall be taken to avoid noise during construction near middle and high-rise buildings as well as sensitive receptors as given in able 3.14.

The noise control measures during construction phase include provision of caps on the equipment and regular maintenance of the equipment. Workers would be provided with earmuffs and earplugs. Overall, the impact of noise generated on the environment is likely to be insignificant, reversible and localized in nature and mainly confined to the daytime

4.5.12 Vibrations

The construction machinery usually generates Vibrations which may lead to potential annoyance or interference with vibration sensitive activities. Various types of construction equipment have been measured internationally under a wide variety of construction activities with an average of source levels reported in terms of velocity as shown in **Table 4.3** In this table, a crest factor of 4 (representing a PPV-rms difference of 12 VdB) has been used to calculate the approximate rms vibration velocity levels from the PPV values.

Table 4.3 Vibration Source Levels for Construction Equipments

Equipment		PPV at 25ft (Inch/sec)	Approximate L_v^f at 25 ft
Pile Driver (Impact)	Upper range	1.518	112
	Typical	0.644	104
Pile Driver (Sonic)	Upper range	0.734	105
	Typical	0.170	**93**
Clam shovel drop (slurry wall			0.202
Hydromill (slurry wall)	In soil in rock	0.008	**66**
Vibratory Roller		0.017	75

Jackhammer	0.035	**79**
Small bulldozer	0.003	**58**
[†] RMS velocity in decibels (VdB) re 1 micro-inch/second		

The primary concern regarding construction vibration relates to potential damage effects. Possible effects of Construction vibration are given in **Table 4.4** for various structural categories.

Table 4.4 Effects of Construction Vibration

Peak Particle Velocity fin/sec)	**Effects on Humans**	**Effects on Buildinas**
<0.005	Imperceptible	No effect on buildings
0.005 to 0.015	Barely perceptible	No effect on buildings
0.02 to 0.05	Level at which continuous vibrations	No effect on buildings
	begin to annoy in buildings	
0.1 to 0.5	Vibrations considered unacceptable for people exposed to continuous or long- term vibration	Minimal potential for damage to weak or sensitive structures
0.5 to 1.0	Vibrations considered bothersome by most people, however tolerable if short term in length	Threshold at which there is a risk of architectural damage to buildings with plastered ceilings and walls. Some risk to ancient monuments and ruins
1.0 to 2.0	Vibrations considered unpleasant by most people	U.S. Bureau of Mines data indicates that blasting vibration in this range will not harm most buildings. Most construction vibration limits are in this range
>3.0	Vibration is unpleasant	Potential for architectural damage and possible minor structural damage

Care should be taken to stagger the activities to minimize the vibration impact of construction machinery.

4.5.13 Subsidence

Subsidence is the sudden sinking or gradual downward settling of the ground's surface with little or no horizontal motion. The definition of subsidence is not restricted by the rate, magnitude, or area involved in the downward movement. When there is tunneling or huge underground excavation making the substantial gap in strata there are chances of subsidence of upper starta The construction of underground section involves construction of twin tunnels of 6 m diameter each. The construction will be done using TBM. Considering the local geology, groundwater abundance and the working technology it is anticipated that the probilibility of subsidence is very low. Since at a time the exposed cut area is about 1.5 m and cutting and segment installation continues simultaneously.

4.5.14 Impact on Ecology

Ecological impact is the effect that something has on living beings, i.e., organisms, and their non-living environment. The project site is not located in the vicinity of any forest area, ecosensitive locations, any protected habitats etc. The project is located in the city area to provide facilities to the residents of the city.

The initial construction works at the project site involves land clearance, cutting, filling and leveling. These activities result in loss of vegetation (Trees & shrubs). The alignment passes through area having trees at many places. Only those trees would be felled which are essential for construction activity. The project is likely to fell 911 trees on both the alignments. The trees to be felled are common trees like Shisham, Pipal, Neem, Babool etc,

No disruption to migration routes, habitat fragmentation, traffic accident of wildlife and livestock is anticipated. Project activities are likely to affect the avifauna by disturbance to nesting of birds which can be minimized by planting compensatory trees in the vicinity of felled trees. The construction shall not require removal of herbaceous vegetation which generally leads to loosening of topsoil. However, such impacts would be primarily confined to the project site during initial periods of the construction phase and would be minimized through adoption of mitigative

measures like paving and surface treatment, water sprinkling and appropriate plantation programme. As mentioned earlier, only those trees would be felled which are essential for construction activity and compensatory plantation would be done appropriately. There is no major water body all along the proposed alignment. The wastewater generated in the labour colony will be treated and used in the green cover development. Hence, no impact on aquatic ecology is envisaged.

4.5.15 Socio- Economic Impacts

Socio-economically this project would affect the society both positively as well as negatively. It would facilitate the people to get connected to the industrial and commercial hubs both existing as well as forthcoming. Simultaneously it is affecting the people whose land or other property has to be acquired by the project. The matter has been discussed and analysed in details in the Social Impact Assessment.

4.5.16 Loss of Historical and Cultural Monuments

No historical/ cultural monuments will be lost as a result of the proposed development. As per the provisions of Ancient Monuments and Archaeological Sites and Remains (Amendment and Validation) Act, 2010 construction activities around the centrally protected monuments and sites are regulated as Prohibited area (Section 20A) upto 100m from boundary in all directions and Regulated Area upto 300 m (Section 20B). Although the depth of the proposed alignment is generally more than 25m below the ground, care has to be taken during construction activity that no impact shall be felt on these structures.

4.6 Impacts Due to Project Operation

Along with many positive impacts, 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,
- Vibrations,
- Water supply and sanitation at Stations,
- Station refuse disposal and sanitation,
- Pedestrianization and visual issues

- Impact due to oil pollution

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. The main sources of noise are traction motors, cooling fans, wheel-rail interaction, electric generator and miscellaneous noise from rolling stock. Wherever vehicular parking will be proposed at stations, noise levels are expected to increase substantially during the morning and evening hours due to starting, idling and roaring of vehicles. As the alignment runs parallel to existing NH hence the noise levels due to road is already higher than the ambient noise levels. However, because of the metro there is reduction of vehicular traffic, the road traffic noise is expected to come down. It could be concluded that noise in the operation phase of the project would have minor or no negative impact. Suitable noise barriers may be provided if required due to experiencing higher noise levels by receptors as given in Table 3.14.

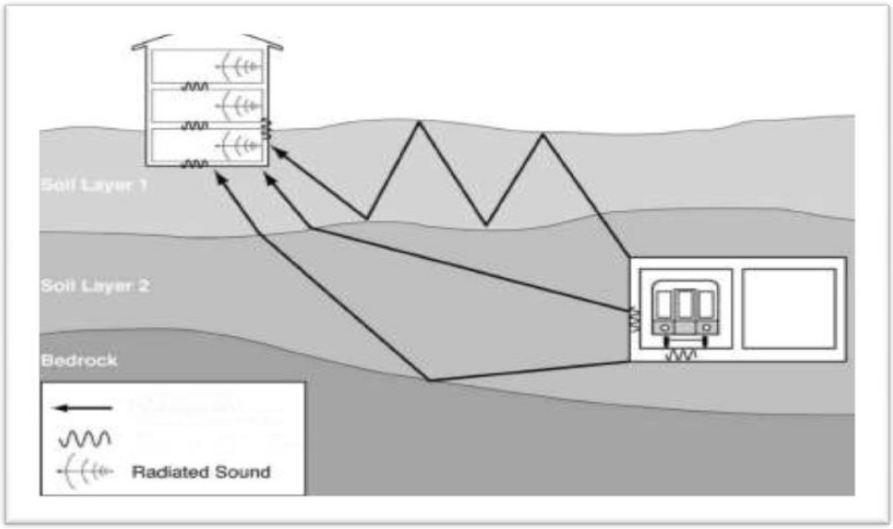
4.6.2 Vibrations

The effects of ground-borne vibration include perceptible movement of the building floors, rattling of windows, shaking of items on shelves or hanging on walls, and rumbling sounds. In extreme cases, such vibration can damage buildings and other structures. In addition, the sound reradiated from vibrating room surfaces, referred to as ground-borne noise, often will be audible in the form of a low-frequency rumbling sound. The train wheels rolling on the rails create vibration energy transmitted through the track support system into the track bed or track structure. The amount of energy that is transmitted into the track structure depends strongly on factors such as how smooth the wheels and rails are and the resonance frequencies of the vehicle suspension system and the track support system.

The vibration of the track or guideway structure excites the adjacent ground, creating vibration waves that propagate through the various soil and rock strata to the foundations of nearby buildings. The vibration propagates from the foundation throughout the remainder of the building structure. The maximum vibration amplitudes of floors and walls of a building often occur at the resonance

frequencies of those building elements. The propagation of Vibrations is shown in **Figure 4.1** for underground section of the corridor.

Figure 4.1 Propagation of Ground Borne Vibrations into Buildings



The criteria for environmental impact from ground-borne vibration and noise presented in **Table 4.5** are based on the maximum levels for a single event. The criteria account for variation in land use as well as the frequency of events, which can differ widely among high-speed rail projects. Most experience is with the community response to ground-borne vibration from rail rapid transit systems with typical headways in the range of 3-10 min and each vibration event lasting less than 10sec.

Table 4.5 Ground-Borne Vibration (GBV) and Ground-Borne Noise (GBN) Impact Criteria for General Assessment

Land Use Category	GBV Impact Levels (VdB re 1 μ inch/sec)			GBN Impact Levels (dB re 20 μPascals)		
	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[5]	N/A[5]	N/A[5]

Category 2: Residences and buildings where people normally sleep.	72 VdB	75 VdB	80 VdB	35dBA	38dBA	43dBA
Category 3: Institutional land uses with primarily daytime use.	75 VdB	78 VdB	83 VdB	40dBA	43dBA	48dBA

Source: Transit Noise & Vibration Impact Assessment Report (2006)

Notes:

1. Frequent Events is defined as more than 70 vibration events of the same kind per day.
2. Occasional Events is defined as between 30 and 70 vibration events of the same kind per day.
3. Infrequent Events is defined as fewer than 30 vibration events of the same kind per day.
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 not sensitive to ground-borne noise.

Human response to Different levels of Ground Borne Noise and Vibrations has been given in **Table 4.6**.

Table 4.6 Human Response to Different Levels of Ground-Borne Noise and Vibration

RMS Vibration Velocity	Noise Level		Human Response
	Low Freq1	Mid Freq2	
65 VdB	20dBA	35dBA	Approximate threshold of vibration perception for many humans. Low-frequency sound usually inaudible, mid-frequency sound marginally acceptable for quiet sleeping areas.

75 VdB	30dBA	45dBA	Approximate dividing line between barely perceptible and distinctly perceptible. Many people find train vibration at this level unacceptable. Low-frequency noise acceptable for sleeping areas, mid-frequency noise annoying in most quiet occupied areas.
85 VdB	40dBA	55dBA	Vibration acceptable only if there are an infrequent number of events per day. Low-frequency noise generally unacceptable for sleeping areas, mid-frequency noise unacceptable even for infrequent events with institutional land uses such as schools and churches.

Source: Transit Noise & Vibration Impact Assessment Report (2006)

Notes:

1. Approximate noise level when vibration spectrum peak is near 30 Hz.
2. Approximate noise level when vibration spectrum peak is near 60 Hz.

The train wheels rolling on the rails will create vibration energy transmitted through the track support system into the track bed or track structure. There is possibility of vibration impact in the vicinity of underground portion of the corridor where it is passing below or very close to residential properties.

4.6.3 Water Supply and Sanitation

Public facilities such as water supply, sanitation and washrooms are very much needed at the stations. The water requirement for stations would be for drinking, toilets, cleaning and also for other purpose like AC. Water shall also be required for fire fighting.

The water demand for all 26 stations (13 elevated and 13 underground) and 1 Depot works out as follows: 13 x 16 kld = 208 kilo liters per day(kld) for elevated stations, 13x 100= 1300 kld for underground stations and 200 kld for depot. Thus, the total water demand during operation shall be about 1708 kiloliters per day for both corridors. The water requirement for the stations will be met through the

public water supply system or purpose built tubewells after taking necessary approvals from CGWA in Patna city.

4.6.4 Station Refuse

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

- Garbage,
- Rubbish, and
- Floor Sweepings.

Food and paper waste are likely to be generated at stations, Depot etc during operations. It is expected that solid waste of about 0.8 – 1.2 cum/day will be generated at stations. At elevated stations, the solid waste generation is more due to airborne dust. The maintenance of adequate sanitary facilities for temporarily storing refuse on the premises is considered a responsibility of the project authorities.

The storage containers for this purpose need to be designed and these should be equipped with side handles to facilitate handling. To avoid odour and the accumulation of fly-supporting materials, garbage containers should be washed at frequent intervals**.** The waste shall be disposed off daily to Municipal Dust Bins which shall be cleared by municipal authorities. The paper wastes shall be recycled through authorized recyclers and the food wastes shall be treated through organic waste converter.

4.6.5 Visual Impacts

The introduction of metro implies a change in streets/ fields 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. Since a low profile would cause the least intrusion, the basic elevated section has been optimised at this stage itself. Care shall be taken to minimize the visual disturbance and aesthetics by designing the stations and viaduct aesthetically.

4.6.6 Impact due to Hazardous Waste

During the operation of metro, change of lubricants, cleaning and repair processes, in the maintenance Depot cum workshop for maintenance of rolling stock can lead to Oil spillage leading to Oil Pollution. In order to curb oil pollution a grit chamber shall be constructed to trap the spilled oil for settling of suspended matter. The collected oil shall be properly stored in the impermeable container and auctioned to CPCB/SPCB authorized recycler, so as to avoid any ground water contamination.

4.7 Impacts Due to Depot

The depot proposed near New ISBT will have following facilities:

- Washing Lines,
- Operation and Maintenance Lines,
- Workshop, and
- Offices.
- Property development area

These facilities will generate water and noise issues. The depot area is almost plain having some low-lying areas as well which may have to be filled up. The earth from underground metro corridor tunnelling can be utilised to fill the deport site. Problems anticipated at depot sites are:

- Water supply,
- Hazardous waste generation,
- Noise Pollution,
- Sanitation,
- Effluent Pollution, and
- Surface drainage.

4.7.1 Water Supply

Water supply will be required for different purposes in the depot. The water requirement will be 200 kld in depot. Based upon the input water, further treatment can be carried out to meet the standard as required in tain washing and for other purpose.

- Wastewater from Depot
- ETP and STP

4.7.2 Hazardous waste generation

Hazardous waste would mainly arise from the maintenance of equipment. These may include, but not be limited to, the following:

- Used engine oils, hydraulic fluids and waste fuel;
- Spent mineral oils/cleaning fluids from mechanical machinery;
- Spent acid/alkali; and
- Spent solvents/solutions, some of which may be derived, from equipment cleaning activities.

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 should 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 vibration of concrete structures also radiates noise. Since the activities are restricted well within the depot boundary, no impact on the ambient noise is anticipated. However, to protect the work force against occupational noise PPE should be provided.

4.7.4 Solid Waste

Solid waste will be generated from the Depot site which will be taken by the cleaning contractor weekly and disposed to the Municipal waste disposal sites.

Sludge is expected to be generated from ETP/STP that will be stored in leak proof containers and disposed off as per State Pollution Control Board site.

Oil and grease will be produced from Depot which will be disposed off through approved re-cyclers.

Iron turning of the Portal wheel Lathe (PWL) for the wheel profiling will also be generated from the Depot. Authorized recyclers shall be engaged for disposal of hazardous wastes.

4.8 E Wastes

E-waste comprises discarded electronic appliances, of which computers and mobile telephones are disproportionately abundant because of their short lifespan. Other E waste contains tubelights, CGF, Timer capacitors, contactors, Relay, Detectors, Indicators, Float switch/ sockets, plastic items, electronic ballasts, addressabale detectors, LCE boards/ PCBs, V3F Drives, Computer servers, monitors, mouse, TVs hard disks etc. E-waste contains valuable metals (Cu, platinum group) as well as potential environmental contaminants, especially Pb, Sb, Hg, Cd, Ni, polybrominated diphenyl ethers (PBDEs), and polychlorinated biphenyls (PCBs). Burning E-waste may generate dioxins, furans, polycyclic aromatic hydrocarbons (PAHs), polyhalogenated aromatic hydrocarbons (PHAHs), and hydrogen chloride. The chemical composition of E-waste changes with the development of new technologies and pressure from environmental organisations on electronics companies to find alternatives to environmentally damaging materials.

E-waste generated from the operation and maintenance activities shall be disposed through authorized e-waste recyclers/collectors. E-waste describes discarded electrical or electronic devices. Used electronics which are destined for reuse, resale, salvage, recycling, or disposal are also considered e-waste.

4.9 Positive Environmental Impacts

The Patna Metro Project being an infrastructure project is designed to promote an efficient and commuter friendly transport sector for the benefit of the communities at large. It is expected to bring in a number of positive impacts on the environment and the general public. Depending upon their significance and magnitude, some of them could be considered as tangible while others could be viewed as intangible benefits. There are several positive impacts (both tangible and intangible), which are expected from the proposed metro corridor. Most of the positive benefits would occur during the operation phase, some of the positive benefits expected from the proposed corridors have been given below:

- Employment Opportunities,
- Enhancement of Economy,
- Mobility,
- Traffic Congestion Reduction,
- Reduced Fuel Consumption,
- Reduced Air Pollution,
- Reduction in travel time resulting in increased accessibility
- Sense of pride to the city and country having a world-class facility
- Presence of comfortable mode of transportation which shall be Safer than road transportation
- Reduction in road accidents resulting in reduced death and injury during road accidents.

4.9.1 Employment Opportunities

The project is likely to be completed in a period of about 4 years. During this period manpower will be needed to take part in various activities. Execution of a project of this nature and scale would provide employment opportunity to about 4000 people during construction corridor and at an average of 35 people per km. The direct employment during operation for this corridor works out as 1125 persons. Thus, the project would provide substantial direct employment. Besides, more people would be indirectly employed in allied activities and trade and commerce.

4.9.2 Enhancement of Economy

The proposed transport facility of the project will facilitate rural population to move quickly towards urban centres and return. With the development of project corridor, it is likely that more people will be involved in trade, commerce and allied services. Project will, however, make it convenient for more people to move to industrial and commercial hubs proposed to be enroute and/ or in proximity of the proposed corridor.

4.9.3 Mobility

The metro network increases the mobility of people at faster rate. The proposed corridor will provide more people connectivity from east to west and north to south

section of Patna city. DPR has predicted daily PHPDT for different horizon year's upto 2051. Thus, there will be significant mobility of people within city area.

4.9.4 Traffic Congestion Reduction

Trip length for passengers in metro have been estimated and has been mentioned in Detailed Project Report (DPR). The same has been reproduced below. Based on it, it is anticipated that large share of passengers will travel from 2km to 12 km through metro. Hence, it will contribute to reduced traffic on road thereby resulting in less traffic congestion.

Trip Length (Km)	% Distribution
0-2	9.62%
2-5	51.50%
5-12	34.88%
>12	4.0%

4.9.5 Reduced Fuel Consumption

Due to implementation of the Metro Rail Project, the number of vehicles on the road will be reduced which in turn results in the reduction of fuel consumption. The reduced vehicle km for the years 2024, 2031, 2041 and 2051 is given in **Table 4.7**

Table 4.7. Annual Savings in Fuel Consumption

Fuel	2024	2031	2041	2051
Diesel (Million Litres)	4.75	6.84	8.65	10.34
Petrol (Million Litres)	3.06	46.53	62.18	77.00
LPG (Million Kg)	1.74	2.54	3,31	4.10

4.9.6 Reduced Air Pollution

Air pollution would be reduced due to reduction in exhaust from vehicles as a result of diversion of mode of transport.

The metro is rail-based mass transit system and replaces partially operations of other mode of transports, operating under mixed traffic conditions. Since metro run by electricity and have high passenger carrying capacity, it is one of least polluting

mode of transport. **Table 4.8** depicts the reduction in pollution due to reduction in vehicle-km on the roads.

Table 4.8 Pollution Reduction in Tonnes per year

Pollution	2024	2031	2041	2051
CO	2635.15	3669.42	4925.76	6161.75
HC	1046.76	1444.72	1952.72	2432.15
NOx	447.43	613.79	821.13	1009.00
PM	87.15	120.62	162.29	202.19
CO_2	89345.83	126481.95	166903.05	197750.78

For calculating the daily vehciles off the raod, vehicle km and mode wise trip lengths have been taken from the Detailed Project Report (DPR). Mode wise number of daily vehicles off the road for different horizon years have been ascertained and tabuled below. It is observed that of the total number of vehicles replaced, 2-wheelers account for the highest share, followed by 3-wheelers and car + taxies. This shift in other mode of vehciles to metro will have many positive impacts including reduction in fuel consumption, air pollution, GHG emisisons etc.

Table 4.9 Daily Vehciles Off the Road

Mode	2024	2031	2041	2051
Buses	3,714	6,055	6,730	8,156
2-Wheeler	3,47,323	5,66,181	6,29,314	7,62,622
Car + Taxi	52,474	85,539	95,077	1,15,217
3-Wheeler	1,01,528	1,65,503	1,83,958	2,22,925
Total	**5,05,039**	**8,23,278**	**9,15,079**	**11,08,920**

The above values have been calculated on the basis of Ridership, Modal Share and Occupancy which have been provided in the Patna Metro DPR at Page No. 0-3 (Table 0.1), 3-33 (Figure 3-21) and 20-6 (Table 20.9) respectively and the same are reproduced below:

Table 4.10 Daily Trips on Metro System

S. No.	Corridor Name	Daily Trips			
		2024	2031	2041	2051
1.	East-West Corridor: Danapur - Mithapur via Patna Railway Station	543022	889674	993623	1231631
2.	North-South Corridor (Patna Railway Station - New ISBT via Gandhi Maidan)	331460	535844	590850	688481
Total Daily Trips		**874482**	**1425518**	**1584473**	**1920112**

Fig 4.2 Distribution of Passenger Trips By Modes (Excluding Walk Trips)

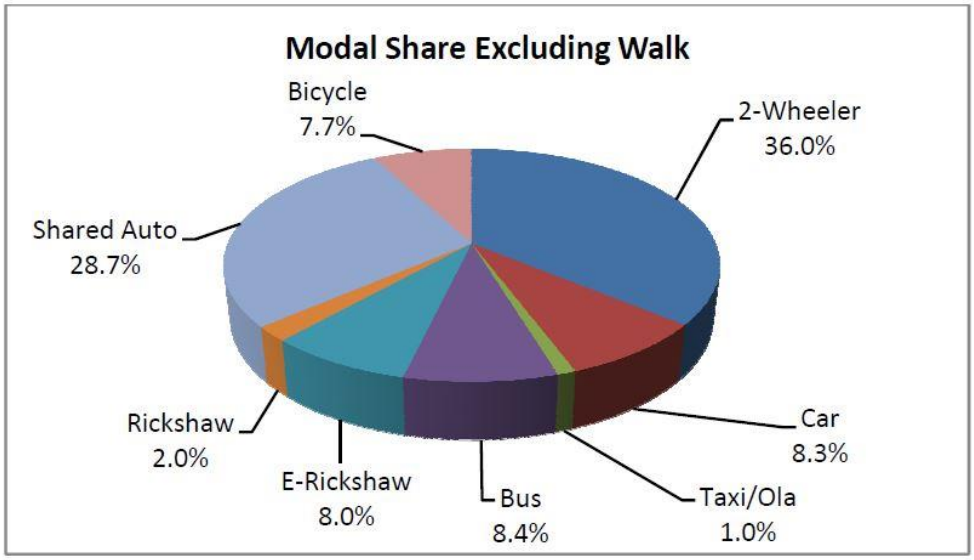


Table 4.11 Mode Wise Operational Parameters – Metro

Mode	Average Lead KM	Veh-KM/ Day	Average Speed (Km/Hr)		Occupancy
			Without MRTS	With MRTS	
Mini Bus	4.77	150	10	13	24
Car	4.97	13	18	24	1.8
2wh	4.97	13	18	24	1.1
Auto/Taxi	4.77	125	16	22	3

The project will reduce air pollution which has been quantified. The project may go for availing UNFCCC incentive schemes for the project once the project becomes operational.

4.10 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 many 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 4.12**.

Table 4.12 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.	Socio-economic Impacts	*		*
v.	Loss of Trees	*		
vi.	Drainage & Utilities Problems	*		
vii.	Impact on Physiography and Topography		*	
B.	**Impact due to Project Design**			
i.	Platforms - Inlets and Outlets		*	

S. No.	Parameter	Negative Impact	No Impact	Positive Impact
ii.	Ventilation and Lighting		*	
iii.	Station Refuse	*		
iv.	Risk due to Earthquakes		*	
C.	**Impact due to Project Construction**			
i.	Top Soil Erosion, Pollution and Health risk	*		
ii.	Traffic Diversions and	*		
iii.	Risk to Existing Buildings	*		
iv.	Problems of Soil Disposal and Seepage Risk	*		
v.	Dust Generation	*		
vi.	Increased Water Demand	*		
vii.	Supply of Construction Material	*		
viii.	Construction and Demolition Waste	*		
ix.	Batching Plant and Casting Yard	*		
x.	Noise	*		
D.	**Impact due to Project Operation**			
i.	Oil Pollution	*		
ii.	Noise	*		
iii.	Water supply and sanitation	*		
iv.	Pedestrian Issues		*	
v.	Visual Impacts		*	
vi.	Station Illumination		*	
vii.	Employment Opportunities			*
viii.	Enhancement of Economy			*
ix.	Mobility			*
x.	Safety			*
xi.	Traffic Congestion Reduction			*
xii.	Less fuel Consumption			*
xiii.	Less Air Pollution			*
xiv.	Carbon dioxide Reduction			*
xv.	Reduction in Buses			*
xvi.	Reduction in Infrastructure			*

CHAPTER – 5
ANALYSIS OF ALTERNATIVES

The purpose of analysis of alternatives is to find the most effective way of meeting the need and purpose of the project, either through enhancing the environmental benefits of the proposed activity and or through reducing or avoiding potentially significant negative impacts, so that project will become environment as well as people-friendly. The primary objectives of an analysis of alternatives are to identify alternate project options at a systemic (technology, route or alignment, *etc.*), and as well as engineering (materials, construction methods, operating practices, *etc.*) levels. An analysis of alternatives, conducted early into the project design and planning stage, helps identify more cost-effective alternatives, reduce adverse impacts and risks, improve performance and validate the appropriateness of the selected option.

In the present Patna metro project two corridors have been finalized 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.

The 'with' and 'without' project scenarios are analyzed concerning the development of the metro routes by the backdrop of the requirement of reliable quality infrastructure for safe and faster travel. With project, it will provide better and faster connectivity and will ensure that people from areas covered by the project can move in and out of the areas more efficiently.

Without this project, it is expected that there will be an increase in air pollution and exhaust emission due to slow-moving traffic and congestion. Travel will take longer thus impacting productivity and reducing the economic growth of the area.

Overloading of existing transport infrastructure will also affect safety and lead to loss of human life due to the increase in accidents.

5.1 LONG TERM SCENARIO "WITH" AND "WITHOUT" PROJECT

Qualitative analysis of the long-term scenarios likely to occur *"with"* and *"without"* project scenario is presented in **Table 5.1**. The *"with"* project scenarios will, however, occur only if the recommendations provided in mitigation measure and EMP for the construction stage will be followed and all construction activities will be carried out according to principles of Environment and social Friendly Construction.

Table 5.1: "With" and "Without" Project Scenarios.

Scenario type	Long-Term Scenario *"With"* Project	Long-Term Scenario *"Without"* Project
Physical Environment		
Atmosphere and Climate	Travel time and traffic congestion will reduce as a result of the proposed new metro corridor. Overall, an insignificant level of air pollution. Due to the small section of the route, no change in climatic condition is anticipated	Congested road will consume more travel time and will increase air pollution/ exhaust emission. No change in climatic condition
Noise and vibration	Noise will reduce due to the underground routes, but localized vibration will slightly increase	Both noise and vibration will deteriorate further
Soil and drainage	No major impact on existing soil conditions. There may be a significant change in underground drainage pattern due to the proposed route which will adversely impact the localized environmental condition.	As it is there are no changes in present problems associated with inadequate drainage.

Scenario type	Long-Term Scenario *"With"* Project	Long-Term Scenario *"Without"* Project
Geology and Seismology	No significant Impact envisages on seismology however, the geology will get impacted due to tunnel construction but as compared to the project benefit it will be negligible.	No change as it is
Ecological Environment		
Flora	Due to proposed project around 911 trees will be felled. However, 3612 saplings will be planted and maintained.	No change in vegetation and the number of trees. No change in present land use
Fauna	Due to proposed alignment, there is no impact on fauna	Continued, and possibly increased disturbance to the fauna
Social and Cultural Environment		

Scenario type	Long-Term Scenario *"With"* Project	Long-Term Scenario *"Without"* Project
Social and Cultural Environment	Increased comfort and safety while travelling. An improved business environment for those living along the project corridor. Once the project becomes operational, it will result in the reduction of GHG emission. Significant reduction in fuel consumption due to expected modal shift in vehicles The proposed project will cause acquisition of about 38.84 Ha private land. A total of 146 families are likely to be displaced and resettled/ rehabilitated due to the project.	Travelling may increase time, thereby transportation costs will increase. Reduction in comfort and safety due to congestion and deterioration in road condition. Business opportunities remain largely the same as before. No reduction in GHG emission. Higher fuel consumption due to the increased number of private vehicles. There will be no displacement
Connectivity	Improve the connectivity between the various interlinked centers.	No change
Economic Situation		
Financial Implications	Higher capital costs for underground routes and using Environmentally and socially Friendly techniques during civil work. Costs will also be incurred for the training of PIU officials if required.	No capital costs. However, increasing road maintenance and vehicle operating costs as road deteriorates and as travel times increase.
Institutional Requirements		

Scenario type	Long-Term Scenario *"With"* Project	Long-Term Scenario *"Without"* Project
Training of PIU	Training needs to be provided to relevant PIU officials to improve their environmental and social monitoring capacity during and after project construction. More staff will need to be recruited at the PIU office to enable smooth flow of all paperwork with regard to implementation of environmental and social policies and regulations as per the MOEFCC and JICA guidelines	No institutional strengthening is required.
Overall		
	Long term improved socio-economic and environmental conditions but an increase in expenses for project activities during project construction. However, with project scenario have lots of positive impacts like – reduced travel cost, reduced travel time, reduced exhaust emission, reduced GHG emission, also enhancing employment and economic growth of the area.	Small deteriorations in environmental conditions, no increase in economic opportunities and increased expenses associated with maintenance.

In case the 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) emission 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. Without the project, congestion constrains the long-term attractiveness and potential impact of the regular bus service and with project scenario avoiding congestion problems appear to be an excellent alternative for public transport. The construction of the project will offer more equitable access to transport choices for passengers wishing to access employment, education or commercial facilities.

Development of new high capacity, high-frequency public metro route system from Danapur to Khemni Chak and Patna Station to New ISBT corridors have the potential to cater for existing and future passenger demand and will relieve congestion on the road corridor and the existing public transport network. Besides, this form of public transport will significantly benefit the environment. The project will, therefore, be of benefit to the population in the project area.

Further analysis of alternatives considered as per old DPR prepared by RITES in December 2018 and revised Alignment (by DMRC) along with No project alternative which have been analyzed for both the corridors.

5. 2 Alternative Scenarios for Danapur to Khemni Chak Corridor

Alternative 1

No project

Alternative 2 (as per RITES DPR)

This corridor was proposed between Danapur and Mithapur having 12 stations in a length of about 16.9 Km via Saguna Mor, Rukanpura, Raja Bazar, Zoo, Patna Station and Mithapur in the DPR. One depot was planned at Aitwarpur.

On Danapur- Mithapur alignment five alternatives were considered in a length of about 2.7 Km near elevated road between Jagdev Path to Sheikhupura Mor. Main route for all the alternatives is same; however, possibility of elevated and UG alignment is explored to pass through the stretch of elevated road from Jagdev Path to Sheikhpura Mor. Alternative 1: Single viaduct in single height (ruled out); Alternative 2: Split viaducts in single height (ruled out); Alternative 3: Split viaducts in double height (ruled out); Alternative 4: Split underground tunnel in both side (ruled out); and Alternative 5: Underground tunnel in one side (recommended).

Alternative 3 (as per Revised Alignment)

The corridor is proposed from Danapur to Khemni Chak via Saguna Mor, Rukanpura, Zoo, Patna Station, Mithapur, Jaganpura and terminates at Khemni Chak. The Khemni Chak will be the interchange station for both the corridors. Separate Depot is not proposed for this corridor and the Depot proposed near New ISBT for Patna Station- New ISBT corridor will be used for this corridor also.

Comparison of Alternatives

Comparison of alternatives in corridor 1 is given in Table 5.2. It is evident from the above that all the alternatives have some advantage and disadvantage in terms of cumulative environmental and social impact. On the assessment of the advantages and disadvantages of the three alternatives and certain limitation, it is considered that **Alternative 3** is the preferred option. The comprehensive comparison of both alternatives is summarized and presented in Table below:

Table 5.2: Comprehensive comparison of alternatives of Corridor 1

Sr. No.	Issues	Alternative 1 No Project	Alternative 2 (as per RITES DPR)	Alternative 3 (as per Revised Alignment)
1.	Length and no. of stations	No Project	16.94 km and 12 stations	17.933 km and 14 stations (including 2

Sr. No.	Issues	Alternative 1 No Project	Alternative 2 (as per RITES DPR)	Alternative 3 (as per Revised Alignment)
				interchange stations)
2.	Length of elevated section and no. of elevated stations	Nil	5.48 km and 3 stations	7.393 km and 8 stations
3.	Length of underground section and no. of underground stations	Nil	11.20 Km and 8 stations	10.54 Km and 6 stations
4.	Length of at grade section and no. of at grade stations	Nil	0.26 km and 1 station	0
5.	No. of Depots	Nil	1	0
6.	Safety	No specific safety standard on Roads	High Safety Standard	High Safety Standard
7.	Permanent Land requirement	Nil	24.39 ha	3.251 ha
8.	No. of trees to be felled	Nil	490	551
9.	No. of ASI protected archaeological structures within the 100m periphery (prohibitory zone) of the alignment	Nil	Nil	Nil
10.	Impact on the	Employment	Loss of trees	Loss of trees

Sr. No.	Issues	Alternative 1 No Project	Alternative 2 (as per RITES DPR)	Alternative 3 (as per Revised Alignment)
	Environment and Social Issues	Opportunity Stagnant Economy Road Congestions Increased Air Pollution Safety and Accident Increment Reduced social interactions Road Infrastructure	C & D waste management No loss on Fauna	C&D waste management No loss on Fauna
11.	No. of structures affected	Nil	88	19
12	Issues of noise and vibration	Noise increment due to traffic and honking	Issue of noise during construction and operation which can be mitigated in scientific manner.	Issue of noise during construction and operation which can be mitigated in scientific manner.
13	Conclusion	This option is inferior to Alt 2 and 3	This plan is inferior to Alt 3.	This is the most desirable plan.

5.3 Alternative Scenarios for Patna Station- New ISBT Corridor

Alternative 1:

No Project

Alternative 2 (as per RITES DPR)

Patna Railway station to PMCH elevated, University to Rajendra Nagar underground and then elevated up to ISBT

In this alternative, the corridor takes-off from Patna Railway station along Frazer road as elevated towards Dak-Banglow Chowk, Akashvani, Gandhi Maidan, PMCH as elevated track. After PMCH, a ramp is proposed along the boundary line of PMCH & university to ramp down for underground. Then alignment runs underground through Dinkar Chowk and Rajendra Nager Railway station. After Rajendra Nagar station ramp is again proposed to come out for elevated section near Railway Coach Maintenance. Alignment then runs as elevated for remaining section upto proposed ISBT through Gandhi Setu, Zero mile and Bodhgaya road.

Alternative 3 (as per Revised Alignment)

Patna Railway station to Rajendra Nagar Underground with remaining part Elevated up to ISBT through Malahi Pakdi

The proposed alternative was between Patna Station to ISBT via Gandhi Maidan, PMCH, Patna University and Rajendra Nagar. In this route, the underground section is from Patna station to Rajendra Nagar. After Rajendra Nagar station ramp is proposed near Doctor's colony Malahi Pakri to get elevated and then runs elevated upto proposed ISBT through Khemni Chak- Bhootnath- Zero Mile. A depot is proposed near ISBT. Comparison of alternatives in corridor 2 is given in Table 5.3.

Table 5.3: Comprehensive comparison of three alternatives of Corridor 2

Sr. No.	Issues	Alternative 1 (No Project)	Alternative 2 (as per RITES DPR)	Alternative 3 (as per Revised Alignment)
1.	Length and no. of stations	Nil Nil	14.45 km and 12 stations	14.564 km and 12 stations
2.	Length of elevated section and no. of elevated stations	Nil Nil	9.90 km and 9 stations	6.638 km and 5 stations
3.	Length of	Nil	4.55 km and	7.926 km and

Sr. No.	Issues	Alternative 1 (No Project)	Alternative 2 (as per RITES DPR)	Alternative 3 (as per Revised Alignment)
	underground section and no. of underground stations	Nil	3 stations	7 stations
4.	No. of Depots	Nil	1	1
5.	Safety	No specific safety standard on Roads	High Safety Standard	High Safety Standard
6	Permanent Land Requirement	Nil	21.10 ha	21.89 ha
7.	No. of trees to be felled	Nil	705	360
8.	No. of archaeological structures	Nil	4 (with in prohibitory zone)	0
10.	Impact on the Environment	Employment Opportunity Stagnant Economy Road Congestions Increased Air Pollution Safety and Accident Increment Reduced social interactions Road Infrastructure	Loss of trees C&D waste management No loss on Fauna	Loss of trees C&D waste management No loss on Fauna

Sr. No.	Issues	Alternative 1 (No Project)	Alternative 2 (as per RITES DPR)	Alternative 3 (as per Revised Alignment)
11.	No. of structures affected	Nil	118	83 including 45 squatters
12.	Issues of noise and vibration	Noise increment due to traffic and honking	Noise pollution in elevated corridor and vibration issue in underground corridor which will be mitigated in scientific manner	Noise pollution in elevated corridor and vibration issue in underground corridor which will be mitigated in scientific manner.
13.	Conclusion	This plan is inferior to ALT2 and ALT3.	This plan is inferior to ALT1 and Alt 3	This is the most desirable plan.

5.4 Environment and Social Considerations

Limited analysis of alternatives was done due to the limited option for the metro route. However, the alignment of the above corridors is so selected that they 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 area, the alignment is kept under the ground so as to lessen the social impacts that may have resulted from the acquisition of property. Similarly, to avoid the archaeological/historical monuments, the proposed metro corridor near the monuments in Kumharar area has been shifted to Malahi Pakri. The entire underground section will be constructed by tunneling through State of Art Tunnel Boring Machine (TBM). The proposed depot near ISBT will be utilized for these corridors.

CHAPTER 6
ENVIRONMENTAL MANAGEMENT PLAN

6.1 Management Plans

The Patna Metro Project 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 have 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 to be taken during project construction and operation to mitigate or bring down the adverse environmental impacts to acceptable levels based on the proposed 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 should be investment links for:

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

The purpose of the first link is to ensure that proposed 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,
- Disaster management, and
- Emergency measures.

6.2 Mitigation Measures

The main aim of mitigation measures is to protect and enhance the existing environment of the project. Mitigation measures have to be adopted during construction at all the construction sites including Batching Plant and Casting Yards on all the aspects. The mitigation measures to be adopted have been described under following heads:

- Compensatory Afforestation,
- Construction Material Management,
- Labour Camp,
- Energy Management
- Hazardous Waste Management
- Environmental Sanitation,
- Utility Plan,
- Air Pollution Control Measures,
- Noise Control Measures,
- Vibration Control Measures,
- Traffic Diversion/Management,
- Soil Erosion Control,
- Water Supply, Sanitation and Solid Waste management,
- Waste Water
- Management Plans for Depot
- Training and Extension
- Archaeological Monuments

6.3 Compensatory Afforestation

The objective of the afforestation program should be to develop natural areas in which ecological functions could be maintained on a sustainable basis. According

to the results of the present study, it is found that about 911 trees are likely to be lost due to the project. Three additional saplings are to be planted for felling a single tree. Hence 3612 trees need to be planted. Plantation program will be finalized in consultation with Forest Department and project proponent would provide the funds for compensatory afforestation as per government policy.

6.3.1Construction Material Management – Storage and procurement

The major construction material to be used for construction of the proposed corridor 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 PMRC controlling Officer 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 shall be responsible for management of such construction material during entire construction period of the project. Sufficient quantity of materials should be available before starting each activity. The contractor should test all the materials in the Government labs or Government approved labs in order to ensure the quality of materials before construction. This is also the responsibility of the contractor, which would be clearly mentioned in the contractor's agreement. Care shall be taken to avoid spillage of material during construction. Procurement of material would be from environment friendly source. The materials shall be procured from nearest available source and shall be transported in coverd trucks. All the material would be stored in a manner to avoid multiple handling for use in construction activities.

6.3.2 Labour Camp

The Contractor during the progress of work will provide, erect and maintain the necessary (temporary) living accommodation and ancillary facilities for labour to standards and scales approved by the PMRC. All temporary accommodation must be constructed and maintained in such a fashion that hygenic, hospitable and safe conditions achieved. Uncontaminated water shall be made available for drinking, cooking and washing. Safe drinking water should be provided to the dwellers of the construction camps. Adequate washing and bathing places shall be provided and kept in clean and drained condition. Construction camps are the responsibility of the concerned contractors and these shall not be allowed in the construction areas but sited away. Adequate health care is to be provided for the work force.

Sanitation Facilities: Construction sites and camps shall be provided with sanitary latrines and urinals/bio toilet. Sewerage drains should be provided for the flow of used water outside the camp. Drains and ditches should be treated with bleaching powder on a regular basis. The sewage system for the camp must be properly designed, built and operated so that no health hazard occurs and no pollution to the air, ground or adjacent watercourses takes place. Garbage bins must 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 separately for use of men and women labourers. Sheds shall be maintained in proper hygienic conditions.

First aid facilities: At every workplace, a readily available first-aid unit including an adequate supply of sterilized dressing materials and appliances shall be provided. Suitable transport shall 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 25 or more women are ordinarily employed, at least a hut shall be provided for use of children under the age of 6 years belonging to such women. Huts shall be provided with suitable and sufficient openings for light

and ventilation. Size of crèches shall vary according to the number of women workers employed.

6.3.3 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 PMRC request.

Measures to conserve energy 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.
- Installation of renwable energy at site. These include solar power. By doing so, it will reduce the energy demand on grid.

The contractor shall design site offices with 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 explored.

6.3.4 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 Bihar State 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 needs to 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 Patna Metro Rail Corporation (PMRC).

6.3.5 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 at all times at Work Site, Construction Depot, Batching Plant, Labour Camp, Stores, Offices and toilets/urinals. The contractor shall employ a special group of environmental sanitation personnel to carry out following activities:

- 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, DMRC 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 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.
- 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.

6.3.5 Utility Plan

The proposed Metro alignment runs along major arterial roads of the city, which serve Institutional, Commercial and Residential areas. A 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. exists 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 needs to be initiated in advance. Prior to the actual execution of work at site, detailed investigation of all utilities and location will be undertaken well in advance by making trench pit to avoid damage to any utility. While planning for diversion of underground utility services e.g. sewer lines, water pipe lines, cables etc., during construction of Metro alignment, the following guidelines could be adopted:

- Utility services shall be kept operational during the entire construction period and after completion of project. All proposals should 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 Piles. In underground sections the utilities came across on the alignment will be shifted in advance by organizations responsible for tilities and services.

6.3.7 Air Pollution Control Measures

During the construction period, the impact on air quality will be mainly due to increase in PM_{10} along haul roads and emission from vehicles and construction machinery. Though the estimation of air quality during construction shows some 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 minimise 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 minimize 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 should be covered and loaded with sufficient free - board to avoid spills through the tailboard or sideboards.

- The temporary dumping areas shall be maintained by the Contractor at all times until excavate is re-utilized 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 must be used daily especially on windy, dry days to prevent any dust from blowing across the site perimeter.
- The Contractor shall water down construction sites as required to suppress dust, during handling of excavation soil or debris or during demolition. The Contractor will make water sprinklers, water supply and water delivering equipment available at any time that it is required for dust control use. Dust screens will be used, as feasible when additional dust control measures are needed especially where the work is near sensitive receptors.
- The Contractor shall 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.

Wheel Washing:

- The Contractor shall provide wet automated wheel washing facility with two stage sedimentation tank at the exit of Batching Plant, Casting Yard, and Underground stations. It shall also be provided at off the road elevated stations. At other locations i.e. viaduct, on the road elevated stations etc. where there are space restrictions, the contractor shall adopt dry wheel cleaning mechanism with prior approval from employer.
- Wheel washing facility shall be provided with efficient drainage, incorporating silt traps to prevent any excessive build-up of water. These facilities should include water re-circulation mechanism to minimize water consumption.

Betonwash:

- The Contractor shall provide Beton Wash facility (concrete recycling/wash plant) of suitable capacity at casting yard and/ or batching plant to reclaim slurry water and aggregate from transit mixer wash out. The contractor shall ensure the facility remains functional till the end of contract. The washing facility shall be provided with two stage sedimentation pit and efficient drainage system. The water from the final chamber of sedimentation tank shall be reused. The use of slurry water in concrete batching can be explored.

Bio toilets:

The contractor shall provide bio toilets at every construction site. The general specification of bio-toilets is listed below:

- Single Cabin FRP Structure with water tank and bio-digester.
- The cabin shall be made of FRP material.
- Bio-Digester tank of required capacity (Bio Digester Tank will be minimum 5 mm thick FRP material).
- Very easy to install at site

Mist Based Sprinkling System:

- The Contractor shall use nozzle based mist system at construction sites such as elevated station, underground station, launching shaft, depot, retrieval shaft, batching plant & casting yard as required to suppress dust.
- Nozzle based mist system shall also be used during the delivery and handling of sand and aggregate and other similar materials, when dust is likely to be generated.

Other Mitigation Measures

- Minimize idling of construction equipments
- Avoid altering the topography.
- Cleaning and rinsing of the job sites.
- Staggering of construction activities to avoid concentration.
- Training and guideance of workers.

6.3.8 Construction and Demolition Waste

Waste prevention, reuse and recycling can not only save money, but also generate broad environmental benefits, including the conservation of natural resources. Reuse and waste prevention reduce the air and water pollution associated with materials manufacturing and transportation. This saves energy and reduces attendant greenhouse gas production. The recycling of many materials requires less energy than production from virgin stock, and can also reduce transportation requirements and associated impacts. Opportunities for reducing C&D waste focus on three approaches, typically expressed as **Reduce-Reuse-Recycle**.

The source of C & D waste are pile caps, excess RMC and demolition material. An effort shall be made to recover embedded energy and to recycle the maximum quantity of C & D Waste to manufacture tiles, curb stones, paver block etc. The contractor shall store C&D waste separately at the site covered with tarpaulene and shall be used for low lying areas for land filling. An effort shall be there to reuse the maximum quantity of C & D waste on site itself.

The C & D waste shall be sent to C & D waste processing facility. Currently the facility is not available in Patna. PMRC can set up the C & D waste processing facility for their requirement. It is estimated that C&D plant of 150 TPD requiring an area of about 3 acre, may suffice.

6.3.9 Noise Control Measures

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

- Job rotation,
- Training and guidance to workers to reduce noise,
- Automation,
- Use of low noise/ vibration generating construction equipments,
- Selection of construction equipments matching the scale of construction,
- Adjustment of working hours of noisy equipments,

- Adoption of low noise generating construction methods,
- Routine inspection and timely maintenance of construction equipments,
- Make plan for movement of construction vehicles within prescribed speed without honking and loading within capacity,
- Instruction and guidance to workers to minimize noise,
- Construction of permanent and temporary noise barriers,
- Use electric instead of diesel-powered equipment,
- Use hydraulic tools instead of pneumatic tools,
- Acoustic enclosures should be provided for individual noise generating construction equipment like DG sets,
- Scheduling and staggering truck loading, unloading and hauling operation,
- Schedule and stagger work to avoid simultaneous activities which generate 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,
- Smooth and gradual control of door,
- Provision of sound absorbing material in the supply duct and return grill of air conditioner,
- Timely proper maintenance of vehicles asper manufacturer schedule.
- Consideration regarding operation plan of construction equipments.
- 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 should be provided for individual noise generating equipments, wherever possible. Workers in sections where periodic adjustment of equipment/ machinery is necessary, should be provided with sound proof control rooms so that exposure to higher noise level is reduced. During construction,

there may be high noise levels due to pile driving, use of compressors and drilling machinery. Effective measures should 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: 5121:2014 *'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.

During operation phase the application of Noise barriers can effectively reduce the exposure of rail noise to the public. The noise barrier may be provided at those locations of the tracks where more polulation is exposed to rail traffic. Ballast-less track on two layers of rubber pads are proposed which will reduce track noise and also ground vibrations due to operations. In the operational stage, there may be issues of noise at sensitive receptors near the elevated track. Additional screening of noise can be arranged by providing parabolic noise reflecting walls on each side of the track, if required.

In underground sections contractor shall follow the following procedures, viz. adoption of environmental friendly ventilation facilities, installation of silencers and vibration isolators, installation of bending portion to the ventilation duct and maintenance of performance of ventilation facilities by routine inspection.

6.3.10 Vibration Control Measures

Mitigation can minimize the adverse effects of project ground-borne vibration on sensitive land uses. During underground tunneling care shall be taken to minimize the vibration generation by adjusting the timings of operation. All heavy machinery for construction shall not be operated simultaneously as simultaneous operation can lead to multiple time vibration impact. Staggering of machine operation shall be adopted. Vibration Mitigation can minimize the adverse effects of project

ground-borne vibration on sensitive land uses. Mitigation of construction vibration requires consideration of equipment location and processes.

Design considerations and project layout:

- Route heavily loaded trucks away from residential streets and selecting streets with few homes.
- Operate earth-moving equipment on the construction site as far as possible away from vibration-sensitive residential/ commercial sites.

Sequence of operations:

- Phase demolition, earth-moving and ground-impacting operations so as not to occur at the same time. Unlike noise, the total vibration level produced could be significantly less when each vibration source operates separately.
- Avoid nighttime vibration generation activities

Alternative construction methods:

- Avoid impact pile-driving where possible in vibration-sensitive areas. Drilled piles or the use of a sonic or vibratory pile driver causes lower vibration levels where the geological conditions permit their use (however, see cautionary note below).
- Select demolition methods not involving vibration impact. For example, sawing bridge decks into sections that can be loaded onto trucks results in lower vibration levels than impact demolition by pavement breakers, and milling generates lower vibration levels than excavation using clam shell or chisel drops.
- Avoid vibratory rollers and packers near sensitive areas.

Pile-driving is one of the greatest sources of vibration associated with equipment used during construction of a project. However, continuous operation at a fixed frequency may be more noticeable to nearby residents, even at lower vibration levels. Furthermore, the steady-state excitation of the ground may induce a growth in the resonant response of building components. Resonant response may be unacceptable in cases of fragile buildings or vibration-sensitive

manufacturing processes. Impact pile drivers, on the other hand, produce a high vibration level for a short time (0.2 seconds) with sufficient time between impacts to allow any resonant response to decay.

Coontractor shall adopt following measures during construction to minimize vibrations:

- Adopt low vibration generating equipments and construction methods,
- Staggering of construction activities at site.

During operations, vibrations arise due to rail - wheel interaction during oprations. Vibrations could be reduced by improving track geometry, providing elastic fastenings, minimizing surface irregularities of wheel and rail, and separation of rail seat assembly from the concrete plinth with insertion of resilient and shock absorbing pad. Adequate wheel and rail maintenance in controlling levels of ground-borne vibration is very important. Problems with rough wheels or rails can increase vibration levels by as much as 20 VdB, negating the effects of even the most effective vibration control measures. When ground-borne vibration problems are associated with existing rails and rolling stock, often the best control measure is to implement new or improved maintenance procedures. Grinding rough or corrugated rail and implementing wheel turning to restore the wheel surface and contour may reduce vibration more than completely replacing the existing track system with floating slabs.

Assuming that the track and vehicles are in good condition, further reduction of ground-borne vibration shall be carried out by (1) proper maintenance, (2) adoption of location and design of special track work, (3) vehicle modifications, (4) changes in the track support system, (5) building modifications, (6) adjustments to the vibration transmission path, and (7) operational changes.

- Adoption of elastic railroad ties, direct fastened track for reduction of vibrations,
- Adoption of long rails,
- Aoption of heavy rails,
- Aplication of lubricating oil at sharp curves,
- Thorough maintenance of vehicles and rails etc
- Installation of silencers and vibration isolators,

6.3.11 Traffic Diversion/ Management

During construction, traffic is 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 of the corridor. During construction, adequate road width will be ensured for smooth flow of the road traffic and to avoid any congestion. The implementation of proposed corridors will ease the traffic congestion and reduce the traffic accidents as number of road vehicles will be reduced on the road. 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 etc. Maintenance of diverted roads in good working condition to avoid slow down and congestion shall be a prerequisite during construction period.

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

- The requirement would be mainly along the central verge/ side of the road.

Only temporary diversion plans will be required during construction of the proposed Metro corridor. At the onset, all encroachments from road ROW will have to be removed. These encroachments vary from ‘on-street’ parking to informal activities.

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 should be provided with high visibility jackets with reflective tapes as most of viaduct and station works are on the 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.

6.3.12 Soil Erosion Control

Prior to the start of the relevant construction, the Contractor shall submit his schedules for carrying out temporary and permanent erosion/sedimentation control works are as applicable for the items of clearing and grubbing, roadway and drainage excavation, embankment/sub-grade construction, bridges and/ or 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 project authority.

It shall be ensured that no toxic substance shall be used at construction site. Periodic investigation of heavy metals shall be done. 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, dykes, 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. Top soil shall be preserved by the contractor

and stacked separately at designated place and utilize it to cover the refilled area and to support vegetation.

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.

Contractor will have to develop construction drainages for appropriate disposal; monitor the construction drains, minimize alteration of topography, install temporary grit chabers to curb turbidity and adjust temporary pier installations to minimize alterations of topography at water flowing locations. Measures will have to be taken for vegetation protection on slope faces, to cover the temporary stacks of sand and excavated earth with tarpaulin to restrict muddy water from flowing during rains

Temporary erosion/sedimentation and pollution control measures will be used to control the phenomenon of erosion, sedimentation and pollution that may develop during normal construction practices, but may neither be foreseen during design stage or associated with permanent control features on the Project. 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 project authority.

Sedimentation and pollution control measures then become necessary as a part of the work as scheduled or ordered by the project authority, and these shall be carried out at the Contractor's own expense.

PMRC would explore the users who need the excavated earth for their inhouse use like filling low lying areas etc for disposal purpose.

6.3.13 Water Supply and Sanitation

During Construction

The public health facilities, such as water supply, sanitation and toilets are much needed at the stations. Water should be treated before use up to national drinking water standards. The collection and safe disposal of human wastes are among the most important problems of environmental health. The water carried sewerage

solves the excreta disposal problems. The sewerage disposal systems should be adopted for sewage disposal. The water for domestic consumption shall be sourced from public water supply or alternatively designated borewells may be installed with due permission from statuatory authority prior to installation of borewell.

The construction water shall be sourced from Patna Municipal Corporation and other agencies responsible for sewage treatment and disposal in Patna. Alternatively, contractor shall arrange tie up for surface water supply or bore wells or tanker water supply for construction activity.

During Operations

Practically, public facilities at stations have to be operated by regular staff or may be designated to any NGO working in the area in the field of sanitation as per policy of Patna Metro Rail Corporation (PMRC). Requirement of drinking water supply at station shall be provided from PMC/ Patna authority sources.

6.3.14 Wastewater

Soil runoff from the bare lands resulting from earthmoving activities, such as cutting and filling will not cause any water quality degradation in downstream water areas since there are no down stream water areas

Effluent from stations will be domestic sewage only and the same will be disposed off through public sewers. Effluent from Depots shall be treated at wastewater treatment plants, within the Depot before discharge so as to meet the national water quality standards. Wastewater will be re-used for holiculture or other purpose as much as possible. No possibility is visualized that the effluents will cause areas not to comply with the country's ambient water quality standards.

Domestic Waste generated from project facility will be collected and disposed by Municipal corporation of Patna. Industrial waste generated from Depots will be waste oil, used metal, rubber and so on, and the industrial waste will be collected and disposed to authorized companies.

6.3.15 Solid Waste Management

Solid waste shall be stacked at designated place and when sufficient quantity accumulates it shall be disposed off through covered trucks to land fill site designated and authorized by PMRC. Solid waste shall be segregated a municipal waste, ewasteand hazardous wastes. Solid waste will be generated at station is about 0.8 – 1.2 m3/Day. The maintenance of adequate sanitary facilities for temporarily storing refuse on the premises is considered a responsibility of the project authority. The storage containers for this purpose need to be designed and these should be equipped with side handles to facilitate handling. To avoid odour and the accumulation of fly-supporting materials, garbage containers should be washed at frequent intervals. This should be collected and transported to local municipal bins for onward disposal to disposal site by municipality.

6.3.16 Compensatory Afforestation:

There is requirement of felling 911 trees during construction of Metro corridors in Patna. An attempt shall be made to minimize the tree felling. As remediation of tree felling it is suggested to plant additional 3 trees for each tree felled as per the provisions made in “Guidebook on Application & Inspection Procedure for Obtaining NOC/ Transit Permit for Tree Felling/ Transportation and Use of Forest Land for Non-Forest Use” issued by Department of Environment, Govt. of Bihar. Thus 3612 trees would be planted. Moreover, PMRC would chalk out the plantation program in close coordination with Tree Authority or will get plantation done through PMC by making the payment for plantation work including after care for three years. A provision of 122.81 Lakh has been made @ Rs. 3400/- per tree to be planted and maintained for a period of three years. An attempt would be made to minimize the felling of trees to the bare minimum while working and undertaking construction work. The left-out trees shall be protected by providing metal or brick tree guard around the tree at a distance of one metre surrounding the tree. Scope of transplantation of trees would also be explored with discussion with the Forest Department/ Patna Nagar Nigam.

6.3.17 Archaeological Monuments

No heritage structure is being relocated or demolished due to implementation of the Project. The laws and regulations applicable for keeping the heritage in tact

will be observed. No local archaeological, historical, cultural and religious heritage sites will be affected as a result of the proposed alignment.

6.3.18 Management Plans for Depot

The management plans for depot site includes:

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

Water supply: Water will be required for operation and functioning of depot. This could be either taken from water supply Authority or through boring tube well into the ground after taking permission from Central Ground Water Authority. The ground water will need treatment depending upon its quality and end use. The water treatment plant flow chart is given in **Figure 5.1.** The cost of water treatment plant shall be included in Project Cost.

Oil Pollution Control: The oil from canteens and the used oil from workshops tend 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 have 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.

Sewage/Effluent Pollution Control: Sewage is likely to be generated at depot and stations. The sewage could be treated up to the required 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 5.2.** The cost of sewage treatment plant shall be included in Project Cost.

Process of Biological Sewage Treatment – Biological sewage treatment is a process where biological organisms are cultured and allowed to consume the

organic matter and multiply their population. This is by a process where the enzymes solubilise the organic matter. The organisms grow and multiply whereby each organism splits into two complete new organisms. The multiplied organisms are settled out and the clear treated sewage is free from the organic matter.

The metabolism can be by:

(a) aerobic organisms needing oxygen

(b) anaerobic organisms that do not need oxygen.

This process is based on several synthetic biofilm carrier elements developed for use in the aeration tank of the ASP and are suspended in the activated sludge mixed liquor in the aeration tank. These processes are intended to enhance the activated sludge process by providing a greater surface area to unit volume of the aeration tank for the additional surfaces for increased microbial population and metabolism and hence, the biomass concentration in the tank and offers the potential to reduce the basin volumes.

This process is a sort of aeration tank and secondary clarifier being a two in one. Essentially it has a suspended solids free treated sewage and retains higher MLSS and reduces the volume of aeration tanks.

For the purpose of effluent generated from train washing, an effluent treatment plant is proposed (Figure 6.3). As a general process, an EC based technology is used for treatment of waste water. The EC system is an advanced technology based on electro-chemical principals of oxidation, reduction and precipitation. The system comprises of an anode, a cathode and a high frequency power supply.

The anode is at the reduction potential, and the source for the positive voltage to enter the cell. Depending on the type of the wastewater, the desired current is applied and the treatment is accomplished. Oxygen and hydrogen is liberated at the anode and cathode respectively. The positively charged ions neutralize the charges of the suspended colloidal matter thereby causing them to coagulate and precipitate in the form of hydroxides which is removed in the form of sludge in Tube Settler.

Figure 6.1 Flow Chart for Water Treatment Plant

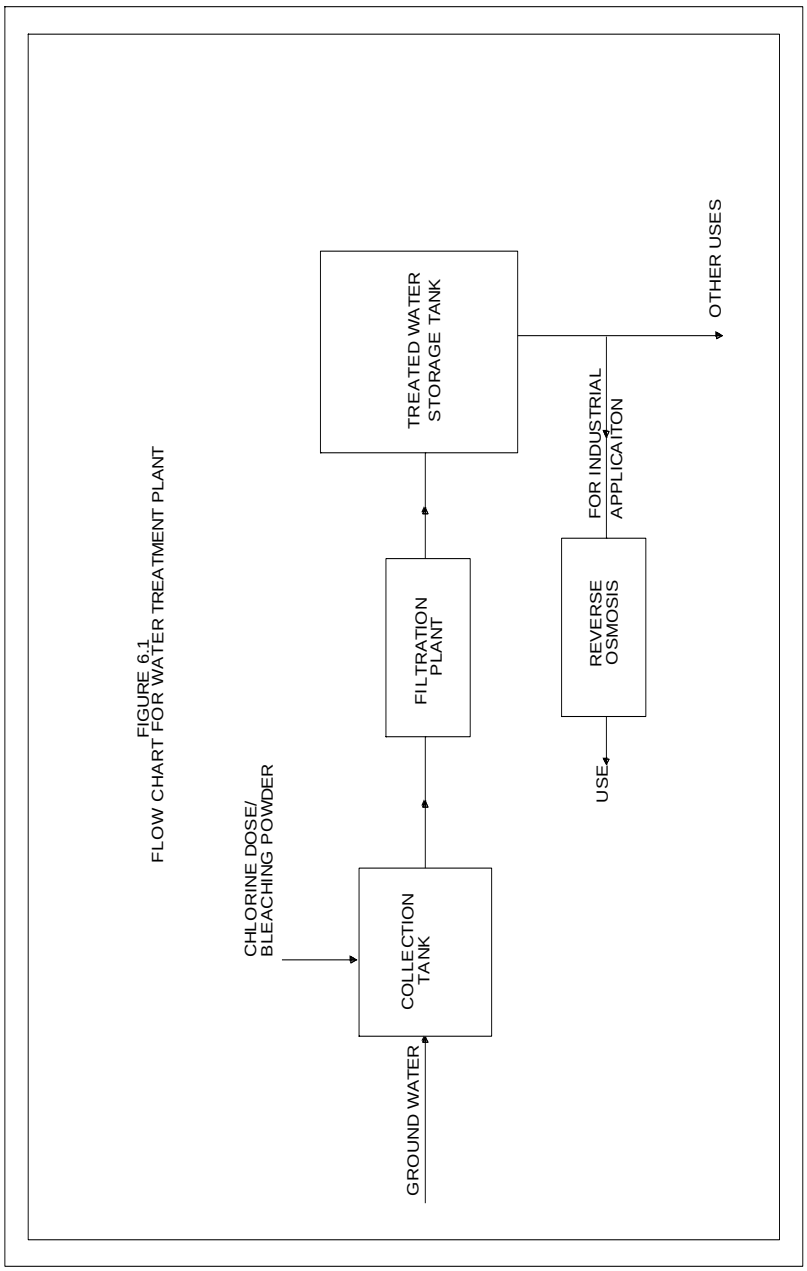


Figure 6.2 Flow Chart for Sewage Treatment Plant

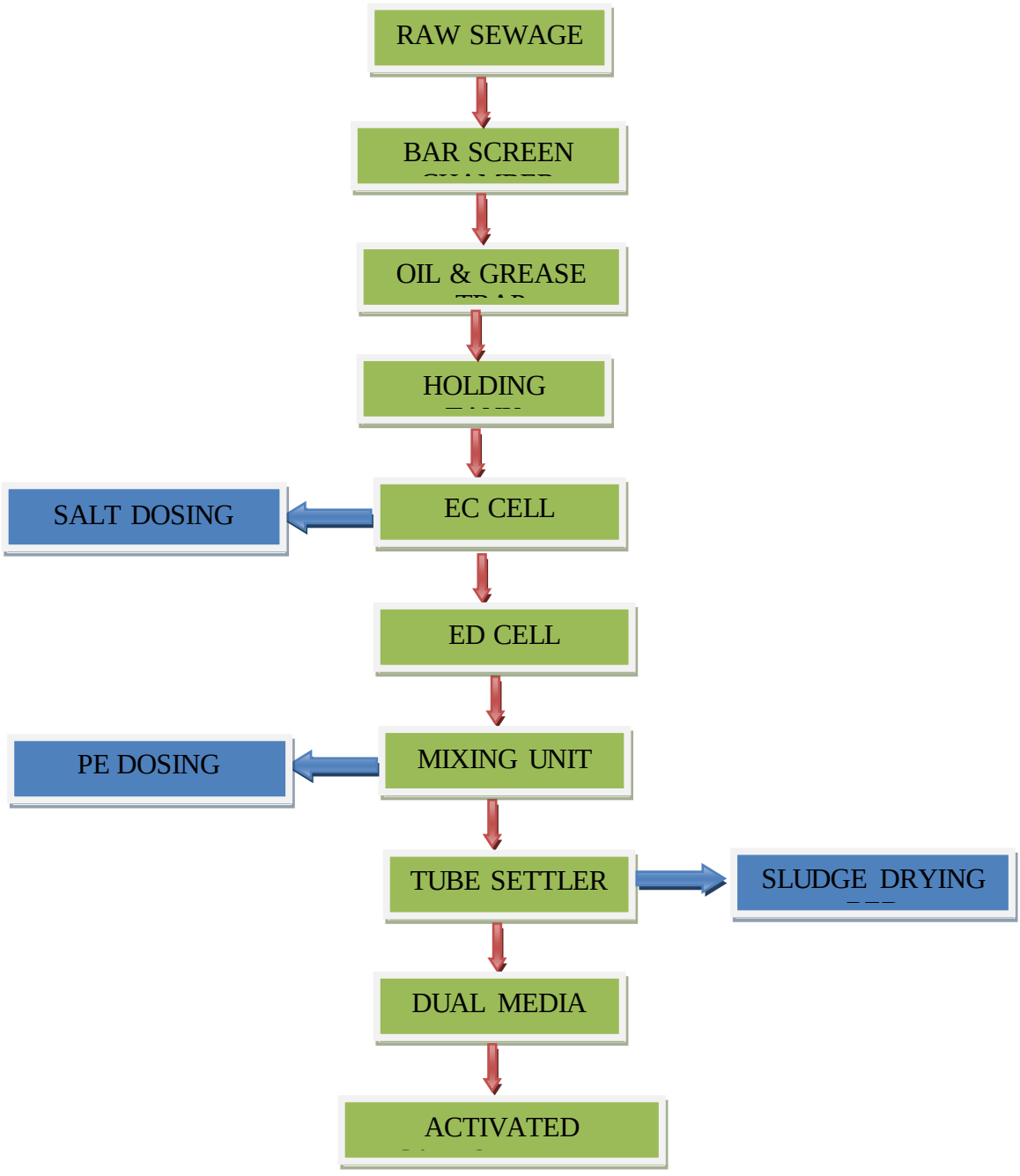
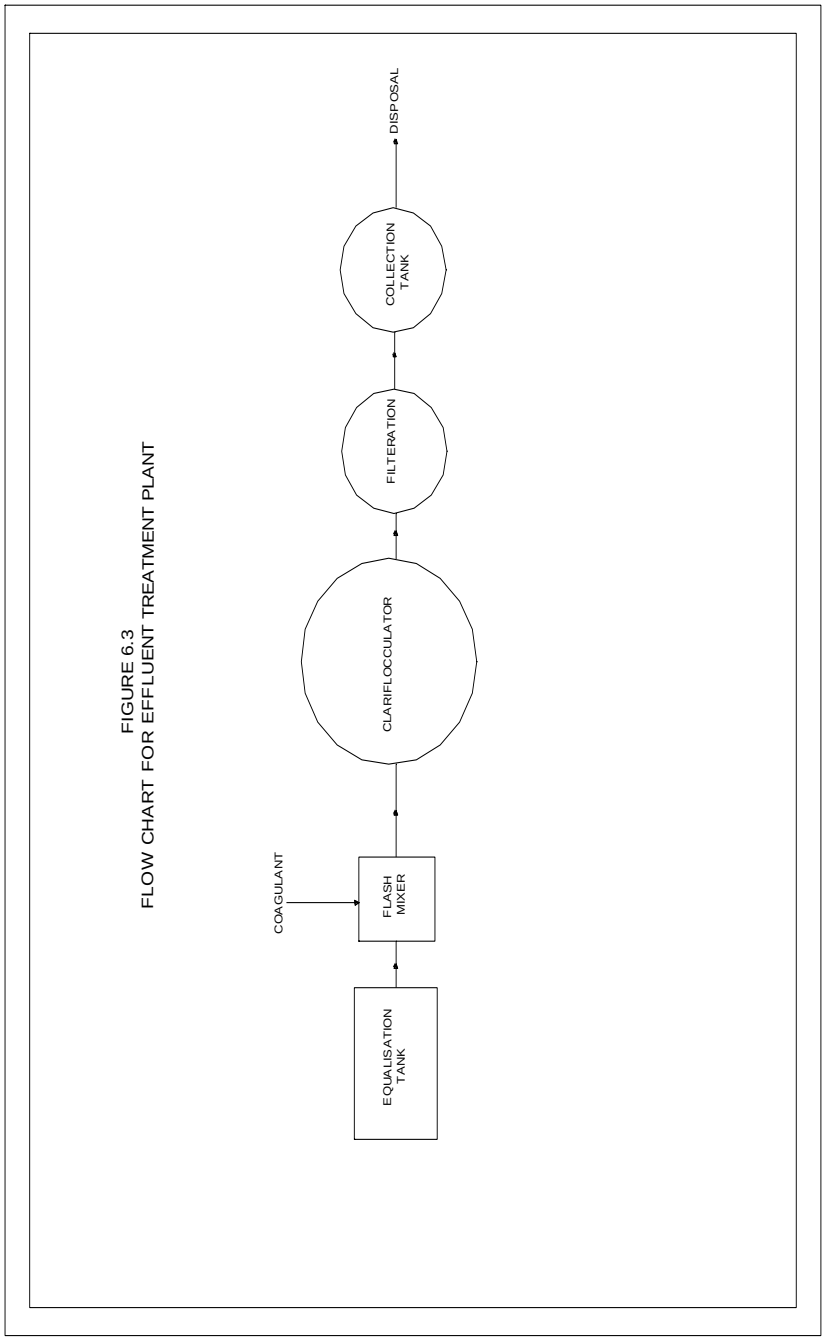


Figure 6.3 Flow Chart for Effluent Treatment Plant



The cathode is the negative pole or the pole through which the negative voltage leaves the cell. Hydrogen gas is emitted at the cathode based upon the current applied or works performed.

- Mixing Unit
- Tube Settler
- Sludge Collection

Process flow chart of effluent treatment plant is shown in Figure 5.3. The cost of Effluent Treatment Plant shall be included in Project Cost.

Surface Drainage: The depot area should have proper drainage. The Storm water of the depot will be collected through the drain. Rain water harvesting structures at different locations in the drains and for surplus storm water, the drainage system is to be connected to 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. It is recommended to have a provision of Rs 20.00 Lakh in the cost estimate for the green belt development.

Recycling of treated waste water: The Waste Water to be generated at the depot shall be treated using ETP & STP. The treated waste water shall be recycled for horticulture work of the depot.

The cost of environment management measures has been included in the project cost as construction and civil costs of Depot.

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 overhead rail. The potential causes are excessive load, cracks,

failure and malfunctioning of sensing instruments, accident, etc. Additionally, there may be possibility of flooding in project during construction, flooding in low lying areas near river and Fire outbreaks during construction and Operation and Maintenance. Mitigation plans will be required before start of construction.

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 should 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 should be increased both in frequency and details.

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 fool proof communication system.

6.4.3 Emergency Measures

The emergency measures are adopted to avoid any failure in the system such as lights, fire, means of escape 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 should also include preventive action, notification, warning procedures and co-ordination among various relief authorities. These are discussed in following sections.

6.4.4 Emergency Lighting

The emergency lights operated on battery power should be provided at each station. The battery system should supply power as per electricity Rules, at least 25% of the lights at the station, platforms, viaduct for a period of 2 hours.

6.4.5 Fire Protection

The building materials should be of appropriate fire resistance standard. The fire resistance period should be at least 2 hours for surface or over head structures as per fire rules. 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.

A. Fire Prevention

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:

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 provided,
- Provision of layout which permits ease of maintenance for equipment and cleaning of the station premises,
- Prohibition of smoking in fire prone areas,
- Provision of cigarette and litter bins, and
- Good housekeeping.

B. Fire Alarm and Detection System

A complete fire detection system with equipment complying with the requirements of Patna 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.

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. While designing the fire fighting system, Patna Fire Services shall be taken into account for linking with the same.

6.4.6 Flood Control Plan

Excessive rainfall during monsoon can lead to situation of water logging, particularly in underground station and in structures in low lying areas during construction. In situation like flood, a flood control plan shall be prepared covering the following aspects:

1. An emergency response team including Engineers and supervisors to be set up.
2. Estimate of maximum amount of rainfall can be prepared. Based on amount of rainfall, a drainage plan can be prepared.
3. Closure of gaps below barricades by bund walls to avoid muck flow from construction area on to road.
4. Fogging inside casting yards to prevent mosquito breeding.
5. Testing of electrical equipment to avoid electrical hazards.
6. Different capacity Dewatering Pumps are mobilised to drain the water.
7. Clean drains to be ensured.

Further to above, mock drills can be carried out to evaluate monsoon/flood preparedness.

6.5 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 5.1, 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.

Additionally, project authority should prepare and establish Environmental and Health Policy and Procedures as per earlier Phases and that should become an integral part of contract 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 PMRC and prepare a follow on timetable of actions.

TABLE 6.1

ENVIRONMENTAL MANAGEMENT ACTION PLAN (EMP)

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 environmentally sensitive areas.	During Design	DPR and design consultant	PMRC/DMRC
Cultural Heritage	Avoided by adjustment of alignment.	During Design	DPR and design consultant	PMRC/ DMRC
Flood	Bridges shall be well designed	During Design	DPR and design consultant	PMRC/ DMRC
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-IV.	DPR and detailed design stage	DPR and design consultant	PMRC/ DMRC
PRE –CONSTRUCTION STAGE				
Water requirement	The requirement of water for construction purpose etc shall be planned and shall be arranged from available and authorized sources in order to avoid digging of Tube wells.	Pre construction stage	Contractor	PMRC/ EMP implementing agency
Disposal of final treated effluent from treatment plant	Options for final disposal shall be studied and the suitable disposal route shall be decided carefully to minimize the impact on receiving bodies. As far as possible zero discharge rules may be adopted.	During design stage / and pre construction of treatment plant	Contractor	PMRC/ EMP implementing agency

Environmental Impact	Mitigation Measures Taken or to Be Taken	Time Frame	Implementing Organization	Responsible Organization
Batching Plant and Casting Yard	These facilities to be located away from habitation. Consent to Establish and Consent to Operate to be taken from BSPCB and to comply with all stipulations.	During Pre-construction Stage	Contractor	PMRC/ EMP implementing agency
CONSTRUCTION PHASE				
Environmental Management and Monitoring	This will include institutional requirements, training, environmental management and monitoring	During and after construction	Contractor	PMRC/ EMP implementing agency
Dust	Water should be sprayed during construction phase, wherever it is required to avoid dust. Vehicles delivering materials should be covered to reduce spills and dust blowing off the load.	During construction	Contractor	PMRC/ EMP implementing agency
Air Pollution	Vehicles and machinery are to be regularly maintained so that emissions conform to National and State AAQ Standards. No vehicle without valid PUC certificate would be allowed at Construction Sites.	Beginning with and continuing throughout construction period	Contractor	PMRC/ EMP implementing agency
Equipment Selection maintenance and operation	Construction plants and equipment will meet acceptable standards for emissions and will be maintained and operated in a manner that ensures that relevant air, noise, and discharge regulations are met.	During construction	Contractor	PMRC/ 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 should 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 to be provided noise barriers	Beginning and through construction	Contractor	PMRC/ EMP implementing agency

Environmental Impact	Mitigation Measures Taken or to Be Taken	Time Frame	Implementing Organization	Responsible Organization
	(Stone walls and plantation) for silence zones including schools and hospitals.			
Vibration	The vibration level limits at work sites adjacent to the alignment shall conform to the permitted values of peak velocity as given in Environmental Manual	Beginning and through construction	Contractor	PMRC/ EMP implementing agency
WATER				
Contamination from Wastes	All justifiable measures will be taken to prevent the wastewater produced in construction from entering directly into any rivers, drainage and irrigation system	Throughout construction period	Contractor	PMRC/ 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	PMRC/ EMP implementing agency
Sewerage disposal during construction at Service Centres	A minimum distance of any sewage or toilet facility from water sources should be 200 meters.	Throughout construction period	Contractor	PMRC/ 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. Garbage will be collected in a tank and disposed off daily. Special attention shall be paid to the sanitary condition of	Before and during building of construction camps	Contractor	PMRC/ EMP implementing agency

Environmental Impact	Mitigation Measures Taken or to Be Taken	Time Frame	Implementing Organization	Responsible Organization
	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. All environmental mitigation measures shall be enforced at Quarry site also.	During construction	Contractor	PMRC/ 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. Four trees will be planted against every tree felled as per norms.	During and after completion of construction activities	PMC	PMC/ PMRC
SOCIAL				
Loss of Access	Temporary access should be built at the interchange and other roads.	During construction	Contractor	PMRC/ Traffic department
Traffic jams and congestion	If there are traffic jams during construction, measures should be taken to relieve the congestion with the co-ordination of transportation and traffic police department	During construction	Contractor	PMRC/ 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	PMRC/ Traffic department
Increase in disease	Make certain that there is good drainage at all construction areas, to	During construct	Contractor	PMRC/ EMP implementing

Environmental Impact	Mitigation Measures Taken or to Be Taken	Time Frame	Implementing Organization	Responsible Organization
Water-borne Insect-borne Communicable diseases	avoid creation of stagnant water bodies. Provide adequate sanitation and waste disposal at construction camps. Provide adequate health care for workers and locate camps away from vulnerable groups, if any	ion At start-up Throughout construction		agency
Location of camps depots and storage areas	Location of camps depots and storage areas shall be as per the contract specifications.	Throughout construction	Contractor	PMRC/ EMP implementing agency
OPERATION PHASE				
Noise and Vibration	Suitable measures should be considered where warranted. The public shall be educated about the regulations of noise and vibration pollution and its implications.	After completion of construction	PMRC/EMP implementing agency	PMRC/ EMP implementing agency
WATER				
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	PMRC/EMP implementing agency	PMRC/ EMP implementing agency

CHAPTER 7

ENVIRONMENTAL MONITORING PLAN

7.1 Environmental Monitoring Plan

Environmental monitoring programme is a vital process of any management plan of a development project. It helps in signaling the potential problems that resulting from the proposed project and will allow for prompt implementation of effective corrective measures. The environmental monitoring will be required for base line data, the construction and operational phases. The main objectives of environmental monitoring are:

- to assess the changes in environmental conditions,
- to monitor the effective implementation of mitigation measures,
- to warn significant deteriorations in environmental quality for further preventive action.

In order to meet the above objectives, the following parameters need to be monitored:

- Afforestation,
- Water Quality and Public Health,
- Air and Noise Quality,
- Soil Conservation Measures and
- Rehabilitation and Resettlement Programme.

7.1.1 Afforestation and Ecology

Afforestation should commence with the start of project cycle. The Forest Department of Patna city should implement the afforestation programmes. PMRC should transfer the cost of afforestation to Forest Department of Patna City. Preferably the trees need to be planted at appoved locations before the construction is over.

7.1.2 Water Quality Parameters

Water quality parameters shall be monitored for one year before and for at least three years after the completion of the project thus for total 4 years. Monitoring should be carried out by any recognized private or Government agency at least

twice a year. Water quality shall be analyzed by applying the standard technique. The parameters for monitoring would be:

- pH
- Dissolved Oxygen (DO)
- Biochemical Oxygen Demand (BOD)
- Chemical Oxygen Demand (COD)
- Total Dissolved Solids (TDS)
- Chlorides
- Nitrates
- Sulphates
- Total nitrogen
- Total Phosphate
- Oils and Grease

The monitoring points could be ground and surface waters if any. The ground water sampling could be carried out along the proposed Patna Metro Corridors. Surface and ground water also need to be monitored near soil disposal sites.

7.1.3 Air Quality and Noise

Ambient air quality and Noise levels should be monitored during pre-construction phase, during construction phase and after the completion of the project. It is proposed to have the monitoring programme at all the 14 stations between Danapur and Khemni Chak will and 12 stations from Patna Station to New ISBT Corridors, depot and casting yards, batching plants etc. The parameters recommended for monitoring are:

- Particulate matter,
- Sulphur-di-oxide,
- Carbon monoxides,
- Nitrogen Oxides and
- Noise levels dB (A).

7.1.3.1 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. Historically, environmental monitoring has been integral part of project towards 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 proposed to be monitored:

- Water Quality,
- Air Quality,
- Noise and Vibration,
- Afforestation,

Environmental monitoring during pre-construction phase is important to know the baseline data and to predict the adverse impacts during construction and operations phases. Ambient Air, water, Noise levels, Vibrations and soil quality shall be monitored at all the sites of proposed stations, depot before starting any construction activity on ground to have baseline environmental values before start of work. The monitoring schedule may be as follows:

- Air - 9 Locations 2 sample for 24 hours (18@2200=39600)
- Water - 9 Locations 9 sample (9 @7500 = 67500)
- Noise - 9 Locations 9 sample (9@1500 =13500)
- Vibration - 5 Locations for 2 hours (5@17000 =85000)
- Soil - 8 Locations 8 sample (8@3000=24000)

The total cost of environment monitoring during pre-construction had been Rs. 2,29,600/- only.

7.1.3.2 Construction Phase

During construction stage environmental monitoring will be carried out for air quality, noise levels and water quality. The number could be modified based on

need when the construction actually commences. Keeping a broad view of the sensitive receptors an estimate of locations has been made and is summarized below:

7.1.3.2.1 Groundwater 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. Water quality should be analyzed following the procedures given in standard methods. Parameters for monitoring will be as per BIS: 10500:2012. The monitoring points could be ground and surface water. The contractor shall also monitor soil leachate monitoring.

7.1.3.2.2 Air Quality

Air quality should be monitored at the locations of baseline monitoring. The parameters recommended are Particulate Matter (PM_{10}), ($PM_{2.5}$). The contractor will be responsible for carrying out air monitoring during the entire construction phase under the supervision of project authority.

7.1.3.2.3 Noise and Vibration

The noise levels will be monitored at construction sites for entire phase of construction by the site contractor and under the supervision of project authority. At sensitive locations Vibration shall also be monitored as per the directions of the employer.

7.1.3.2.4 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 for 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 Schedule for Water Air, noise and ecology are presentedbelow:

- Air - 25 Locations 2 sample for 24 hours (50@2200=110000)
- Water - 2 Locations 2 sample (2 @7500 =15000)
- Noise - 25 Locations 25 sample (25@1500 =37500)
- Total Rs.162500/- per month for say 48 months = Rs. 78,00,000/-
- Vibration –5 Locations for 2 hours (30@12000 =360000/-)

The total cost of environment monitoring during construction will be Rs. 81,60,000/- only. The number could be modified based on need when the construction actually commences. The cost of monitoring during construction will be part of contract and will be borne by contractor.

7.1.3.3 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, water, waste water, solid waste and ecology during operation phase of the project. The parameters monitored during operation will be $PM_{2.5}$ and PM_{10} for air, pH, TSS, BOD, COD, oil and grease for waste water. However water quality parameters that will be monitored will be as per BIS 10500:2012. The monitoring program shall be conducted by an external agency under the supervision of PMRC officials. The PMRC will be responsible for successful environmental monitoring of the proposed project during operation phase.

- Air - 7 Locations twice a month for 24 hours for 3years (504@2200=1108000/-)
- Water - 1 Location per year (3 @7500 =22500/-)
- Noise - 15 Locations per year (45@1500 =67500/-)
- Vibration –15 Locations per year (45@12000 =540000/-)

Total monitoring cost- Rs. 1738000/-

The results of Air quality, water quality, noise and vibrations will be submitted to management quarterly during construction phase and as per schedule during operation phase.

7.2 Implementation of Environmental Management Plan

Implementation of the environmental management plan is very important in order to reduce the impacts arising due to the proposed project. These impacts are mitigated with the preparation of environmental management plan by contractors and implementation of EMP by the client. Lack of environmental awareness among engineers and managers is a common problem encountered duringansuring of implementation of environmental management plans during construction activities. This can only be resolved through regular environmental manangment trainings.

7.3 Formation of an Environmental Management System (EMS) –ISO 14001 (2015)

The environmental management system should be formed by the project proponent to enable the project proponent to maximize its beneficial effects and minimize its adverse effects with emphasis on prevention. The EMS shall:

- Identify and evaluate the environmental aspects arising from the proposed activities, and services to determine those of significance;
- Identify and evaluate the environmental aspects arising from incidents, accidents and potential emergency situations;
- Identify the relevant legislative and regulatory requirements;
- Enable priorities to be identified and pertinent environmental objectives and targets to be set;
- Facilitate planning, control, monitoring, auditing and review activities to ensure that the policy is complied with; and
- Allow periodic evaluation to suit changing circumstances so that it remains relevant.

7.3.1 Implementation of an Environmental Management System

It is essential that the top management of the Project Proponent is committed to development of its activities in an environmentally sound manner and supports all efforts in achieving this objective. Experience has shown that efficient management of all the activities pertaining to the PMRC operations leads to reduce/prevent wastes and efficient use of resources, which ultimately result not only in environmentally sound practices but also better business returns.

7.3.2 Main Components of an Environmental Management System

7.3.2.1 Environmental Policy

The management of the Project Proponent will actively initiate, develop and support the environmental policy, which is relevant to its activities and services and their environmental effects. Broadly, this will cover the following:

- Be consistent with the occupational health and safety policy and other operational policies (such as quality policy);
- Indicate which of the activities are covered by the environmental management system;
- Be communicated and implemented at all levels of the operation; and
- Be available publicly.

The objective of the Environmental policy is to create sound and eco-friendly environment for sustainable development.

7.3.2.2 Organization and Personnel

To facilitate the implementation of the EMS, one of the most important aspects relate to the organization and personnel. PMRC will have to develop an Environmental Division with a suitable setup to look after the environmental issues. The related issues are:

- Define and document the responsibility, authority and inter-relations of key personnel involved in the implementation of the environmental policy, objectives and environmental management system;
- Identify the in-house verification requirements and procedures including resources and personnel;
- Appoint a Management Representative (MR);
- Commitment from concessionaries/tenants to adhere to the EMS;
- Communicate to employees at all levels the importance of compliance with the environmental policy, their role and responsibilities in achieving compliance, the potential consequences of departures from the specified procedures and identify and provide appropriate training; and

Establish and maintain procedures to ensure that contractors are made aware of the environmental management system requirements and provisions.

7.3.2.3 Environmental Impacts Monitoring Procedures

The Project Proponent shalll establish and maintain procedures for:

- Receiving, documenting and responding to internal as well as external communications concerning environmental aspects and management;
- Identifying, examining and evaluating the environmental effects of its activities under normal and abnormal/emergency situations (including risk assessment) and compiling significant effects in a register; and
- Recording all legislative, regulatory and other policy requirements and codes in a register.

7.3.2.4 Environmental Objectives and Targets

The objectives shall be set with a view to realizing gradual and steady improvements in environmental performance through application of best available and economically viable practices. The areas targeted for improvement will be those where improvements are most necessary to reduce risks (to environment) and liabilities. These will be identified through cost-benefit analysis wherever practicable.

7.3.2.5 Environmental Management Program

The establishment of an environmental management program is the key to compliance with the proposed environmental policy and achievement of the environmental objectives and targets. It will designate the responsibility for achieving the targets at each level and the means thereof. It will deal with the actions required for the consequences of the past activities as well as address the life cycle of development of new practices so as to effectively control adverse impacts.

7.3.2.6 Environmental Management through Conditions of contract and Documentation

The documentation is intended to provide an adequate description of the environmental management system. The conditions of contract will guide to implement the environmental safeguards as part of the contract.

7.3.2.7 Operational Control

The management responsibilities will be defined to ensure that the control, verification, measurement and testing of environmental parameters within the project are adequately co-ordinated and effectively performed. The control, verification, measurement and testing will be made through documented procedures and work instructions defining the manner of conducting activities, the absence of which can lead to violation of the environment policy. In the event of non-compliance, procedures for investigation of the causative mechanism will be established and the factors reported for corrective actions.

7.3.2.8 Environment Management Records

The Project Proponent will establish and maintain a system of records to demonstrate compliance with the environmental management systems and the extent of achievement of the environmental objectives and targets. In addition, the other records (legislative, audit and review reports) and management records will address the following:

- Details of failure and prevention in compliance and corrective action;
- Details of incidents and corrective action;
- Details of complaints and follow-up action;
- Appropriate contractor and supplier information;
- Inspection and maintenance reports;
- Monitoring data;
- Environmental training records; and
- House keeping.

7.3.2.9 Environmental Management Audits

The management audits are to determine whether the activities are conforming to the environmental management systems and effective in implementing the environmental policy. They may be internal or external, but carried out impartially and effectively by a person properly trained for it. Broad knowledge of the environmental process and expertise in relevant disciplines is also required. Appropriate audit programs and protocols will be established.

7.3.2.10 Environmental Management Reviews

The senior management will periodically review the Environmental Management System (EMS) to ensure its suitability and effectiveness. The need for possible changes in the environmental policy and objectives for continuous improvement will be ascertained and revisions made accordingly.

CHAPTER 8

PUBLIC CONSULTATIONS

8.1 Background

Public consultation is a continuous process throughout the project period, during project preparation, implementation, and monitoring stages. The sustainability of any infrastructure development depends on the participatory planning in which public consultation plays a major role. Experience indicates that involuntary resettlement generally causes numerous problems for the affected population. 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. The overall objective of the consultation program is to minimize negative impact in the project corridors and to make people aware of the project.

Public consultation is required after giving advanced notice of fifteen days at fixed locations easily accessible to PAFs and other interested stakeholders. Due to spread of Corona pandemic throughout the country and Patna city, alternative method has been used for public consultation keeping in view the requirement of social distancing. Group Discussions were held with various sections of affected persons such as traders, women and other inhabitants in the areas likely to be affected by land acquisition.

Advance Notice was served to the Project Affected Families and others interested to participate on 8th May and delivered to them by hand and the time of Public consultation was fixed for 27th to 30th May 2020 for conducting individual meetings at their place keeping sanitization, wearing masks and maintaining social distancing in view of the spread of corona infections and ongoing pandemic of Covid-19.

Thus, the meeting arranged at the place of individual PAF and with small group of PAPs in the vicinity of their structure wherever feasible. During such meetings, use of mask was emphasized along with sanitization and maintaining social distancing and discussions were conducted to get wider public input from the

primary and secondary stakeholders. The PAFs and communities, particularly the affected small business enterprises, took interests in the meetings. This consultative approach led to identification of a range of issues related to road diversion and improvements before construction of the Project including the Route alignment and depot, reducing disruption of livelihoods and improved design for roadside amenities/ services for the residents. Perhaps more importantly, the affected communities strongly felt a sense of participation in the decision-making process.

Keeping in mind the significance of consultation and participation of the people likely to be affected or displaced due to the proposed project, both formal and informal discussions were conducted with PAPs during visits during **27th to 30th May 2020**. During field visits the social experts of DMRC consulted with the key Project Affected People/ stakeholders and discussed the issues regarding land acquisition, structures likely to be affected, high social risk, presence of significant CPR (Common Property Resource) and vulnerable population, mitigation measures, value of affected assets, and other assistance & allowances. In this chapter detailed methodology adopted for stakeholder consultation and key findings of consultations are discussed.

8.2 Approach and Methods of Consultation

Public consultations/ Group Discussions were held with various sections of affected persons such as traders, women and other inhabitants in the areas likely to be affected by land acquisition. During public consultations, issues related to land acquisition, compensation, income restoration, employment generation, information flow, grievance redressal, safety, role of administration etc. were discussed. The RAP addresses all issues raised during public consultation and recommends institutional strengthening measures as well. The following methods were adopted for conducting public consultation:

- Served Notice of meeting on 8th May for arranging the meetings at different locations in the vicinity of affected structures.
- Group consultation at affected places along the alignment.

- Focus Group Discussions (FGD) with different groups of affected people including the PAPs.
- Discussions and interviews with key informants
- Sharing the opinion and preferences of the PAPs

The signatures of the PAP participants were taken on attendance sheets at different locations. The brief project details and summary of EIA report were explained to them. Information about environment baselime and anticipitated environment impacts and mitigation measures were explained to them. PAPs were asked to put forward their point of view and suggestions. Public consultations were organized at Rukanpura, Raja Bazar, Zero Miile Gandhi Maidan and Bigrahpur between 27th May 2020 and 30th May 2020.

Notice date	8 May 2020
Date of meetings	27th to 30th May 2020
Locations of Meetings	Rukanpura, Raja Bazar, Bigrahpur, Gandhi Maidan and Zero Mile
No. of Participants	40

8.3 Key Findings of Consultations

The key findings of public consultation are presented in **Table 8.1**.

Table 8.1 Stakeholder Consultation

Place	No. of Attendees	Issues Discussed	Important Opinion & Views	Reply
Rukanpura on 27-05-2020	Meeting held at individual level. 3 people in a	Displacement	The private land acquisition should be avoided	Due to site constraints /land constraints, private land acquisition is necessary.

Place	No. of Attendees	Issues Discussed	Important Opinion & Views	Reply
	group.	Dust Generation during construction	People expressed that construction may generate dust in atmosphere. How, it will be controlled.	Sprinkling of water proposed intermittently during dry weather which will manage and control dust spread
		Noise due to working of Machinery	Heavy macjhinery will work on the project creating Noise.	Timely maintenance as per manufacturer's schedule will be carried out to keep Noise under control. Activities of heavy machinery would be staggered to reduce cumulative impacts.
Raja Bazar on 27-02-2020 and 30-5-2020	Meeting held at individual level. 7 people in a group. Three different meetings held.	Dust and Smoke will be there due to the project	Participants pointed out that construction may generate dust and smoke in atmosphere.	Sprinkling of water proposed intermittently during dry weather which will manage and control the spread of dust and emissions. Other air pollution control measures will be there as per EMP.
		Displacement	Many Participants mentioned that they were having their shops on rent and they will be displaced due to project	At the time of payment of award money this aspect shall be considered and both owner and tenant may be involved.

Place	No. of Attendees	Issues Discussed	Important Opinion & Views	Reply
		Traffic Hinderance	Many participants had the fear that project activity may lead to traffic Jams	Project activities in the area will be undergarund and will be confined to barricaded area and Traffic Management Plan will be in place in consultation with Traffic Police.
Gandhi Maidan on 29-05-2020	Meeting held at individual level. 8 people in a group. One stakeholder meeting held	Rehabilitation	Mainly discussed social Issues of rehabilitation and alternate land was discussed. Expressed that there may be dust and smoke in the area. They also fear that excavated earth will be lying there blocking pathways	- Compensation/ rehabilitation will be as per Entitlement matrix - Air Pollution control measures will be adopted - There will be instruction to contractor to not allow stacking of excavated earth on pathways and timely removal of all wastes will be in place.
Bigrahpur-Mithapur On 29.05.2020	Meeting held at individual level. 16 people in a group	Noise Genaration due to Project working	The participants wished that Noise generated during construction and operation should be controlled	Project Authority shall adopt measures to contain Noise durng construction and Operations.
		The alignment is after Mithapur will affect many	Stakeholder suggested to review the alignment	Alternatives have been considered and thereafter the route has

Place	No. of Attendees	Issues Discussed	Important Opinion & Views	Reply
		structures.		been finalized.
		Waste dispersal in the area	People fear that even small construction activities lead to debris, such large project will generate huge quantity of wastes.	There will be instruction to contractor to not allow stacking of excavated earth on pathways and timely removal of all wastes will be in place.
Zero Mile	Meeting held at individual level. 6 people in a group	Displacement	Being Kiosks on Govt land they had no major issues. However, asked for consideration for avoiding them	Advised that compensation will be given as per R&R policy framework.
		Dust and Smoke	Participants pointed out that construction may generate dust and smoke in atmosphere.	Sprinkling of water proposed intermittently during dry weather which will manage and control the spread of dust and emissions. Other air pollution control measures will be there as per EMP.

From the above table it is evident that different people have different type of concern due to implementation of Metro project considering that the land acquisition and project construction will affect them adversely. However, some of them opined that the project is in the larger interest of people. According to them loss of land/ loss of shop will mean a lot of problem for people. Compensation for acquisition of private land should be given to those who are likely to lose their land at the current market price. Simultaneously, the tenants are also equally

important because of livelihood impacts. Many people have also requested employment by absorbing their youth in Project / Other organization on permanent basis. People wanted compensation and Job opportunity in the project. During public consultations, issues related to land acquisition, compensation, income restoration, employment generation, information flow, grievance redressal, safety, role of administration etc. were discussed. The environmental impacts of the project, both during construction and operation, were explained. Measures to mitigate hardships caused by environmental impacts were shared with the stakeholders. However, the RAP addresses all social issues raised during public consultation and recommends institutional strengthening measures as well.

Glimpses of Public Consultation Meetings

Public Consultation Meetings

Public Consultation Meetings

Public Consultation Meetings

8.4 Information Disclosure and Consultation

Advance notice was served to all the PAPs giving time of 15 days to conduct Public Consultation meeting at their venues in the light of Corona pandemic spread. The notice were send to them on 8th May 2020 fixing the date of public consultation on 27 to 30th May 2020. Accordingly, a team of consultant and Project Authority visited the locations of PAPs and conducted consultation meetings to get wider public input from the primary and secondary stakeholders. The roadside communities, particularly the affected small business enterprises, took tremendous interests in the meetings. This consultative approach led to identification of a range of issues related to road diversion and improvements before construction of Danapur to Khemni Chak and Patna Station to New ISBT corridors including the Route alignment and depot, reducing disruption of livelihoods and improved design for roadside amenities/ services for the community. Perhaps more importantly, the affected communities strongly felt a sense of participation in the decision-making process. People mainly wanted compensation and jobs in the project.

During project implementation, Project Implementation Unit (PIU) of DMRC with the help of Dy. Chief Engineer (Project Authority) will conduct Information and Community Consultation Program (ICCP) in the project area before starting the process of land acquisition. The main objectives of the ICCP should be to: (i) inform and explain the entitlement policy and the various options to the affected people prior to payments of compensation and other assistance; and (ii) socially prepare the Small Business Enterprises (SBE), and households for relocation and assist them in the process. As a result, the affected families/ persons will be

well informed about the project and their entitlements. PIU of DMRC will prepare an information brochure in local language, i.e., Hindi, explaining the RAP, the entitlements and the implementation schedule. The RAP will be distributed to all affected households/ SBEs.

8.5 Community Participation during Project Implementation

The effectiveness of the EMP is directly related to the degree of continuing involvement of those affected by the project. Several additional rounds of consultations with PAPs will form part of the project implementation. Consultations during EMP implementation will involve agreements on compensation and assistance options and entitlement package. Another round of consultation will occur when compensation and assistance are provided. The following set of activities will be undertaken for effective implementation of the plan:

a) PIU will conduct information dissemination sessions in the project area and solicit the help of the local community/ leaders and encourage the participation of the PAP's in EMP implementation.

b) Consultation and focus group discussions will be conducted with the vulnerable groups to ensure that the vulnerable groups understand the process and their needs are specifically taken into consideration.

c) Project Authority will organize public meetings, and will appraise the communities about the progress in the implementation of project works and payment and assistance paid to the community.

d) Taking into consideration the risks of HIV/ AIDs during the project construction period and road safety issues, specialist will be invited to undertake activities related to their core competencies.

Lastly, participation of PAPs will also be ensured through their involvement in various local committees. PIU and field offices will maintain an ongoing interaction with PAPs to identify problems and undertake remedial measures.

CHAPTER 9

SUMMARY OF COSTS

9.1 Summary of Costs

All costs involved in Environmental mitigation, management and monitoring to be put on account of Danapur - Khemni Chak and Patna Station to New ISBT Corridors of patna Metro**.** A summary of these is presented in **Table 9.1.**

Table 9.1 Environmental Costs

Sr. No	ITEM	Corridor I		Corridor II		Total COST Rs. Lakh	
		Parameter	Cost	Parameter	Cost	Parameter	Cost
1	Compensation for Trees and Afforestation Rs. 3400/- per tree to be planted and maintained for a period of three years.	2204 trees (551 trees to be felled & afforestation is 1:4)	**73.85**	1440 trees (360 trees to be felled & afforestation is 1:4)	**48.96**	3612 trees	**122.81**
2	Water Treatment Plants at Depots (RO) *		-		-		-
3	Sewage Treatment Plants at Depot *		-		-		-
4	Sewage Treatment Plants at 24 stations @ Rs.20 Lakh each	12 stations	**240.00**	12 stations	**240.00**	24 stations	**480.00**
5	Effluent Treatment Plants at Depot *		-		-		-
6	Green Belt Development at	-	-	Depot	**20**	Depot	**20.00**

Sr. No	ITEM	Corridor I		Corridor II		Total COST Rs. Lakh	
		Parameter	Cost	Parameter	Cost	Parameter	Cost
	Depot						
7	Monitoring of Air, Noise, vibration, Water, Waste Water, Solid waste, Ecological monitoring during construction **		-		-		-
8	Monitoring of Air, Noise, vibration, Water, Waste Water, Solid waste, Ecological monitoring during operation	*Air 4x72=288* *No. of samples 288* *Rs 2200 per samples*	*6.33*	*Air 3x72=216* *No. of samples 216* *Rs 2200 per samples*	*4.75*	*Air 7x72=504*	**17.38**
		Water -	*-*	*Water 1x3 =3* *No. of samples 3* *Cost- Rs 7500 per samples*	*0.225*	*Water 1x3 =3*	
		Noise 8 x3= 24	*0.36*	*Noise 7x3 =21*	*0.315*	*Noise 15x3 =45*	
		Vibration 8x3= 24	*2.88*	*Vibration 7x3=21*	*2.52*	*Vibration 15x3=45*	
			9.57		**7.81**		
	Total		**323.42**		**316.77**		**640.19**

Note: * refers that cost has been taken as part of project cost in DPR

**** refers that the monitoring cost during construction is part of contract**

Thus, environment management cost has been worked out to Rs. 640.19 Lakh. The compensation for loss of land, rainwater harvesting, fire control, information systems and contractor's obligations etc has been incorporated in project costs. Costs of Resettlement and Rehabilitation have been dealt separately in Social Impact Assessment Report. The Environmental management plan should be implemented in phases so that optimum benefit could be achieved and should be synchronized with the construction schedules.

9.2 Conclusion

The proposed Danapur - Khemni Chak and Patna Station to New ISBT Corridors of Patna Metro is proved to have significant positive effects for the development of Patna City. Benefits to the economy, traffic congestion reduction, quick and safe transport, employment opportunities, fuel consumption reduction, and air quality improvement are the obvious positive effects from this PMRC corridor. Besides, the potential adverse environmental impacts on air quality (during construction phase), water environment, noise, solid waste, ecology, population resettlement are also taken into consideration.

Based on these detailed potential adverse environmental impacts, appropriate mitigation measures have been developed for consideration. The EIA concludes that project impacts from both construction and operation will be minimal, and can be mitigated through the use of prevailing current practices and appropriate technologies. With the implementation of the EMP and the monitoring plan, the Project is not expected to have significant environmental impacts.

Annexure 1

DRINKING WATER QUALITY STANDARDS (IS 10500:2012)

S. No.	Substance or Characteristic	Requirement (Desirable Limit)	Undesirable Effect outside the Desirable limit	Permissible limit in the absence of alternate source
Essential Characteristics				
1	Colour, Hazen units, Max	5	Above 5, consumer acceptance decreases	15
2	Odour	Agreeable	-	Agreeable
3	Taste	Agreeable	-	-
4	Turbidity NTU, max	1	Above 5, consumer acceptance decreases	5
5	pH Value	6.5 to 8.5	Beyond this range the water will affect the mucous membrane and/or water supply system	No relaxation
6	Total Hardness (as $CaCO_3$) mg/l, Max	200	Encrustation in water supply structure and adverse effects on domestic use	600
7	Iron (as Fe) mg/l, max	0.3	Beyond this limit taste/appearance are affected, has adverse affect on domestic uses and water supply structures and promotes iron bacteria	No relaxation
8	Chloride (as Cl) mg/l, Max	250	Beyond this limit, test, corrosion and palatability are affected	1000
9	Residual free Chlorine, mg/l, Min	0.2	-	1
10	Fluoride (as F) mg/l, Max	1.0	Fluoride may be kept as low as possible. High fluoride may cause florosis	1.5
11	Dissolved solids mg/l, Max	500	Beyond this palatability decreases and may cause gastro intestinal	2000

S. No.	Substance or Characteristic	Requirement (Desirable Limit)	Undesirable Effect outside the Desirable limit	Permissible limit in the absence of alternate source
Essential Characteristics				
			irrigation	
12	Calcium (as Ca) mg/l, Max	75	Encrustation in water supply structure and adverse effects on domestic use	200
13	Magnesium (as Mg) mg/l, Max	30	Encrustation in water supply structure and adverse effects on domestic use	100
14	Copper (as Cu) mg/l, Max	0.05	Astringent taste, discoloration and corrosion of pipes fitting and utensils will be caused beyond this	1.5
15	Manganese (as Mn) mg/l, Max	0.1	Beyond this limit taste/appearance are affected, has adverse effect on domestic uses and water supply structures	0.3
16	Sulphate (as SO_4) mg/l, Max	200	Beyond this causes gastro intestinal irritation when magnesium or sodium are present	400
17	Nitrate (as NO_2) mg/l, Max	45	Beyond this methaemoglobinemia takes place	No relaxation
18	Phenolic compounds (as C_6H_5OH) mg/l, Max	0.001	Beyond this, it may cause objectionable taste and odour	0.002
19	Mercury (as Hg) mg/l, Max	0.001	Beyond this, the water become toxic	No relaxation
20	Cadmium (as Cd), mg/l, Max	0.003	Beyond this the water become toxic	No relaxation
21	Selenium (as Se), mg/l, Max	0.01	Beyond this the water become toxic	No relaxation

S. No.	Substance or Characteristic	Requirement (Desirable Limit)	Undesirable Effect outside the Desirable limit	Permissible limit in the absence of alternate source
Essential Characteristics				
22	Arsenic (as As), mg/l, Max	0.01	Beyond this the water become toxic	0.05
23	Cyanide (as CN), mg/l, Max	0.05	Beyond this the water become toxic	No relaxation
24	Lead (as Pb), mg/l, Max	0.01	Beyond this the water become toxic	No relaxation
25	Zinc (as zn), mg/l, Max	5	Beyond this limit it can cause astringent taste and an opalescene in water	15
26	Anionic detergents (as MBAS), mg/l, Max	0.2	Beyond this limit it can cause a light froth in water	1.0
27	Chromium (as Cr^{+6}) mg/l, Max	0.05	May be carcinogenic above this limit	No relaxation
28	Polynuclear aromatic hydrocarbons (as PAH) mg/l, Max	0.0001	May be carcinogenic	No relaxation
29	Mineral oil mg/l Max	0.05	Beyond this undesirable and odour chlorination place	No relaxation
30	Pesticides mg/l Max	Absent	Toxic	0.001
31	Radioactive materials a) Alpha emitters Bq/l max b) Beta emitters Bq/l, Max	0.1 1	- -	No relaxation No relaxation
32	Alkalinity mg/l Max	200	Beyond this limit taste becomes unpleasant	600
33	Aluminium (as Al), mg/l Max	0.03	Cumulative effect is report to cause demntia	0.2
34	Boron, mg/l, Max	0.5	-	1.0

Annexure 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.	^{o}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

S.No.	Parameter	Unit	Standards
25	Dissolved phosphates (as P), Max.	mg/l	5.0
26	Sulphides (as S), Max.	mg/l	2.0
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 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^o 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 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), $\mu g/m^3$	Annual	50	20
	24 Hours**	80	80
Nitrogen Dioxide as NO_2, $\mu g/m^3$	Annual	40	30
	24 Hours**	80	80
Particulate Matter (size less than 10mm) or PM_{10} $\mu g/m^3$	Annual	60	60
	24 Hours**	100	100
Particulate Matter (size less than 2.5mm) or PM2.5 $\mu g/m^3$	Annual *	40	40
	24 Hours**	60	60
Ozone (O3) $\mu g/m^3$	8 hours**	100	100
	24 Hours**	180	180
Lead (Pb) $\mu g/m^3$	Annual *	0.50	0.50
	24 Hours**	1.0	1.0
Carbon Monoxide (CO) mg/m^3	8 Hours**	02	02
	1 Hour**	04	04
Ammonia (NH_3) $\mu g/m^3$	Annual *	100	100
	24 Hours**	400	400
Benzene (C_6H_6) $\mu g/m^3$	Annual *	05	05
Benzo (a) pyrene (BaP)particulate phase only nm^3	Annual *	01	01
Arsenic (AS) $\mu g/m^3$	Annual *	06	06
Nickle (Ni) ng/m^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 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*

Night Time is from 10:00PM to 6:00 AM

** ***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 6

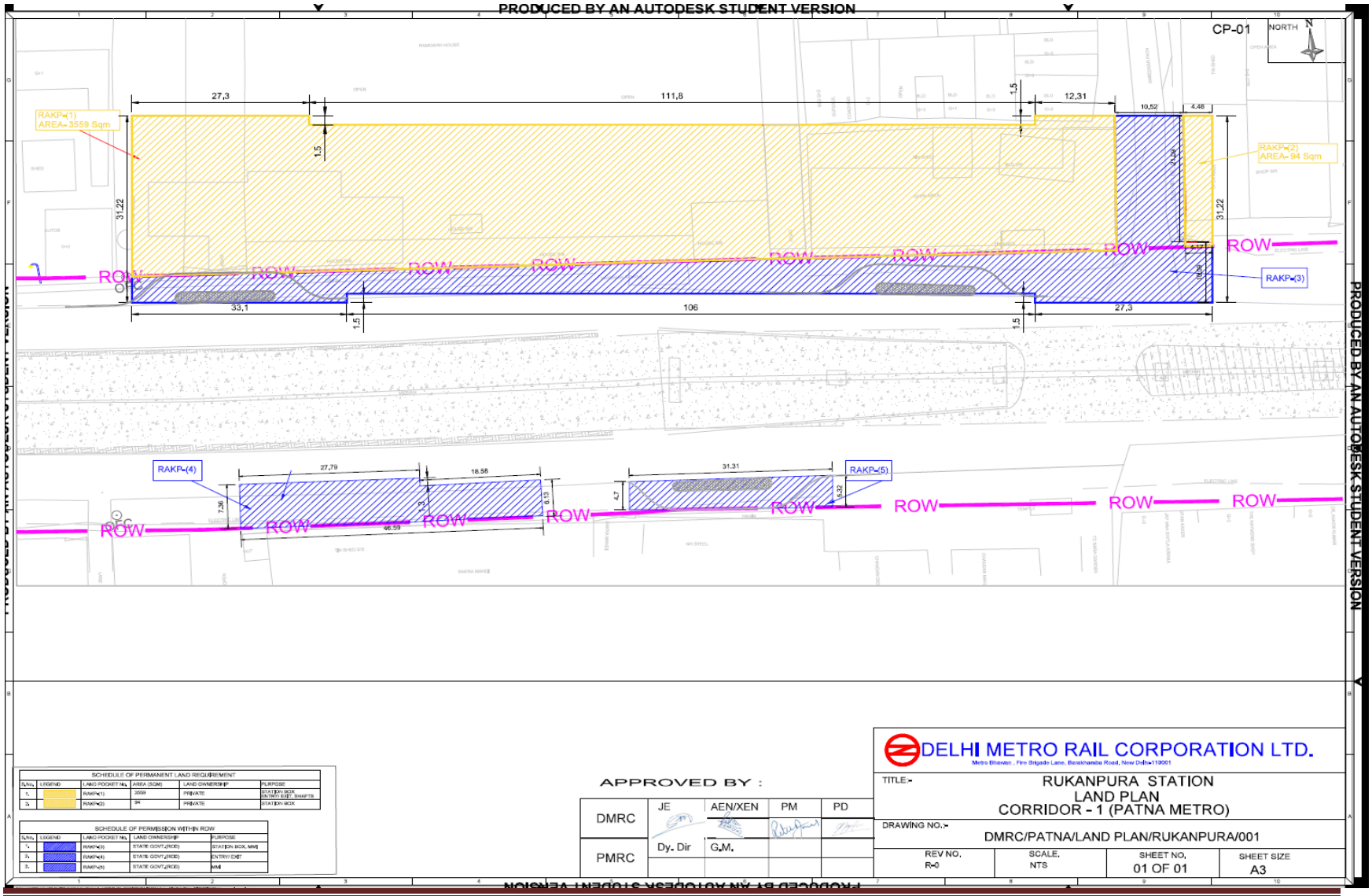
C&D WASTE DIPLAY BOARD FORMAT

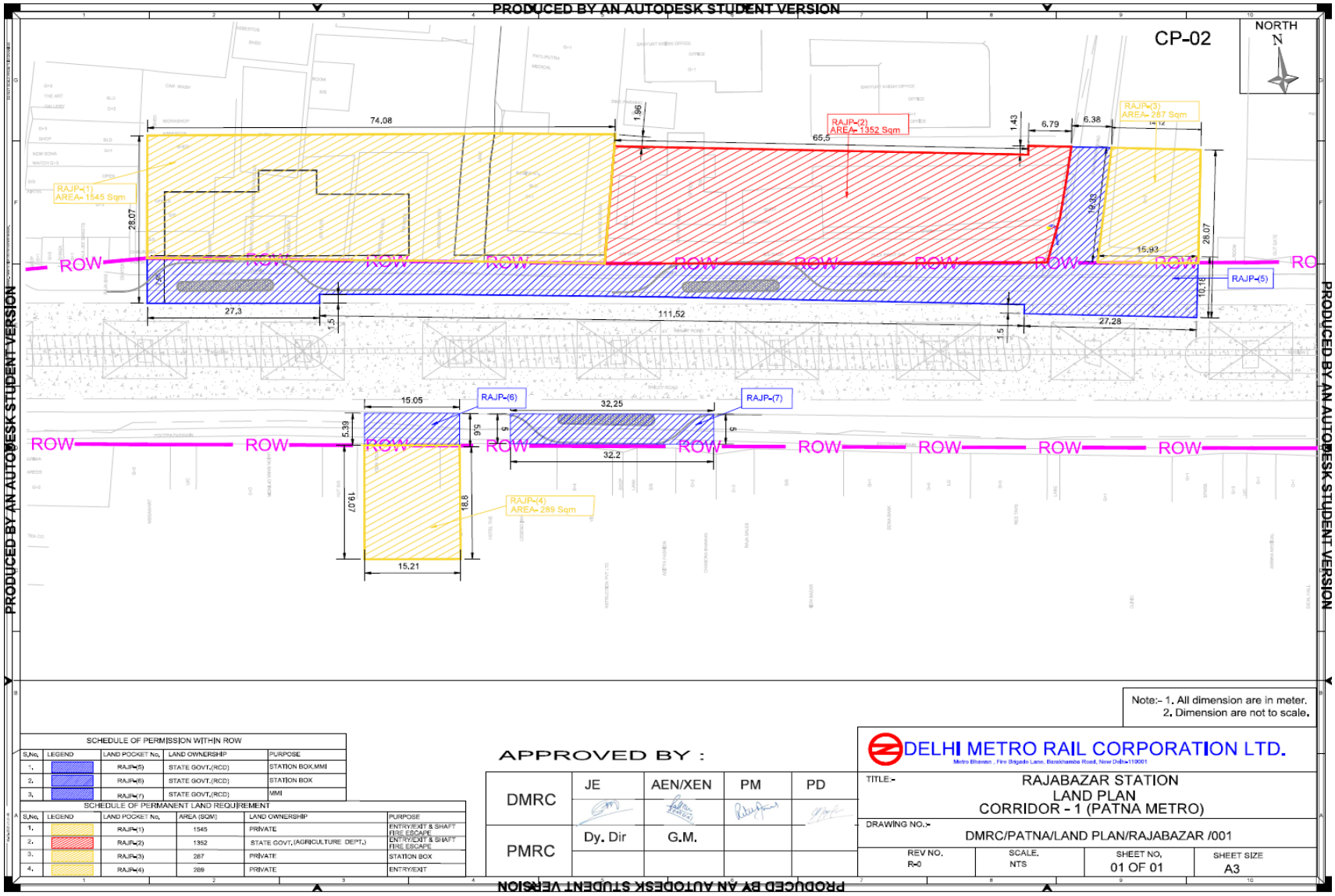
All contractors associated in construction works and C&D waste handling need to display a board at the site indicating dust control measures being adopted in English and Hindi. A sample display is given below for guidance:

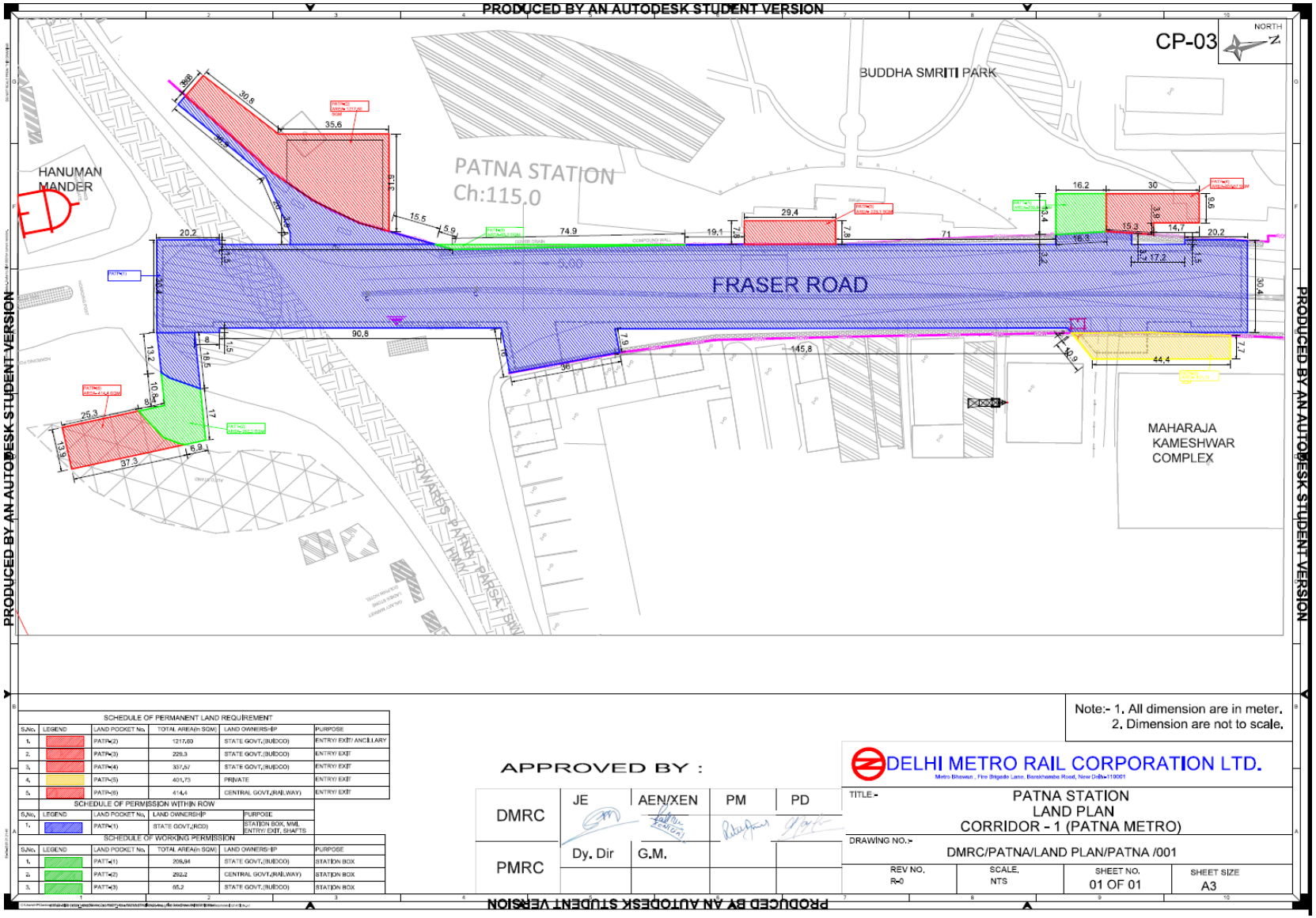
1. Dust affects health cause problems ranging from eye, nose and throat irritation besides the respiratory system
2. This project site adopts dust reduction measures
3. All light (potential to be wind blown) construction material is covered or put in sealed bags
4. Loading / unloading areas are barricaded
5. Water sprinkling for dust reduction is being practiced
6. Adequate covering material shall be used to reduce dust generation
7. Workers health & safety is our concern
8. Staffs at site have been apprised of CPCB's Guidelines on DUST reduction w.r.t. handling of C&D wastes & construction material.

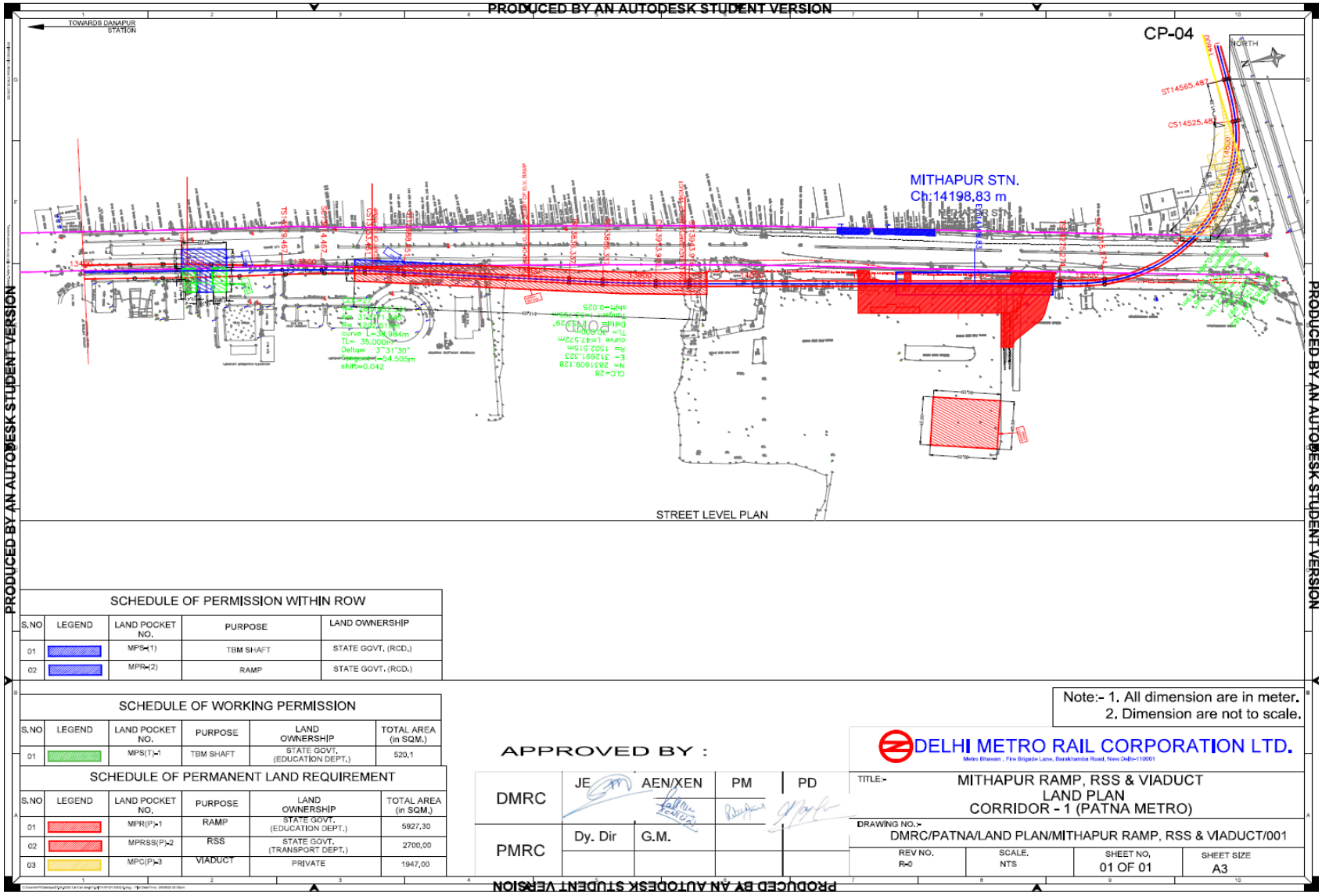
Annexure 7

LAYOUT MAP OF STATIONS




PRODUCED BY AN AUTODESK STUDENT VERSION
CP-02
NORTH
RAJP-(1) AREA- 1545 Sqm
RAJP-(2) AREA- 1352 Sqm
RAJP-(3) AREA- 287 Sqm
RAJP-(4) AREA- 289 Sqm
RAJP-(5)
RAJP-(6)
RAJP-(7)
ROW
74.08
65.5
6.79
6.38
28.07
27.3
111.52
27.28
15.93
15.05
32.25
32.2
19.07
15.21
Note:- 1. All dimension are in meter.
2. Dimension are not to scale.
SCHEDULE OF PERMISSION WITHIN ROW
SCHEDULE OF PERMANENT LAND REQUIREMENT
APPROVED BY :
DMRC
PMRC
JE
AEN/XEN
PM
PD
Dy. Dir
G.M.
DELHI METRO RAIL CORPORATION LTD.
TITLE:- RAJABAZAR STATION LAND PLAN CORRIDOR - 1 (PATNA METRO)
DRAWING NO.:- DMRC/PATNA/LAND PLAN/RAJABAZAR /001
REV NO. R-0
SCALE. NTS
SHEET NO. 01 OF 01
SHEET SIZE A3


PRODUCED BY AN AUTODESK STUDENT VERSION
CP-03
NORTH
BUDDHA SMRITI PARK
HANUMAN MANDER
PATNA STATION
Ch:115.0
FRASER ROAD
MAHARAJA KAMESHWAR COMPLEX
TOWARDS PATNA JUNCTION
SCHEDULE OF PERMANENT LAND REQUIREMENT
SCHEDULE OF PERMISSION WITHIN ROW
SCHEDULE OF WORKING PERMISSION
Note:- 1. All dimension are in meter.
2. Dimension are not to scale.
APPROVED BY :
DMRC
PMRC
JE
AEN/XEN
PM
PD
Dy. Dir
G.M.
DELHI METRO RAIL CORPORATION LTD.
TITLE:-
PATNA STATION
LAND PLAN
CORRIDOR - 1 (PATNA METRO)
DRAWING NO.:-
DMRC/PATNA/LAND PLAN/PATNA /001
REV NO. R-0
SCALE. NTS
SHEET NO. 01 OF 01
SHEET SIZE A3



SCHEDULE OF PERMISSION WITHIN ROW				
S.NO	LEGEND	LAND POCKET NO.	PURPOSE	LAND OWNERSHIP
01		MPS-(1)	TBM SHAFT	STATE GOVT. (RCD.)
02		MPR-(2)	RAMP	STATE GOVT. (RCD.)

SCHEDULE OF WORKING PERMISSION					
S.NO	LEGEND	LAND POCKET NO.	PURPOSE	LAND OWNERSHIP	TOTAL AREA (in SQM.)
01		MPS(T)-1	TBM SHAFT	STATE GOVT. (EDUCATION DEPT.)	520,1

SCHEDULE OF PERMANENT LAND REQUIREMENT					
S.NO	LEGEND	LAND POCKET NO.	PURPOSE	LAND OWNERSHIP	TOTAL AREA (in SQM.)
01		MPR(P)-1	RAMP	STATE GOVT. (EDUCATION DEPT.)	5927,30
02		MPRSS(P)-2	RSS	STATE GOVT. (TRANSPORT DEPT.)	2700,00
03		MPC(P)-3	VIADUCT	PRIVATE	1947,00

Note:- 1. All dimension are in meter.
2. Dimension are not to scale.

APPROVED BY :

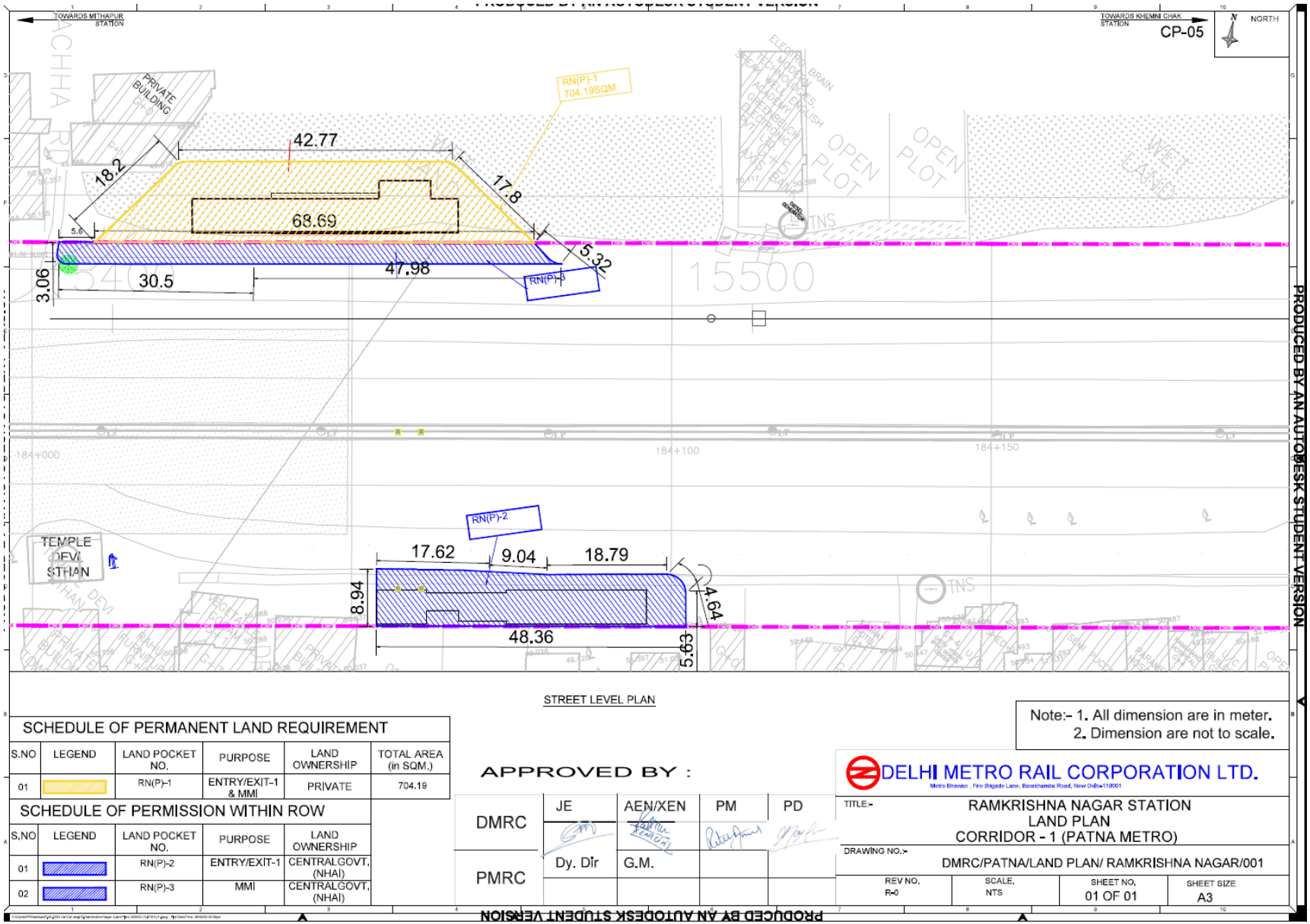
	JE	AEN/XEN	PM	PD
DMRC				
PMRC	Dy. Dir	G.M.		

DELHI METRO RAIL CORPORATION LTD.
Metro Bhawan , Fire Brigade Lane, Barakhamba Road, New Delhi-110001

TITLE:- MITHAPUR RAMP, RSS & VIADUCT LAND PLAN CORRIDOR - 1 (PATNA METRO)

DRAWING NO.:- DMRC/PATNA/LAND PLAN/MITHAPUR RAMP, RSS & VIADUCT/001

REV NO.	SCALE.	SHEET NO.	SHEET SIZE
R-0	NTS	01 OF 01	A3



STREET LEVEL PLAN

SCHEDULE OF PERMANENT LAND REQUIREMENT					
S.NO	LEGEND	LAND POCKET NO.	PURPOSE	LAND OWNERSHIP	TOTAL AREA (in SQM.)
01		RN(P)-1	ENTRY/EXIT-1 & MMI	PRIVATE	704.19

SCHEDULE OF PERMISSION WITHIN ROW				
S.NO	LEGEND	LAND POCKET NO.	PURPOSE	LAND OWNERSHIP
01		RN(P)-2	ENTRY/EXIT-1	CENTRALGOVT. (NHAI)
02		RN(P)-3	MMI	CENTRALGOVT. (NHAI)

Note:- 1. All dimension are in meter.
2. Dimension are not to scale.

APPROVED BY :

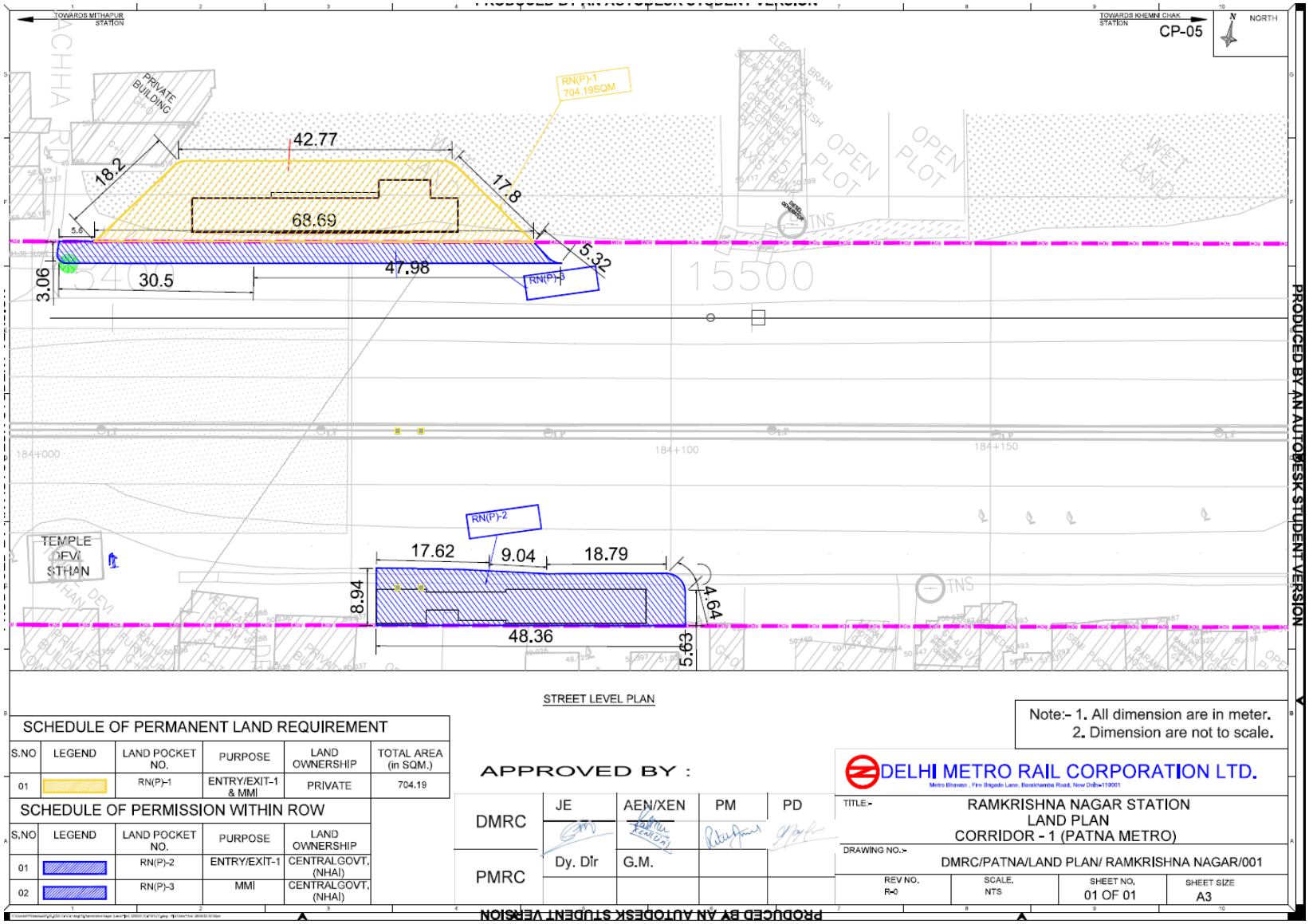
	JE	AEN/XEN	PM	PD
DMRC				
PMRC	Dy. Dir	G.M.		

DELHI METRO RAIL CORPORATION LTD.
Metro Bhawan , Fire Brigade Lane, Barakhamba Road, New Delhi-110001

TITLE:- RAMKRISHNA NAGAR STATION
LAND PLAN
CORRIDOR - 1 (PATNA METRO)

DRAWING NO.:- DMRC/PATNA/LAND PLAN/ RAMKRISHNA NAGAR/001

REV NO.	SCALE.	SHEET NO.	SHEET SIZE
R-0	NTS	01 OF 01	A3



STREET LEVEL PLAN

SCHEDULE OF PERMANENT LAND REQUIREMENT					
S.NO	LEGEND	LAND POCKET NO.	PURPOSE	LAND OWNERSHIP	TOTAL AREA (in SQM.)
01		RN(P)-1	ENTRY/EXIT-1 & MMI	PRIVATE	704.19

SCHEDULE OF PERMISSION WITHIN ROW				
S.NO	LEGEND	LAND POCKET NO.	PURPOSE	LAND OWNERSHIP
01		RN(P)-2	ENTRY/EXIT-1	CENTRALGOVT. (NHAI)
02		RN(P)-3	MMI	CENTRALGOVT. (NHAI)

Note:- 1. All dimension are in meter.
2. Dimension are not to scale.

APPROVED BY :

	JE	AEN/XEN	PM	PD
DMRC				
PMRC	Dy. Dir	G.M.		

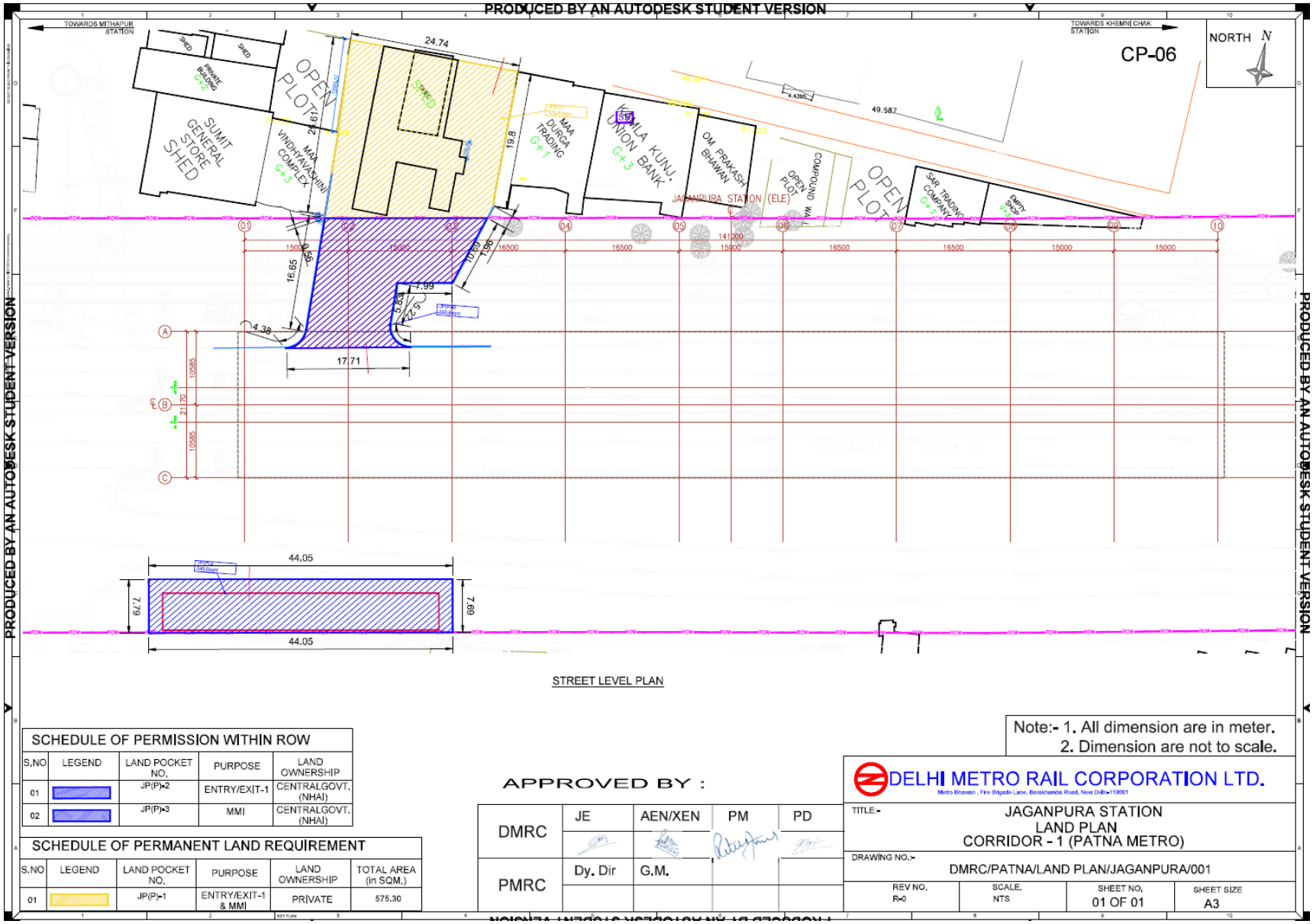
DELHI METRO RAIL CORPORATION LTD.
Metro Bhawan , Fire Brigade Lane, Barakhamba Road, New Delhi-110001

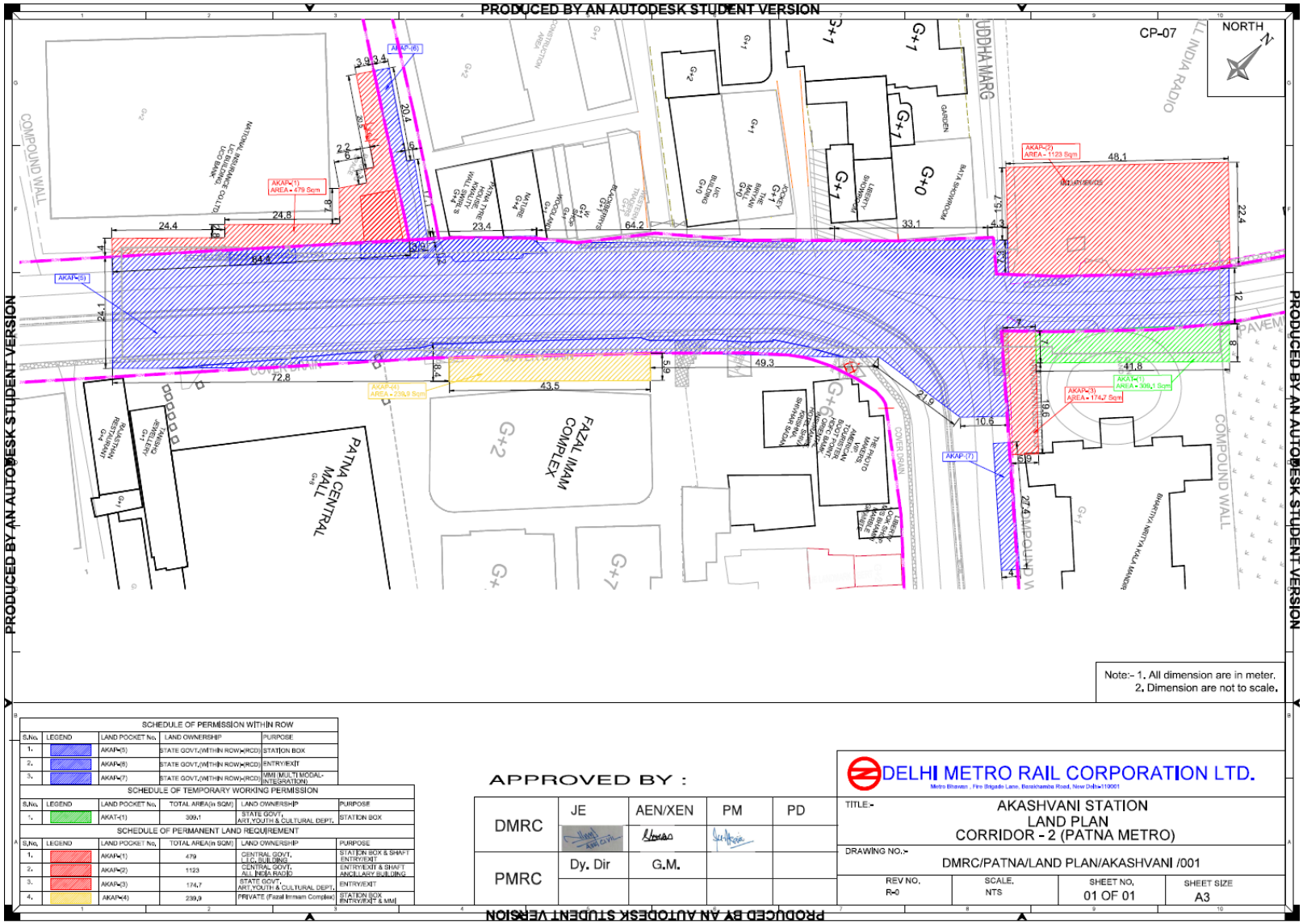
TITLE:- RAMKRISHNA NAGAR STATION
LAND PLAN
CORRIDOR - 1 (PATNA METRO)

DRAWING NO.:- DMRC/PATNA/LAND PLAN/ RAMKRISHNA NAGAR/001

REV NO.	SCALE.	SHEET NO.	SHEET SIZE
R-0	NTS	01 OF 01	A3

PRODUCED BY AN AUTODESK STUDENT VERSION


PRODUCED BY AN AUTODESK STUDENT VERSION
TOWARDS MITHAPUR STATION
TOWARDS KHEMNI CHAK STATION
CP-06
NORTH
SUMIT GENERAL STORE SHED
OPEN PLOT
SHED
MAA VINDHYAVASHINI COMPLEX G+3
MAA DURGA TRADING G+1
KAMLA KUNJ, UNION BANK G+3
OM PRAKASH BHAWAN
COMPOUND WALL
SAR TRADING COMPANY G+1
EMPTY SHED G+0
JAGANPURA STATION (ELE)
24.74
19.8
49.587
16.65
17.71
7.99
44,05
7.69
STREET LEVEL PLAN
SCHEDULE OF PERMISSION WITHIN ROW
S.NO | LEGEND | LAND POCKET NO. | PURPOSE | LAND OWNERSHIP
01 | JP(P)•2 | ENTRY/EXIT-1 | CENTRALGOVT. (NHAI)
02 | JP(P)•3 | MMI | CENTRALGOVT. (NHAI)
SCHEDULE OF PERMANENT LAND REQUIREMENT
S.NO | LEGEND | LAND POCKET NO. | PURPOSE | LAND OWNERSHIP | TOTAL AREA (in SQM.)
01 | JP(P)-1 | ENTRY/EXIT-1 & MMI | PRIVATE | 575.30
APPROVED BY :
DMRC | JE | AEN/XEN | PM | PD
PMRC | Dy. Dir | G.M.
Note:- 1. All dimension are in meter.
2. Dimension are not to scale.
DELHI METRO RAIL CORPORATION LTD.
TITLE:- JAGANPURA STATION
LAND PLAN
CORRIDOR - 1 (PATNA METRO)
DRAWING NO.:- DMRC/PATNA/LAND PLAN/JAGANPURA/001
REV NO. R-0
SCALE. NTS
SHEET NO. 01 OF 01
SHEET SIZE A3
PRODUCED BY AN AUTODESK STUDENT VERSION



SCHEDULE OF PERMISSION WITHIN ROW

S.No.	LEGEND	LAND POCKET No.	LAND OWNERSHIP	PURPOSE
1.		AKAP-(5)	STATE GOVT.(WITHIN ROW)-(RCD)	STATION BOX
2.		AKAP-(6)	STATE GOVT.(WITHIN ROW)-(RCD)	ENTRY/EXIT
3.		AKAP-(7)	STATE GOVT.(WITHIN ROW)-(RCD)	MMI (MULTI MODAL-INTEGRATION)

SCHEDULE OF TEMPORARY WORKING PERMISSION

S.No.	LEGEND	LAND POCKET No.	TOTAL AREA(in SQM)	LAND OWNERSHIP	PURPOSE
1.		AKAT-(1)	309.1	STATE GOVT, ART,YOUTH & CULTURAL DEPT.	STATION BOX

SCHEDULE OF PERMANENT LAND REQUIREMENT

S.No.	LEGEND	LAND POCKET No.	TOTAL AREA(in SQM)	LAND OWNERSHIP	PURPOSE
1.		AKAP-(1)	479	CENTRAL GOVT, LIC BUILDING	STATION BOX & SHAFT ENTRY/EXIT
2.		AKAP-(2)	1123	CENTRAL GOVT, ALL INDIA RADIO	ENTRY/EXIT & SHAFT ANCILLARY BUILDING
3.		AKAP-(3)	174.7	STATE GOVT, ART,YOUTH & CULTURAL DEPT.	ENTRY/EXIT
4.		AKAP-(4)	239.9	PRIVATE (Fazal Immam Complex)	STATION BOX ENTRY/EXIT & MMI

APPROVED BY :

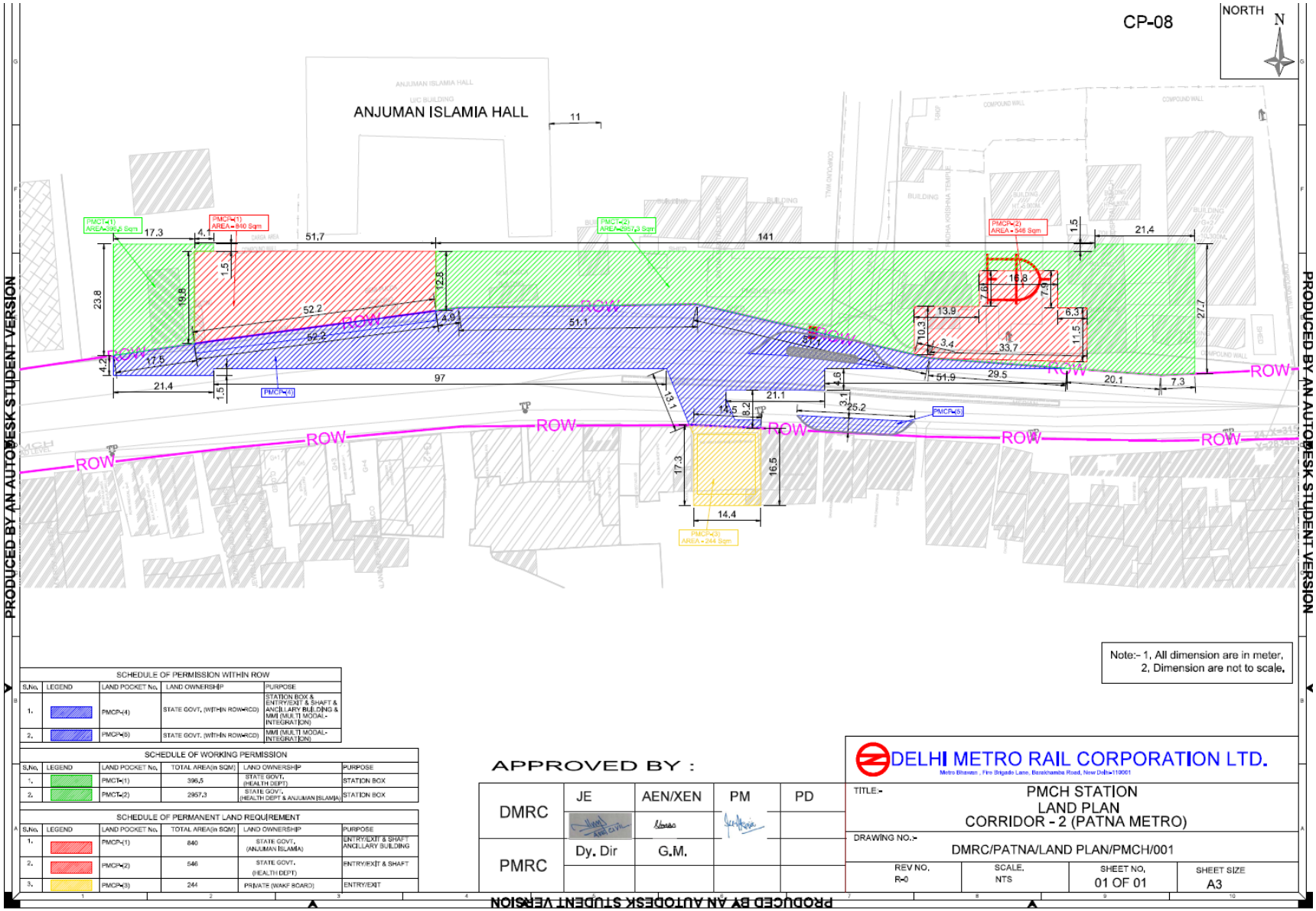
	JE	AEN/XEN	PM	PD
DMRC				
PMRC	Dy. Dir	G.M.		

DELHI METRO RAIL CORPORATION LTD.
Metro Bhawan , Fire Brigade Lane, Barakhamba Road, New Delhi-110001

TITLE:- AKASHVANI STATION
LAND PLAN
CORRIDOR - 2 (PATNA METRO)

DRAWING NO.:- DMRC/PATNA/LAND PLAN/AKASHVANI /001

REV NO.	SCALE.	SHEET NO.	SHEET SIZE
R-0	NTS	01 OF 01	A3



SCHEDULE OF PERMISSION WITHIN ROW

S.No.	LEGEND	LAND POCKET No.	LAND OWNERSHIP	PURPOSE
1.		PMCP-(4)	STATE GOVT. (WITHIN ROW-RCD)	STATION BOX & ENTRY/EXIT & SHAFT & ANCILLARY BUILDING & MMI (MULTI MODAL-INTEGRATION)
2.		PMCP-(5)	STATE GOVT. (WITHIN ROW-RCD)	MMI (MULTI MODAL-INTEGRATION)

SCHEDULE OF WORKING PERMISSION

S.No.	LEGEND	LAND POCKET No.	TOTAL AREA(in SQM)	LAND OWNERSHIP	PURPOSE
1.		PMCT-(1)	396.5	STATE GOVT. (HEALTH DEPT)	STATION BOX
2.		PMCT-(2)	2957.3	STATE GOVT. (HEALTH DEPT & ANJUMAN ISLAMIA)	STATION BOX

SCHEDULE OF PERMANENT LAND REQUIREMENT

S.No.	LEGEND	LAND POCKET No.	TOTAL AREA(in SQM)	LAND OWNERSHIP	PURPOSE
1.		PMCP-(1)	840	STATE GOVT. (ANJUMAN ISLAMIA)	ENTRY/EXIT & SHAFT ANCILLARY BUILDING
2.		PMCP-(2)	546	STATE GOVT. (HEALTH DEPT)	ENTRY/EXIT & SHAFT
3.		PMCP-(3)	244	PRIVATE (WAKF BOARD)	ENTRY/EXIT

APPROVED BY :

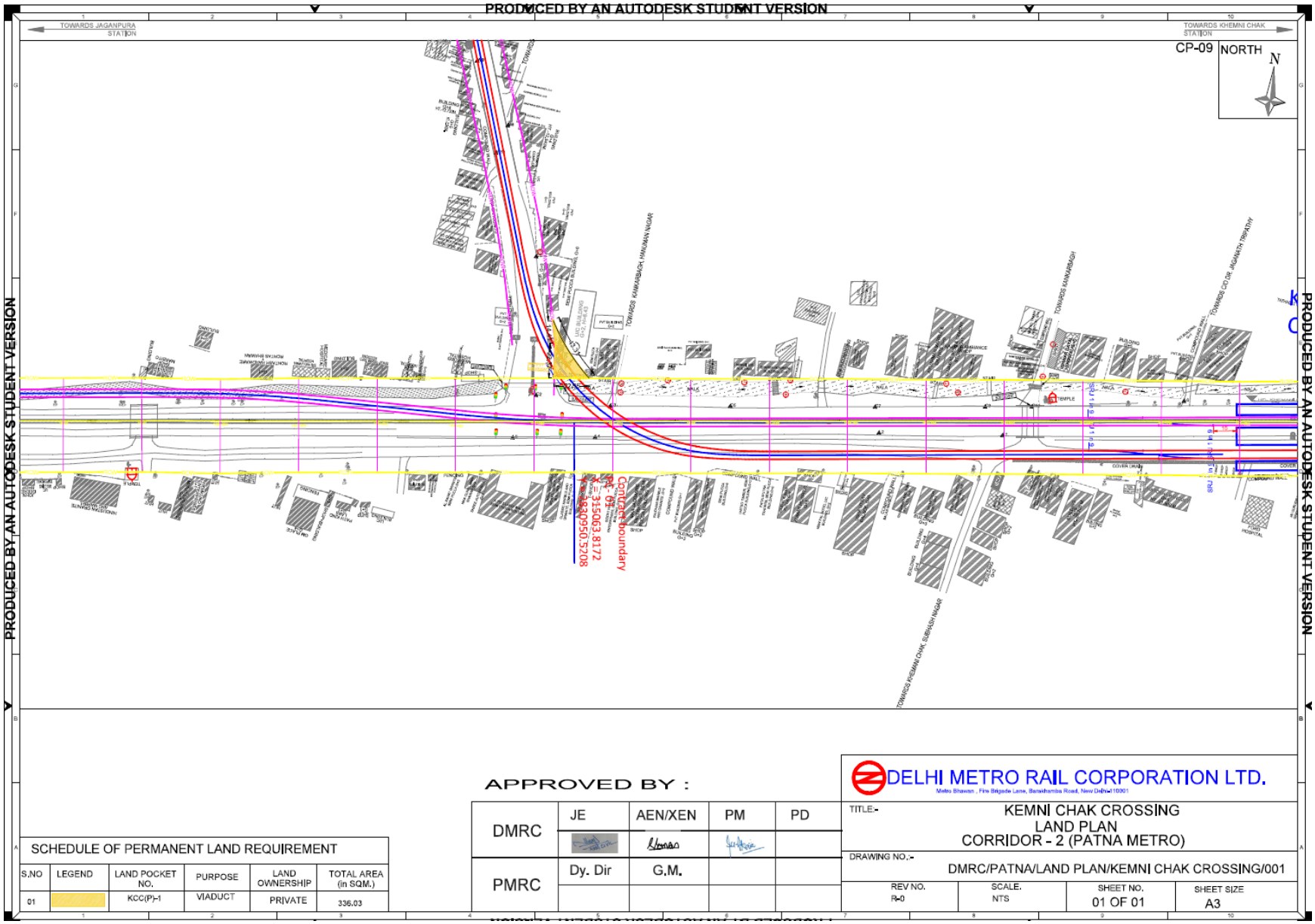
	JE	AEN/XEN	PM	PD
DMRC				
PMRC	Dy. Dir	G.M.		

DELHI METRO RAIL CORPORATION LTD.
Metro Bhawan , Fire Brigade Lane, Barakhamba Road, New Delhi-110001

TITLE:- PMCH STATION LAND PLAN CORRIDOR - 2 (PATNA METRO)

DRAWING NO.:- DMRC/PATNA/LAND PLAN/PMCH/001

REV NO.	SCALE.	SHEET NO.	SHEET SIZE
R-0	NTS	01 OF 01	A3



SCHEDULE OF PERMANENT LAND REQUIREMENT

S.NO	LEGEND	LAND POCKET NO.	PURPOSE	LAND OWNERSHIP	TOTAL AREA (in SQM.)
01		KCC(P)-1	VIADUCT	PRIVATE	336.03

APPROVED BY :

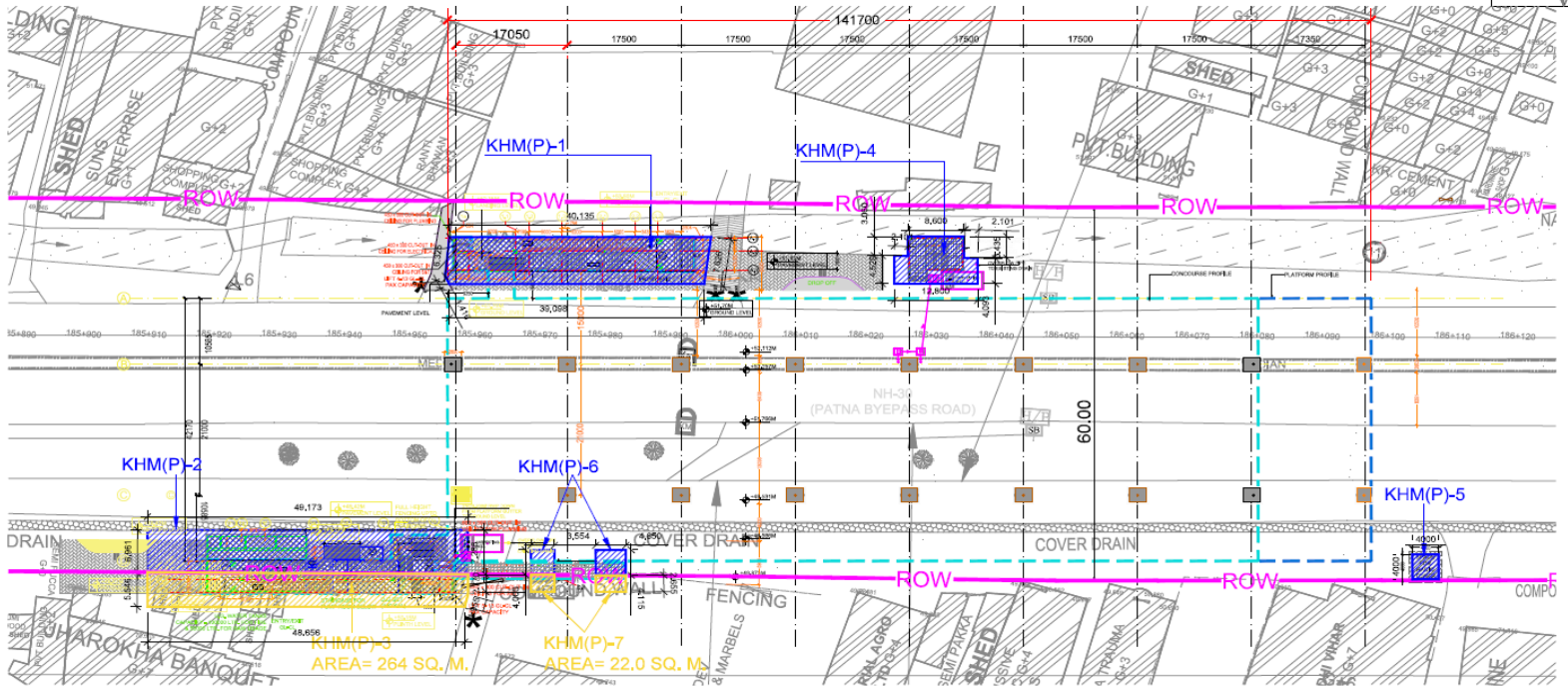
	JE	AEN/XEN	PM	PD
DMRC				
PMRC	Dy. Dir	G.M.		

DELHI METRO RAIL CORPORATION LTD.
Metro Bhawan , Fire Brigade Lane, Barakhamba Road, New Delhi-110001

TITLE:- KEMNI CHAK CROSSING
LAND PLAN
CORRIDOR - 2 (PATNA METRO)

DRAWING NO.:- DMRC/PATNA/LAND PLAN/KEMNI CHAK CROSSING/001

REV NO.	SCALE.	SHEET NO.	SHEET SIZE
R-0	NTS	01 OF 01	A3



* DUE TO AN EXISTING ROAD IN THIS PORTION, LAND PROFILE HAS BEEN MODIFIED ACCORDINGLY (2100MM DISTANCE FROM THE STRUCTURE NOT CONSIDERED HERE).

** DUE TO AN EXISTING ROAD IN THIS PORTION, LAND PROFILE HAS BEEN MODIFIED ACCORDINGLY (8000MM DISTANCE IN FRONT OF PLINTH STEPS NOT CONSIDERED HERE).

SCHEDULE OF PERMANENT LAND REQUIREMENT

S.No.	LEGEND	LAND POCKET NO.	TOTAL AREA (in SQM.)	LAND OWNERSHIP	PURPOSE
1.		KHM(P)-3	264	PRIVATE LAND	ENTRY/EXIT-2
2.		KHM(P)-7	22	PRIVATE LAND	FUTURE EMERGENCY STAIRCASE COLUMNS

SCHEDULE OF PERMISSION WITHIN ROW

S.No.	LEGEND	LAND POCKET NO.	LAND OWNERSHIP	PURPOSE
1.		KHM(P)-1	CENTRAL GOVT (NHAI)	ENTRY/EXIT-1
2.		KHM(P)-2	CENTRAL GOVT (NHAI)	ENTRY/EXIT-2
3.		KHM(P)-4	CENTRAL GOVT (NHAI)	FUTURE EMERGENCY
4.		KHM(P)-5	CENTRAL GOVT (NHAI)	STAIRCASE RADIO TOWER
5.		KHM(P)-6	CENTRAL GOVT (NHAI)	FUTURE EMERGENCY STAIRCASE COLUMNS

Note:- 1. All dimension are in meter.
2. Dimension are not to scale.

APPROVED BY :

	JE	AEN/XEN	PM	PD
DMRC				
PMRC	Dy. Dir	G.M.		

DELHI METRO RAIL CORPORATION LTD.
Metro Bhawan, Fire Brigade Lane, Barakhamba Road, New Delhi-110001

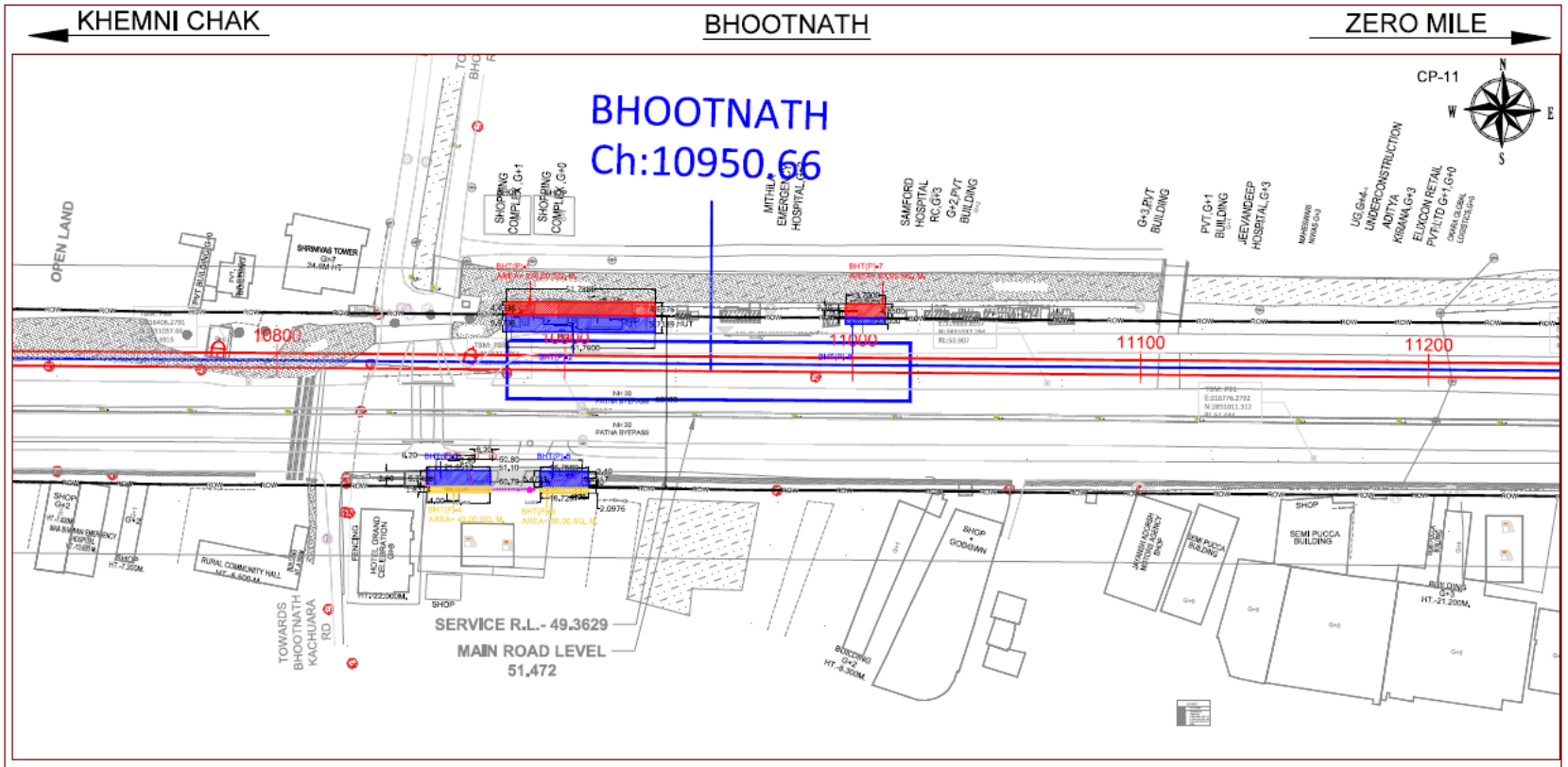
TITLE:- KHEMNI CHAK STATION
LAND PLAN
CORRIDOR - 2 (PATNA METRO)

DRAWING NO.:- DMRC/PATNA/LAND PLAN/KHEMNI CHAK /001

REV NO.	SCALE.	SHEET NO.	SHEET SIZE
R-0	NTS	01 OF 01	A3

PRODUCED BY AN AUTODESK STUDENT VERSION

PRODUCED BY AN AUTODESK STUDENT VERSION



SCHEDULE OF PERMISSION WITHIN ROW

S.No.	LEGEND	LAND POCKET NO.	LAND OWNERSHIP	PURPOSE
1.		BHT(P)-2	CENTRAL GOVT. (NHAI)	ENTRY/EXIT-1
2.		BHT(P)-3	CENTRAL GOVT. (NHAI)	ENTRY/EXIT-2
3.		BHT(P)-5	CENTRAL GOVT. (NHAI)	ENTRY/EXIT-2
4.		BHT(P)-8	CENTRAL GOVT. (NHAI)	FUTURE EMERGENCY ESCAPE STAIRCASE

SCHEDULE OF PERMANENT LAND REQUIREMENT

S.No.	LEGEND	LAND POCKET NO.	TOTAL AREA (in SQM.)	LAND OWNERSHIP	PURPOSE
1.		BHT(P)-1	236.00	STATE GOVT. (RCD)	ENTRY/EXIT-1
2.		BHT(P)-4	42.00	PRIVATE LAND	ENTRY/EXIT-2
3.		BHT(P)-6	35.00	PRIVATE LAND	ENTRY/EXIT-2
4.		BHT(P)-7	67.00	STATE GOVT. (RCD)	FUTURE EMERGENCY ESCAPE STAIRCASE

Note:- 1, All dimension are in meter,
2, Dimension are not to scale.

APPROVED BY :

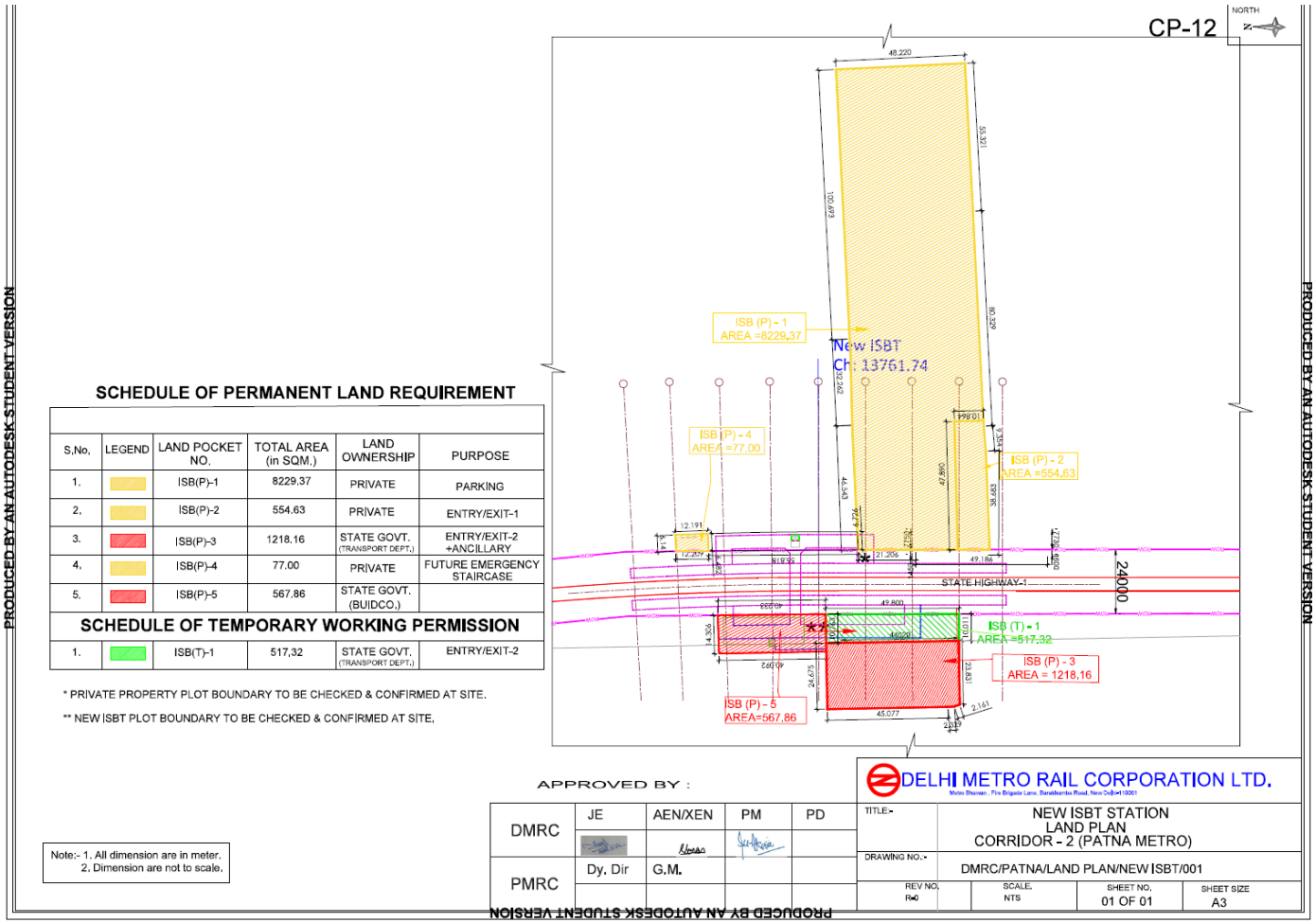
	JE	AEN/XEN	PM	PD
DMRC				
PMRC	Dy. Dir	G.M.		

DELHI METRO RAIL CORPORATION LTD.
Metro Bhawan, Fire Brigade Lane, Barakhamba Road, New Delhi-110001

TITLE:- BHOOTNATH STATION
LAND PLAN
CORRIDOR - 2 (PATNA METRO)

DRAWING NO.:- DMRC/PATNA/LAND PLAN/BHOOTNATH /001

REV NO.	SCALE.	SHEET NO.	SHEET SIZE
R-0	NTS	01 OF 01	A3



SCHEDULE OF PERMANENT LAND REQUIREMENT

S.No,	LEGEND	LAND POCKET NO.	TOTAL AREA (in SQM.)	LAND OWNERSHIP	PURPOSE
1.		ISB(P)-1	8229.37	PRIVATE	PARKING
2.		ISB(P)-2	554.63	PRIVATE	ENTRY/EXIT-1
3.		ISB(P)-3	1218.16	STATE GOVT. (TRANSPORT DEPT.)	ENTRY/EXIT-2 +ANCILLARY
4.		ISB(P)-4	77.00	PRIVATE	FUTURE EMERGENCY STAIRCASE
5.		ISB(P)-5	567.86	STATE GOVT. (BUIDCO.)	
SCHEDULE OF TEMPORARY WORKING PERMISSION					
1.		ISB(T)-1	517.32	STATE GOVT. (TRANSPORT DEPT.)	ENTRY/EXIT-2

* PRIVATE PROPERTY PLOT BOUNDARY TO BE CHECKED & CONFIRMED AT SITE.

** NEW ISBT PLOT BOUNDARY TO BE CHECKED & CONFIRMED AT SITE.

Note:- 1. All dimension are in meter.
2. Dimension are not to scale.

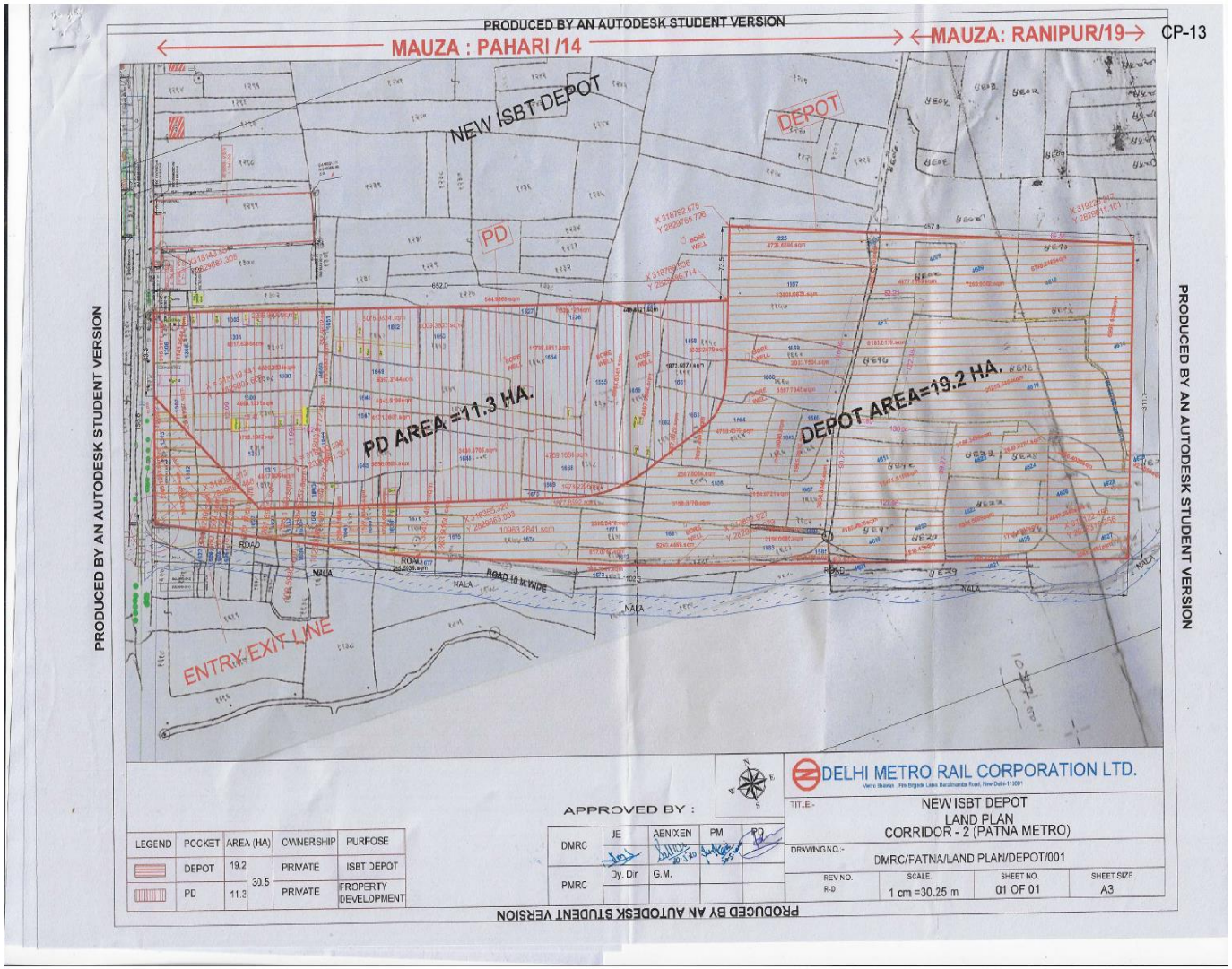
APPROVED BY :

	JE	AEN/XEN	PM	PD
DMRC				
PMRC	Dy. Dir	G.M.		

DELHI METRO RAIL CORPORATION LTD.
Metro Bhawan , Fire Brigade Lane, Barakhamba Road, New Delhi-110001

TITLE:-	NEW ISBT STATION LAND PLAN CORRIDOR - 2 (PATNA METRO)
DRAWING NO.:-	DMRC/PATNA/LAND PLAN/NEW ISBT/001
REV NO. R-0 / SCALE NTS / SHEET NO. 01 OF 01 / SHEET SIZE A3	

PRODUCED BY AN AUTODESK STUDENT VERSION


PRODUCED BY AN AUTODESK STUDENT VERSION
MAUZA : PAHARI /14
MAUZA: RANIPUR/19
CP-13
NEW ISBT DEPOT
DEPOT
PD
PD AREA =11.3 HA.
DEPOT AREA=19.2 HA.
ROAD
NALA
ROAD 10 M WIDE
ENTRY/EXIT LINE
PRODUCED BY AN AUTODESK STUDENT VERSION
PRODUCED BY AN AUTODESK STUDENT VERSION
LEGEND
POCKET
AREA (HA)
OWNERSHIP
PURPOSE
DEPOT
19.2
30.5
PRIVATE
ISBT DEPOT
PD
11.3
PRIVATE
PROPERTY DEVELOPMENT
APPROVED BY :
DMRC
JE
AEN/XEN
PM
PD
PMRC
Dy. Dir
G.M.
DELHI METRO RAIL CORPORATION LTD.
TIT.E:-
NEW ISBT DEPOT
LAND PLAN
CORRIDOR - 2 (PATNA METRO)
DRWING NO.:-
DMRC/PATNA/LAND PLAN/DEPOT/001
REV NO.
R-0
SCALE:
1 cm =30.25 m
SHEET NO.
01 OF 01
SHEET SIZE
A3
PRODUCED BY AN AUTODESK STUDENT VERSION