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GENERAL CONSULTANT (GC) FOR PHASE- II CORRIDOR FROM JLN STADIUM TO INFOPARK VIA KAKKANAD OF KOCHI METRO RAIL PROJECT.

EIA DUE DILIGENCE REPORT

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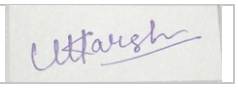
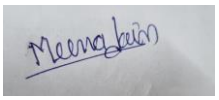
R4	Author	**Utkarsh Dixit**	Environment Engineer	29/01/2024		Formatting Modifications
	Checked by	**Meena Jain**	Senior Principal Engineer-Environment	29/01/2024		
	Authorised by	**Deshmukh Niteen**	Team Leader	29/01/2024		

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ABBREVIATIONS

AAQ	Ambient Air Quality
AADT	Annual Average Daily Traffic
ADB	Asian Development Bank
AC	Alternating Current
AIIB	Asian Infrastructure Investment Bank
BOD	Biochemical Oxygen Demand
CESMP	Construction Environmental and Social Management Plan
COD	Chemical Oxygen Demand
CORDEX	Coordinated Regional Climate Downscaling Experiment
CoI	Corridor of Influence
CPCB	Central Pollution Control Board
CRZ	Coastal Regulation Zone
DPR	Detailed Project Report
DC	Direct Current
DO	Dissolved Oxygen
ECA	Ecologically Critical Area
EIA	Environmental Impact Assessment
EMP	Environmental Management Plan
EMoP	Environmental Monitoring Plan
EMMP	Environmental Management and Monitoring Plan
EDDR	Environmental Due Diligence Report
ESS	Environmental and Social Standards
ESDD	Environmental and Social Due Diligence
ESF	Environmental Social Framework
ESZ	Eco-sensitive Zone
FTA	Federal Transit Administration
GC	General Consultant
GCM	Global Climate Model
GPS	Global Positioning System
GRM	Grievance Redress Mechanism
GRC	Grievance Redress Committee
GI	Geographical Indication
IRC	Indian Road Congress
IUCN	International Union for Conservation of Nature and Natural Resources
KMRL	Kochi Metro Rail Limited

KSDMA	Kerala State Disaster Management Authority
KSPCB	Kerala State Pollution Control Board
LULC	Land use Landcover
MoEF&CC	Ministry of Environment, Forests and Climate Change
MoHUA	Ministry of Housing and Urban Affairs
MDB	Multilateral Development Bank
NAAQS	National Ambient Air Quality Standards
OHS	Occupational Health and Safety
PAP	Project Affected Persons
PIA	Project Impact Area
PIU	Project Implementation Unit
PPV	Peak Particle Velocity
PSC	Pre-Stressed Concrete
RCM	Regional Climate Model
RCPs	Representation Concentration Pathways
RP	Resettlement Plan
RoW	Right of Way
RDSO	Railway Design and Standards Organization
RTW	River Training Work
SDDR	Social Due Diligence Report
SEZ	Special Economic Zone
SPL	Sound Pressure Level
SIA	Social Impact Assessment
TDS	Total Dissolved Solid
ToR	Terms of Reference
UNESCO	United Nations Educational, Scientific and Cultural Organization
WHO	World Health Organization

0 EXECUTIVE SUMMARY

In an effort to improve the transportation system of the Kochi city and to move towards the cleaner and sustainable mode of transportation, the Government of Kerala intends to develop metro rail network (elevated) system for the entire city with the financial aid from Asian Infrastructure Investment Bank (AIIB). A Special Purpose Vehicle (SPV), i.e., Kochi Metro Rail Limited (KMRL), has been formed by the Government of Kerala for implementation, operation, and maintenance of the Metro projects. KMRL has already constructed Phase I of the Kochi Metro Rail from Aluva to Petta and has planned to expand it from Petta to Tripunithura. Now KMRL has planned to develop Phase II from JLN to Info Park.

This phase-II corridor of 11.2 km of length will relate to the Phase-I at JLN Stadium Metro station to ensure integration of Phase I.

0.1 Need for EDDR

The Asian Infrastructure and Investment Bank (AIIB) has extended its financial support to Kochi Metro Rail Limited (KMRL) for the execution of the Phase II project expansion. Guided by the AIIB's Environmental and Social Framework (ESF), which was updated in January 2022, this framework outlines principles and guidelines for managing environmental and social risks associated with financed projects. Emphasizing the significance of environmental and social due diligence (ESDD), the AIIB requires a thorough examination of existing or under-construction facilities to identify past or present concerns related to environmental and socio-economic attributes. In line with these requirements, Environmental and Social Due Diligence study has been conducted for KMRL Phase II project, and two distinct reports namely Environmental Due Diligence (EDDR) and Social Due Diligence (SDDR) has been prepared. This report focuses specifically on the Environmental Due Diligence.

KMRL has previously initiated key activities, including Environmental Impact Assessment and the preparation of a Detailed Project Report, ahead of the AIIB's appraisal. In this EDDR, a comprehensive assessment of these reports is conducted. The primary objective is to confirm their adherence to AIIB's Environmental and Social Framework (ESF), pinpoint any existing gaps, conduct additional studies to address identified gaps, and to propose essential action plans.

0.2 Categorization of Project

The Kochi Metro project has been categorized as category A according to AIIB's project categorization, necessitating a comprehensive impact assessment to be documented in an Environmental & Social Impact Assessment (ESIA) Report, in accordance with the requirements of Multilateral Development Banks (MDBs) ESF.

0.3 Regulatory Framework

As per provisions of the Environmental Impact Assessment (EIA) Notification 2006 and its subsequent amendments by the Ministry of Environment, Forests and Climate Change (MoEF&CC), Metro Rail Projects are exempted from requirements of Environmental Clearance.

The key national and state policies, acts and regulations related to environment, that are applicable to the Project are, Environmental (Protection) Act 1986, Water (Prevention and Control of Pollution) Act 1974, Air (Prevention and Control of Pollution) Act 1981, Noise Pollution (Regulation and Control) rules 2000, Hazardous and Other Wastes (Management and Transboundary Movement) Rules, 2016, Solid Waste Management Rules 2016, Construction and Demolition Waste Rules 2016, Forest (Conservation) Act 1980, Wildlife Protection Act 1972, CRZ Notification 2011, The Building and Other Construction Workers' (Regulation of Employment and Conditions of Service) Act 1996, Contract Labour (Regulation and Abolition) Act 1970, Workmen Compensation Act 1923, etc. Mangalavanam Bird Sanctuary exists at 3 km from JLN Stadium. There is a notification on ESZ of said bird sanctuary which states that ESZ varies from 0-1.5 km around the boundary of the bird sanctuary however the notification is in draft stage hence the ESZ of the sanctuary shall be considered as 10km. Although project is passing through eco-sensitive zone, wildlife clearance will note be required as the project is exempted from requirement of environment clearance.

The EIA report listed the laws, regulations, policies, and guidelines which are applicable as well not applicable for the project. The guidelines and regulations as provided in the EIA are in line with the national standards, for the MDB's requirement, the report is in context with the WB operational policies. However, in August 2016, the World Bank adopted a new set of environment and social policies called the Environmental and Social Framework (ESF). Given that the project is to be funded by the AIIB, it's pertinent to note that, akin to various other international financial institutions, AIIB has established its own Environmental and Social Framework to provide guidance on the environmental and social aspects of projects. The Environmental Due Diligence Report (EDDR) comprehensively addresses this framework.

0.4 Project Features

Proposed project involves development of the Phase II of Kochi Metro rail, i.e., from JLN Station to Info Park via Kakkanad. Length of the Phase II is approx.11.2 km. There are in total 11 stations planned to be developed in Phase II excluding JLN stadium station. Phase II will connect the existing Phase I line with the busy areas of the city like Palarivattom, Chembmukku, Vazhakaal, Padamughal, metro city etc. Planned metro rail line is elevated section and will traverse through the road median and road edges. Roads are narrow from JLN to Kakkanad area where the road has been proposed to widen, however after Kakkanad road width is more than 30 m.

0.5 Environmental Baseline

The Environmental Impact Assessment (EIA) report comprehensively details the baseline environmental conditions of the Corridor of Influence (CoI) and Project Impact Area (PIA). The profile covers physiography, geology, land use, soil, hydrogeology, flora, wildlife, forest/vegetation cover, climate, ambient air quality, water quality, and ambient noise levels.

The baseline data collection for the Air, Water, Noise and Soil was done in June 2019 during the EIA stage. However, the sensitive receptors along the alignment were not entirely covered. Also, the baseline monitoring for ground-born vibration was not carried out during EIA stage.

Baseline monitoring data of 2019 offer valuable context and overview of the conditions of that time. However, it's essential to consider the context and changes that may have occurred since then, a more recent update could provide a more accurate reflection of the current situation. For a clear comparison between the current state and any potential changes or impacts from the EIA stage, a baseline environmental monitoring was conducted during Due Diligence study.

During the EDDR, a fresh baseline data has been generated on key location representative of the project area including the sensitive receptors for air quality, water quality, noise, soil, and vibration for the period of 20st November 2023 to 22nd November 2023. During the EDDR stage, all sensitive receptors for noise and vibration monitoring were considered, as was not covered during the EIA stage.

It is observed that both the daytime and night-time noise level are on higher sides and exceeds the CPCB Noise Standards limits at almost all locations except at locations near Palarivattom jn and KINFRA station. The major source of noise pollution is the traffic congestion and the along the alignment the major land use is commercial contribution to the higher noise level.

During EDDR, vibration monitoring was conducted at 6 locations along the alignment. The RMS VdB baseline vibration values were found to be within the acceptable criteria for ground borne vibration prescribed by the Federal Transit Administration (FTA) USA and Railway Design and Standards Organisation (RDSO) India which are more valid for operation of this project. The observed level of vibration is primarily due to movement of traffic and other anthropogenic sources.

For the EDDR, the soil sample near Kakkanad station was collected and analysed to assess the change in soil characteristics from 2019 to current date. Also, groundwater and surface water monitoring was done and the results were observed to be within the prescribed standards.

0.6 Climate Risk Assessment

Established at the same time as the Paris Agreement, the Asian Infrastructure Investment Bank's (AIIB or the Bank) strategies, policies and operations recognize the importance of addressing the climate change challenge.

All projects funded by the bank must align with the emissions goals of the host countries. They must also include physical climate risks as part of the project planning and implementation. A climate risk assessment was not conducted during the EIA stage. At the EDDR stage a detailed assessment has been carried out to identify the physical climate risks that the proposed project and its components are exposed and to identify the adaptation measures to manage these risks.

In the area flood hazard is classified as high based on climate screening tool AwareTM, wind speed and temperature increase has also been identified as moderate risk for the project area.

For the KMRL metro project's Phase II, the design norms and parameters have been determined and finalized drawing from the experience gained in the Phase I metro project along with adherence to standard codes of practices. Notably, many adaptations addressing current operational challenges contribute to building resilience, even if their primary focus is not specifically on climate change. The assessment of climate change adaptation measures for Phase II infrastructural components is derived from the findings of the DPR, aligning with climatic parameters influencing the nature and severity of natural hazards. This information is presented in the EDDR, even though adaptation to climate change impacts was not the primary focus in the DPR. The Due Diligence study has incorporated climate risk assessment and corresponding adaptation measures.

0.7 Anticipated Impacts and Mitigation Measures

Apart from the listed impacts in the EIA, such as impacts related to air, water, land, waste generation, flora and fauna, noise, vibration, health and safety, energy, etc., the EDDR has identified impacts such as noise and vibration during construction and operation phase of the project, as the Phase-II alignment is passing close to residences and commercial establishments. The EDDR stage specifically conducted a detailed study for Noise and Vibration Impact assessment.

The impact resulting from train operation falls within a zone of no severe impact. Nonetheless, to mitigate noise levels associated with metro train operation, the Contractor is obligated to adhere to established good practices. This includes the provision of noise barriers with specified details for installation, explicitly outlining the location, design, material, and future maintenance requirements. It is advisable for the contractor, in collaboration with KMRL, stakeholders, and PAPs, to identify potential locations for noise barriers (if necessary). The finalized locations should then be incorporated into the CESMP (Construction Environment and Social Management Plan).

The major impacts include (i) acquisition of 5.1495 ha of land; (ii) cutting of 669 trees; (iii) noise & vibration during construction and operation phase; (iv) impacts due to natural hazards.

The main mitigation measures proposed are as follows:

(i) To plant ten saplings for each tree to be cut as against ten saplings ordered for infrastructure projects by the Honourable Madras High Court, with estimated compensatory afforestation cost in place: accordingly,
(ii) Noise reduction measures (i.e. noise barriers at sensitive receptor locations); and
(iii) Reuse of excavated material where feasible and disposal of construction waste in a regulated manner.

The project will take into consideration the climate change effects of an anticipated continuous increase in ambient temperature, heavy precipitation events, and flooding in the future. Several climate change considerations to be integrated into design include:

(i) Improving adaptability to seasonal thermal variations in the stations through the use of large open spaces for unrestricted air movement, cross-ventilation and ensuring that enclosed areas are well ventilated.
(ii) Designing for better adaptability to heavy flooding through the use of higher plinth levels.
(iii) Using solar panels on station buildings and roofs to reduce the extensive use of grid generated electricity supplied to the station for its operation and maintenance; and
(iv) Through better station roof design, providing rainwater harvesting by channelling rainwater through gutters and pipes to harvesting tanks.

0.8 Public Consultation and Stakeholder Identification

Meaningful consultations were carried out with various stakeholders during SIA and also during EDDR study and will continue throughout project implementation. Women felt that project will provide (i) better access to higher levels of education, health services (especially in emergencies), and social interactions; (ii) better transport option; and (iii) increase in leisure time. Concerns voiced by Project Affected Persons (PAPs) and stakeholders have been incorporated in project design. Individual consultation of PAPs will also be carried out during implementation. Information disclosure will follow the procedure for MDBs' Category A projects.

0.9 Grievance Redress Mechanism

KMRL is committed to address the grievances of all the stakeholders of Kochi Metro. In its endeavour to ensure transparent and timely redressal of grievances, KMRL has devised the following grievance redressal mechanism.

(i) KMRL website
(ii) A toll-free helpline,
(iii) Written feedback forms (available at stations' customer cares),
(iv) An email,
(v) A WhatsApp chat bot,
(vi) Social media channels,
(vii) Station controller mobiles,
(viii) Metro Promo Centre.

KMRL has an established escalation process for addressing complaints received from these channels.

Grievance Redress Mechanism (GRM) at project construction phase has been proposed, comprises the procedures to address grievances i) first at the Project Implementation Unit (PIU) level, ii) second at Grievance Redress Committee (GRC), to ensure grievances from PAPs and workers are addressed to facilitate timely project implementation. A GRC will be formed which will have representatives from Contractors, General Consultant (GC), KMRL, local administration, and PAPs. Unsatisfied PAPs will have the option to escalate the grievances at any point of time.

0.10 Environmental Management & Monitoring Plan

An Environmental Management Plan (EMP) with institutional arrangements, budgetary provisions, schedule for EMP implementation and its monitoring has been prepared, including appropriate mitigation measures, provisions related to occupational health and safety, labour camp and construction site management, and traffic and public utility management etc. to address all impacts during Project preconstruction, construction and operation phases. The EMP has been developed in conjunction with general safety, health and environment provisions (which are included in the standard bidding document) and it forms part of the contract document of the contractors. Bi-annually monitoring reports will be prepared by GC and submitted to MDBs through KMRL.

Benefits far outweigh negative impacts. Overall, the major social and environmental impacts associated with Kochi metro phase II are limited to the construction period and can be mitigated to an acceptable level by implementation of recommended measures and by best engineering and environmental practices. In addition, stringent monitoring requirements and actions have been included in the Environmental Monitoring Plan (EMoP) on noise and vibration levels that will be generated during construction and operation. KMRL shall ensure that the EMP and EMoP are included in Bill of Quantity and forms part of bid document and civil works contract. The same shall be revised if necessary, during project implementation or if there is any change in the project design and with approval of MDBs.

1 INTRODUCTION

1.1 Background of the Project

Kochi is the most densely populated city in the state and is part of an extended metropolitan region, which is the largest urban agglomeration in Kerala. Kochi city is also a part of the Greater Cochin region. Kochi consists of mainland Ernakulam; the islands of Willingdon, Bolghatty and Gundu in the harbour; Fort Kochi and Mattancherry on the southern peninsula and Vypeen Island, north of Fort Kochi.

Rapid urbanization and intense commercial developments in the recent past have resulted in steep rise in travel demand putting Kochi's transport infrastructure to stress.

In effort to improve the transportation system of the Kochi city and to move towards the cleaner and sustainable mode of transportation, Government of Kerala intends to develop metro rail network (elevated) system for the entire city with the financial aid from Asian Infrastructure Investment Bank (AIIB). A Special Purpose Vehicle (SPV), i.e., Kochi Metro Rail Limited (KMRL), has been formed by the Government of Kerala for implementation, operation, and maintenance of the Metro projects. KMRL has already constructed Phase I of the Kochi Metro Rail from Aluva to Petta, which is operational. Subsequently, it was expanded from Petta to S N Junction (currently operational) and from S N Junction to Tripunithura (currently under construction). Now KMRL has planned to develop Phase II from JLN to Info Park. This phase-II corridor of 11.2 km of length will relate to the Phase-I at JLN Stadium Metro station to ensure integration of Phase I.

1.2 Rationale for Environmental Due Diligence Report (EDDR)

The Beijing headquartered Asian Infrastructure and Investment Bank has agreed to provide financial assistance to KMRL to support the execution of the project expansion works (Phase II). the Asian Infrastructure Investment Bank (AIIB) has an Environmental and Social Framework (ESF) as updated in January 2022, outlines the principles and guidelines for managing environmental and social risks associated with the projects it finances. The AIIB's ESF typically emphasizes the importance of conducting environmental and social due diligence (ESDD) as part of the project appraisal process for projects which have facilities or business activities that already exists or are under construction to identify past or present concerns related to impacts on Environmental & Socio-economic attributes. An Environmental and Social Due Diligence is conducted, and two separate reports Environmental Due Diligence (EDDR) & Social Due Diligence (SDDR) is prepared for the KMRL Phase-II. The Present report details the Environmental Due Diligence.

Further, since the KMRL has proceeded with Environmental Impact Assessment, Detailed Project Report and other activities prior to its appraisal, the EDDR includes an assessment of such actions to verify their compliance with AIIB's ESF, identified the gaps, conduct the additional studies to address the identified gaps and suggest further action plans, as may be necessary.

1.3 Objective and Scope of Due Diligence Study

The objective of the EDDR is to review and assess the Environmental & Social status and performance of Project, including to identify the compliance gaps, issues, improvement opportunities, to fill the missing gaps and develop an action plan to ensure compliance to applicable national and international environmental and social legislation as well as AIIB's Environmental Social Framework (ESF). This typically entails:

This due diligence involves both site visits and desk reviews, supplemented using data from the EIA Report, carried out at the DPR stage.

Scope of the study is given below.

- Assessment & Verification of Project and its key components and aspects vis-à-vis with the requirements of applicable local, national and international environmental and social legislation and AIIB's ESF;
- Reviewing the adequacy of DPR/revised DPR for Metro Rail Corridor from JLN Stadium to Info Park via Kakkanad and Environmental Impact Assessment Report

- These data and information shall be verified and supplemented through field reconnaissance & public consultation. The due diligence process shall address any deficiencies or limitations identified in the EIA assessment through additional studies.
- The conclusions/results from the additional studies and the key findings/outcomes of the EIA studies shall be integrated into the due diligence report.
- Update impact assessments based on the integrated information to ensure a more comprehensive understanding of potential impacts.
- Review and, if necessary, update mitigation measures based on the revised understanding of potential impacts.
- To prepare Environmental Management and Monitoring Plan (EMMP) for the necessary actions to minimize potential environmental and social impacts as well as to propose proper mitigation measures. Environment management plan shall include pollution prevention plan for air pollution, water pollution, soil contamination, noise & vibration, waste, offensive odour, bottom sediments and disasters.
- Preparation of Due Diligence Report

1.4 Project Status and Environmental Safeguards Reports

The Phase-II project will be implemented under design consultant and civil work contracts. As part of preparatory works, road widening was taken up from (i) JLN Stadium to Palarivattom (ii) Palarivattom to Kakkanad (iii) Media Academy (Kakkanad) to Infopark. The road widening was intended to ensure smooth road traffic during and after construction of Kochi metro rail extension from JLN Stadium to Infopark. The road widening work is in progress, at the entire stretch sub grade has been completed at site at few stretches till DBM completed and wearing course is in progress, at few stretches side drain is in progress.

The geotechnical investigation work has been completed for the metro, construction work has begun at five stations in entry and exit locations. Metro rail projects are not considered under the purview of EIA Notification, 2006 but in order to ensure that development is sustainable it is essential to integrate environmental concerns into development activities. EIA is currently the only explicit legal instrument available to comprehensively assess resource impacts of large buildings and townships. An Environmental Impact Assessment (EIA), an Environmental Management Plan (EMP) and four social impact assessments (SIAs)/resettlement plans (RPs) were prepared by Kochi Metro Rail Limited (KMRL) to meet international lender's requirements. These documents adequately address the project risks and impacts, consultations, and management approaches, albeit with minor gaps. Comprehensive Environmental Impact Assessment (EIA) was conducted for the Phase-II corridor in the year 2018.

1.5 Categorization of The Project

Although, the proposed project will bring in many benefits to the area, there is potential for environmental impacts on the physical cultural structures during construction and future operation of the metro. AIIB's Environmental and Social Policy (ESP), including the Environment and Social Standards (ESSs) and the Environmental and Social Exclusion List, will apply to this project. The project has been categorized as Category "A" based on the potential environmental and social (E&S) impacts due to civil works in a densely urbanized environment, land acquisition, occupational health, and safety (OHS), vehicular traffic, pollution, dust, noise, and vibration.

Here are some key points related to the classification:

Category A - A Project/activity is categorized A if it is likely to have significant adverse environmental and social impacts that are irreversible, cumulative, diverse or unprecedented. These impacts may affect an area larger than the sites or facilities subject to physical works and may be temporary or permanent in nature.

Category B - A Project /activity is categorized B when: it has a limited number of potentially adverse environmental and social impacts; the impacts are not unprecedented; few if any of them are irreversible or cumulative; they are limited to the Project area; and can be successfully managed using good practice in an operational setting.

Category C - A Project /activity is categorized C when it is likely to have minimal or no adverse environmental and social impacts.

1.6 Structure of the Report

The Due Diligence Report is presented as defined below:

Chapter 1: Introduction

This chapter provides background information of the project.

Chapter 2: Policy Legal and Administrative Framework

This chapter deals with the identification & listing of applicable legislations and applicable administrative framework. It also provides screening of applicable operational policies of World Bank and IFC EHS Guidelines on the project.

Chapter 3: Project Description

This chapter deals with the details of the Proposed Project, project components, site settings, surroundings & connectivity, land & utility requirement, project cost and implementation schedule.

Chapter 4: Environmental Baseline

This chapter describes the baseline environmental conditions around the surrounding area of the proposed project for various environmental attributes, viz., physical, biological, and socio-economic.

Chapter 5: Climate Risk Assessment

This chapter details the assessment of climate change events and risks, and appropriate, technical, and economically feasible climate change adaptation measures are recommended.

Chapter 6: Anticipated Impacts & Mitigation Measures

This chapter details the inferences drawn from the environmental impact assessment of the proposed project. It describes the overall impacts of the project activities and underscores the areas of concern, which need mitigation measures.

Chapter 7: Public Consultation & Stakeholder Engagement

This chapter provide details of consultation carried out in order to know the feedback. Public consultation meetings were held with the stake holders to record their views on the environmental, social & safety issues pertaining to the project and the suggested remedies to be adopted during project construction and operation stage.

Chapter 8: Grievance Redress Mechanism

This chapter provide details of grievance redressal system to assist the citizens, users of the Metro and other stakeholders communicate their queries, complaints and suggestions in connection with implementation of EMP and EMoP during pre-construction phase to continue through different phases.

Chapter 9: Environmental Management & Monitoring Plan

This chapter details the pollution prevention & management plan, disaster management plan, Institutional Framework for Implementation of EMP, Environment Monitoring Plan, SHE Policy, Trainings, Monitoring & Audits, Environment management Budget, Documentation, Updation and Record Keeping.

Chapter 10: Conclusion and Recommendation

This chapter briefs the EIA due diligence study outcome along with recommendation for the project.

2 POLICY, LEGAL AND ADMINISTRATIVE FRAMEWORK

India has well defined institutional and legislative framework. With the growth and introduction of developmental project, need of conserving environment and interest of society was felt and accordingly Government of India has framed adequate legislation and policies to safeguard the all components of environment viz. air, water, soil, terrestrial and aquatic flora and fauna, natural resources, and sensitive habitats. India is also signatory to various international conventions and protocols. MDBs have also defined its Environmental and Social Standards. This chapter will describe the applicability of above laws and regulations, conventions, protocols, and safeguards.

Review of EIA & Identified gaps : The EIA report listed the laws, regulations, policies, and guidelines which are applicable, as well as not applicable for the project. The guidelines and regulations as provided in the EIA are in line with the national standards, for the MDB's requirement, the report is in context with the WB operational policies however, in August 2016, the World Bank adopted a new set of environment and social policies called the Environmental and Social Framework (ESF).

Due diligence covers: Given that the project is to be funded by the AIIB, it's pertinent to note that, akin to various other international financial institutions, AIIB has established its own Environmental and Social Framework to provide guidance on the environmental and social aspects of projects. The Environmental Due Diligence Report (EDDR) comprehensively addresses this framework. The subsequent sections of the EDDR systematically summarize the laws, regulations, policies, and guidelines pertinent to the project based on its location, design, construction, and operation.

- National (India) Environmental Legislation and Legal Administrative Framework,
- Summary of international treaties and applicability to the project.
- AIIB and World Bank environmental and social policies and standards

2.1 National (India) Environmental Legislation and Legal Administrative Framework

The policies and requirements which are applicable for the project are provided in Table 2.1 below:

- The Metro Railways (Operation & Maintenance) Act 2002 as amended vide The Metro Railways (Amendment) Act 2009 (disaster management)
- Metro Rail Transit System, Guidelines for Noise and Vibrations, RDSO, Ministry of Railways, September 2015
- ISO/ TC 108 (vibration)
- CPCB guidelines for ambient air quality monitoring, ambient noise monitoring and water quality monitoring
- NBC, 2016
- Energy Conservation Building Code 2017 & IGBC Green MRTS Abridged reference guide.
- The Child Labour (Prohibition and Regulation) Act, 1986
- The Bonded Labour System (Abolition) Act 1976
- Minimum Wages Act, 1948
- The Payment of Wages Act, 1936, amended in 2005.
- Equal Remuneration Act, 1976
- Workmen's Compensation Act, 1923
- Maternity Benefit Act, 1961
- Inter-State Migrant Workmen's (Regulation of Employment & Condition of Service) Act, 1979
- Petroleum Rules, 2002
- The Employees Provident Fund and Miscellaneous Provisions Act, 1952
- Payment of Bonus Act, 1965 and Amendment Act No.43 of 1977 and No.48 of 1978 and amendments
- Payment of Gratuity Act, 1972
- Public Provident Fund Act, 1968
- Employee State Insurance Act, 1948

- The Contract Labour (Regulation & Abolition) Act, 1970 and Rules
- Employer's Liability Act, 1938 (as amended)
- Labour (Regulation and Abolition) Act 1970
- Sexual Harassment of Women at the Workplace 9 Prevention, Prohibition and Redressal) Act 2013
- The Personal Injuries (Compensation Insurance) Act, 1963 (as amended)
- Building and Other Construction Workers (Regulation of Employment and Conditions of Service) Act, 1996

Table 2.1 Environment legislations Applicable to Metro projects

Legislation	Key Requirements	Applicability	Concerned Authority	Responsibility of Obtaining & implementation	Monitoring & Supervision
Environment (Protection) Act, 1986 with Rules amended 1991	1. Overall Environment Protection 2. Compliance to environmental (Air, Water, Noise) Standards issued under EPR	Applicable	MoEF&CC	Contractor	GC & KMRL
Air (Prevention and Control of Pollution) (Union Territories) Rules, 1982, 1983 Air (Prevention and Control of Pollution) Act, 1981 with Rules, amended 1987	3. An act to prevent and control Air pollution	Applicable: Consent to Establish prior start of construction and Consent to operate prior start of operation	KSPCB	Contractor	GC & KMRL
Water (Prevention and Control of Pollution) Act, 1974 with Rules.	4. An act to prevent and control water pollution.	Applicable: Consent to Establish prior start of construction and Consent to operate prior start of operation	KSPCB	Contractor	GC & KMRL
Noise Pollution (Regulation and Control) (Amendment) Rules, 2010	5. Compliance with Ambient Noise and emission Standards in accordance to use classification for the area	Applicable, involves generation of noise due to operation of DG sets, pumps, and vehicular movement ad day to day operations	KSPCB	Contractor – Construction Phase KMRL-Operation Phase	GC & KMRL
Kerala Forest Act, 1961 as amended	6. This act was enacted in Kerala in 1961 to unify and amend the law relating to the protection and	Applicable as the project involves cutting of roadside trees	Kerala Forest Department	KMRL to obtain and Contractor to follow the conditions	KMRL

Legislation	Key Requirements	Applicability	Concerned Authority	Responsibility of Obtaining & implementation	Monitoring & Supervision
	management of forests in the state of Kerala	Tree cutting permission has already been obtained for cutting of 669 no. of trees			
Hazardous & Other Waste (Management & Handling) Rules, 2016	7. Protection to public against improper handling storage and disposal of hazardous waste. The rules prescribe the management requirement of hazardous wastes from its generation to final disposal.	Applicable, involves generation of used oil from machineries and DG sets	KSPCB	Contractor	GC & KMRL
Solid Waste Management Rules, 2016	8. Management of solid waste to be generated from labour camp/accommodations and the construction site	Applicable. Waste will be generated from labour camps/ accommodations and construction site	Local Bodies like Kochi Municipal Corporation	Contractor – Construction Phase KMRL-Operation Phase	GC & KMRL
Construction and Demolition Waste Management Rules, 2016	9. Management of construction and demolition waste to be generated from project site	Applicable as project will involve demolition of existing road, associated structure and private/government structures within RoW	Local Bodies like Kochi Municipal Corporation	Contractor – Construction Phase KMRL-Operation Phase	GC & KMRL
Plastic Waste Management Rules, 2016	10. Management of plastic waste to be generated from project site during construction and operation phase	Applicable as there may be generation of plastic waste at site like pipes, broken plastic buckets, dustbins, storage containers and packaging waste	Local Bodies like Kochi Municipal Corporation	Contractor – Construction Phase KMRL-Operation Phase	GC & KMRL

Legislation	Key Requirements	Applicability	Concerned Authority	Responsibility of Obtaining & implementation	Monitoring & Supervision
Bio-medical Waste Management Rules, 2016	11. To control storage, transportation, and disposal of Bio Medical Waste.	Applicable for the disposal of bio-medical waste from first aid centre	KSPCB	Contractor	GC & KMRL
Manufacture, Storage and Import of Hazardous Chemicals Rules, 1989 (as amended)	12. Notifying regulatory authority (in this case, the State Factories Inspectorate) of storage of hazardous substances like HSD 13. Follow guidelines on such storage, maintain updated MSDS, submit annual Safety Report to authority. 14. Prepare Onsite Emergency Plan	Applicable, only if there is storage of hazardous chemical above threshold limit as defined under schedule 2 & 3. License	Chief Controller of Explosives, MoEF&CC and DC	Contractor	GC & KMRL
Motor Vehicles Act with Rules, 1988 and amendments	15. Lay down restriction for vehicles not having Pollution Under Control Certificate (PUC) or proper labelling to enter premises	Applicable as the motor vehicle movement is involved both during construction and operation phase	Motor Vehicle Department (Licensing authority, registration authority &State Transport Authorities)	Contractor – Construction Phase KMRL-Operation Phase	GC & KMRL
Irrigation Department	16. Withdrawal of water from Surface water Bodies	Applicable if withdrawal of water from river/canal	Irrigation Department	Contractor – Construction Phase KMRL-Operation Phase	GC & KMRL
State Groundwater Regulation	17. Conform to restriction for drawing of groundwater. 18. Arrange for recharge	Applicable, if ground water is	Central ground Water	Contractor – Construction Phase	GC & KMRL

Legislation	Key Requirements	Applicability	Concerned Authority	Responsibility of Obtaining & implementation	Monitoring & Supervision
	through Rainwater Harvesting Schemes (as applicable)	utilized/withdrawn	Development Authority	KMRL-Operation Phase	
The Batteries (Management and Handling) Rules 2001	19. To regulate the disposal and recycling of lead acid batteries	Applicable Applicable for disposal of used lead acid battery if likely to be used in any equipment during construction and operation stage.	MoEF&CC	Contractor – Construction Phase KMRL-Operation Phase	GC & KMRL
Petroleum Rules, 2002	20. Use and Storage of Petroleum products	Applicable if storage of HSD/LPG or any other petroleum product may be required for the project purpose more than the defined threshold limits License	Chief Controller of Explosives/DC	Contractor	GC/KMRL
The Gas Cylinder Rules 2004	21. To regulate the storage of gas / possession of gas cylinder more than the exempted quantity	Applicable if contractor store more than the exempted quantity of gas cylinder.	Chief Controller of explosives	Contractor	GC/KMRL
Building and Other Construction Workers (Regulation of Employment and Conditions of Service) Act, 1996	To regulate the employment and conditions of service of buildings and other construction workers and to provide for their safety, health and welfare measures and for other matters connected therewith or incidental thereto.	Yes, as the project involve construction activities and handling of heavy machinery	Labour Commissioner	Contractor	GC/KMRL

2.2 International and Regional Agreements and Conventions

India is member of almost all major Multilateral Environmental Agreements (MEAs), under four clusters, namely the following:

A. Nature conservation.

No.	Nature Conservation
1	Ramsar Convention on Wetlands
2	CITES (Convention on International Trade in Endangered Species of Fauna and Flora)
3	TRAFFIC (The Wildlife Trade Monitoring Network)
4	CMS (Convention on the Conservation of Migratory Species)
5	CAWT (Coalition Against Wildlife Trafficking)
6	6 CBD (Convention on Biological Diversity)
7	ITTC (International Tropical Timber Organisation)
8	UNFF (United Nations Forum on Forests)
9	IUCN (International Union for Conservation of Nature and Natural Resources)
10	GTF (Global Tiger Forum)

B. Hazardous material.

No.	Hazardous material
1	Cartagena Protocol on Biosafety
2	SAICM (Strategic Approach to International Chemicals Management)
3	Stockholm Convention on Persistent Organic Pollutants (POPs)
4	Basel Convention on the Control of Trans-boundary Movement of Hazardous Waste and Their Disposal
5	Rotterdam Convention on Prior Informed Consent (PIC) for certain Hazardous Chemicals and Pesticides in International Trade

C. Atmospheric emissions.

No.	Atmospheric emissions
1	UNFCCC (United Nations Framework Convention on Climate Change)
2	Kyoto Protocol
3	UNCCD (United Nations Convention to Combat Desertification)
4	Montreal Protocol (on Ozone Depleting Substances)

D. Marine environment.

IWC (International Whaling Commission)

2.3 MDBs' Requirements Applicable to the Project

A. Environmental and Social Framework (ESF) 2019 of AIIB

ESF of AIIB comprises the following:
i. Environmental and Social Policy (ESP). This comprises mandatory environmental and social requirements for each Project.
ii. Environmental and Social Standards. Three associated mandatory environmental and social standards (ESSs) set out more detailed environmental and social requirements relating to the following:

ESS 1 (Environmental and Social Assessment and Management).	Project is likely to have adverse environmental and/or social risks and impacts, it requires the Client to conduct an environmental and social assessment relating to these risks and impacts, and design appropriate measures to avoid, minimize, mitigate, offset or compensate for them, all as required under ESS 1	Applicable for the project The ESS 1 requires EA for project irrespective of its type. However, in national regulation the metro projects are not included in the schedule-7 of the EIA Notification-2006, does not attract the requirements of the Environmental clearance and further for EA. As per the MDB's requirement the EIA has been prepared for the project road.
ESS 2 (Land Acquisition and Involuntary Resettlement)	If the Project is likely to involve Involuntary Resettlement, the Bank requires the Client to address this in the social section of the assessment report, complemented by more in-depth coverage, as required under ESS 2.	Applicable for the project as the project involves the Land Acquisition as well rehabilitation and resettlement.
ESS 3 (Indigenous Peoples).	If the Project would involve Indigenous Peoples, the Bank requires the Client to address this in the social section of the assessment report, complemented by more in-depth coverage, as required under ESS 3.	Not Applicable, as no indigenous people area residing along the project alignment.

B. Environmental & Social Standards World Bank

ESS 1. Assess & Management of Env & Social Risks and Impacts
ESS 2. Labour and Working Conditions
ESS 3. Resource Efficiency and Pollution Prevention and Management
ESS 4. Community Health and Safety
ESS 5. Land Acquisition, Restrictions on Land Use and Involuntary Resettlement
ESS 6. Biodiversity Conservation and Sustainable Management of Living Natural Resources
ESS 7. Indigenous Peoples/Sub-Saharan African Historically Underserved Traditional Local Communities
ESS 8. Cultural Heritage
ESS 9. Financial Intermediaries
ESS 10. Stakeholder Engagement and Information Disclosure

3 PROJECT DESCRIPTION

Review of EIA & Identified gaps: The EIA thoroughly addresses the specifics of the Proposed Project. This would typically include the project's objectives, scope, and key features such as project components, site settings, surroundings & connectivity, land & utility requirement, project cost and implementation schedule

The Detailed Project Report (DPR) was prepared between 2016 and 2018, and since then, there have been significant changes in IT developments. The need to cater to the updated infrastructure requirements and accommodate new developments likely influenced the decision to divert the corridor, the last leg of the corridor is planned to divert to the left from Infopark to the Edachira (Info park-II).

Due Diligence Covers: The brief project description and adopted technologies has been covered in the due diligence report. The revised alignment from Info Park I station to Smart city station has also been covered in the EDDR.

3.1 Introduction

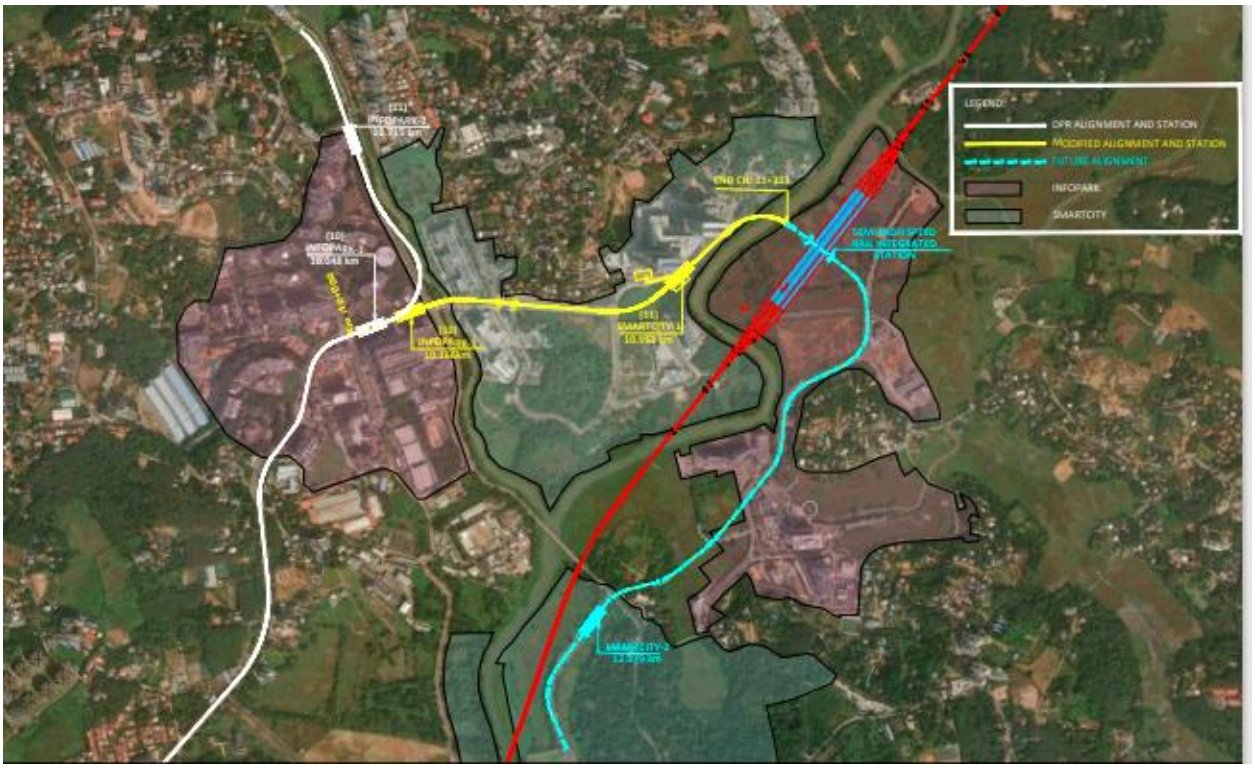
Considering the urban development, population growth, transportation needs, and the overall vision for the city Kochi Metro Rail Ltd (KMRL) has planned to develop Phase II from JLN to Info Park. KMRL engaged the services of M/s RITES Ltd. to carry out the feasibility study and preparation of detailed project report for the proposed second Phase. RITES submitted the Feasibility Report and DPR in 2014 followed by a revised report in September 2016. However, with the notification of the new Metro Rail Policy and Appraisal Guidelines for Metro Rail Project Proposals by the Ministry of Housing and Urban Affairs (MoHUA), Urban Mass Transit Company Limited (UMTCL) has been appointed for the preparation of feasibility & Detailed Project Report for Phase-II in the year in 2018 as per the Appraisal guidelines for Metro Rail Project Proposals issued by MoHUA.

Phase-II metro route is proposed within the Kochi city of Kerala. Land use of the RoW and the surroundings is mix of residential and commercial. Proposed project traverses through Kaloor, Palarivattom, Chembumukku, Vazhakkala, Padamughal, Kakkanad, SEZ area, Chittethukara and Info Park. Proposed project is being developed as Phase II but will be connected to Phase I at JLN stadium. Phase II will connect JLN stadium to Info Park via Kakkanad thereby providing metro rail connectivity in the busiest corridor of city. Entire corridor is elevated and is along the road. However, roads are narrow thus it is proposed to widen the road prior undertaking metro construction work to minimize the issues due to traffic congestion.

The Key plan of the recommended route is shown below.

Figure 3.1 – Key plan of recommended route

Revised Alignment – Kochi has fast developed in the last 5 years and a lot of developments took place during this short period of time. Kochi has come a long way from being the port city to tourist capital to the IT hub of the state of Kerala. Due to the slight delay in the approval of the Phase –II corridor and the subsequent developments after 2018 period in the Smart city area and Info park-II Area, KMRL rethink on the final leg of this corridor so that invested resources can be utilized to the maximum by the public. Accordingly, Major stakeholders like Infopark, Smart city and Thrikkakara municipality were consulted for finalizing the terminal station of Phase-II of the projects. Accordingly, the alignment of the last leg of the corridor beyond Infopark 1 station was changed from Infopark 2 towards the Smart City. On the modified alignment, a new station is proposed at Smart City area, which will be named 'Smart City' station. This Smart City station will be located at coordinates X650405.2462/Y1107003.0109 and will be at chainage10860, with interstation distance of 812 m from Infopark 1 station (Annexure-1, 4, 5, 8 & 9). Since this station is situated inside the notified zone of Smart city, this station shall be access controlled for public. There is no envisaged Environmental Impacts or Social impacts on the identified location of the proposed 11th station of Phase –II since the land has already been allocated by the Government of Kerala to Smart city for Business Development aspects.



3.2 Future Growth and Transport Demand Forecast:

The Development Plan for Kochi City Region 2031 gives the likely growth to take place in various areas in the city region. Based on the CMP prepared in the year 2017, the study area is estimated to have population of about 22.7 Lakh in 2015, 24.79 Lakh in 2025, 26.09 Lakh in 2031 and 26.99 Lakh by the year 2035.

The employment in the study area, which is 7.7 Lakh in 2013, is expected to grow to 10.81 Lakh in 2025 and 13.04 Lakh in 2035. Similarly, student enrolment is expected to grow from 5.69 Lakh in 2015 to 6.19 Lakh in 2025 and to 6.74 Lakh in 2035. A four-stage travel demand model has been developed and is used for transport demand forecasting for the horizon years of 2023 and 2048.

The transport system plans have been developed on the basis of this travel forecast. The maximum peak hour peak direction trips (PHPDT) in JLN Stadium station – Info Park 2 metro corridor for horizon years 2023, 2035 and 2048 are estimated to be 7340, 10310 and 15851 respectively. Daily ridership in the corridor is projected to be 1.04 Lakh, 1.94 Lakh and 5.56 Lakh in the years 2023, 2035 and 2048 respectively.

3.3 System and Technology Selection

The Metro rail systems operating and under implementation in Indian cities are constructed to the latest technology adopted world over. Generally, the metro trains are operating on Standard Gauge (1435 mm) and run on electric traction. A train unit comprises of 3 or 4 coaches/cars Electro motive units. The cars are light weight Stainless Steel or Aluminium bodied. The controlling criteria for coaches are reliability, low energy consumption, lightweight and high efficiency, leading to lower annualized cost of service. The coach should have high rate of acceleration and deceleration. The signalling system should provide the means of an efficient train control with minimum human intervention, ensuring safety in train movements and efficient train operation on the network. The telecommunication system in metro systems acts as the communication backbone for Signalling and other systems and provides telecommunication services to meet operational and administrative requirements of metro network. It comprises of Optical Fibre cable network and mobile radio communication system. As the metro rail system handles large number of passengers, the issue of tickets and fare collection play a vital role in the efficient and proper operation of the system. To achieve this objective, ticketing system should be simple, easy to use/operate, easy on accounting facilities, capable of issuing single/multiple journey tickets, amenable

for quick fare changes and should require lesser manpower. Automatic fare collection system meets these requirements. Keeping the developments taking place in the metro rail technology and the system provided on the Kochi Metro Phase-I, in view the system specifications in brief, proposed for Kochi Metro Phase-II, are shown in the Table 3.1 below:

Table 3.1: Key specifications

S.N.	Important Parameters	Specifications
1	No. of lines	Two parallel lines, one for each direction with Ballast-less Tracks on main lines
2.	Gauge	Standard Gauge (1435mm)
3	Track Structure	60 kg Head Hardened rails, ballast less track on mail lines
4	Class of Travel	One; Air-conditioned
5	Rolling Stock Type	EMU, Light weight stainless steel/Aluminium coaches provided with fire retarding material
6	Broad Limits of Coach Dimensions	2.9 m wide x 23 m long buffer to buffer x 3.96 m height
7	Coach Features	Seated passengers: 136
	a) 3 car Train capacity (766 and 975 Pass.)	Standing passengers: 630 @ 6 pass. /Sqm 766 @ 8 pass. /Sqm
	b) seating style	Longitudinal seats along both sides of coach, and space in between for standing
	c) Standing	Allowed
	d) No. of Decks	Single
	e) Space for toilets	No
	f) Propulsion System	3 phase drive system with VVVF control
	g) No. of Doors	Four doors a side of adequate width, Bi-parting sliding type
8	Axle Load	16 tonnes
9	Train Composition	3 car train – DMC-TC-DMC
10	Max. Operating Speed	80 Kmph
11	Design Speed	90 Kmph
12	Acceleration/Deceleration / Emergency Braking (m/s2)	1.2 (a) / 1.1 (d) / 1.3 l m/s2
13	Traction Type	750 V dc Third Rail
14	Signalling & Train Control System	Communication Based Train Control (CBTC) System with CATC sub-systems viz ATP, ATS and ATO; Computer Based Interlocking (CBI) and LED type fixed signals at Interlocked stations with points & Crossings
15	Telecommunications	Radio based TETRA and OFC.
16	Fare collection system	Automatic
17	Platform Length	Platform length 81 m to accommodate 3 coach train
18	Toilet Location at station	Inside paid area
19	Access to Stations and trains	Universal; Divyang friendly

3.4 Civil Engineering and Alignment Details

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 80 kmph. Tracks will be carried on pre-cast segments supported by single circular piers, generally spaced at 25m c/c and located on the median of the road mainly. At few locations special span of more than 25m to avoid placing of

piers/ portals in private land has been planned as shown in the alignment and land plans. Horizontal alignment and vertical alignment are, therefore, dictated to a large extent by the geometry of the road followed by the alignment. Track centre on the elevated section is kept as 4.20 m, which will accommodate horizontal curve up to 120 m radius. Width of viaduct is kept 10.00 m to accommodate two parallel tracks.

Other parameters proposed are as under: -

i. Length of platforms = 81 m (for 3 Coaches)
ii. Platform width for side platforms = 5.5 m.
iii. Minimum radius of horizontal curve for elevated sections 200 m (desirable) and 120 m (absolute minimum). Minimum curve length is 25 m.
iv. Minimum radius of curve in stations = 1000 m
v. Gradient at stations to be in level or maximum 1 in 1000.
vi. Gradient in mid-section – not steeper than 2% (desirable) and at critical locations maximum 4%.
vii. Points and crossin–s - 1 in 9 on main lines and 1 in 7 on divergent tracks.
viii. Vertical curve radius on main line 2500m and at other locations 1500 m (Minimum). Minimum length of vertical curve = 20 m.
ix. Minimum Overhead clearance for Road/highways to be 5.5 m and for Railway lines 6.0 m on OH electrified Railway track.
x. Cant limits
    - Maximum permissible cant (Ca): 125 mm
    - Maximum desirable cant (Ca): 110 mm
    - Maximum cant deficiency (Cd): 100 mm
    - Desirable cant deficiency (Cd): 85 mm
xi. Transition curves
    - Minimum length of Transitions of Horizontal curves (m): 0.44 times actual cant or cant deficiency (in mm), whichever is higher.
    - Desirable: 0.72 times actual cant or cant deficiency, (in mm) whichever is higher.
    - No overlap is allowed between transition curves and vertical curves.
    - Minimum straight between two Transition curves: either 25 m or NIL.
    - Minimum curve length between two transition curves: 25 m

3.5 Station Planning

Based on the Alignment proposed by Kochi Metro Rail for Metro Phase II, A total of twelve stations including JLN station are proposed along the 11.2Km long corridor with an average inter-station spacing of 974m. The station locations were strategically selected to be near main road intersections and Inter-modal interchange points such as Railway stations/ bus terminals so as to improve passenger interchange and accessibility, for ensuring higher passenger convenience and ridership on the proposed Metro corridor. All stations are considered elevated with 81m length of the platforms suitable for 3 coach rakes with 5.5m wide side platforms unless otherwise mentioned in the alignment plans. At stations with length of platforms as 81 m located above central median, the rail level will be 12.5 m above the road level if concourse is provided below the station structures. These levels will, however, vary marginally depending upon where the stations are located. Height can be reduced to 8.5m in case space is available on road level for planning entry/exit and concourse facilities. This aspect may be reviewed during detailed design/ execution stage.

List of all proposed stations along the metro corridor are mentioned in the Table below:

Table 3.2 List of proposed stations

S.No.	Name of Station	Chainage (m)	Distance c/c
1	JLN Stadium (PH-II)	0	0
2	Palarivattom JN	890	890
3	Alinchuvadu	1622	732
4	Chembumukku	2790	1168
5	Vazhakkala	3580	790

6	Padamughal	4218	638
7	Civil Station Junction	5312	1094
8	Cochin SEZ	6366	1054
9	Chittethukara	7457	1091
10	KINFRA PARK	8735	1278
11	Infopark	10048	1313
12	Smart City	10860	812

(New Station names approved by GoK vide G.O.(Ms) No.50/2023/TRANS dated 26-12-2023)

3.6 Train Operation Plan

The salient features of the proposed train operation plan are:

- Running of services for 19 hours of a day (5 AM to Midnight) with a station dwell time of 30 seconds.
- Operation of 3 car rake Rolling stock, similar to Kochi Metro Phase-I, to meet the projected traffic demand.
- Two Driving Motor Coaches (DMC) and one Non-driving Training Coach (TC) will form a basic unit capable of independent operation. Capacity of 3 car rake is 766 passengers with a seating capacity of 136 and 630 standees @ 6 passengers/ m^2. The capacity would be 975 passengers with 136 seating and 839 standees @ 8 passengers/ m^2.
- Scheduled speed of 34 kmph.
- Make up time of 5-10% with 8-12% coasting.
- Adequate services to ensure comfortable journey for commuters even during peak periods.

3.7 Rolling Stock

Rolling Stock proposed for the corridor will be similar to Kochi Metro Phase – I. The specifications of the rolling stock and its procurement may be decided on the basis of the project implementation mechanism. The important criteria for selection of rolling stock are as under:

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

The controlling criteria are reliability, low energy consumption, lightweight and high efficiency leading to lower annualized cost of service. The coach should have high rate of acceleration and deceleration.

3.8 Power Supply and Traction

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

The 750V DC third rail system is being provided on the phase-I corridor of Kochi Metro. Thus, to ensure consistency with the existing system, 750V DC third rail traction system is proposed for JLN Stadium to Info Park 2 corridor. Since the route is entirely grade separated there is no danger of safety hazard to passengers from third rail.

3.9 Ventilation and Air-Conditioning System

As the entire Phase-II metro rail corridor is proposed to be elevated and there is no underground section, therefore, no tunnel ventilation and air conditioning of stations is required.

3.10 DEPOT

Muttom Depot provided for Phase-I metro is proposed to be utilized for the Phase-II trains also. There is enough capacity for expansion of this Depot to meet the future requirement. Smart City Terminal station is proposed to have stabling lines for two trains in each track (total four trains) for overnight stabling, which will be sufficient for initial years of operation.

4 ENVIRONMENTAL BASELINE

As a precursor for the prediction of various types of environmental impacts likely to arise due to implementation of the project, it is essential to establish the baseline environmental status in project study area. Details of baseline environment parameters are required for decision making for the project. Baseline data provide vital information on the existing environmental quality in which a development is planned.

Review of EIA & Identified gaps: The baseline environmental profile of the Corridor of Impact (CoI) and Project Influence area (PIA) for project road in particular and Ernakulam district as a whole in general has been described in the EIA report. The environmental profile covers all major key attributes like physiography, geology, land use, soil, hydrogeology, flora, fauna, forest/vegetation cover, climate, ambient air quality, water quality and ambient noise levels, of the PIA among others.

In the EIA report for carrying-out the baseline environmental assessment, CoI is considered as 500m and PIA as 10 km radius from project centre line shown in Figure 4-1 as well as the respective tehsil/district as a whole in general.

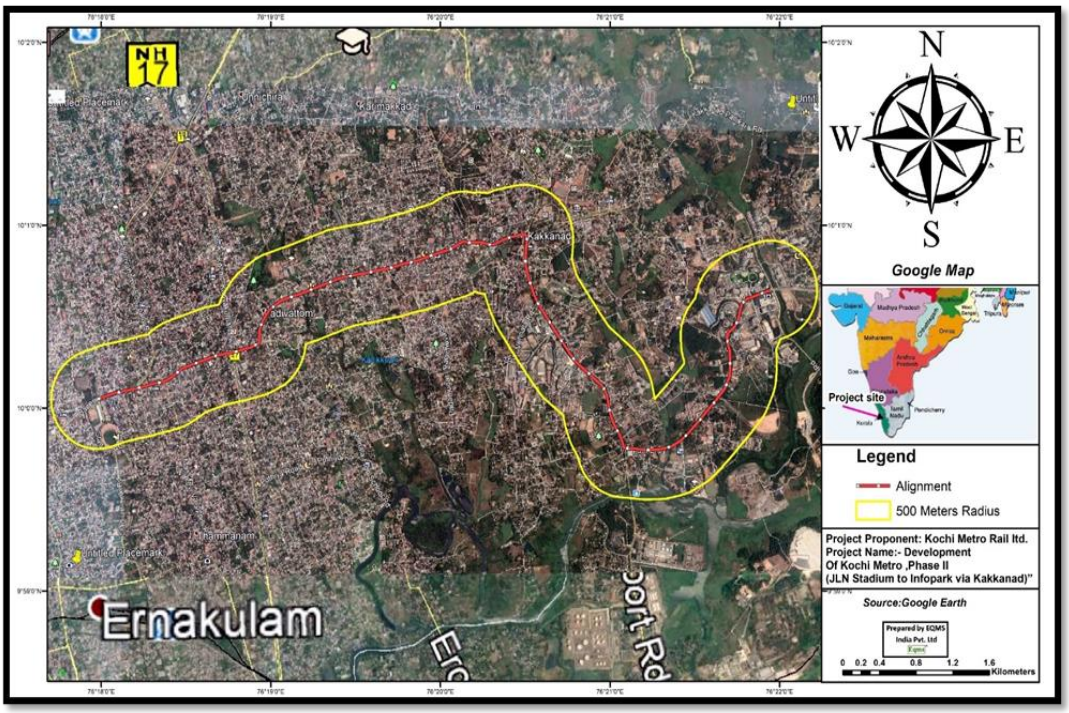


Figure 4.1 Map showing study area

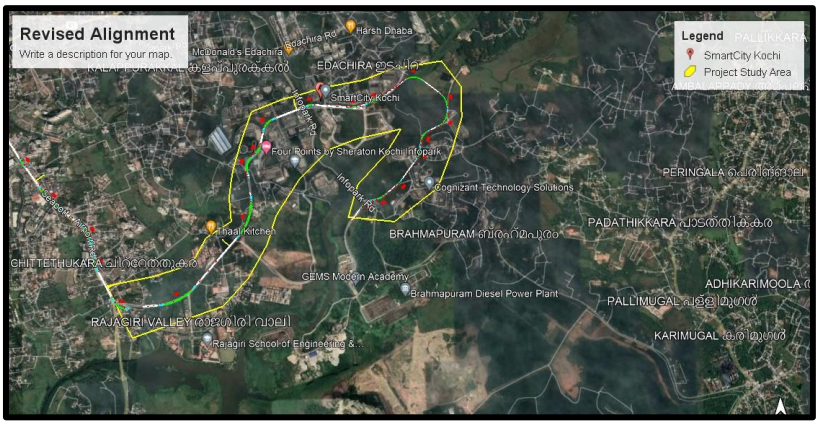


Figure 4.1 (a) Map showing the study area from Info Park 1 to Smart City (Revised during EDDR study)

The baseline data collection for the Air, Water, Noise and Soil was done in June 2019 during the EIA stage. However, the sensitive receptors which are in the direct impact zone were not entirely covered. Also, the baseline monitoring for ground-born vibration was not carried out during EIA stage.

Due Diligence Covers: The due diligence covers the brief of key environmental attributes like physiography, geology, land use, soil, hydrogeology, flora, fauna, forest/vegetation cover, ambient air quality, water quality and ambient noise levels, of the PIA among others.

Baseline monitoring data of 2019 offer valuable context and overview of the conditions of that time. However, it's essential to consider the context and changes that may have occurred since then, a more recent update could provide a more accurate reflection of the current situation. For a clear comparison between the current state and any potential changes or impacts from the EIA stage, a baseline environmental monitoring was conducted during Due Diligence study.

During the EDDR, a fresh baseline data has been generated on key location representative of the project area including the sensitive receptors for air quality, water quality, noise, soil, and vibration for the period of 20st November 2023 to 22nd November 2023. For Air Quality Monitoring Palarivattom jn has been considered as the heavy traffic and commercial area. Vazhakkala has been considered as road has been widened at this location. Changes in infrastructure, such as road widening, can influence traffic patterns and emissions. Monitoring at this location allows for the assessment of air quality impacts associated with such modifications and the third location KINFRA considered due to the subsequent development in the area from the EIA stage. During the EDDR stage, all sensitive receptors for noise and vibration monitoring were considered, as was not covered during the EIA stage. The locations for baseline sampling are presented in table 4.1.

Table 4.1: Location for Baseline Data Collection

Parameters	No of Sampling locations during EIA stage	No of Sampling locations during EDDR stage	Remarks
Ambient Air Quality			
PM10, PM2.5, SO2, NO2, CO	3 locations: JLN Stadium (Pump House) Chembumukku, Chittethukara (Hyundai Showroom)	3 locations – Palarivattom jn, Vazhakkala and KINFRA	as per CPCB guidelines (CPCB Gazette notification dated 18.11.2009 on AAQ).
Groundwater Quality			
pH, Temperature, Conductivity, Turbidity, TDS, Aluminum, Calcium, Chlorides, Copper, Fluoride, Free residual chlorine, Iron, Magnesium, Manganese, Nitrate, Phenolic compounds, Sulphate, Sulphide, Total Alkalinity, Total Hardness, Zinc, Cadmium, Cyanide, Lead, Mercury, Nickel, Total Arsenic, Total Chromium	3 locations: Palarivattom Junction, Chembumukku, Hyundai Showroom	2 locations: Kakkanad and Palarivattom	Ground water sample is collected within project area. Samples was preserved, transported, and analyzed for different parameters based on APHA methods. Temp, conductivity, and pH were measured at site itself
Surface water Quality			
IS:10500, BOD, COD, E coli, DO, SS and others	1 location: Kadambrayar River	1 location: Edapally thodu	

Soil			
Texture, bulk density, pH, conductivity, cation exchange capacity, organic matter, Total N,P,K, and Heavy metals	3 locations: Chembumukku, Info Park Phase II, Palarivattom Junction	1 location: Kakkanad station	Soil samples was collected and analyzed as per IARI method.
Noise			
Noise profiling for 24 hrs	At 11 locations	At 6 locations	24 hrs using integrated sound level meter, as per CPCB guidelines
Vibrations			
Vibrations from Existing Metro Operation	JLN Stadium	At 6 locations	As per FTA guidelines

4.1 Physical Environment

4.1.1 Physiography

Kochi is part of the district of Ernakulam in the state of Kerala. Kochi is located at latitude 90^0 42' 38'' North and longitude 76^0 12' East with an average elevation of 1.2 m above mean sea level. The topography of Kochi is almost flat. The average altitude towards the eastern fringes is about 7.5 m above M.S.L but towards west most part of the city is only about 1.00 m above M.S.L. Kochi is characterized by sand bars running in north – south direction with tidal canals in between.

Elevation of the project alignment varies from 2-29 m AMSL. Digital elevation map and Contour map for project alignment and surrounding area within 500 m radius area are given in Figure 4.2 and 4.3.

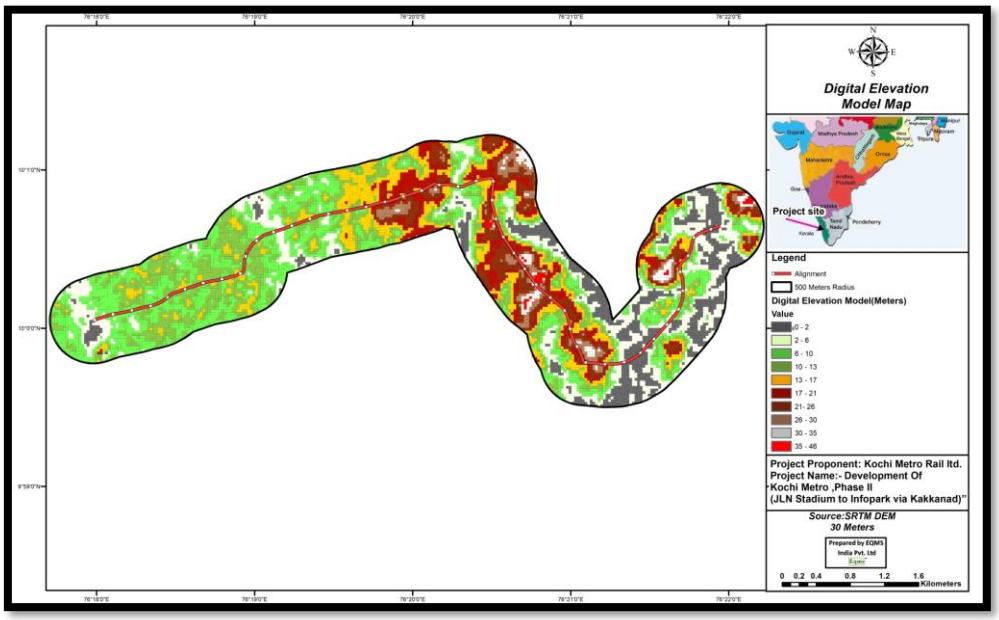


Figure 4.2 – Digital Elevation map for the project alignment

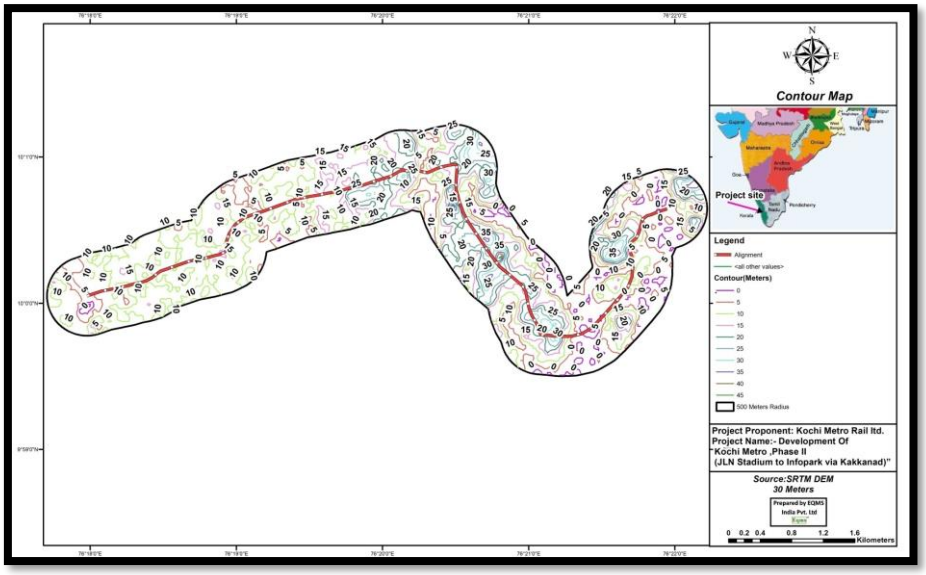


Figure 4.3 - Contour map for project alignment

4.1.2 Geology

Proposed project area falls under Kochi city of Ernakulum District. Project area is majorly covered with the Laterite of quaternary group and minor Dolerite of upper cretaceous group. The geology of the project area and surroundings is presented below in Table 4.2.

Table 4.2 Geology of Project Area and Surroundings

Age	Group	Lithology
Cenozoic	Quaternary and Tertiary	Laterite, Warkalli beds, Paleo beach deposit
Mesozoic	Upper Cretaceous	Dolerite
Archaean	Migmatites Complex	Hornblende-biotite gneiss
	Charnockite Group	Charnockite/Charnockite Gneiss, Pyroxene granulite
	Khondalite group	Quartzite

4.1.3 Land use pattern

Proposed alignment is traversing through the city and having residential, commercial and mixed land use. Area through which alignment will traverse are Kaloor, Palarivattom, Chembumukku, Vazhakkala, Padamughal, Kakkanad, SEZ area, Chittethukara, KINFRA, Infopark. Land use of the project influence area (500 m radius area) and graphical representation of land use of the study area is shown in Table 4.3 and Figure 4.4. Land use map of the project influence area is given in Figure 4.5. As per the land use analysis for project influence area it is understood that most of the area is under settlement, i.e., 73.2% followed by vegetation and open scrub land.

Table 4.3 Land use of the Study Area

Class	Area (Sq. Km)	Percentage (%)
Agricultural Land/Plantation	0.23	2.1
Settlement	8.18	73.2

Vegetation	2.38	21.3
Water body	0.05	0.4
Open Scrub Land	0.33	3.0
Total	11.17	100%

Source: Satellite Image Analysis by EQMS

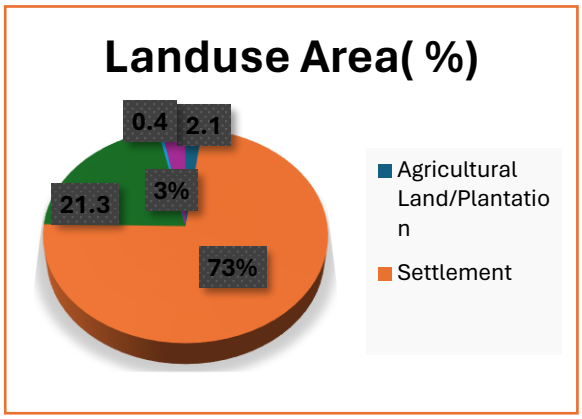


Figure 4.4 Graphical representation of land use of the study area

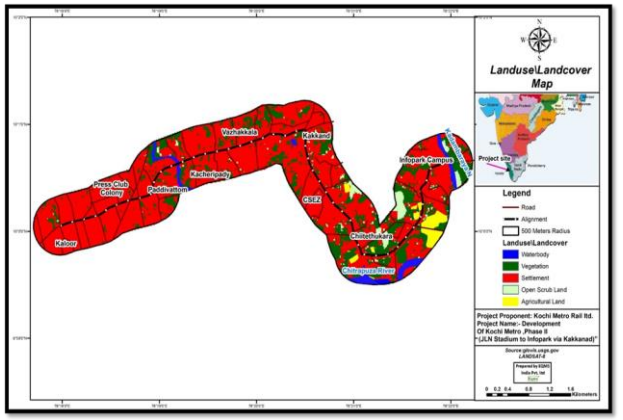


Figure 4.5 Land use map of the study area

4.1.4 Soil

The soils in and around the Kochi City vary from lateritic soils on the Northern part to the Marine clays on the Southern part of the city. Based on morphological features and physico-chemical properties, the soils of the district are classified as Lateritic, Hydromorphic saline, Brown hydromorphic, Riverine alluvium and Coastal alluvium. Lateritic soil is the most predominant soil type of the district followed by Brown hydromorphic soil. Coconut is the major crop in these soils. Other crops grown in this soil are tapioca, rubber, arecanut, pepper, cashew, and spices.

In the EIA stage, an examination of soil quality within the project influence area along the proposed alignment was conducted. Random samples were taken from the study area at a depth of approximately 15 cm, ensuring that the collected samples were homogeneous and representative of the sampling locations.

During the Environmental Due Diligence, a soil sample was gathered near Civil Station Junction station (Kakkanad) and analyzed to evaluate any alterations in soil characteristics from the year 2019 to the present date. The soil sampling photograph is shown in table 4.4.

Table 4.4 Soil Sampling Photographs

Kakkanad

The soil samples were examined for various physicochemical parameters, to determine the existing soil characteristics of the study area. Physicochemical characteristics of soil are presented in Table 4.5 and 4.6.

Table 4.5 – Results of soil sampling during EIA stage

S. No.	Parameters	Unit	Palarivattom	Chembumukku	Info Park
	Physical Characteristics				
1.	Color	-	Reddish Brown	Reddish Brown	Reddish Brown
2.	Texture	USDA	Clay Loam	Clay Loam	Clay Loam
3.	**Particle Size Distribution**				
i).	Sand (0.02 to 0.20-mm)	%	28	24	26
ii).	Silt (0.002 to 0.02-mm)	%	42	41	40
iii).	Clay (< 0.002-mm)	%	30	35	34
4.	Porosity	%	47.8	51.3	49.2
5.	Bulk Density (BD)	gm/cc	1.38	1.29	1.35
6.	Water Holding Capacity	%	31.2	30.2	29.5
7.	Permeability	cm/hr	0.42	0.32	0.33
	Chemical Characteristics				
8.	pH (at 25^{0}C)	1:2 Suspension	6.82	6.84	7.05
9.	Conductivity (EC)	µmhos/cm	398	385	412
10.	CEC	meq/100-gm	19.5	18.5	17.6
11.	Organic Matter	%	0.88	1.14	1.17
12.	Organic Carbon	%	0.51	0.66	0.68
13.	Copper as Cu	mg/Kg	0.54	0.72	0.65
14.	Zinc as Zn	mg/Kg	0.85	0.81	0.77
15.	Iron as Fe	mg/Kg	12.8	11.6	14.2
16.	Boron as B	mg/Kg	0.60	0.58	0.61
17.	Manganese as Mn	mg/Kg	8.12	6.16	5.24
18.	**Available Nutrients**				
i).	Nitrogen as N	kg/ha	391.5	384.5	410.5
ii).	Phosphorus as P	kg/ha	18.2	22.6	21.4
iii).	Potassium as K	kg/ha	179.2	182.8	196.8

Table 4.6 – Results of soil sampling during EDDR stage at Kakkanad Junction

Sl. No.	Parameters	Unit	Method	Result
Physical Characteristics				
1.	Color			Reddish Brown
2.	Texture	USDA	Clay Loam	Clay Loam
3.	**Particle Size Distribution**			
a	Texture - Sand	%	SOP No. EEL/WP/SO/08	63.35
b	Texture - Silt	%	SOP No. EEL/WP/SO/08	10.02
c	Texture - Clay	%	SOP No. EEL/WP/SO/08	26.63
4.	Porosity	%	FAO Methods of analysis for soils: 2007	70.09
5.	Water Holding Capacity	%	Indian Bureau of Mines Analysis of Soil: 2012	58
6.	Permeability	cm/s	SOP No. EEL/WP/SO/19A	0.028
7.	Soil Type (Texture)	--	SOP No. EEL/WP/SO/08	Reddish brown Sandy Clay loam
	Chemical Characteristics			
8.	pH	--	IS 10158: 1982	6.7
9.	Conductivity	µS/cm	IS 14767 : 2000	289
10.	Cation Exchange Capacity	meq/100g	Indian Bureau of Mines Analysis of Soil: 2012	7.81
11.	Organic Matter	%	IS 2720 (Pt 22): 1972	0.53
12.	Exchangeable Potassium	meq/100g	Indian Bureau of Mines Analysis of Soil: 2012	26.56
13.	Exchangeable Sodium	meq/100g	Indian Bureau of Mines Analysis of Soil: 2012	68.94
14.	Exchangeable Calcium	meq/100g	Indian Bureau of Mines Analysis of Soil: 2012	3.01
15.	Exchangeable Magnesium	meq/100g	Indian Bureau of Mines Analysis of Soil: 2012	0.79
16.	Sodium Absorption Ratio	--	IS 11624: 2019	0.60
Available Nutrients				
17.	Phosphorus	mg/kg	SOP No. EEL/WP/SO/10	285.32
18.	Total Kjeldhal Nitrogen	%	IS 10158: 1982	0.12

Interpretation and Comparison of Results

Physical Properties - Reddish Brown colour soil is observed in the study area. Texturally the soil of study area is Clay Loam Soil. The Bulk Density (BD) of the soil found in the range 1.29-1.35 gm/cc. Water Holding Capacity (WHC) of study area soils was observed as range of 29.5%-31.2%, whereas at Kakkanad Junction the water holding capacity of soil is 58%. Permeability values were found in the range vary from 0.32-0.42 cm/hr during the EIA stage monitoring whereas it was found to be 0.028cm/sec during the EDDR stage monitoring.

Chemical Properties - The soil pH is indicating the soil is neutral in nature. The organic carbon content in sampled soil was observed as range of 0.51%-0.68% thereby implying that soils are sufficient in organic content.

Macronutrients - Available nitrogen content was observed in the surface soil as 384.5 -410.5 kg/ha while the Total kjeldhal nitrogen was found to be 0.12%. This indicates that soil is medium in available nitrogen content. Available phosphorus content was observed as range of 18.2-22.6 kg/ha during EIA whereas 285.32mg/kg during EDDR stage, thereby indicating that soil is medium in available phosphorus. The soil found medium in potassium content as well.

4.1.5 Seismicity

According to the seismic-zoning map of India, the project area falls in Zone III of seismicity where the maximum expected intensity is 5.6 M. Thus, lies among the moderate-risk earthquake areas. The seismicity map of study area is shown in Figure 4.6.

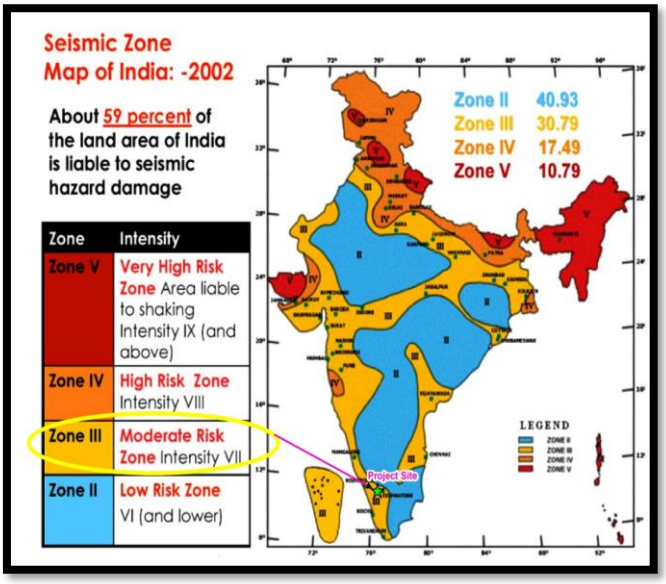


Figure 4.6 – Seismic Zone Map of India

4.2 Ambient Environment

4.2.1 Ambient Air Quality

Primary baseline data was collected for 1 week from 31st May to 6th June 2019 during EIA stage. Ambient air quality monitoring was carried out at JLN Stadium, Chembumukku, Top of Guard Room of Hyundai Showroom.

In the EDDR stage, ambient air quality monitoring was conducted for a continuous 24-hour period at three different locations on November 21, 2023. The specific details regarding the monitoring station locations can be found in Table 4.7, and photographs of the monitoring process is provided in Table 4.8. A comparative representation of the monitoring results during both the EIA and EDDR stages is presented in Table 4.9.

Table 4.7 Detail of Air Quality Monitoring Station during EDDR

S. No.	Location	Coordinates	Land Use	Date of Monitoring
1.	Palarivattom Junction Metro Station site	10°0' 15.10" N 76°18 '33.38" E	Commercial Area	21st Nov to 22nd Nov, 2023
2.	Vazhakkala Metro Station site	10°0' 44.66" N 76°19 '33.33" E	Commercial Area	21st Nov to 22nd Nov, 2023
3.	KINFRA Metro Station site	10°0' 10.59" N 76°21 '39.95" E	Commercial Area	21st Nov to 22nd Nov, 2023

Table 4.8 Photographs of Ambient Air Quality Monitoring

		
Palarivattom jn	Vazhakkala	KINFRA

Table 4.9: Analysis of Ambient Air Quality

Location	Date	PM10 (µg/m^3)	PM2.5 (µg/m^3)	SO2 (µg/m^3)	NO2 (µg/m^3)	CO (mg/m^3)
EIA Stage						
JLN Stadium (Pump House)	01/06/2019	68	33.2	7.4	13.7	0.42
	02/06/2019	76	37.4	6.7	16.8	0.51
Chembumukku	03/06/2019	66	29.6	6.1	15.2	0.39
	04/06/2019	59	26.3	5.7	13.6	0.27
Chittethukara (Hyundai Showroom)	05/06/2019	72	32.8	7.2	18.4	0.45
	06/06/2019	65	30.3	5.7	13.9	0.39
EDDR stage						
Palarivattom	21/11/2023	68.56	23.2	19.74	16.19	1.20
Vazhakkala	21/11/2023	76.32	25.14	21.56	18.37	1.30
KINFRA	21/11/2023	62.35	20.58	18.56	15.33	0.90

To assess whether air quality levels measured during the study adhere to the regulatory limits set by the environmental authorities, National Ambient Air Quality Standards is presented in table 4.10.

Table 4.10: National Ambient Air Quality Standards (NAAQS)

Concentration in Ambient Air				
Pollutants	**Time Weighted Average**	**Industrial, Residential, Rural and other areas**	**Ecologically sensitive area (notified by central government)**	**Method of Measurement**
1	2	3	4	5
Sulphur Dioxide (SO_2) µg/m^3	Annual*	50	20	Improved West & Gaeke method
	24 hours**	80	80	Ultraviolet fluorescence
Oxides of Nitrogen (NO_x) µg/m^3	Annual	40	30	Jacob & Hochheiser (Na-Arsenite)
	24 hours**	80	80	Gas Phase Chemiluminescence's
Carbon Monoxide (CO) mg/m^3	8 hours**	02	02	Nondispersive infrared spectroscopy
	1 hour	04	04	
PM_{10} µg/m^3 Particulate Matter size less than 10µm	Annual*	60	60	-Gravimetric - TOEM -Beta attenuation
	24 hours**	100	100	
$PM_{2.5}$ µg/m^3 Particulate Matter size less than 2.5µm	Annual*	40	40	-Gravimetric - TOEM -Beta attenuation
	24 hours**	60	60	

Source: *National Ambient Air Quality standards, CPCB Notification dated18thNovember 2009*

Observation on Ambient Air Quality

Particulate Matter (PM10): Upon comparison of both sets of results, it was observed that the concentration ranged between 59-76.32 µg/m3. The monitored PM10 levels were found to be well within the permissible limit, i.e., the National Ambient Air Quality Standards (NAAQS) level of 100 µg/m3.

Particulate Matter (PM2.5): Upon comparing the results, it was observed that the PM2.5 concentration ranged between 20.58-37.4 µg/m3. The monitored PM2.5 level was found to be well within the permissible limit, i.e., the National Ambient Air Quality Standards (NAAQS) level of 60 µg/m3.

Sulphur Dioxide (SO2): Upon comparison of both sets of results it was observed that the concentration ranges between 21.56 - 5.7 µg/m^3. The monitored SO2 level are found well within the permissible limit i.e., NAAQMS level 80µg/m^3.

Oxides of Nitrogen (NOx): Upon comparison of both sets of results it was observed that the concentration ranges between 18.4 - 13.6 µg/m^3. The monitored NOx levels are found well below the permissible limit i.e., NAAQMS level 80µg/m^3.

CO: On comparing both the results it was observed that the concentration ranges between 1.30 - 0.27 mg/m^3. The monitored CO levels are found well below the permissible limit i.e., NAAQMS level 04µg/m^3.

Upon comparing the monitoring results between the EIA and EDDR stages, an increase in SO2 levels is evident in the EDDR stage, suggesting an augmented movement of vehicles, particularly those involved in public transportation. It is important to note that despite this increase, the results remain well within the permissible limits.

4.2.2 Ambient Noise Quality

Noise level monitoring was conducted at eleven locations along the alignment during the EIA stage and at six locations during the EDDR stage. Details of noise quality monitoring stations are provided in Table 4.11, while Table 4.12 displays photographs, and Table 4.13 presents the results of the noise monitoring.

Table 4.11: Location of Noise Level Monitoring

Stations	Location	Land use/Zone	Geographical Coordinates	Date of Monitoring
NQ 1	Palarivattom Junction Metro Station site	Commercial	10°0' 14.58" N 76°18 '33.53" E	20th Nov, 2023
NQ 2	Alinchuvadu Metro Station site	Sensitive Receptor	10°0' 18.68" N 76°18 '48.49" E	20th Nov, 2023
NQ 3	Vazhakkala Metro Station site	Sensitive Receptor	10°0' 44.66" N 76°19 '33.33" E	20th Nov, 2023
NQ4	Civil Station Junction Metro Station site	Sensitive Receptor	10°0' 50.11" N 76°20 '30.16" E	20th Nov, 2023
NQ5	Chittethukara Metro Station site	Residential	9°59' 48.48" N 76°21 '5.29" E	20th Nov, 2023
NQ6	KINFRA Metro Station site	Commercial	10°0' 10.59" N 76°21 '39.95" E	20th Nov, 2023

Table 4.12: Photographs of Noise Level Monitoring

Palarivattom Jn

Alinchuvadu

Vazhakkala

Civil Station Junction (Kakkanad)

	
Chittethukara	KINFRA

Table 4.13: Analysis of Noise Level Monitoring

Location	Land Use	Standards		Day Time	Night Time
		Day	Night	Leq	Leq
During EIA					
Palarivattom Junction	Commercial Area	65	55	62.0	51.2
Chembumukku	Field Area near Residential complex	55	45	50.7	41.8
Hyundai Showroom (Between Chittethukara and KINFRA Metro Stations)	Commercial Area	65	55	62.8	53.6
Info Park Gate	Commercial Area	65	55	59.3	51.3
Info Pak Phase I-Sanskar School	Sensitive Receptor	50	40	47.9	41.4
Kakkanad	Commercial Area	65	55	62.9	52.8
Vazhakala	Sensitive Receptor -St Joseph Church	50	40	60.3	51.2
CSEZ	Commercial Area	65	55	54.3	43.9
JLN Stadium	Metro Station/Commercial	65	55	63.9	53.4
Palarivattom Bypass	Commercial Area	65	55	61.3	51.7
Padamughal	Residential Area	55	45	52.9	43.5
During EDDR					
Palarivattom Junction Metro Station site	Commercial	65	55	69.1	50.4

Alinchuvadu Metro Station site	Sensitive Receptor	50	40	71.2	52.3
Vazhakkala Metro Station site	Sensitive Receptor	50	40	69.3	49.4
Civil Station Junction Metro Station site	Sensitive Receptor	50	40	71.5	51.7
Chittethukara Metro Station site	Residential	55	45	68.8	48.3
KINFRA Metro Station site	Commercial	65	55	64.8	43.5

Observation on Noise Levels of Area

At the EIA stage, baseline values at monitoring locations adhered to the prescribed CPCB standards, except for Vazhakala station. However, during the EDDR stage, it is noted that both daytime and night time noise levels are elevated, exceeding the CPCB Noise Standards at all locations except those near Palarivattom Junction and KINFRA station.

The major source of noise pollution is attributed to increased traffic, traffic congestion, and the predominant commercial land use along the alignment.

In DPR, traffic survey study has been carried out for various locations in Kochi. It is significant to note that 10% of the vehicles now in Ernakulum are cars. Total registered vehicles in Ernakulum district by 2016-2017 were 1768869. The analysis of mode wise growth of registered vehicles as given DPR shows that the personalized mode of transport i.e., two wheelers and cars, have been growing tremendously with the annual increase of 9% and 14% respectively. The buses registered annual growth of 4% and auto rickshaws showed annual growth of 8%. Current scenario of traffic is shown below in figure 4.7 -

Figure 4.7 Current traffic scenario

Vibration: During the EDDR study, it was identified that baseline monitoring for ground-borne vibration had not been conducted during the EIA stage. Consequently, vibration monitoring was undertaken at six locations along the alignment to establish baseline data. Vibration measurements and recordings were conducted continuously for 24 hours at these six identified locations using high-grade seismic sensors configured in three mutually perpendicular directions (x, y, z). The recorded data was processed to derive Peak Particle Velocity (PPV) and VdB values. Ultra-low frequency vibration transducers (seismic grade) were employed for this task, coupled to the ground in three mutually perpendicular directions (x, y, z) at the monitoring locations. Table 4.14 provides a list of these locations for vibration monitoring.

Table 4.14 List of monitoring locations

Location No.	Measurement location name and setback distance from proposed alignment in meters	GPS Coordinates
Loc 1	Private house (Residence) 40 m	Lat : 10.004285° Long: 76.309184°
Loc 2	Pastoral Orientation Center (Public gathering area) 29 m	Lat : 10.006241° Long: 76.315062°
Loc 3	St. Michael's Church (Institutional) 37 m	Lat : 10.011202° Long: 76.32023°
Loc 4	Hidayathul Islam Madrassa (Institutional) 13 m	Lat : 10.013776° Long: 76.33207°
Loc 5	Cochin Special Economic Zone (Commercial) 30 m	Lat : 10.006393° Long: 76.344818°
Loc 6	Infopark (Commercial IT space) 47 m	Lat : 10.010365° Long: 76.365576°

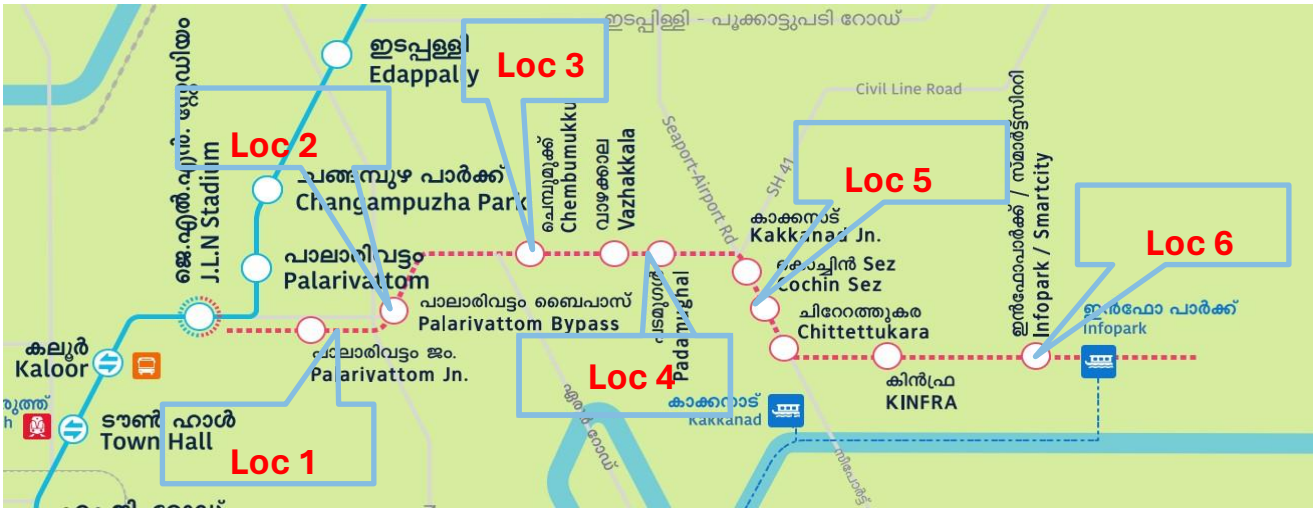


Figure 4.8 Alignment schematic showing locations of measurements.

Photographs of vibration monitoring

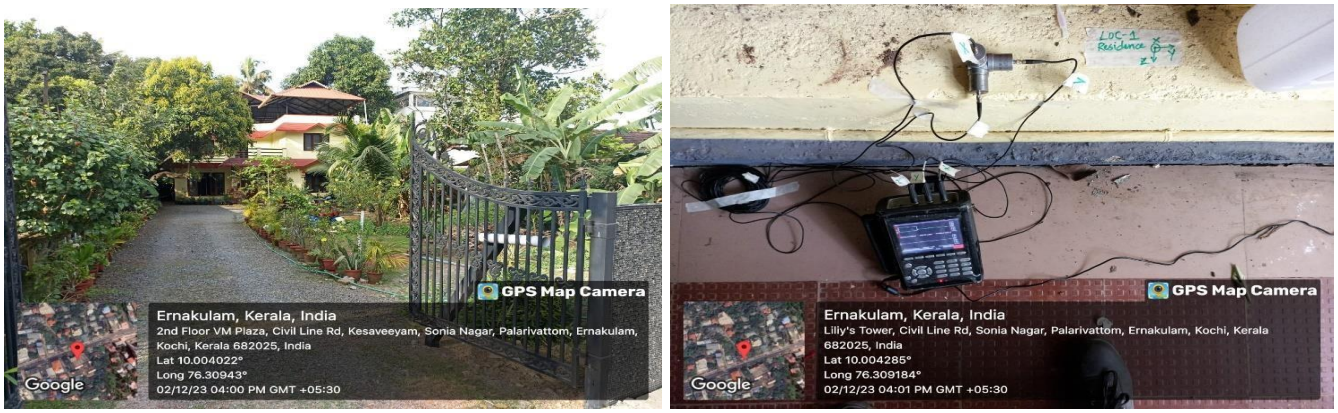


Figure 4.9 Site photographs taken at Private House (Residence) during measurements (Loc-1)

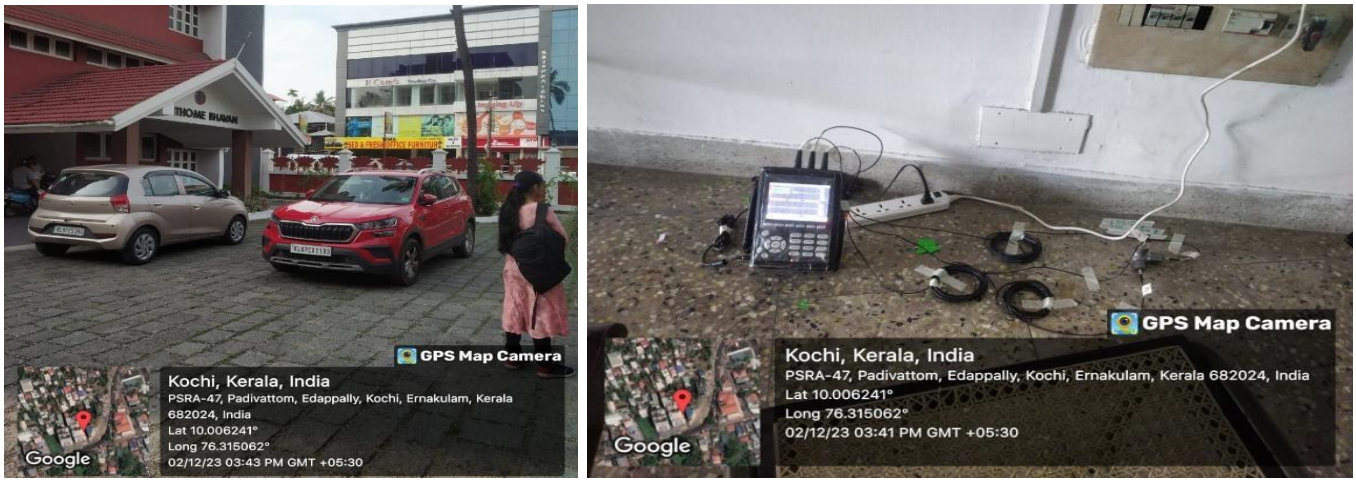


Figure 4.10 Site photographs taken at POC (Public gathering area) during measurements (Loc-2)

Figure 4.11 Site photographs taken at St Michaels Church during measurements (Loc-3)

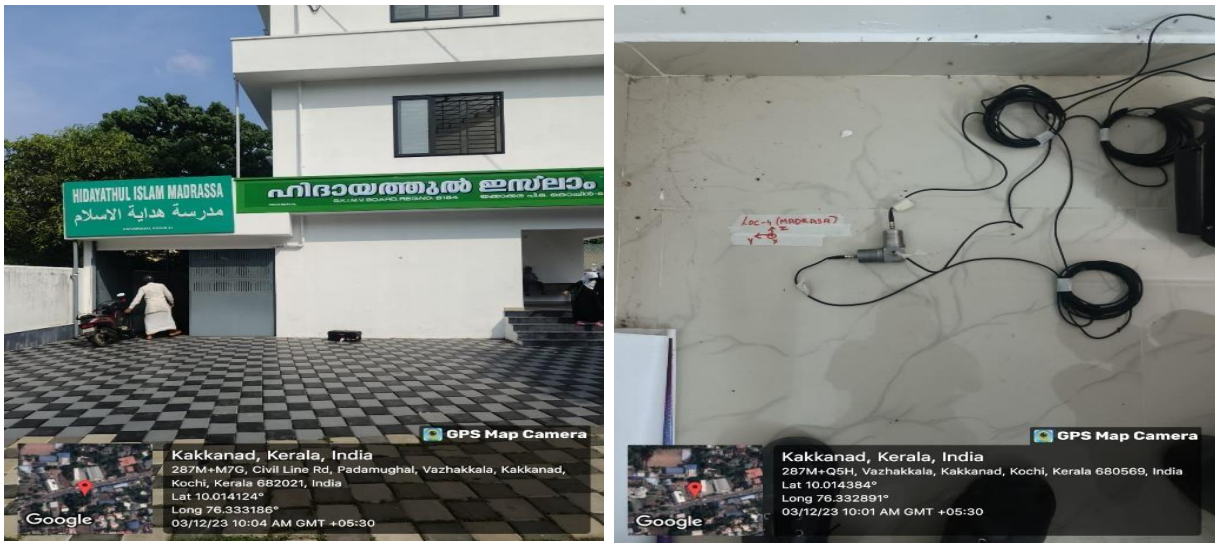


Figure 4.12 Site photographs taken at Madrasa during measurements (Loc-4)

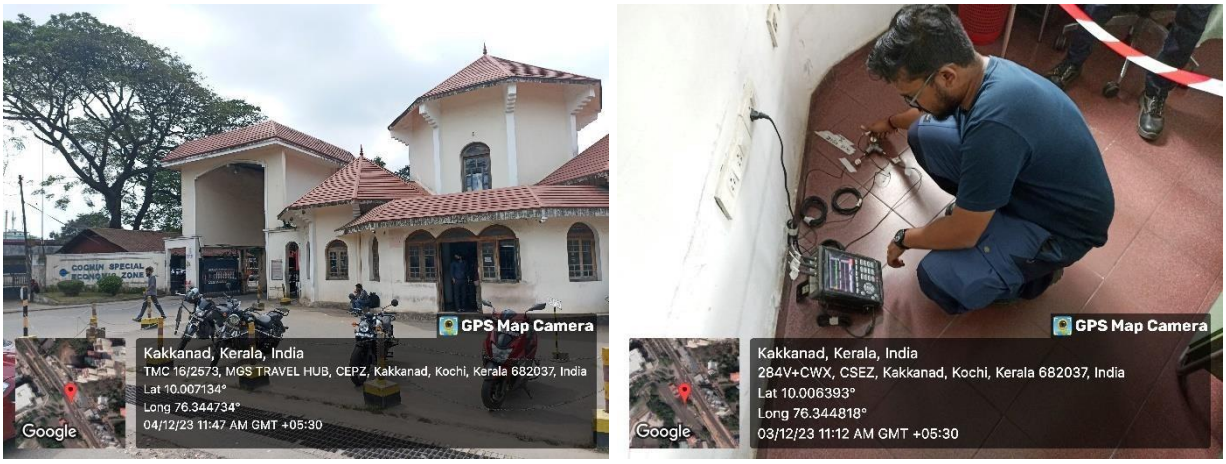


Figure 4.13 Site photographs taken at Cochin Special Economic Zone during measurements (Loc-5)

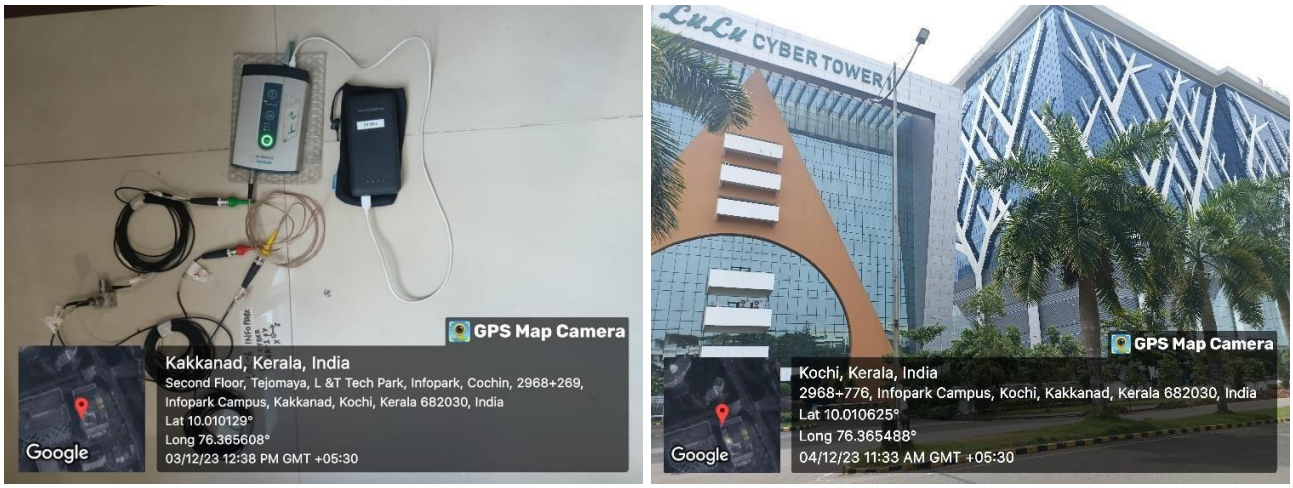


Figure 4.14 Site photographs taken at Infopark during measurements (Loc-6)

Table 4.15 summarizes the induced ground vibration levels, with all measurements characterized at ground level (pickup point). The vibration levels at each monitored location are observed to comply with the acceptable criteria for ground-borne vibration as prescribed by both the Federal Transit Administration (FTA) in the USA and the Railway Design and Standards Organisation (RDSO) in India. These criteria, deemed more relevant for the operation of this project, are detailed in Table 4.16

Table 4.15 Results of Vibration monitoring

S.no	Location	PPV (mm/sec)			VdB			VdB acceptable
		X	Y	Z	X	Y	Z	
Loc 1	Private house (Residence) 40 m	0.18	0.09	0.14	52	50	52	72
Loc 2	Pastoral Orientation Center (Public gathering area) 29 m	0.07	0.12	0.15	52	58	58	75
Loc 3	St. Michael's Church (Institutional) 37 m	0.12	0.06	0.07	50	49	50	75
Loc 4	Hidayathul Islam Madrassa (Institutional) 13 m	0.08	0.14	0.16	45	45	45	75
Loc 5	Cochin Special Economic Zone	0.24	0.20	0.21	48	58	58	75

	(Commercial) 30 m							
Loc 6	Infopark (Commercial IT space) 47 m	0.14	0.16	0.19	52	58	58	75

Table 4.16 Acceptable vibration impact criteria by FTA and RDSO

Land use category	GBV Impact Levels (VdB re 1 micro-inch/sec)		
	Frequent Events	Occasional Events	Infrequent Events
Category 1: Buildings where vibration would interfere with interior operations	65 VdB	65 VdB	65 VdB
Category 2: Residences and buildings where people normally sleep	72VdB	75VdB	80VdB
Category 3: Institutional land uses with primarily daytime use	75VdB	78VdB	83VdB

4.2.3 Hydrogeology

Hydrogeological map of the district is given in Figure 4.15. The laterites are highly porous and permeable. The depth of wells in laterite ranges from 3.4 to 14.8 mbgl and depth to water level ranges from 1.55 to 11.06 mbgl. Water level in project area during pre-monsoon season varies from 2-5 mbgl and during post monsoon season, it varies from 0-2 mbgl. All the blocks of the district are either falling in safe zone or semi-critical. Project area falls in safe category and map showing categorization of the district is given in Figure 4.16.

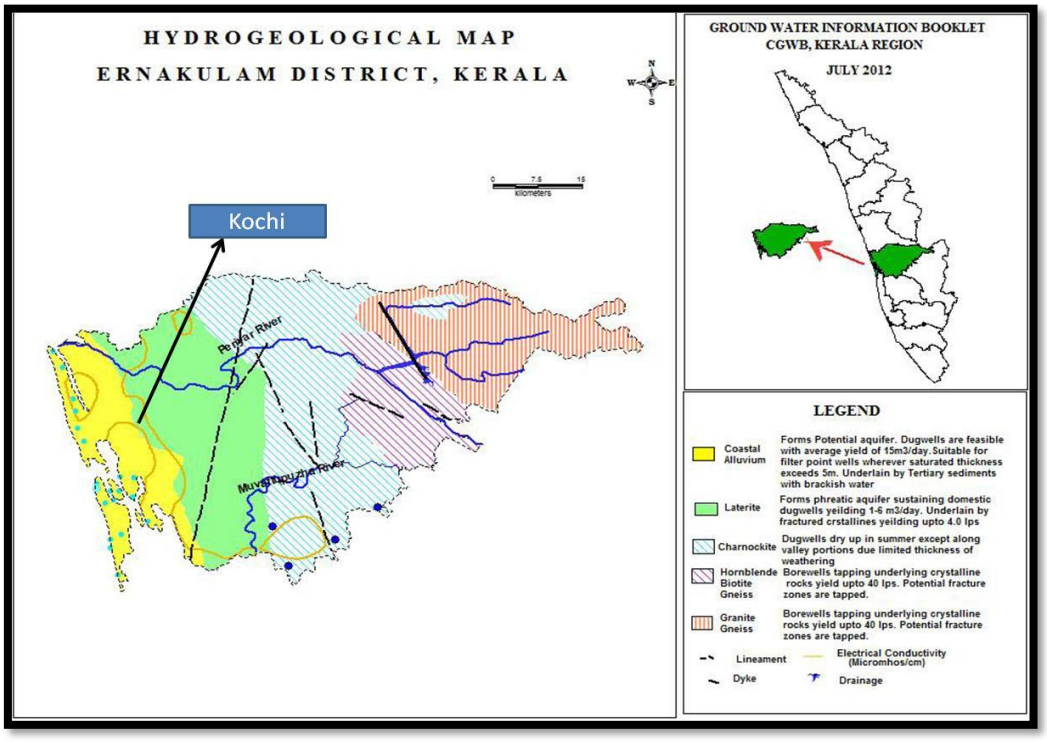


Figure 4.15 Hydrogeological map of Ernakulum District

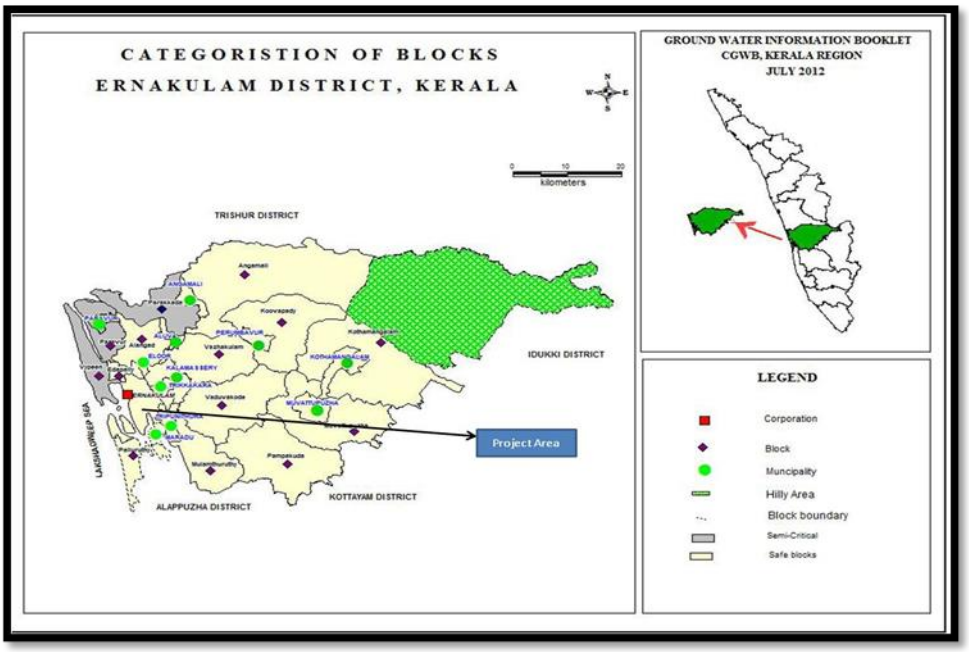


Figure 4.16 Categorization of District

4.2.4 Ground water quality

Groundwater quality assessment during the EIA study period involved sampling at Palarivattom Junction, Chembumukku, and the Hyundai Showroom (located between Chittethukara and KINFRA Metro Stations). Subsequently, during the EDDR study, groundwater samples were collected from local residents of Palarivattom and Kakkanad and analyzed in the laboratory. The locations for groundwater collection are detailed in Table 4.17, while Table 4.18 provides photographs of the sampling process. The results for the EIA stage and EDDR stage are presented in Table 4.19 and Table 4.20, respectively.

Table 4.17 Location for Ground Water Quality Monitoring

S. No.	Stations	Land Use	Lat	Long	Date
GW1	Palarivattom Junction	Residential Area	10° 0'7.39"N	76°18'24.24"E	21st Nov, 2023
GW2	Kakkanad	Commercial Area	10°0' 49.07" N	76°20 '32.91"E	21st Nov, 2023

Table 4.18: Photographs of Ground Water Quality Monitoring

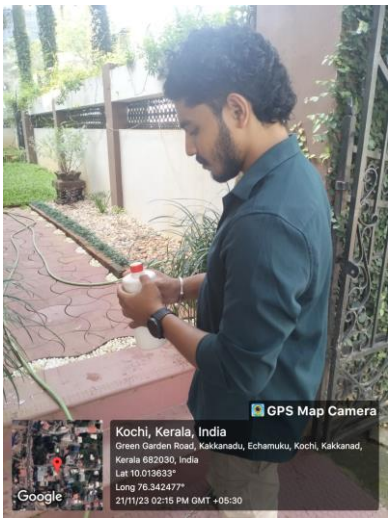
	
Palarivattom Junction	Kakkanad

Table 4.19 Results of Analysis of Ground Water Quality during EIA

S.N.	Parameters	Palarivattom Junction	Chembumukku	Hundai Showroom, Chittethukara Near Info Park Gate way
1	pH Value	7.24	7.90	7.58
2	Temperature 0C	25.2	25.0	25.2
3	Conductivity, µmhos/cm	608	767	1314
4	Turbidity (NTU)	<1	<1	<1
5	Total Dissolved Solids mg/l	384	487	841
6	Total Suspended Solids mg/l	<2	<2	<2
7	Total Hardness as CaCO3 mg/l	198	214	222
8	Chloride as Cl mg/l	47	72	259
9	Total Alkalinity mg/l	184	252	240
10	Sulphates as SO4 mg/l	42	45	39
11	Nitrates as NO3 mg/l	7.6	18.3	19
12	Fluoride as F mg/l	0.42	0.52	0.40
13	Iron as Fe mg/l	0.24	0.28	0.22
14	Zinc as Zn mg/l	0.58	0.88	0.95
15	Calcium as Ca mg/l	72	78	73.4
16	Magnesium as Mg mg/l	4.5	4.7	9.4
17	Sodium as Na mg/l	48	81	194
18	Potassium as K mg/l	3.5	7	18

19	Cadmium as Cd mg/l	<0.01	<0.01	<0.01
20	Copper as Cu mg/l	<0.01	<0.01	<0.01
21	Nickel as Ni mg/l	<0.01	<0.01	<0.01
22	Lead as Pb mg/l	<0.01	<0.01	<0.01
23	Mercury as Hg mg/l	<0.001	<0.001	<0.001
24	Chromium (Total as Cr) mg/l	<0.05	<0.05	<0.05
25	Arsenic as As mg/l	<0.01	<0.01	<0.01
26	Phenolic compound mg/l	<0.001	<0.001	<0.001
27	Total coliform MPN/100ml	ND <2	ND <2	ND <2

Table 4.20 Results of Analysis of Ground Water Quality during EDDR

S.N.	Parameters	Units	Palarivattom	Kakkanad
1	pH at 25 ^{0}C	---	6.9	6.6
2	Colour	Hazen Units, max	4.0	4.0
3	Turbidity	NTU, max	0.7	0.8
4	Total Dissolved Solids	mg/l, max	42	76
5	Total Hardness as CaCO3	mg/l, max	25.20	27.30
6	Chloride as Cl	mg/l, max	8.93	22.83
7	Sulphate as SO4	mg/l, max	2.50	13.59
8	Fluoride as F	mg/l, max	BDL(MDL-0.2)	BDL(MDL-0.2)
9	Alkalinity as CaCO3	mg/l, max	12.30	8.20
10	Iron as Fe	mg/l, max	0.10	0.12
11	Nitrate as NO3	mg/l, max	1.24	1.83
12	Calcium as Ca	mg/l, max	8.42	8.42
13	Magnesium as Mg	mg/l, max	1.03	1.53
14	Copper as Cu	mg/l, max	BDL(MDL-0.01)	BDL(MDL-0.01)
15	Manganese as Mn	mg/l, max	BDL(MDL-0.01)	BDL(MDL-0.01)
16	Phenolic compounds as C6H5OH	mg/l, max	BDL(MDL-0.0005)	BDL(MDL-0.0005)
17	Cadmium as Cd	mg/l, max	BDL(MDL-0.001)	BDL(MDL-0.001)
18	Arsenic as As	mg/l, max	BDL(MDL-0.005)	BDL(MDL-0.005)
19	Lead as Pb	mg/l, max	BDL(MDL-0.005)	BDL(MDL-0.005)
20	Zinc as Zn	mg/l, max	0.06	0.04
21	Total Chromium as Cr	mg/l, max	BDL(MDL-0.01)	0.02
22	Ammonia	mg/l, max	BDL(MDL-0.1)	BDL(MDL-0.1)

23	Sodium as Na	mg/l	2.01	12.74
24	Total Suspended Solids	mg/l	1.0	1.0
25	Oil & Grease	mg/l	BDL(MDL-0.2)	BDL(MDL-0.2)
26	Temperature	0C	30	30
27	Dissolved oxygen	mg/l	5.6	5.7
28	Phosphate	mg/l	BDL(MDL-0.05)	BDL(MDL-0.05)
29	Conductivity	µS/cm	71	127

Observations of two results

- Total dissolve solids value is found in the desired range and within permissible range (2000 mg/l) of IS 10500:2012.
- Chloride is found in within desired range (250 mg/l) and within permissible range (1000 mg/l) of IS 10500:2012.
- Total hardness values are found well within desired range (200 mg/l) and within permissible range (600 mg/l) of IS 10500:2012.
- Total alkalinity values are found well within desired range (200 mg/l) and within permissible range (600 mg/l) of IS 10500:2012.
- Mg values are found well within desired range (30 mg/l) and within permissible range (100 mg/l) of IS 10500:2012.
- Overall, the ground water quality of the study area is found well within the permissible limit of Indian standard IS 10500:2012.
- No metallic and bacterial contaminations were observed in ground water samples.

4.2.5 Surface Water Quality

The proposed alignment intersects Edappally thodu, the stream from Chitraphuza river, Kadambrayar river, and various drains and nallas. To assess the surface water quality in the study area, a sample was obtained from Kadambrayar river at Info Park during the EIA study. Subsequently, during the EDDR stage, a sample was taken from Edappally thodu. The sampling location detail is provided in Table 4.21, and photographic documentation of the sampling process is available in Table 4.22. The results for the EIA stage and EDDR stage are presented in Table 4.23 and Table 4.24, respectively.

Table 4.21: Location of Surface Water Quality Monitoring Stations

S. No.	Stations	Lat	Long	Date of Sampling
SW1	Edappally thodu	10°0' 38.95" N	76°19 '10.04" E	21st Nov, 2023

Table 4.22 Photograph of Surface Water Quality Monitoring

Edappally thodu

Table 4.23 Analysis of Surface Water Quality of Kadambrayar river

S.N.	Parameters	Kadambrayar River
1.	pH Value	7.11
2.	Temperature 0C	25.0
3.	Conductivity, µmhos/cm	3088
4.	Turbidity (NTU)	14
5.	Total Dissolved solids mg/l	1976
6.	Total Suspended solids mg/l	4
7.	Total Hardness as CaCO3 mg/l	454
8.	Chloride as Cl mg/l	756
9.	Total Alkalinity mg/l	318
10.	Sulphates as SO4 mg/l	132
11.	Fluoride as F mg/l	0.68
12.	Iron as Fe mg/l	0.42
13.	Zinc as Zn mg/l	1.02
14.	Calcium as Ca mg/l	132
15.	Magnesium as Mg mg/l	30.8
16.	Cadmium as Cd mg/l	<0.01
17.	Copper as Cu mg/l	<0.01
18.	Nickel as Ni mg/l	<0.01
19.	Lead as Pb mg/l	<0.01
20.	Mercury as Hg mg/l	<0.001
21.	Chromium (Total as Cr) mg/l	<0.05

22.	Arsenic as as mg/l	<0.025
23.	Oil & Grease mg/l	<2
24.	Chemical Oxygen Demand as COD mg/l	18
25.	Bio- Chemical Oxygen Demand as BOD (for 3 Days 27 ˚C) mg/l	3.4
26.	Dissolved Oxygen mg/l	5.2
27.	Total Coliform MPN/100ml	$2.1x10^3$

Table 4.24 Analysis of Surface Water Quality of Edappally thodu

S.N.	Parameters	Units	Edappally thodu (canal)
1.	pH at 25 ^{0}C	---	7.3
2.	Colour	Hazen Units	80
3.	Turbidity	NTU	120
4.	Total Dissolved Solids	mg/l	202
5.	Total Hardness as $CaCO_3$	mg/l	115.50
6.	Chloride as Cl	mg/l	37.72
7.	Sulphate as SO_4	mg/l	1.40
8.	Fluoride as F	mg/l	BDL(MDL-0.2)
9.	Alkalinity as $CaCO_3$	mg/l	123
10.	Iron as Fe	mg/l	5.64
11.	Nitrate as NO_3	mg/l	3.04
12.	Calcium as Ca	mg/l	39.56
13.	Magnesium as Mg	mg/l	4.08
14.	Copper as Cu	mg/l	0.56
15.	Manganese as Mn	mg/l	0.48
16.	Phenolic compounds as C_6H_5OH	mg/l	BDL(MDL-0.0005)
17.	Cadmium as Cd	mg/l	BDL(MDL-0.001)
18.	Arsenic as As	mg/l	BDL(MDL-0.005)
19.	Lead as Pb	mg/l	0.005
20.	Zinc as Zn	mg/l	1.16
21.	Total Chromium as Cr	mg/l	0.38
22.	Ammonia (as Total Ammonia -N)	mg/l	16.51
23.	Sodium as Na	mg/l	22.28

24.	Total Suspended Solids	mg/l	150
25.	Oil & Grease	mg/l	0.80
26.	Temperature	0C	30
27.	Dissolved oxygen	mg/l	5.4
28.	Phosphate	mg/l	0.40
29.	Conductivity	µS/cm	338
30.	Biochemical Oxygen Demand @ 27°C for 3 days	mg/l	93
31.	Chemical Oxygen Demand	mg/l	162

Observations

The analysis of surface water quality was conducted in accordance with the Designated Best Use Criteria set by the CPCB. The water quality aligns with Category D, indicating that the water body is suitable for the propagation of aquatic life and fisheries.

4.3 Ecological Environment

The survey conducted during the EIA study period aimed to assess the ecological status of the project area in terms of flora and fauna, with the details outlined below:

4.3.1 FLORA

Proposed alignment traverses through the urban area and the flora in the study area (RoW& 500 m buffer zone) is in form of roadside plantation, agriculture fields/plantations and homestead plantation. Major tree species are Azadirachtaindica, Bombax malabaricum, Syzygiumcumini, Pletophorumpterocarpum, Ipomoea carnea, Terminalia catappa, Azadirachtaindica, Thespesia populnea, Mangiferaindica, Mimusopselengi, Macaranga pelata, cocus nucifera, Delonix regia, Areca catechu, Alstoniascholaris, Neolamarckiacadambaetc. Some of the important medicinal trees found in study area are Cassia fistula, Azadirachta Indica, Aegle marmelos, Areca catechu etc. Total 3645nos of trees were observed within RoW during EIA stage and 669 no. of trees were identified as impacted tree. Majorly impacted trees are due to the proposed road widening and at station locations.

4.3.2 FAUNA

Due to urbanization and presence of human activities, no significant wildlife was observed/reported in the area. There is no forest area or notified eco-sensitive zone or jungle within 500 m of the proposed RoW. No wildlife habitat or notified eco-sensitive zone under Wildlife Act. 1972 is present within the 10 km radius area of proposed RoW except Managlavanam bird sanctuary which is present at 3 km from JLN station. Thus, fauna in study area is confined to the cattle/stray animals. Major faunal species found/observed/reported in the project area during the visit and through secondary sources are given in Table 4.25.

Table 4.25: Fauna Species in Study Area (RoW & 500 m Radius Area)

Name	Botanical Name
Mammals	
Squirrel	Funumbuls palmarum
Rat	Mus rattus

Porcupine	Hystrixindica
Mouse	Mus musculus
Indian Hare	Lapusnigricollis
Reptiles	
Lizard	Hemidactylus sp
Garden Lizard	Calotesvescicolor
Chameleon	Chameleon zeylanicus,
Krait	Bangarussp
Indian Cobra	Najanaja
Russel viper	Viperasp
Amphibians	
Common frog	Rana tigrina
Toad	Bufomelanosticus

Notified Eco-sensitive Area within 10 km Radius

Mangalavanam bird sanctuary exists at 3 km from the proposed alignment. The sanctuary was notified as bird sanctuary in 2004. The Mangalavanam Bird Sanctuary lies between latitudes 9°59'13.4" N and longitudes 76°16'26.1" E in the east of Central Marine Fisheries Research Institute (CMFRI) and National Institute of Oceanography (NIO) close to the new building complex of the High court of Kerala. Map showing location of the project alignment and Manglavanam sanctuary is given in Figure 4.9.

A Draft notification, SO 2810 (E) is also issued by MoEF&CC for declaring ESZ for Mangalavanam bird sanctuary according to which the buffer zone around the sanctuary varies from 0-1.5 km from the boundary of sanctuary. The notification is still in the draft and hence the ESZ for the sanctuary shall be considered as 10 km.

Figure 4.17 Map of Project Alignment and Manglavanam Sanctuary

4.3.3 Aquatic Flora and Fauna

Kochi has fair network of rivers, streams, and backwaters. Kochi backwaters form a significant habitat for aquatic and amphibian species. These backwaters support life of mangroves and variety of aquatic animals. Large scale shrimp farming is carried out in these back waters. Proposed alignment is at distance of approx. 3.4 km from Vembanad lake and National waterways. Proposed alignment crosses Edappally thodu, stream from Chitraphuza river, Kadambrayar river, drains and nallas. Plankton and benthose species found in the backwaters of Kochi is given in Table 4.26 and Table 4.27.

Table 4.26 Planktons in Kochi back Waters

S No	Species name	S No	Species name
Phytoplanktons			
1	Skeletonemacostatum	18	C.wailesii
2	Stephanopyxisturris	19	Protoperidiniumconicoides
3	Leptocylindrusdanicus	20	P. diabolum
4	Chaetocerosconstrictus	21	P. pentagonum
5	C. capense	22	Triceritium favus
6	C. didymus	23	Bacteriastrumhyalinum
7	C.compressus	24	Bacillariapaxillifera
8	C.decipiens	25	Pleurosigma directum
9	C.diversus	26	P.formosum
10	C. fusus	27	P. diverse-striatum
11	C. lineatum	28	Pseudo-nitzschiaseriata
12	Coscinodiscus centralis	29	P.nitzschiapungens
13	C.asteromphalus	30	Plagiotropis lepidoptera
14	C. marginatus	31	Actinocyclusoctonarius
15	C.granii	32	Pyrophacussteinii
16	C.radiatus	33	Thalassionemanitzschioides
17	Gyrosigmadiminutum		
Zooplanktons			
1	Acartiagravelyi	9	O. brevicornis
2	Acartiaplumosa	10	T. tocantinensis
3	Acrocalanussimilis	11	Doliolum sp.
4	B. quadridentatus	12	Microsetellanorvegica
5	B. rotundiformis	13	M. rosa
6	Oithonabrevicornis	14	Macrosetellagracilis
7	O. similis	15	Bivalve spot
8	O. simplex	16	Gastropod larvae

Table 4.27 Benthos in Kochi back Waters

S No	Species	S No	Species
Polychaeta worms		Bivalves	
1	Cossuracoasta	1	Corbicula fluminea
2	Prionospiocirrifera	2	Corbicula cyreniformis
3	P. pinnata	Insect larvae	
4	P. polybranchiata	1	Cirolanafluviatilis
5	Paraprionospiopinnata	2	Gammarus lacustris
6	Capitella capitata	3	Americorophiumtriaeonyx
7	Capitella sp.	4	Chironomus
8	Heteromastusfiliformis	5	Ctenapseudes
9	Heteromastussilllilis		

4.3.4 Fish and Fisheries

Due to presence of backwaters and network of rivers/streams and other water bodies, fishing is one of the major occupations of people in study area. Fishermen in the area use principally Chinese nets, cast nets, shore seine, stake nets and gill nets for catching fish. The Kochi metro phase II route crosses Edappally thodu, stream from Chitraphuza river, Kadambrayar river, drains and nallas. These water bodies are ultimately connected to NW-3 and forms part of NW-3. As per secondary literature available there are approx. 150 species of fishes found in NW-3 and back water system of Kochi.

As per study carried out by Sahadevan P (Diversity of fishes, Crustaceans and Molluscs of Puthuvypeen of Ernakulam District, Kerala, South India) for identifying the fisheries in Kochi backwaters and connected water bodies, 57 species of fin fishes belonging to 27 families, 19 species of crustaceans belonging to 7 families and 11 species of molluscs belonging to 7 families were found in Kochi backwaters and connected water bodies. As per the study, among the fin fishes one species (Anguilla bicolor) belonged to Near Threatened (NT) category and another species (Hyporhamphusxanthopterus) to Vulnerable (V) category as defined in IUCN list. 17 species belonged to the category of Least Concern (LC), 2 species belonged to Data Deficient (DD) category and 36 species were not evaluated (NE). Of the crustaceans 3 species belonged to LC and 16 species to NE category. Among the molluscs 4 species belonged to LC and 7 to NE categories. One species (Oreochromis mossambicus) was an alien species. Shrimps and prawns are also found in the back waters and common prawns and shrimp species found in the area are Metapenaeusdobsoni, M. affinis, M. Monoceros, Peneaussemisulcatus, P. monodon etc.

4.4 Socio Economic Environment

4.4.1 Utilities

The utilities to be impacted due to the proposed road widening encompass electricity lines, gas and oil pipelines, telecom cables, and water supply lines. The alignment has been carefully determined to steer clear of significant utility areas. Additionally, as a part of the preparatory measures for the metro construction, all electricity lines, water pipelines, and telecom lines will be relocated before commencing the project. The utility shifting work is ongoing at the.

Figure 4.18 Utility Shifting Work is in Progress

4.4.2 Cultural and Religious Properties

Religious structures situated along the proposed Right of Way (RoW) include St. Martin's Church (Chainage 540 - 10° 0'6.37"N, 76°18'13.52"E), Guru Temple (Chainage 1987 - 10° 0'23.65"N, 76°18'55.79"E), and St. Michael's Roman Catholic Church (Chainage 2790 - 10° 0'40.13"N, 76°19'15.09"E). While there are additional religious structures along the RoW, they are not directly affected. Other sensitive receptors include an Ayurveda Hospital and a special school. Measures will be implemented during construction to minimize disturbance to these structures. Photographic documentation is provided in Table 4.28.

Table 4.28 Sensitive Structures

	
Guru Temple	Martin church
	
Special School	Padamughal Mosque
	
Malabar church	Ayurveda Hospital

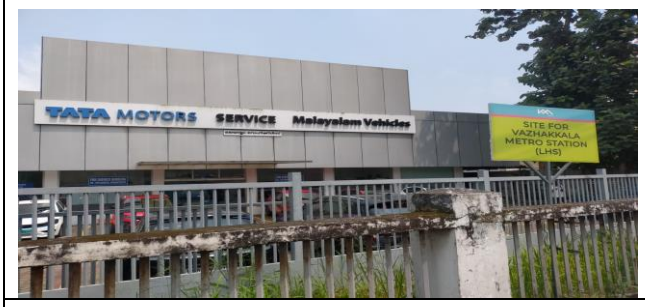
4.4.3 Demographic Features

As per the census records 2011, the total population of the study area was recorded as 678819 persons living in urban part of the study area under Kochi Municipal Corporation (Ward no. 1 to 71) and two census towns namely Kakkanad (CT) and Vazhakkala (CT) under two Sub-District / Tehsil namely Kochi and Kanayannur of Ernakulum District of Kerala. Study zone mainly falls in urban part of Ernakulum district in Kerala. Total number of 'Households' was observed as 169942 in the study zone. Male-female wise total population was recorded as 334732 males and 344087 females respectively.

4.5 Findings during EDDR Site Visit

As part of the EDDR study, a site visit was conducted to evaluate the current conditions along the alignment. The sensitive receptors identified remained consistent with those mentioned in the EIA. The status of land acquisition, conducted as part of preparatory work, and potential impacts were verified. Informal public consultations were undertaken to gain insight into the community's perspective on the project. The results of these assessments are presented in the following table:

Table 4.28 Findings during EDDR Site Visit

	
Impacted structure at Palarivattom jn station location	Impacted utilities at Alinchuvadu station location
	
Ongoing road widening work in front of orientation centre.	Impacted Martins church due to road widening. The negotiation with church authorities is in process for further LA.
	
Impacted structure Tata motors due to Vazhakkala station location RHS	Station location of Vazhakkala RHS
	
Ongoing demolition work for road widening at Chembumukku	Area properly barricaded for piling work at Cochin SEZ RHS

	
Ongoing piling work at Cochin SEZ station LHS	Trees affected due to KINFRA station location
	
Trees affected due to Chittethukara station location	On going demolition work at Vazhakkala

5 CLIMATE RISK ASSESSMENT

Climate Change is referred to as the change in the state of the climate that can be identified by changes in the mean and variability of climate properties that persist for an extended period, typically decades or longer. Such changes in the climate may be due to natural internal processes or external forcing, changes in the composition of the atmosphere, or land use due to anthropogenic causes. The Paris Agreement has aimed to limit global warming to well below 2°C, preferably to 1.5°C, compared to pre-industrial levels. Thus, it is imperative to install readiness along with other measures into the systems to adapt to the possible impacts of any temperature rise of that magnitude. This Plan is primarily built upon the region-specific assessments made regarding the systemic vulnerabilities of various sectors to the climate change scene taking district as the basic unit of all such assessments.

While promoting climate-resilient development, Countries submitted Nationally Determined Contributions (NDC) goals and targets. The Government of India also submitted NDC goals and targets. India is also committed to the United Nations (UN) Sustainable Development Goals (SDGs). The 2030 agenda for global sustainable development envisions the development and application of technology that is climate-sensitive, addresses biodiversity concerns, and climate resilient.

The National Action Plan on Climate Change (NAPCC) was formulated by the Government of India in 2008, as a sustainable development strategy that was integrated to the climate change. The NAPCC aimed at enhancing current and planned programmes to address climate change through appropriate institutional mechanisms, and by building effective linkages with civil society, local government institutions, and public-private partnerships. NAPCC, through its sectoral missions, provided a detailed road map and the SAPCCs prepared by States aimed at realizing the objectives.

Review of EIA & Identified gaps : A climate risk assessment was not conducted during the EIA stage.

Due Diligence Covers: For the KMRL metro project's Phase II, the design norms and parameters have been determined and finalized drawing from the experience gained in the Phase I metro project along with adherence to standard codes of practices. Notably, many adaptations addressing current operational challenges contribute to building resilience, even if their primary focus is not specifically on climate change. The assessment of climate change adaptation measures for Phase II infrastructural components is derived from the findings of the DPR, aligning with climatic parameters influencing the nature and severity of natural hazards. This information is presented in the EDDR, even though adaptation to climate change impacts was not the primary focus in the DPR. The Due Diligence study has incorporated climate risk assessment and corresponding adaptation measures.

5.1 Scope of Work:

A detailed assessment has been carried out to identify the physical climate risks that the proposed project and its components are exposed and to identify the adaptation measures to manage these risks.

The physical climate risk assessment (CRA) considered the embedded physical climate risk reduction project design features and identify potential adaptation measures that are suitable for inclusion in the Project design to address the residual physical climate risks. The assessment process and results has been presented in the chapter. Key climate hazards to be considered include those identified through the use of the risk screening tool Aware.

The CRA is consist of the following tasks:

1) Define the scope and CRA methodology: relevant project documents like DPR report, EIA report, metrological data etc. has been reviewed including the physical, social, and environmental boundaries to be considered; time horizon and relevant climate (& hydrological) variables for risk analyses; socio-economic and emissions scenarios under which climate scenarios has been developed for the assessment.
2) all required datasets and information, including historic hydrometeorological data, initial project design documents, flood zoning maps if relevant, etc has been collected.
3) Assessed physical climate risks that the proposed project is exposed to:

a) Identify all climate-sensitive components of the proposed project, and relevant climate hazards.
b) Assess the sensitivity of project components to relevant climate hazards.
c) Assess climate risks to each project component from all relevant climate hazards.
d) Identify embedded climate-resilient project design features and assess the degree to which they are expected to moderate the risks identified above.
e) Asses the residual climate risks after taking into account the effect of embedded climate-resilient design features.

4) Potential adaptation measures that are included/proposed to be included in the Project design to address the residual climate risks.

5.2 Climate Screening:

To align with the AIIB's & National regulation for Climate risk assessment Climate Risk Screening has been carried out for identifying short- and long-term climate and disaster risks to build resilience in project. Identifying risks and proactively incorporating resilience measures – at an early stage of project design or even sustainable construction practices – can help projects achieve their development objectives. The screening is based on the AwareTM geographic data set, compiled from the latest scientific information on current geological, climate and related hazards together with projected changes for the future where available. These data are combined with the project's sensitivities to hazard variables, returning information on the current and potential future risks that could influence its design and planning. The overall climate risk of the project is medium as summarised in figure 5.1.

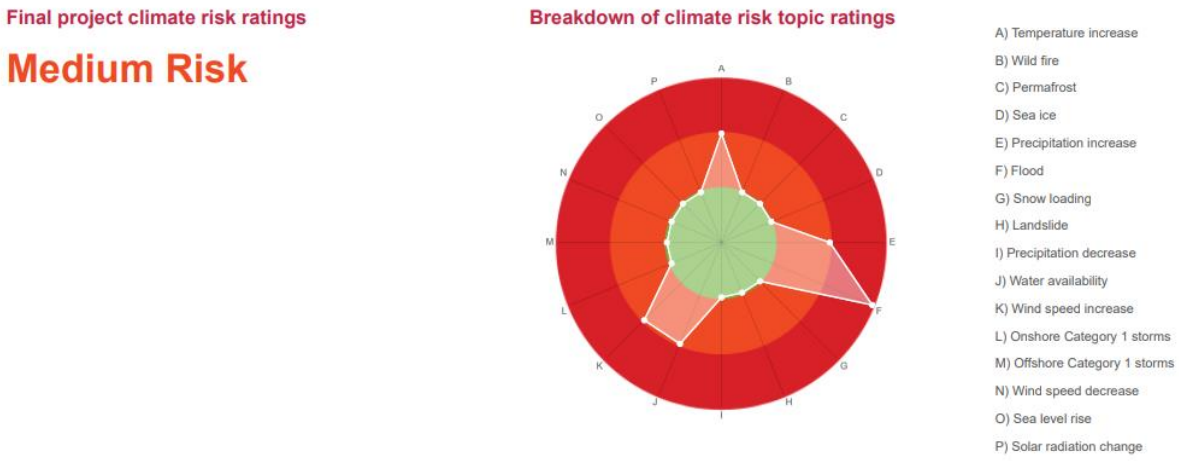


Figure 5.1 Climate risk of the project

5.2.1 Flood

In the area flood hazard is classified as high based on modelled flood information currently available to this tool. This means that potentially damaging floods are expected to occur at least once in the next 10 years. Project planning decisions, project design, and construction methods must take into account the level of flood hazard.

5.2.2 Temperature

In the area temperature increase/heat hazard is classified as medium. This means that prolonged exposure to extreme heat, resulting in heat stress, is expected to occur at least once in the next ten years. Project planning decisions, project design, and construction methods must take into account the temperature increase. There is a potential for an increase in incidences where current design standards will not be sufficient. Heatwaves put stress on buildings and other infrastructure, including roads and other transport links. In cities, the 'urban heat island' can increase the risk of heat related deaths.

Warm weather can raise surface water temperatures of reservoirs used for industrial cooling. In addition, this could impact local eco-systems, improving the growing conditions for algae and potentially harmful micro-organisms in water courses.

Heatwaves can have an impact on agricultural productivity and growing seasons. High temperatures can have implications for energy security. Peak energy demand due to demand for cooling can exceed incremental increases on base load in addition to the risk of line outages and blackouts. Human health can be affected by warmer periods. Wildfire risk is elevated during prolonged warm periods that dry fuels, promoting easier ignition and faster spread. Permafrost and glacial melt regimes as impacted by warm periods.

5.2.3 Precipitation Increase

Climate model projections agree that annual average precipitation will increase in the project location. This indicates a relatively low degree of uncertainty that precipitation will increase in the region.

The project would be unaffected by decreases in precipitation. Decreased seasonal runoff may exacerbate pressures on water availability, accessibility, and quality. Variability of river runoff may be affected such that extremely low runoff events (i.e., drought) may occur much more frequently. Pollutants from industry that would be adequately diluted could now become more concentrated.

5.2.4 Water Availability

In the area water scarcity is classified as medium to low there is lesser chance drought will occur in the coming 10 years. Based on this information, the impact of drought should be considered in all phases of the project, in particular its effect on personnel and stakeholders, and during design of buildings and infrastructure. Project planning decisions, project design, and construction methods may take into account the level of drought hazard.

5.2.5 Wind Speed increase

The project is considered to have moderate sensitivity to wind. Given the energy in the wind is the cube of wind speed, a small change in the wind climate can have substantial consequences for the wind energy available. Similarly, small changes could have dramatic consequences for wind related hazards e.g., windstorm damage. Note that damages can not only occur due to wind but also cyclone induced heavy rainfall and subsequent flooding as well as coastal floods in coastal areas. Project planning, design, and construction practices should account for strong wind from potential cyclones in project area.

5.2.6 Tsunami

The data suggest that the project is located in a region where there is a tsunami run up hazard associated with a 500yr return period event. This is based on post-processed data from the International Centre for Numerical Methods in Engineering (CIMNE) and INGENIAR Ltda (GAR15).

5.3 The Baseline Climate

5.3.1 Kerala

Following Koppen's Climate classification, Kerala has a dominant tropical monsoon climate with seasonally excessive rainfall and hot summer except over Thiruvananthapuram, where the climate is tropical savanna with seasonally dry and hot summer weather. The year could be divided into four seasons1. The period from March to the end of May is the hot season (Pre-monsoon). This is followed by the southwest monsoon season (Monsoon) that continues till the beginning of October. October to December is the northeast monsoon season (post-monsoon) and the two months of January and February comprise the winter season (Winter). The entire State is classified as one among the 36 meteorological sub-divisions in India for climatological purposes. Day temperatures are more or less uniform over the plains throughout the year except during monsoon months when these temperatures drop down by about 3 to 5°C. March and April are the hot months with a mean maximum

temperature of about 33 °C (Vijay and Varija, 2022). The diurnal range of temperature is maximum during summer months. Kerala receives high average annual rainfall compared to other Indian states. The mean annual rainfall over Kerala from 1871 to 2016 is 2816mm2. Historical (Baseline) Period for temperature analysis is considered as : 1990 – 2019 and Historical (Baseline) Period for rainfall analysis is considered as : 1991 – 2020.

A moderate warming trend has been observed in the summer maximum and the winter minimum temperatures during the historical period. In general, a decreasing trend in the mean annual and monsoon rainfall is observed over the State during the historical period (Figure 5.3).

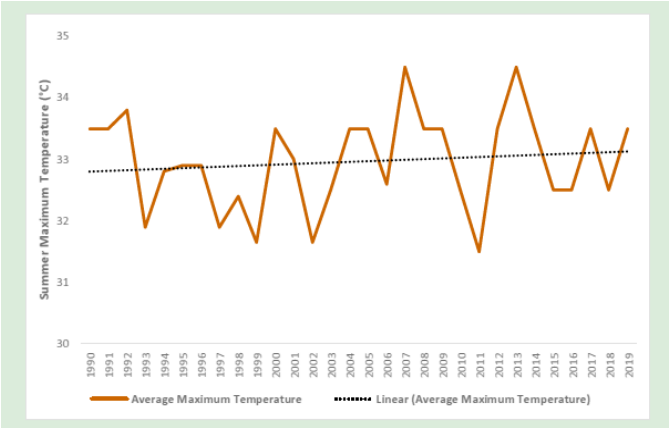


Figure 5.2: Mean Summer Maximum Temperature During the Historical Period

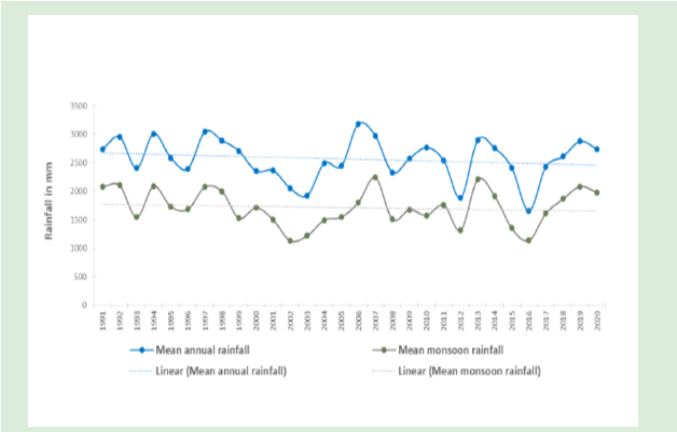


Figure 5.3: Mean Annual and Monsoon Rainfall During the Historical Period

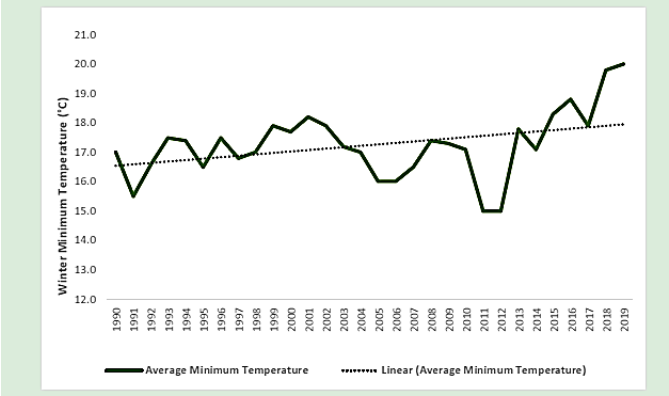


Figure 5.4: Mean Winter Temperature During the Historical Period

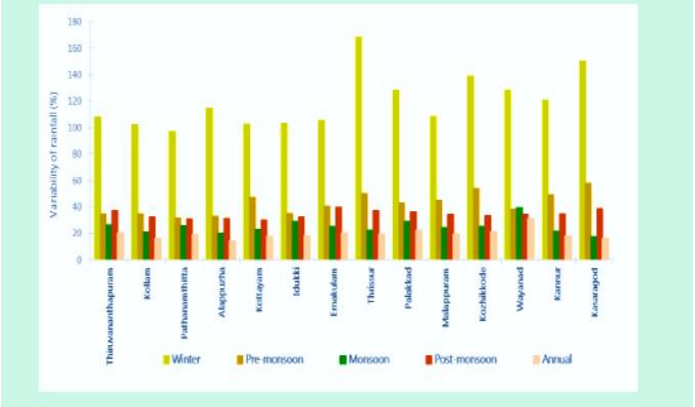


Figure 5.5: District Wise Annual and Seasonal Rainfall Variability During the Historical Period

Source: Kerala State Action Plan on Climate Change 2023-2030

5.3.2 Average Weather Kochi

The climate is tropical in Kochi. During most months of the year, there is significant rainfall in Kochi. There is only a short dry season. In Kochi, the mean yearly temperature amounts to 26.5 °C | 79.8 °F. The annual rainfall is 2882 mm | 113.5 inch. The driest month is January.

There is 5-20 mm precipitation in January. Most precipitation falls in June, with an average of 568 mm | 22.4 inch. With an average of 28.2 °C | 82.8 °F, March is the warmest month. In August, the average temperature is 25.4 °C | 77.8 °F. It is the lowest average temperature of the whole year.

The month with the highest relative humidity is July (89.14 %). The month with the lowest relative humidity is February (73.56 %). The month with the highest number of rainy days is July (28.73 days). The month with the lowest number of rainy days is January (5.73 days).

Table 5.1 Average Weather of Kochi

	January	February	March	April	May	June	July	August	September	October	November	December
Avg. Temperature °C (°F)	26.5 °C (79.6) °F	27.3 °C (81.2) °F	28.2 °C (82.8) °F	28.1 °C (82.6) °F	27.3 °C (81.2) °F	25.9 °C (78.7) °F	25.5 °C (77.8) °F	25.4 °C (77.8) °F	25.8 °C (78.4) °F	26 °C (78.8) °F	26.2 °C (79.2) °F	26.2 °C (79.2) °F
Min. Temperature °C (°F)	23.2 °C (73.7) °F	24.1 °C (75.3) °F	25.3 °C (77.6) °F	25.8 °C (78.4) °F	25.6 °C (78) °F	24.7 °C (76.4) °F	24.2 °C (75.6) °F	24.1 °C (75.4) °F	24.2 °C (75.5) °F	24.2 °C (75.5) °F	24 °C (75.2) °F	23.4 °C (74) °F
Max. Temperature °C (°F)	29.9 °C (85.9) °F	30.8 °C (87.5) °F	31.5 °C (88.7) °F	31 °C (87.8) °F	29.7 °C (85.4) °F	27.8 °C (82) °F	27.3 °C (81.2) °F	27.3 °C (81.2) °F	27.9 °C (82.3) °F	28.3 °C (83) °F	28.8 °C (83.8) °F	29.3 °C (84.7) °F
Precipitation / Rainfall mm (in)	22 (0)	27 (1)	66 (2)	177 (6)	337 (13)	568 (22)	514 (20)	379 (14)	264 (10)	303 (11)	169 (6)	56 (2)
Humidity(%)	75%	74%	75%	81%	85%	89%	89%	89%	87%	87%	84%	79%
Rainy days (d)	4	6	12	19	20	21	22	21	20	20	15	7
avg. Sun hours (hours)	9.9	9.9	9.7	8.6	7.4	6.8	7.1	7.4	8.0	8.1	9.1	9.6

Data: 1991 - 2021 Min. Temperature °C (°F), Max. Temperature °C (°F), Precipitation / Rainfall mm (in), Humidity, Rainy days. Data: 1999 - 2019: avg. Sun hours Source: Kochi climate: Average Temperature by month, Kochi water temperature (climate-data.org)

5.3.3 Wind speed and Direction

Generally, light to moderate winds prevail throughout the year. Winds were light and moderate particularly during the morning hours. While during the afternoon hours the winds were stronger. The annual mean wind speed is 2.9 km/hr in Kochi district however the historical data suggest the wind speed upto 114km/hr for the project area. Graphical presentation of wind speed is given in Figure 5.6. The monsoon creates steady strong winds from March to September, and calm winds from November to February. Pre-dominant wind direction in the area is W, NW and SW. Annual wind rose for Kochi city is given below in Figure 5.7.

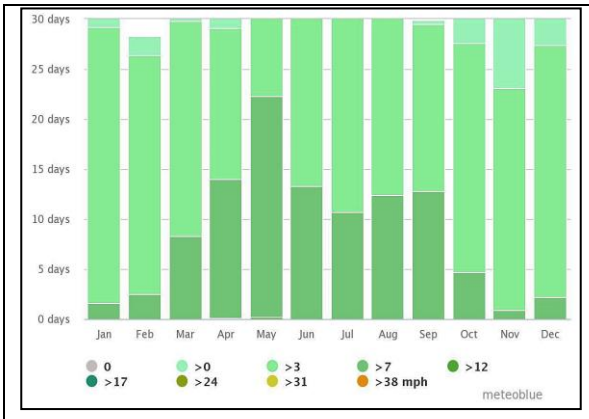


Figure 5.6: Graphical Representation of wind speed

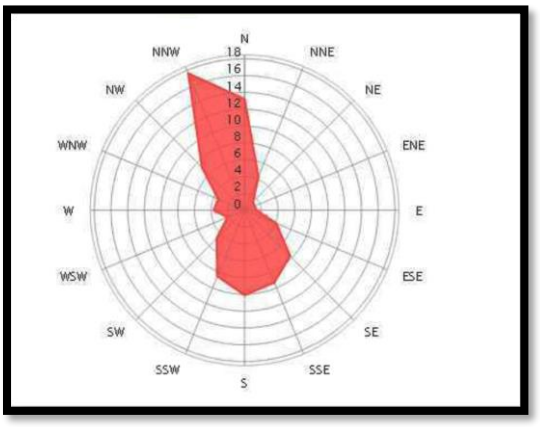


Figure 5.7: Annual Windrose of Kochi

5.4 Climate Projection

Climate screening identified flooding, windspeed and temperature increase as a significant risk, however the proposed project is elevated, therefore, the structures including the main stations and viaduct are above HFL and any impact on above elements due to flooding from climate changes are ruled out.

The wind speed specified in IS 875 – Code of Practice for Design Loads (Part 3: Wind Load) of 39 m/s has adequate margin of safety (of 25%) to cater to future climate risks as maximum wind speed recorded so far for the Project Area (Kochi) is 31.1 m/s i.e., 112 kmph (refer Climate & Tidal information: Cochin Port Authority at *https://cochinport.gov.in/climate-tidal-info*). It is to be noted that the Project Area (Kochi) lies beyond the cyclone belt.

Climate projections for temperature changes has been assessed to understand the potential impact on project infrastructure and to incorporate the adaptive measures to cater those impacts.

Climate projection was carried-out for the temperature changes in the Kerala Climate Action Plan for the various districts in the state. The models covering the entire globe are referred to as Global Climate Models (GCMs) and the downscaled region-specific models are called Regional Climate Models (RCMs). The assessment made here is aligned with the World Meteorological Organization (WMO) baseline approach, which is 30-year averages (WMO, 2017). Under this plan, temperature for both summer maximum (pre-monsoon; March to May), potentially causing heat stress, and winter minimum (January to February), critical for human comfort and winter crops, were analysed for the projected period of near-term (2021 – 2050).

The high-resolution, downscaled climate projections for different climate scenarios provided by the Centre for Climate Change Research (CCCR) at the Indian Institute of Tropical Meteorology (IITM) under the Coordinated Regional Climate Downscaling Experiment (CORDEX) South Asia programme are utilised to investigate the future change in temperature over the State of Kerala. The global climate projections are dynamically downscaled to 50 km spatial resolution using Regional Climate Models (RCM) over the larger domain (19.25° – 116.25°E; 15.75°S – 45.75°N) covering CORDEX South Asia (Sanjay et al., 2017)

Representative Concentration Pathways (RCPs) are trajectories of greenhouse gas concentration in the atmosphere adopted by the IPCC for its Fifth Assessment Report. It refers to the development of a scenario set containing emission, concentration, and land use trajectories. Four concentration pathways based on four different global developmental paradigms are represented by RCP2.6, RCP4.5, RCP6.0, and RCP8.5. Each of the numbers next to the RCPs, represent the radiative forcing (W/m2) in the year 2100.

RCP8.5 is a highly energy-intensive scenario as a result of high population growth and a lower rate of technology development.

However, depending on penetration of low carbon technologies including renewable technologies and carbon capture and storage into the economy, the concentrations can correspond to intermediate scenarios -RCP2.6 to RCP6.0 (IPCC, 2014).

5.4.1 Temperature

CORDEX South Asia modelled simulations were used for temperature projections for Ernakulam district, results from these bias-corrected model simulations were used to produce the ensemble mean to assess the future temperature change. Change in temperature during the projected period was computed as a difference between the 30-year historical period and the models simulated ensemble average of the 30-year projected period.

The summer maximum temperature increases by 1.4°C under RCP 4.5 and 1.8°C under RCP 8.5 and the winter minimum temperature increases by 1.3°C under RCP 4.5 and 1.8°C under RCP 8.5.

Table 5.2 Seasonal temperature variation

District	Change in temperature (° C) during the 2030s (2021–2050) compared to the historical period (1990–2019)			
	Summer maximum temperature		Winter minimum temperature	
	RCP 4.5	RCP 8.5	RCP 4.5	RCP 8.5
Ernakulam	1.4	1.8	1.3	1.8

Source: Kerala State Action Plan on Climate Change 2023-2030

5.5 Vulnerability Assessment

There are several uncertainties associated with future projections of climatic and non-climatic factors; however, such information helps to build awareness about the need for initiating affirmative anticipatory action to deal with expected future risks. Given an uncertain future, the immediate adoption of resilience-building measures is a 'no-regret' strategy that has the benefit of the availability of multiple options at affordable costs.

5.5.1 Flooding resulting from Anomalous Heavy Rainfall

Kerala has been receiving excess rainfall for the past few years. The percentage of excess being 23.34% in the year 2018, 12.72% in 2019 and 9% in 2020. Due to global climatic changes, Kerala coast is now getting prone to cyclonic storms also. The heavy rains received in a short duration is found to cause inundation in the Kochi city area. Across all risk and vulnerability factors, it is ranked as the highest. In terms of socio-economic vulnerability, it stated that especially low-income areas and informal settlements are at risk. Furthermore, past floods have disrupted water supply and transport facilities, which disabled the movement of people and commodities.

Kochi's infrastructure is built to take the Monsoon climate and occasional heavy rains into account. The bed of many natural canals was concreted thus making infiltration of flood water through canal bed impossible. The improvement of proper drainage and new facilities for rainwater harvesting and use were suggested as important measures to enhance capacities and lower its vulnerability.

Government of Kerala launched a comprehensive rebuild framework and emergency action plan, under the umbrella scheme of the Rebuild Kerala Programme, that is being directed by the Kerala Public Works Department (PWD), with the core vision, strategy and way forward being articulated in the Government document titled "Rebuild Kerala Development Programme: A Resilient Recovery Policy Framework and Action Plan for Shaping Kerala's Resilient, Risk-Informed Development and Recovery from 2018 Floods". The Project comprises the repair and climate-resilient reconstruction of flood damaged roads and bridges and reduce its vulnerability towards future climate-related damages.in Kerala under the responsibility of Public Works Department (PWD) of Government of Kerala.

The flagship programme 'Operation Breakthrough' was launched in Kochi City by the Hon' Chief Minister following the flash flooding which happened during October 2019. Technical committee of Operation Breakthrough comprising of Executive Engineers from all major work execution departments such as PWD,

Irrigation, LSGD, GCDA etc in the district prioritised the remedies suggested by various teams and arranged the prioritised works under Phase 1 of the Project on a war footing basis. The Phase 2 of Operation Breakthrough Program was led by Irrigation department the desilting and rejuvenation major canals and Kayal mouths in the city were taken up.

5.5.2 Water Scarcity

General water availability in Kochi is good, due to natural water resources (rivers and groundwater) and annual rainfall volumes. However, a decrease in rainfall or shift in precipitation patterns is associated with a greater likelihood of shortages of drinking water, increased water pollution due to less dilution and flushing, more extensive saltwater intrusion, and possibly increased costs of electricity if hydropower potentials are affected (ORNL & CUSAT 2003). These shortages would become even more relevant, when the demand of water and electric power rises due to higher temperatures, e.g., due to increased rates of water evaporation or an increasing use of electric cooling devices. With a performance of wastewater treatment of about 4 % (Government of Kerala 2015), and no real infrastructure for rainwater harvesting.

5.5.3 Temperature Increase

A major contributor to the high temperatures in cities is the urban heat island effect (UHI), which is a predominant climate risk in urban areas. Amongst others, it is a result of lacking vegetation and surface moisture, extensive paved surfaces, the canyon effect of buildings, heat-trapping pollutants in the atmosphere, as well as human activities in urban space.

5.5.4 Change in Biological System

Climate change has an immediate impact on the local biological system in terms of the condition, population dynamics, habitat availability, migratory patterns, and overall composition of native flora and fauna species. Given that nature is the basis of human life and activity, these implications can have a direct and major impact on cities and people. Potential risk areas thereby include agriculture and crop growth (Ashalatha et al. 2012; Pande et al. 2010), marine life and fisheries (Vivekanandan 2011; Badjeck et al. 2010), or biodiversity in general (Sharma and Bazaz 2012; Rani et al. 2016).

5.5.5 Wind Speed/ Cyclones

Cyclones are not seen to affect the district in recent past but the impact due to gustnadoes and high velocity winds due to localized cyclonic or convective systems have caused damage to life and property in the district. Ernakulum district was affected due to the cyclone in Nov 1978 and damage was restricted to Paravoor of Ernakulum district. No major cyclonic event causing damage is observed in Ernakulum district in past 20 years. Recent cyclone which affected Kerala state is Ockhi, but not direct damage was caused in Ernakulum district due to it.

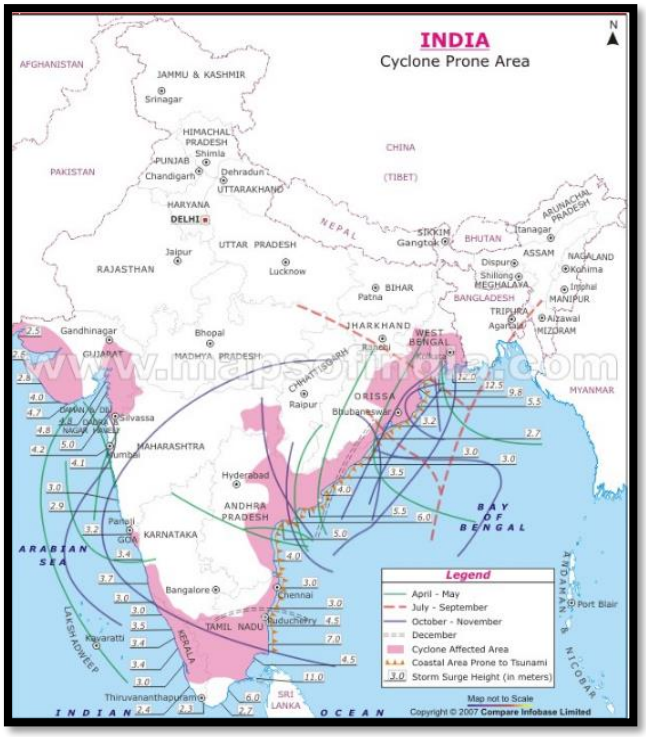


Figure 5.9 Cyclone Prone Area Map of India

5.6 Climate Change Adaption Measures

Climate-resilient infrastructure is one that is planned, designed, built, and operated in a way that anticipates, prepares for, and adapts to changing climate conditions. It must, therefore, aim to withstand, respond to, and recover rapidly from disruptions caused by climate conditions.

5.6.1 Comprehensive Mobility Plan

The growth of Kochi city being strongly fostered by tourism, trade and commerce thus reducing the impact of urban development on environment is a conscious component of the city's urban planning. In addition, Ministry of Housing and Urban Affairs recommends focus on the movement of people and goods rather than private vehicles that adversely affect the environment, thereby reducing pollution levels and providing enhanced mobility options for all. A Comprehensive Mobility Plan (CMP) has been recommended by Ministry of Housing and Urban Affairs (MoHUA) for a long-term vision of desirable mobility patterns in the city and comprehensive and integrated transportation strategies and policy measures.

The following sustainable mobility strategies have been adopted in tandem to meet the various goals set for the study area.

Land Use and Transport Strategy: The land-use transport strategy developed focuses on accessibility, connectivity, and mixed land use developments to minimize private vehicle trips, encourage transit-oriented development. I

Road Network Development Strategy: In order to provide mobility solutions for the Study Area. it is vital that there is effective integration between land use and transport in the entire region. The Road network strategy includes:

- Development of clear network pattern.
- Upgradation of existing road network capacities.
- Development of new links.
- Development of River bridges, ROBs, RUBs wherever necessary.

Public Transit Improvement Strategy: Public transport is one of the most environmentally sustainable forms of transport. The public transport improvement strategy includes service improvements for buses, trams and paratransit, appropriate Mass Rapid Transit (MRT) Options and infrastructure development plans and intermodal integration plans.

Intermediate Public Transit Improvement Strategy: IPT modes of transport, such as auto-rickshaws and shared auto-rickshaws serve the mobility the needs users which lack reliable Public Transit (PT) services, they act as feeders to the existing public transport system expanding their coverage.

Non-Motorized Transport Strategy: The strategies framed for improving non-motorized transport infrastructure include:

- Provision a complete footpath network in the city.
- Introduce cycle tracks for safe movement of cyclists in the city.
- Redesign the intersections to ensure better accessibility for pedestrians and bicycles.
- Last and First Mile connectivity
- Encourage NMT through community outreach programs.

Freight Management Strategy: Restricting the heavy goods vehicle movement in major mobility corridors during peak hours is the long-term strategy that need to be considered to avoid excess congestion caused by goods traffic during peak hours.

Traffic Engineering and Travel Demand Management Strategy: Traffic demand measures aims at achieving safe and efficient movement of people and goods on roadways. It focusses on road geometry, sidewalks, crosswalks, cycling infrastructure, traffic signs, road surface markings, traffic signals, traffic flow, area improvements etc. Traffic management includes various strategies adopted to efficiently manage the movement of vehicles like one-way systems, no parking zones, etc.

In line with the CMP, the state government of Kerala initiated the study of Phase II of the Metro project and the detailed project reports (DPR), were prepared in March 2017. The finalized alignments have been decided on the basis of high ridership potential, least land acquisition, geologic conditions, and economic considerations. The design norms and parameters of the Phase II metro have been decided and finalized based on their experience gained from the Phase I metro project and also after consultation and examination of the experiences and lessons from similar projects. The technical designs for the metro infrastructures have been made, keeping in view of technological advancements and upgrades and adaptation to needs specific to the Project Area.

5.6.2 Adaptation Measures for Climate Risk in Project Design

Temperature/Heat - The major concern for the metro/railway is the maintenance and renewal of track and its related infrastructure caused by temperature induced defects such as buckling and kinks (areas of rail weakened by exposure to excessive heat) and rolling contact fatigue defects (RCF) as a result of intensive usage. Risks to rail tracks due to extreme temperature are well known as elevated metro rail tracks will be constantly exposed to elements of nature, including extreme high temperatures resulting from direct exposure to sunlight and variable temperature. Steel rail tracks have been proposed for the Phase-II metro based on current experience of Phase I metro operations, temperature impacts have been minimal as compared to other metros in India. For the project rail tracks, the DPR has proposed the use of head- hardened (HH) 1080 steel grade (UIC60), a product of recent advances in special heat treatment of steel that achieves an increase in hardness by nearly 50% in comparison with standard steel grades.

Change in temperature during the projected period was computed as a difference between the 30-year historical period and the models simulated ensemble average of the 30-year projected period. The summer maximum temperature increases by 1.4°C under RCP 4.5 and 1.8°C under RCP 8.5 and the winter minimum temperature increases by 1.3°C under RCP 4.5 and 1.8°C under RCP 8.5.

The maximum and minimum temperature recorded in the Project Area are 36.5°C and 16.3°C respectively (Please refer Annexure F of IRC 6- 2017 attached as Appendix 5.1 for ready reference). Therefore, average temperature variation at the Project Area works out to be 10.1°C. A further allowance of approximately 10°C has been considered in the design over and above the above variation of 10.1°C. Consequently, Kochi Metro Rail

Phase II infrastructure are being designed to cater to a temperature variation of +/-20 °C (please refer Clause 6.5 of Section VII Works requirements -Subsection B - Outline Design Specifications of the contract KBC 03 attached as Appendix 5.2). The above allowance of approx. 10 °C is adequate to cater for the anticipated rise due to future climatic changes in summer maximum temperature by 1.4°C under RCP 4.5 and 1.8°C under RCP 8.5 and the winter minimum temperature increases by 1.3°C under RCP 4.5 and 1.8°C under RCP 8.5 during Service Life of Kochi Metro Rail Phase 2.

Earthquake - The metro structures comply with provisions for earthquake resilience adapted to seismic zone III according to the IRS seismic design code of India.

Wind -

The wind speed specified in IS 875 – Code of Practice for Design Loads (Part 3: Wind Load) of 39 m/s has adequate margin of safety (of 25%) to cater to future climate risks as maximum wind speed recorded so far for the Project Area (Kochi) is 31.1 m/s i.e., 112 kmph (refer Climate & Tidal information: Cochin Port Authority at *https://cochinport.gov.in/climate-tidal-info*). It is to be noted that the Project Area (Kochi) lies beyond the cyclone belt.

Urban Flooding –

A thorough analysis of flood data for the state of Kerala has been done by Kerala State Disaster Management Authority (KSDMA), Government of Kerala, for producing flood return probability assessments considering the historical rainfall records and future climate change scenarios. This analysis serves as a baseline for understanding the context of floods in the Project Area. An assessment of the KSDMA data indicates that there is no high flood risk along the Phase II metro alignment. The indicative location of Kochi Metro Phase II alignment on the flood hazard map prepared by KSDCMA is shown in Figure 5.10.

Further, the proposed project is elevated, therefore, the structures including the main stations and viaduct are above HFL and any impact on above elements due to flooding from climate changes are ruled out. The plinth levels of the entry/exit buildings of stations have been planned considering the existing road level to ensure seamless passenger movement. These have been planned with a minimum of 600 mm margin from existing road level (refer Appendix 5.3). The road levels at 9 stations out of 11 station locations are above high flood level. The two station locations namely, KINFRA PARK and Info Park comes below high flood level. In case of an extreme flood event, the chances of flooding and its impact are limited to the DG room and pump room which are located at the ground level of the entry/exit building. DG sets are only used as backup power supply for lighting, lift and fire pump. Hence, the non-functionality of DG shall in no way affect the train operation. The location of equipment related to traction, power supply and signalling are ensured at the concourse level and the power supply and signal cables are routed through the viaduct to ensure the seamless operation of the metro in the event of floods. Even though there are lifts and escalators having travel from street to concourse, the control panels which may be affected by water ingress are proactively installed at the concourse level to mitigate the adverse effect due to flood.

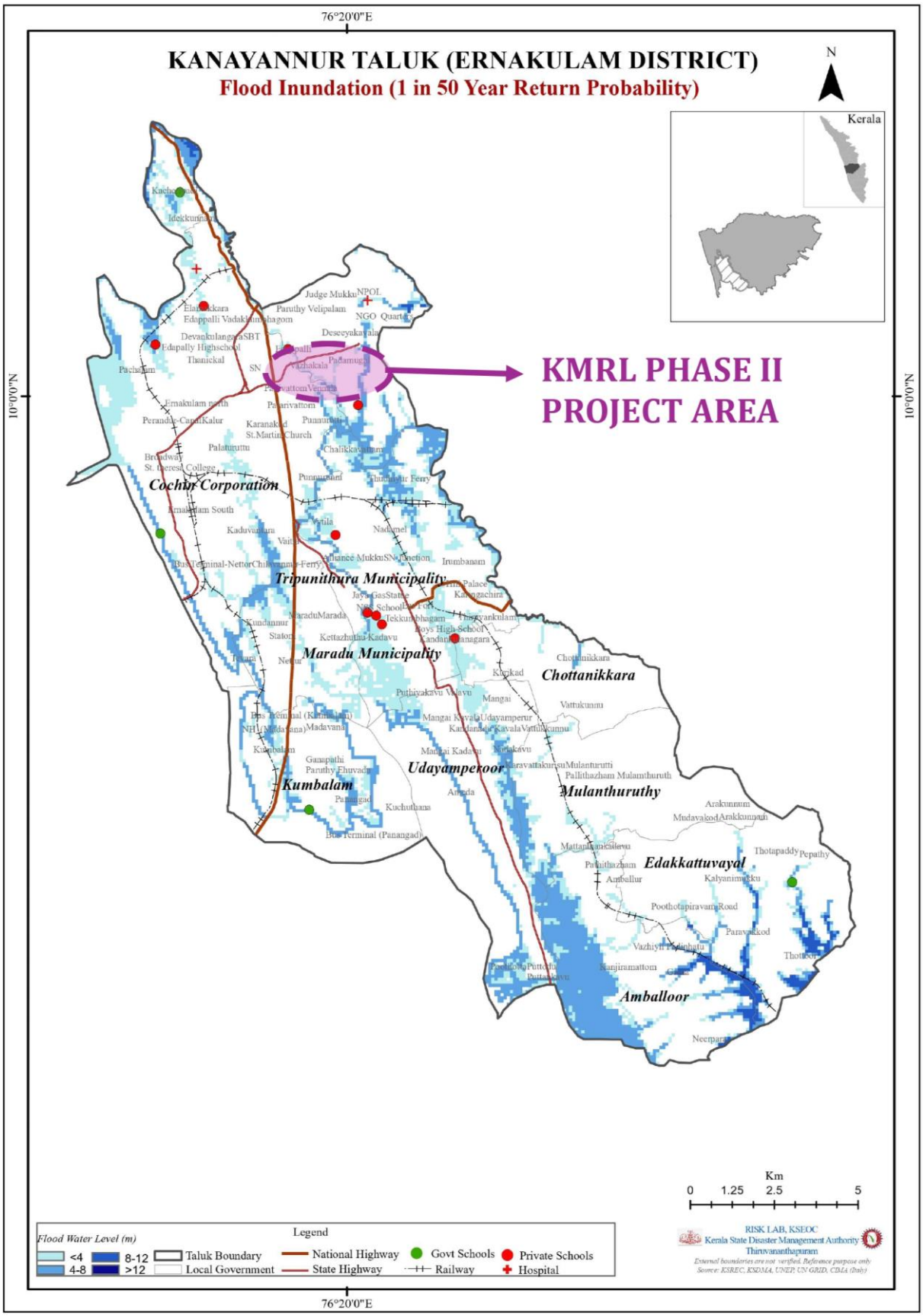


Figure 5.10 Hazard Map for flood Inundation of Project Area

The footpaths are vulnerable to recurrent urban floods and the design of walkways has been taken into account anticipated localized high urban flood levels.

A total of twelve stations including JLN station are proposed along the 11.2Km long corridor with an average inter-station spacing of 974m. The station locations were strategically selected to be near main road intersections and Inter-modal interchange points such as Railway stations/ bus terminals to improve passenger interchange and accessibility, for ensuring higher passenger convenience and ridership on the proposed Metro corridor.

With the vision of providing seamless transportation to the residents and visitors of the city of Kochi, Kochi Metro Rail Limited, has prepared a Non-Motorized Transportation Master Plan. The NMT Master Plan identifies a network for walking and cycling facilities along the phase – I metro corridor, with area improvement proposals to encourage active use of public spaces, walking, cycling and use of public transport systems. Following the similar vision for seamless transportation it is proposed that a NMT plan for the phase – II metro corridor be developed to help increase accessibility to the metro stations and thereby the overall mobility and user experience. The details for the NMT proposal have been included in the DPR report for Kochi Metro Phase -II.

The last and first mile connectivity will be ensured by developing the following arrangements,

a) Battery powered electric auto on both hire and shared mobility option.

b) Feeder electric buses to ferry passengers to the MRTS corridor.

c) Micro mobility option like low powered electric scooters on shared basis.

d) NMT options like bicycles.

Table 5.4 Summary of Adaptation Analysis

S.no	Key Climate Risks	Adaptation Measures adopted during Design
Rise in Temperature		
1	Increased heat stresses and thermal expansion leading to increased incidences of buckling or twisting of tracks, sun kinks, and derailments	The average temperature variation at the Project Area works out to be 10.1°C. A further allowance of approximately 10°C has been considered in the design over and above the above variation of 10.1°C. Consequently, Kochi Metro Rail Phase II infrastructure are being designed to cater to a temperature variation of +/-20 °C. The above allowance of approx. 10 °C is adequate to cater for the anticipated rise due to future climatic changes in summer maximum temperature by 1.4°C under RCP 4.5 and 1.8°C under RCP 8.5 and the winter minimum temperature increases by 1.3°C under RCP 4.5 and 1.8°C under RCP 8.5 during Service Life of Kochi Metro Rail Phase 2. Use of head- hardened (HH) 1080 steel grade (UIC60); The head-hardened rails will result in (i) better mechanical properties in terms of stiffness, higher lateral resistance, and better transmission of thermal stresses, and higher durability; and (ii) reduced maintenance resulting from practically unchanged track geometry over time and at almost any operating speed.
2	Discomfort to metro users and high energy consumption	Improving adaptability to seasonal thermal variations in the stations through the use of large open spaces for unrestricted air movement, cross-ventilation and ensuring that enclosed areas are well ventilated. Raised roofing will be provided in the platform of all metro station for stack ventilation. Minimum 3ft sunshades/projections will be

		provided for all windows and doors.
Floods and raise in precipitation		
3	The exposed impermeable elevated structures will transform rainfall to runoff in much shorter duration that will add to water logging of the already flooded roads below.	To alleviate this distress to some extent, means of water harvesting from elevated structures have been proposed in the design of Phase II viaducts. The cross-slope or camber provided in the viaduct superstructure design permits runoffs to be channelled through drain piping to roadside drains.
4	Flooding and inundation of rail tracks, stations, and stabling depot during high rainfall season	Elevated viaducts, stations, and stabling depot; Complete 11.2 km of elevated line will mitigate the risk of at-grade/underground rail tracks, stations, and stabling depot being inundated and damaged by urban flooding. The elevated line will also help transport and evacuate people during occurrences of floods at grade level.
5	Urban flooding	The proposed project is elevated, therefore, the structures including the main stations and viaduct are above HFL and any impact on above elements due to flooding from climate changes are ruled out. The plinth levels of the entry/exit buildings of stations have been planned considering the existing road level to ensure seamless passenger movement. These have been planned with a minimum of 600 mm margin from existing road level. The road levels at 9 stations out of 11 station locations are above high flood level. The two station locations namely, KINFRA PARK and Info Park comes below high flood level. In case of an extreme flood event, the chances of flooding and its impact are limited to the DG room and pump room which are located at the ground level of the entry/exit building. DG sets are only used as backup power supply for lighting, lift and fire pump. Hence, the non-functionality of DG shall in no way affect the train operation. The location of equipment related

		to traction, power supply and signalling are ensured at the concourse level and the power supply and signal cables are routed through the viaduct to ensure the seamless operation of the metro in the event of floods. Even though there are lifts and escalators having travel from street to concourse, the control panels which may be affected by water ingress are proactively installed at the concourse level to mitigate the adverse effect due to flood. Improved pedestrian access to metro stations; for seamless transportation it is proposed that a NMT plan for the phase – II metro corridor be developed to help increase accessibility to the metro stations and thereby the overall mobility and user experience. The details for the NMT proposal have been included in the DPR report for Kochi Metro Phase -II. Walkways designed with adequate room for many users at a time and safe from anticipated localized high urban flood levels and other obstacles. In summarized way - The last and first mile connectivity will be ensured by developing the following arrangements, a) Battery powered electric auto on both hire and shared mobility option. b) Feeder electric buses to ferry passengers to the MRTS corridor. c) Micro mobility option like low powered electric scooters on shared basis. d) NMT options like bicycles.
6	Stranding of passengers and metro staff in the station or train and accidents during emergency situations triggered by climate change such as floods and cyclones	Standby diesel generator sets in case of emergencies, including flooding in metro stations and tunnels.
7	Increased precipitation resulting in flooding; exacerbated urban flooding due to increased impermeable surface	Through better station roof design, providing rainwater harvesting by channelling rainwater

		through gutters and pipes to harvesting tanks.
Wind Speed Increase		
8	High velocity winds due to localized cyclonic or convective systems may cause damage to life and property	The wind speed specified in IS 875 – Code of Practice for Design Loads (Part 3: Wind Load) of 39 m/s has adequate margin of safety (of 25%) to cater to future climate risks as maximum wind speed recorded so far for the Project Area (Kochi) is 31.1 m/s i.e., 112 kmph (refer Climate & Tidal information: Cochin Port Authority at *https://cochinport.gov.in/climate-tidal-info*). It is to be noted that the Project Area (Kochi) lies beyond the cyclone belt.

5.7 Emissions Mitigation

Kochi metro project development will contribute to improving the microclimate of area by reducing the total CO2 emissions due to transportation in long term. It is anticipated that the vehicle on road will be reduced due to development of the metro rail which will reduce the fuel consumption thereby reducing the emissions due to vehicular fuel burning.

Considering the appraisal Guidelines for Metro Rail Project Proposals (Ministry of Housing & Urban Affairs Government of India) a detailed estimate for Co2 emission reduction has been carried-out as reduction in daily vehicle kilometre due to shifting from current modes of transport to metro.

According to the Central Pollution Control Board (CPCB), the emission factors vary with vehicle type and age of vehicle. Table 5.5 provides the emission factors for pollutants commonly emitted by vehicles, along with the treatment cost per ton of the respective pollutants.

Table 5.5 Volume of pollutants emitted (gram per km) for different modes.

Vehicle Type/ Pollutant	CO	HC	NOX	PM	CO2
2-wheeler	1.4	0.7	0.3	0.05	28.58
3-wheeler	2.45	0.75	0.12	0.08	77.89
Cars (incl. cabs)	1.39	0.15	0.12	0.02	139.52
Bus (incl. BRT)	3.72	0.16	6.53	0.24	787.72
Treatment Cost (Rs. /ton)	1,00,000	1,00,000	1,00,000	1,00,000	500

The simulations emission savings through modal shift yield has been assessed and it has been estimated that net average GHG reduction of 45,806.9 tCO2/year in 2021 and 114,915.7 tCO2/year in 2031 will be achieved by the operation of Phase II metro.

Table below presents the summary of the annual estimates of GHG emissions reduction.

Table 5.6 Summary of annual estimates of GHG emission reduction

S.no	Vehicle Type	Reduction in Daily Vehicle kilometers due to Metro in 2021	Reduction in Daily Vehicle kilometers due to Metro in 2031*	EF CO2 (g/km)	Daily Emission (gram CO2) Reduction 2021	Daily Emission (gram CO2) Reduction 2031
1	2-wheeler	101,560	164,688	28.58	2,902,584.8	4,706,783.0
2	3-wheeler	40,678	45,110	77.89	3,168,409.4	3,513,617.9
3	Cars (incl. cabs)	27,882	75,720	139.5	3,889,539.0	10,562,940.0
4	Bus (incl. BRT)	487,132	756,580	787.7	383,713,876.4	595,958,066.0
5	Total				393,674,409.6	614,741,406.9
6	**Total (tons/year)**				**143,691.2**	**224,380.6**
7	Total emission due to electricity consumption (15000 KWh) at station locations considering 0.661 tCO2/MWh emission factor			0.661 tCO2/MWh	86,855.4	

7(a)	11% of the total energy (1650 KWh) required will be replaced by the solar energy at station locations. Emission due to electricity generated from the solar panels considering 41gCo2/KWh emission factor	41gCo2/KWh	592.6	
7(b)	Emission due to electricity generated from grid will be 89% of the total energy (13350KWh) required, Considering 0.661 tCO2/MWh emission factor	0.661 tCO2/MWh	77,301.3	
8	**Reduction in GHG due to solar panels (tons/year)**		**8,961.5**	
9	**Emission From Train Operation considering the emission factor 0.661 tCO2/MWh and 5 MVA power demand in 2021 and 7MVA in 2031(tons/year)**		**28,951.8**	**40,532.5**
10	**Total Emission from Train Operation including for stations considering the emission factor 0.661 tCO2/MWh and 5 MVA power demand in 2021 and 7MVA in 2031(tons/year) (9+7a+7b)**		**106,845.7**	**118,426.4**
11	**Net Emission Reduction (tons/year) {(6+8)-10}**		**45,806.9**	**114,915.7**

**Source: Revised Feasibility Study & DPR Kochi Metro Phase II*

Table below summaries the reduction in other pollutants emission

Table 5.7 Summary of reduction in pollutant emission

Vehicle Type	CO (2021)	CO (2031)	HC (2021)	HC (2031)	NOX (2021)	NOX (2031)	PM (2021)	PM (2031)
2-wheeler	142184	230563.2	71092	115281.6	30468	49406.4	5078	8234.4
3-wheeler	99661.1	110519.5	30508.5	33832.5	4881.36	5413.2	3254.24	3608.8
Cars (incl. cabs)	38755.98	105250.8	4182.3	11358	3345.84	9086.4	557.64	1514.4
Bus (incl. BRT)	1812131	2814478	77941.12	121052.8	3180972	4940467	116911.7	181579.2
Total	**2092732**	**3260811**	**183723.9**	**281524.9**	**3219667**	**5004373**	**125801.6**	**194936.8**
Total (tons/year)	**763.85**	**1190.20**	**67.06**	**102.76**	**1175.18**	**1826.60**	**45.92**	**71.15**

6 ANTICIPATED IMPACTS AND MITIGATION MEASURES

Review of EIA & Identified gaps : A comprehensive examination of the EIA has been conducted to identify areas requiring a more detailed analysis for the impact assessment study during the Due Diligence stage. While the impact analysis covered all project stages, including design, construction, and operation, and addressed the three broad environmental aspects—physical, biological, and socio-economic—, the EIA does not include the comprehensive assessment of the risks associated with Noise & Vibration during both the metro construction and operation phases.

Due Diligence covers: The due diligence encompasses a summary of expected physical, biological, and socio-economic impacts across the design, construction, and operation stages, aligning with the coverage in the EIA stage. The EDDR stage specifically conducted a detailed study for Noise and Vibration Impact assessment.

Adverse and positive impacts that are likely to result from the project have been listed in Table 6.1 under the following headings:

- Impacts and Mitigation Measures due to Project Location and Design. (D)
- Impacts and Mitigation Measures due to Construction. (C)
- Impacts and Mitigation Measures due to Project Operation. (O)

Table 6.1: Impacts Assessment Matrix

VEC/Sensitivity	Impact/Activity	Stage	Duration	Area	Severity	Significance before mitigation measures	Significance of Residual Impacts if any
1. Physical environment							
1.1 Air quality and GHG emissions (High sensitivity)	More efficient and environmentally friendly movement of people	D	Permanent	Local	High	Major +ve	High +ve
	Sourcing of construction material; Emissions from machinery and vehicles; site operations; operations in construction yard; dumping at excavate and waste disposal sites	C	Temporary	Local	Medium	Major	None
	Modal shift towards public transport	O	Permanent	Local	High	Major	High +ve
1.2 Surface water quality (High sensitivity)	Degradation of water quality due to sewage discharge	D	Permanent	Limited	Low	Moderate	Minimal -ve
	Run-off and wastewater from construction sites, construction yards, waste disposal sites, labour camps	C	Temporary	Local	Low	Moderate	Minimal -ve
	Sanitation at stations	O	Permanent	Local	Low	Moderate	Minimal -ve
1.3 Surface water quantity (High sensitivity)	Use for stations	D	Permanent	Local	Low	Moderate	Moderate -ve
	Use of water for construction purposes	C	Temporary	Local	Medium	Moderate	None
	Increased water demand from public water supply	O	Permanent	Local	Medium	Moderate	Minimal –ve
1.4 Ground water quality (Medium sensitivity)	Degradation of groundwater quality	D	Permanent	Limited	Low	Minor	None
	Run-off and wastewater from construction sites, construction yards, waste disposal sites, labour camps	C	Temporary	Local	Low	Minor	Minimal -ve

VEC/Sensitivity	Impact/Activity	Stage	Duration	Area	Severity	Significance before mitigation measures	Significance of Residual Impacts if any
	Degradation of water quality due to sewage discharge	O	Permanent	Limited	Low	Minor	Minimal -ve
1.5 Ground water quantity (High sensitivity)	Groundwater recharge due to rainwater harvesting	D	Permanent	local	High	Major +ve	High +ve
	Use of water for stations (groundwater extraction will be avoided)	D	Permanent	Limited	Medium	Neutral	None
	Dewatering activities	C	Temporary	Limited	Low	Moderate	None
	Water supply at stations (groundwater extraction will be avoided)	O	Temporary	Local	Low	Neutral	None
1.6 Land degradation/ pollution (Low sensitivity)	Location of construction yards and C&D waste (muck) disposal sites	D	Permanent	Limited	Medium	Minor	Moderate -ve
	Soil erosion due to site clearing andlevelling. pollution due to operations at construction yards, C&D and hazardous waste disposal sites; drainage changes of excavate and C&D waste disposal sites	C	Temporary	Limited	Low	Minor	Minimal –ve Moderate -ve
	None as long as proper waste management procedures are followed	O				Neutral	None
2. Biological environment							
2.1 Trees, terrestrial and aquatic vegetation	Removal of trees	D	Permanent	Local	High	Moderate	Minimal -ve
	Damage to maintained trees and bushes	C	Temporary	Limited	Low	Minor	Minimal -ve

VEC/Sensitivity	Impact/Activity	Stage	Duration	Area	Severity	Significance before mitigation measures	Significance of Residual Impacts if any
(Medium sensitivity)	Siltation of water bodies						
	Growth of compensating trees	O	Permanent	Local	Low	Major +ve	Minimal -ve
2.2 Terrestrial fauna (mammals, birds, insects) (Low sensitivity)	Impact of height of viaduct and lighting on birds	D	Permanent	Local	Low	Moderate	Moderate –ve
	Impact of height of viaduct, noise and vibration, lighting on birds	C	Temporary	Local	Low	Moderate	None
		O	Permanent	Limited	Low	Moderate	Moderate –ve
2.3 Ecologically important areas (Medium sensitivity)	None	D				Neutral	None
	Extraction of sand from riverbeds. Banned.	C	Permanent	Local	Low	Neutral	None
	None	O				Neutral	None
3. Social environment							
3.1 Private land and buildings (Medium sensitivity)	Transfer of private land	D	Permanent	Local	Medium	Major	High -ve
	Aesthetic impact. Limited reduction with proposed sleek structures	D	Permanent	Local	Medium	Major	High –ve
	Temporary use of land for construction, labor camps and traffic detours	C	Temporary	Limited	Medium	Moderate	None
	Aesthetic impact.	O	Permanent	Local	High	Major	High –ve
3.2 Public property/infrastructure/ utility structures (High sensitivity)	Diversions of utility services including water pipelines and high-tension lines	D	Permanent	Local	Medium	Major	None
	Traffic diversions	C	Temporary	Local	High	Major	None
	None	O				Neutral	None
3.3 Noise (High sensitivity)	Metro noise adds to baseline noise which is already high. However, significant reduction with proposed design features.	D	Permanent	Limited	High	Major	Moderate -ve

VEC/Sensitivity	Impact/Activity	Stage	Duration	Area	Severity	Significance before mitigation measures	Significance of Residual Impacts if any
	Noise due to operation of construction equipment and vehicular movement	C	Temporary	Local	Medium	Major	None
	Noise due to metro operations	O	Permanent	Local	Medium	Major	Moderate -ve
3.4 Vibration (High sensitivity)	Metro vibration adds to baseline level which is already high. Limited reduction with proposed design features.	D	Permanent	Limited	Medium	Major	High –ve
	Vibration due to operation of construction equipment	C	Temporary	Local	Medium	Major	None except in cases of building damage
	Vibration due to metro operations	O	Permanent	Local	Medium	Major	High –ve
3.5 Occupational health and safety (Medium sensitivity)	Design of Health and Safety features in stations and trains for construction workers and operating staff	D	Permanent	Limited	Medium	Moderate	Construction, operation accidents, EMR: minimal –ve COVID-19 Moderate –ve
	Impacts due to labor camp, working on heights and with heavy machinery; Transmission risk of COVID-19	C	Temporary	Limited	Medium	Moderate	Works: None except in case of disabling injuries. COVID-19: Moderate –ve
	Electromagnetic interference (EMI) Exposure to electromagnetic radiation Accidents COVID-19 Musculo-skeletal disorders and stress	O	Permanent	Limited	Medium	Moderate	Minimal -ve Minimal –ve Minimal -ve Moderate -ve Moderate -ve

VEC/Sensitivity	Impact/Activity	Stage	Duration	Area	Severity	Significance before mitigation measures	Significance of Residual Impacts if any
3.6 Public health and safety (Medium sensitivity)	Safety risks due to flooding and earthquakes Transmission risk of COVID-19	D	Permanent	Limited	High	Major	Flooding High -ve Earthquake moderate -ve COVID-19 Moderate -ve
	Exposure to traffic, noise, dust and vibrations; Transmission risk of COVID-19	C	Temporary	Limited	Medium	Moderate	None Moderate -ve
	Electromagnetic interference (EMI) Exposure to electromagnetic radiation Incidents which disrupt services. Transmission risk of COVID-19	O	Permanent	Local	Medium	Moderate	Minimal -ve Moderate -ve Minimal -ve Moderate -ve
3.7 Physical cultural resources (PCR) (Medium sensitivity)	Possible impact on religious or cultural buildings / structures within 200 meters ofthe alignment	D	Permanent	Limited	Medium	Minor	Minimal
	Chance finds	C	Short-lived	Limited	Low	Minor	Minimal
	None	O				Neutral	None
3.8 Energy (Medium Sensitivity)	Energy Demand for lighting and equipment	D	Permanent	Limited	Medium	Moderate	Minimal –ve
		C	Short-lived	Limited	Medium	Moderate	None
		O	Permanent	Limited	Medium	Moderate	Minimal -ve
3.8 Utilisation of metro (Medium Sensitivity)	The well-designed alignment offers riding comfort, average speed and system capacity and thus the economical operation of the metro. The rational space planning of stations offers safety of	D	Permanent	Limited	High	Major +ve	High +ve

VEC/Sensitivity	Impact/Activity	Stage	Duration	Area	Severity	Significance before mitigation measures	Significance of Residual Impacts if any
	passengers, optimises time spent in ingress & egress from station and energy consumption. Modal integration will improve ridership.						

6.1 Impacts and Mitigation Measures due to Project Location and Design

Impacts and mitigation measures study in detail is a crucial step in ensuring the comprehensive assessment and management of environmental considerations. Major project specifics Environmental & Social Impacts has been summarised below:

- **Social impact.** Land required for the Phase II will be acquired in 4 stages (i) JLN Stadium to Palarivattom (ii) Palarivattom to Kakkanad (iii) Media Academy (Kakkanad) to Infopark (iv) Station Entry Exit Structures. The total area required is 5.1495. As per DPR, approx. 56 structures occupied by 45-50 families would be affected between JLN Station and Infopark. 21 commercial structures and 17 residential cum commercial structures will be affected due to the project development.
  During the EDD study, it was found out that land acquisition for preparatory works from Palarivattom to Kakkanad has already been acquired and the land acquisition from Kakkanad to Info Park Expressway Entrance and from JLN stadium to Palarivattom is under process. The land acquisition of 1.6510 ha for construction of station entry exit structures is also under process. Table 6.2 shows the status of land acquisition.

Table 6.2 Status of land acquisition during EDDR

Sl. No.	Stretches/Parcel	Taluk, Village	Area of Land (ha)	Purpose of land Acquisition	Status during EDDR
1	Palarivattam- Kakkanad	Edappilly south, Vazhakkala, Kakkanad– Villages	2.8770	RoW Palarivattam – Kakkanad PWD Road	Acquired
2	Kakkanad to Info Park Expressway Entrance	Kakkanad Village, Kanayannur Taluk	0.0380	RoW (Seaport – Airport Road)	Ongoing
3	JLN Stadium - Palarivattam	Kanayannur Taluk, Poonithura Village	0.5835	RoW JLN-Palarivattam	Ongoing
4	Construction of Entry Exit buildings	Edappilly south, Vazhakkala, Kakkanad – Villages	1.6510	Construction of Entry Exit buildings	Ongoing
		Total Area			5.1495 ha
		Total area acquired			2.8770 ha

Land acquisition shall be undertaken as per the LARA Act, 2013, Land Acquisition Policy of KMRL and as per the AIIB's Environmental & Social Safeguard -2

- **Loss of trees and impact on ecosystem**. As per the Social Forestry proceedings, there are a total of 669 trees (402 within the Right of Way (ROW) and 267 at proposed entry/exit locations). Currently, 614 trees have been felled, and an additional 55 trees are planned to be cut at station entry/exit locations. The removal of these trees is expected to result in a reduction of 60,168 kg of CO2 absorption (calculated at 21.8 kg per tree per year for 8 years) and a decrease in oxygen production by 1,35,240 kg (estimated at 49 kg per tree per year for 8 years). To compensate for this impact, a compensatory afforestation shall be undertaken, with a commitment to planting 10 saplings for each felled tree. The plantation plan entails planting 6,140 trees, requiring approximately 12.28 hectares of land (calculated at 500 trees per hectare). The selection of this land will be finalized by KMRL during the construction stage, in consultation with local authorities.

  The permission obtained for tree cutting is given in Appendix 6.1.

- **Utility Shifting.** Utilities to be affected include electricity line, Fuel supply pipeline, BPCL oil pipeline, IOAGPL pipeline, telecom cables, drainage lines and water supply lines. Disturbance to any of this facility may affect the community significantly.

  In collaboration with pertinent authorities such as KWA (Kochi Water Authority), BPCL, IOAGPL, KSEB (Kerala State Electricity Board), and BSNL, a comprehensive utility shifting plan has been devised to relocate each utility, taking into account the metro route's alignment. The finalized alignment ensures the avoidance of major utility areas. Furthermore, as part of the preparatory work for the metro construction, all electricity lines, water pipelines, and telecom lines will be shifted. Currently, utility shifting work is underway at the site. To keep affected stakeholders, including residents, businesses, and relevant authorities, well-informed, communication about the upcoming utility shifting activities is being actively conducted.

- **Impacts Due to Natural Hazards.** The project involves construction of elevated track and stations, buildings, substations etc. Project area lie in moderate seismic risk zone (Zone III) as per BIS classification and prone to moderate intensity earthquakes. Project lies in the High temperature zone and flood prone zone, but all the proposed facilities are elevated and thus will not be directly affected due to flood. Steel track and coach has been selected to minimise the high temperature impact.

  The design includes adequate provisions as per NBC, 2005 for design of structures. The plinth of the entry/exit of station building planned above the HFL to prevent entry of water in the station building. Provision of Bureau of Indian Standards codes like IS: 875:2015 (Part 3), IS: 1893:1984, IS :1893(Part 1):2002, IS: 1893(Part 4):2005, IS: 4326:1993 etc. shall be incorporated suitably while designing the structures. A separate climate risk assessment study has been conducted to identify of potential risks and vulnerabilities associated and to assess the mitigation and adaptation strategies to minimize adverse effects on the climate and enhance the project's resilience to climate change.

- **Water Quality and Drainage.** The stations will have an impact on the amount of sewage to be treated throughout the operational phase and, in case of insufficient treatment, indirectly have an impact on the water quality. Temporary leakages of the sewerage at the stations cannot be ruled out completely. Proposed alignment crosses Edappallytodu, stream from Chitraphuza river, Kadambrayar river, drains and nallas. No metro pier shall be constructed in these water bodies. However, A road bridge may also require to be constructed at chainage 2650-2700 on nalla “Edapallytodu”. Construction of road bridge may have impact on flow of this water body. Also, due to construction of metro system, run-off generation may increase slightly, and this increased run-off will find its way in the nearest water body. The increased run-off also may have impact on the drainage of area.

- **Air quality**. Through modal shift from fossil-fuel driven transport to electric public transport the metro will have a long-lasting high positive residual impact on the air quality. The magnitude of the beneficial impact of metro will increase with increasing ridership. During the construction phase of a metro project, short-term impacts on air quality are common due to various activities. some specific short-term impacts on air quality shall be Dust Emissions due to Excavation, earthmoving, and construction activities, Emissions from Construction Machinery, Increased construction-related traffic etc.

  The transport vehicles and other equipment shall conform to emission standards. Dust screens during excavation and demolition near sensitive receptors will be installed. Dust filters on top of silos will be installed. The trucks carrying loads of sand and aggregate required in construction being transported to construction yards shall be covered and loaded with sufficient free - board to avoid spills--within the largest compartment of tanker truck. Transportation will be scheduled by time and route to minimize air pollution in habitat areas. Low Sulphur diesel only should be used as fuel in DG sets. DG sets should be provided with the stack height of minimum 6 feet. DG sets should be used only in case of power failure. Water sprinkling should be carried out at casting & storage yards, construction site, loading & unloading

area, approach road, haulage road, raw material storage area and muck disposal sites. Flow rate of water sprinklers should be maintained to minimize the run-off and for effective results.

- **Use of energy, water, and materials**. The project will use large amounts of construction material and thus will deplete construction material sources to a certain extent. Materials shall be sourced from the nearest source and from legalized and approved quarries. Requirement of electricity will be optimized by proper use of natural light. Green Building features will be implemented in station design.

  Energy charges of any metro system constitute a substantial portion of operation & maintenance (O & M) costs. Therefore, it becomes imperative to incorporate energy saving measures in the system design itself. The auxiliary power consumption of metros is generally more than the traction energy consumed by train movement. The proposed system includes the following energy saving features:

  i. Modern rolling stock with 3-phase VVVF drive and light-weight stainless steel or aluminium coaches, which has the benefits of low specific energy consumption and almost unity power factor.

  ii. Rolling stock has regeneration features and it is expected that 30% of total traction energy will be regenerated and fed back to 750V dc third rail to be consumed by nearby trains.

  iii. Effective utilization of natural light is proposed. In addition, the lighting system of the stations will be provided with different circuits (33%, 66% & 100%) and the relevant circuits can be switched on based on the requirements (day or night, operation or maintenance hours etc.).

  iv. Switching from monolithic to modular UPS for station lighting and signalling load will result in an increased efficiency of 3 %to 5%.

  v. In case of HVAC systems, R410A refrigerant is used in the project which has a higher heat transfer efficiency, improved system performance, and greater cooling capacity. Additionally, it has a much lower global warming potential than other refrigerants, making it more environmentally friendly.

  vi. Machine-room-less type lifts with gearless drive have been proposed with 3-phase VVVF drive. These lifts are highly energy efficient.

  vii. The proposed heavy-duty public service escalators will be provided with 3-phase VVVF drive which gives energy efficiency & improved power factor. Further, the escalators will be provided with infra-red sensors to automatically reduce the speed (to idling speed) when not being used by passengers.

  viii. The latest state of art and energy efficient electrical equipment (e.g. transformers, motors, light fittings etc.) have been incorporated in the system design.

  ix. Efficient energy management is possible with proposed modern SCADA system by way of maximum demand (MD) and power factor control. VIII. Solar power plant may be installed at each station to produce electricity which may meet the energy requirement of the station. KMRL has already a Power Purchase Agreement with a private company for installing the Solar Power Plants at each of the stations.

  x. Solar power plant may be installed at each station to produce electricity which may meet the energy requirement of the station. KMRL has already a Power Purchase Agreement with a private company for installing the Solar Power Plants at each of the stations.

- **Water quantity:** Water demand at stations will impact the availability of this commodity which cannot be completely mitigated through rainwater harvesting. Addressing water demand at stations and ensuring a sustainable water supply involves a combination of measures to be adopted. water-efficient technologies and fixtures in station buildings and facilities shall be implemented. It is recommended to

purchase STP treated water from municipality. There is 4.5 MLD CSTP existing at Elamkulum which is approx. 5 km from proposed alignment and 14 km from casting yards. Treated water from CSTP can be considered for construction purpose of metro after providing suitable treatment as feasible. Low flow taps shall be provided in toilets and kitchen and all water storage tanks should be covered to minimize loss due to evaporation. Source of water (Portable Ground water from Government Authorised Sources)

- **Water Quality**: Activities such as excavation, soil disturbance, material handling, and runoff from construction sites shall be the major source of impact on nearby waterbodies. Machinery and vehicle should be serviced and maintained regularly to prevent fuel leakages. Leakages from tanks should be regularly inspected. Fuel storage should be minimized at the site. Fuel if stored should be stored in isolated locations in HDPE container on paved surface provided with the drains & oil interceptors.

  Water quality will be affected during operation phase only if the waste/sewage generated is improperly stored and disposed. Sewage or untreated or semi treated effluent and waste should not be stored in unlined pond or area else it may lead to pollution of ground water. Any spillage should be cleaned immediately so as it does not get mixed with the run-off and pollute the surface water quality. Chances of accidents are less in metro as compared to road transportation system thus chances of spillage and leakage of oil also reduces thereby reducing chances of surface water pollution.

- **Waste Management**: The major waste generated during construction stage shall be the Construction Debris, waste generated from the labour camps, reuse/recycle of the construction waste, biodegradable toiletries., and efficient sewage treatment systems shall be the mitigation measures. Hazardous waste would mainly arise from the maintenance of equipment which may include used engine oils, hydraulic fluids, waste fuel, spent mineral oil/cleaning fluids from mechanical machinery, scrap batteries or spent acid/alkali, spent solvents etc. The contractor shall ensure that hazardous wastes from construction activity and equipment are labeled, recorded, stored in impermeable containment and for periods not exceeding mandated periods and, in a manner, suitable for handling storage and transport. The contractor shall maintain a record of sale, transfer, storage of such waste and make these records available for inspection. The contractor shall get Authorized Recyclers to transport and dispose Hazardous Waste, under intimation to the Project Authority.

- **Workplace health and safety:** Occupational Health & Safety is a multidisciplinary field focused on ensuring the well-being, health, and safety of workers in the workplace. Assessment, and mitigation of workplace hazards and the safe and healthy working environment for the workers is the key aspect/regulatory requirement of project implementation. - KMRL has framed the SHE policy and it is essential for all contractors to follow the SHE Policy of the KMRL. The SHE policy is made in line with the requirement of BOCWA and BOCWR. SHE policy addresses safety of the construction workers as well as the safety of the nearby community. Other mitigation measures related to works for the system packages, such as risk mitigation for working at heights or on electrical installations, are covered in KMRL's Requirements for Safety, Health, and Environment. These requirements will be issued to the Contractor as part of the contract documentation.

6.2 Impact on Noise Quality

6.2.1 Noise due to Operation of Construction Equipment's

Source of noise during the construction phase of project are operation of construction machinery such as vegetation removal machinery, hot mix plants, bulldozer, dumpers, back hoes, loaders, JCBs, concrete mixers etc. Expected noise generation from various construction activities in given the table below –

Table 6.3 Noise generation from construction equipment's in dB(A)

Clearing		*Structure Construction*		*Grading and compacting*	
Bulldozer	80	Crane	75-77	Grader	80-93

Front end loader	72 - 84	Welding generator	71-82	Roller	73-75
Dump truck	83-94	Concrete mixer	74-88	***Paving***	
Jack hammer	81-98	Concrete pump	81-84	Paver	86-88
Crane with ball	75-87	Concrete vibrator	76	Truck	83-94
Excavation & Earth Moving		Air compressor	74-87	Tamper	74-77
Bulldozer	80	Pneumatic tools	81-98	***Landscaping and Cleanup***	
Backhoe	72-93	Bulldozer	80	Bulldozer	80
Front end loader	72-84	Cement & dump trucks	83-94	Backhoe	72-93
Dump truck	83-94	Front end loader	72-84	Truck	83-94
Jack Hammer	81-98	Dump truck	86-88	Front end Loader	72-84

Source: FTA Transit Noise and Vibration Guidance Handbook, May 2006 & Construction Noise Handbook, US FHWA, Aug 2006

Other than above equipment, piling is the major activity which generates high noise level ranging from 85-90 dB(A). It is evident that operation of the construction equipment will generate high noise levels which may affect the health of construction labour and nearby residents if the adequate mitigation measures are not taken. As per occupation standards, workers" exposure to 90 dB(A) noise level (at 10 m from source) should not be more than 8 hours. OSHA guidelines should be followed for exposure to specific noise levels for workers and are listed in Table 6.4**.** Thus, the high noise levels are required to be managed by proper noise level reduction measures and preventive measures to minimize the impact on health due to exposure to high noise level. Conducting regular hearing tests for workers may help in monitoring the impact of the higher noise level on workers' health.

Table 6.4 OSHA Noise Exposure Limits for work Environment

Noise Levels in dB(A)	Permissible Exposure (hours & minutes)
85	16 hrs
90	8 hrs
96	3 hrs 30 minutes
102	1 hr 30 minutes
108	40 min
115	15 min
121	6 min
127	3 min
130	1 min

However, the noise associated with the construction activity will be restricted to construction period only and thus the impact is considered to be short term & temporary. Construction machinery & equipment will not be operated throughout the day thus noise generation from this equipment is considered to be of intermittent type. Further, by undertaking the mitigation measures, impact due to noise pollution can be managed.

Noise attenuates with the distance; thus, the impact of high noise level reduces with the increase in distance from activity area. Thus, it is required to maintain safe distance between the noise source and sensitive receptors (residential areas, man-made sensitive receptors and eco- sensitive areas). Considering the noise level to be generated during construction phase as 90 dB(A) at 10 m from source, safe distance is calculated for different land uses. Estimations are also made to calculate the distance at which the sound levels will attenuate to the acceptable noise levels as defined by CPCB in Noise Rules, 2000. Standard sound wave propagation equation is used to calculate the noise levels at receptor and the equation is given below.

$$L2 = (L1 - 20 \log D2/D1)$$

Where, L1 and L2 are the noise levels at D1 and D2 distance from the noise source. Sensitive receptor located 50m either side of the alignment were selected to represent silence zone along the alignment under religious

and educational uses. Table 6.5 shows the list of sensitive receptors along the alignment and their distances from centreline.

Table 6.5 List of representative sensitive receptors along the alignment (within 50m either side of alignment)

S.no	Location	Distance from centreline
1.	St. Martin's Church (near JLN stadium station)	15m
2.	Guru Temple (near Alinchuvadu station)	20m
3.	St. Michael's Church (near Chembumukku station)	30m
4.	Special School (near Chembumukku station)	20m
5.	Malabar Church (near Vazhakkala station)	20m
6.	Ayurveda Hospital (near Padamughal station)	40m

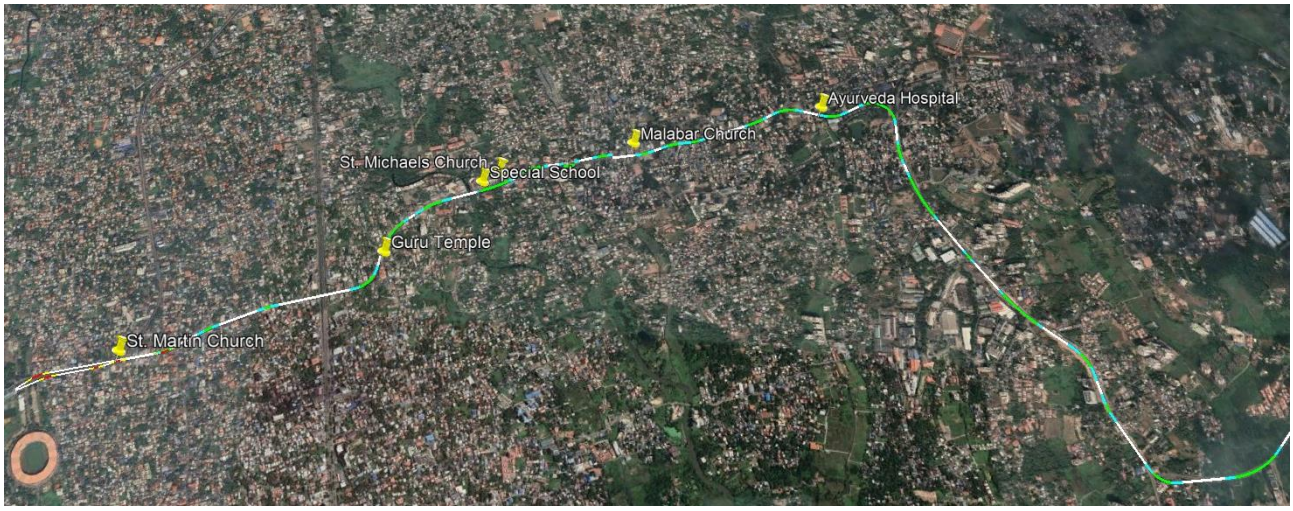


Figure 6.1 showing locations of monitoring along the alignment

Predicted Noise Level

Minimum distance which is required for each type of land use identifying within the project area has defined CPCB under Noise Rules, 2000 as amended in 2010 is calculated using above equation and is given in Table 6.6.

Table 6.6 Minimum distance required for different land uses

Land Use	Day Time Standards dB(A) Leq	Safe Distance (m) Day Time	Nighttime Standards dB(A) Leq	Safe Distance Nighttime
Residential	55	562.3	45	1778.2
Commercial	65	177.8	55	562.3
Industrial	75	56.23	70	100
Silence	50	1000	40	3162.2

The noise level at sensitive locations along the alignment was predicted using the above formula. The results of the predicted noise level is shown in table below –

Table 6.7 Noise level due construction equipment

S.no	Location	Distance from centreline (m)	Predicted Noise Level dB(A)
1.	St. Martin's Church (near JLN stadium station)	15	86.4
2.	Guru Temple (near Alinchuvadu station)	20	84
3.	St. Michael's Church (near Chembumukku station)	30	80.4
4.	Special School (near Chembumukku station)	20	84
5.	Malabar Church (near Vazhakkala station)	20	84
6.	Ayurveda Hospital (near Padamughal station)	40	78

For purpose of calculating noise level using above equation, flat terrain is considered, and environmental attenuation factors are not considered so as to formulate the worst-case scenario. The noise levels predicted here is without considering mitigation measures. It is assumed that with adoption of mitigation measures noise levels will be further restricted within very short distances from the source.

From the baseline study data, conducted on 20.11.2023, it can be seen that the ambient noise levels for day and night are exceeding the specified CPCB standards. Hence a slight increase in noise level induced due to operation of construction equipment's will cause some impacts to nearby residential, religious and institutional structures.

The predicted level of noise from operation of construction equipment at selected locations is mentioned in table 6.6. The predicted noise levels are more than the prescribed CPCB standards. It can be concluded that construction noise will create an impact, however the impact will be short – term and will be confined during the construction phase only. The mitigation measures are proposed for minimizing the noise levels.

6.2.2 Noise due to increased vehicular movement.

During construction phase, there will be significant increase in vehicular movement for transportation of construction material. In addition to the noise mentioned above, there will also be background noise of the usual traffic resulting due to traffic congestion and uncertainty arising due to traffic diversion measures. Efforts should be made to keep the noise levels under control by appropriate noise attenuation and adopting employee safety measures. Temporary route direction markings will be placed in appropriate locations. During construction phase, the increase in vehicular movement is expected to increase up to a maximum of 5 to 6 trucks/hour. Table 6.8 presents the typical increase in ambient noise level due to increased vehicular movement if the background noise level is at 36dB(A).

Table 6.8 Increase in Nosie Level due to increased Vehicular Movement

Distance (m)	Ambient Noise Level dB(A)	Increase in Noise Level dB(A)
10	36	72
20	36	67
50	36	61

100	36	57
200	36	52
500	36	46
1000	36	42

Mitigation Measures – Piling is the major activity which generates high noise level ranging from 85-90 dB(A). It is evident that operation of the construction equipment will generate high noise levels which may affect the health of construction labour and nearby residents if the adequate mitigation measures are not taken. The effective control of construction noise can be achieved by using a three-part approach consisting of control of the noise at the source, path and at the receptor. The following mitigation measures should be employed in order to minimise the impact of increased noise levels during the construction of metro project.

- At sensitive receptors/locations as identified in the report, auger piling shall be carried out in place of mechanical (by driven) piling which will generate less noise than mechanical piling/core barrel will be used (around 70-75 dB(A)).
- 2m high barricade of GI sheet shall be installed on all sides of piling operations. This could effectively cut down noise levels by 10 – 15 dB(A).
- Piling operations shall be restricted during daytime hours only.
- Properly maintained equipment & machinery, designed with built-in silencers, mufflers and enclosures and shock absorbing pads shall be used in the construction. This will reduce the noise by 5 to 10 dB(A).
- The plant and equipment used in construction shall strictly conform to CPCB noise standards. Noise standards for motor vehicles are notified under Central Motor Vehicle Rules, 1989 and amendments. Every motor vehicle shall be constructed and maintained so as to conform to noise standards specified in the Environment (Protection) Rules, 1986.
- Piling rig age limit will be restricted to 6 yrs old, and all other machinery age will be limited to 10 yrs as per KMRL norms, so the noise from these machines will be comparatively less as per their age factor.
- Stationary noise source like generator sets shall be provided with acoustic enclosures. The plants, equipment and vehicle used for construction should strictly conform to CPCB standards. Vehicles and equipment should be fitted with silencer and maintained accordingly.
- Noisy construction activities shall be enclosed by use of transportable noise screens between noise sources and identified noise sensitive areas for the duration of noisy construction activities.
- Residents and shop owners shall be informed about the nature and duration of intended activities including the construction method, probable effects, quality control measures and precautions prior to commencement. Heavy noise generating activities like piling preferably shall not be carried out at residential and sensitive areas during night-time (10:00 PM to 6:00 AM).
- If needed, construction traffic may be confined to certain routes or restricted to certain off -peak hours.
- Personal Protective Equipment (earplugs or earmuffs) should be provided to the workers operating near high noise generating machines.
- Noise monitoring should be carried out to ensure the effectiveness of mitigation measures and develop a mechanism to record and respond to complaints on noise.
- It is recommended that contractor's CESMP should incorporate noise management plan including adherence to site rules and restrictions, making due allowance with detailed programme of works to be carried out at site.

- Contractor shall ensure briefing of management and operatives to ensure all restrictions are clearly noted with method statements. State the types of plant being used including manufacture literature to advise of the sound power level of the plant, and the proposed noise control methods.
- Contractor shall ensure that all fixed items of construction plant are electrical powered rather than diesel or petrol driven if possible. Where this is not practicable, suitable attenuation measures should be provided if necessary.

6.2.3 Noise Levels during Operation Phase

During the operation phase the main source of noise will be from running of metro trains. It depends on various factors like train speed, type of way structure, sound insulations of car body, type and design of mechanical equipment, cooling fan noise, wheel-rail interaction, electric generator etc. An attempt has been made to predict the rise in ambient noise level during the operation phase of metro system using mathematical Continuous Point Source Model. The same model was used in the EIA report considering the rail speed of 32kmph, whereas as per DPR rail speed of 34kmph has been considered for current modelling.

The contact surface of rail-wheel noise proposition two ways side is approximated by the continuous point source model, using the following relations at 2 m distance from the source.

$$\mathbf{LAwr = 30 \log_{10} (V/V0) + 60\ dB} \qquad \mathbf{(1)}$$

where, LAwr - sound pressure level, V - rail car speed, 34 km/hr & Vo - reference sound, 24 km/hr.

From equation (1), Sound pressure level LAwr = 64.53 dB

Traction motor (LAtm) and gear noise (LAg) have been estimated using the following relationship at 2 m distance from the source:

$$\mathbf{LAtm = 60 \log_{10} (V) + C1} \qquad \mathbf{(2)}$$

$$\mathbf{LAg = 10 \log_{10} (V) + C2} \qquad \mathbf{(3)}$$

Where, C1 and C2 are constants having values of -4.6 and 66.7 respectively, and V is the average rail car speed = 34kmph.

From equation (2), Traction motor level LAtm = 87.2 dB

From equation (3), Gear noise level, LAg = 82.0 dB

Every aerodynamic noise that was previously discussed originates from the surface of the car. The distribution, quantity, and magnitudes of noise sources vary from one another. When estimating their impact on performance, various noise sources can be roughly represented as point sources. Strong radiation emanates from the solid surface in the direction perpendicular to the surface for every aerodynamic noise.

Currently, a homogeneous lossless medium is considered in the hemispherical sound wave propagation model. The model's mathematical representation is shown below:

$$\mathbf{L(P) = LPS - 20 \log_{10} (d) - 8} \qquad \mathbf{(4)}$$

Where, L(P) is sound pressure level, LPS is the point source noise level and d is the distance of receptor in meters.

This equation has been used to calculate the maximum noise level at a distance of 5.5m from the source.

For wheel rail noise,

Taking values from equation (1) and using equation (4),

$L(P) = 64.53 - 20\log_{10} (5.5) - 8$

$L(P)_1 = 41.73$ dB

For traction motor noise,

Taking values from equation (2) and using equation (4),

$L(P) = 87.2 - 20\log_{10}(5.5) - 8$

$L(P)_2 = 64.40$ dB

For gear noise,

Taking values from equation (3) and using equation (4),

$L(P) = 82.0 - 20\log_{10}(5.5) - 8$

$L(P)_3 = 59.2$ dB

The cumulative impact of all these different sources in a particular place is calculated by the logarithmic addition model as:

$$\mathbf{LP\ (Total) = 10\ log_{10}\ (10^{\ LP1/10} + 10^{\ LP2/10} + 10^{\ LP3/10})} \qquad \mathbf{(5)}$$

Using equation (5), $LP(Total) = 10\ \log_{10}(10^{4.17} + 10^{6.44} + 10^{5.92})$

$$LP\ (Total) = 65.5\ dB$$

The maximum noise level at particular time at 5.5 m is thus estimated as 65.5 dB(A) including background noise level as 20 dB(A) inside the Metro corridor. Noise level at a distance of 12.5m, 25m, and 50m from the alignment have been calculated similarly and these comes out to be 58.36 dB, 53.0 dB and 46.36 dB(A)respectively. The maximum noise level due to train operation at sensitive receptors are presented in table 6.9 below –

Table 6.9 Noise level at sensitive receptors'

S.no	Location	Distance from centreline (m)	Predicted Noise Level dB(A)
1.	St. Martin's Church (near JLN stadium station)	15	56.84
2.	Guru Temple (near Alinchuvadu station)	20	54.34
3.	St. Michael's Church (near Chembumukku station)	30	50.95
4.	Special School (near Chembumukku station)	20	54.34
5.	Malabar Church (near Vazhakkala station)	20	54.34
6.	Ayurveda Hospital (near Padamughal station)	40	48.32

The increase in noise level with increased frequency of train operation is predicted in the table 6.10 below –

Table 6.10 Prediction of noise level

Distance (m)	Year					
	2028	2033	2038	2043	2048	2053
	Nos. of trains per hour					
	7	9	10	13	18	18

	Max speed = 80 kmph Av Rail car Speed = 34 kmph					
	Noise Level (Leq) during peak hours dB(A)					
5.5	72.5	73.5	74.0	75.1	76.6	76.6
12.5	65.7	66.8	67.2	68.4	69.8	69.8
25	59.7	60.8	61.2	62.3	63.8	63.8
50	53.7	54.7	55.2	56.3	57.8	57.8

6.2.4 Cumulative Noise Impact

Cumulative future noise levels in the project area are calculated based on existing measured Ambient Noise Levels and predicted noise levels due to daily metro rail operations using mathematical logarithmic. Cumulative noise levels at each sensitive monitoring location are given in Table 6.11. Baseline noise levels at the receptor are considered as noise levels of the nearest baseline noise monitoring location.

Table 6.11 Cumulative Noise levels

S.no	Receptor locations	Ambient Noise Level (peak hr), dB(A)	Predicted Noise Level (peak hr), dB(A)	Cumulative Noise Level (peak hr), dB(A)
1.	St. Martin's Church (near JLN stadium station)	69.1	56.84	69.35
2.	Guru Temple (near Alinchuvadu station)	71.2	54.34	71.29
3.	St. Michael's Church (near Chembumukku station)	69.3	50.95	69.36
4.	Special School (near Chembumukku station)	71.5	54.34	71.58
5.	Malabar Church (near Vazhakkala station)	68.8	54.34	68.95
6.	Ayurveda Hospital (near Padamughal station)	64.8	48.32	64.9

The analysis of results shows that –

- The predicted cumulative noise levels due to train operation at sensitive locations are exceeding the noise level standards prescribed by CPCB.
- The cumulative noise levels at receptors are exceeding the IFC standards.
- Noise impact criteria on these receptors is categorised as follows –
  - No Impact – difference between baseline noise levels and cumulative noise levels are less than 3 dB (A)

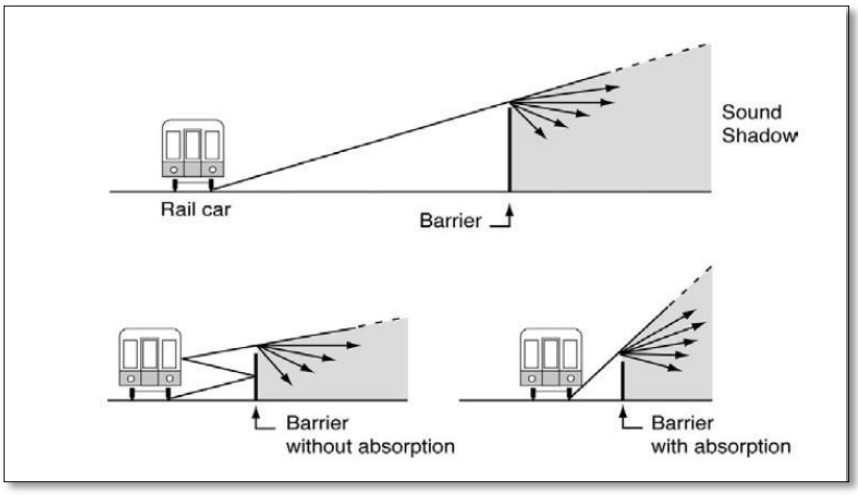
  - ➢ Severe Impact – difference between baseline noise levels and cumulative noise levels are more than 3 dB (A)
- The difference between the baseline values and the predicted cumulative values are not exceeding 3dB, hence the receptors can be categorised in no impact zone.

The impact resulting from train operation falls within a zone of no severe impact. Nonetheless, to mitigate noise levels associated with metro train operation, the Contractor is obligated to adhere to established good practices. This includes the provision of noise barriers with specified details for installation, explicitly outlining the location, design, material, and future maintenance requirements. It is advisable for the contractor, in collaboration with KMRL, stakeholders, and PAPs, to identify potential locations for noise barriers (if necessary). The finalized locations should then be incorporated into the CESMP (Construction Environment and Social Management Plan).

CESMP gives a general environmental and social management approach for roles and responsibilities, procedures and monitoring, audit, reporting requirements of the Contractor during the construction works. This management plan shall be based upon the findings of the ESIA and EDDR specifically, Air Quality Impact Assessment, Noise Impact Assessment, Noise and Vibration Modelling, Traffic Management Plan, and subject to further development for actual Project conditions by the Contractor. The CESMP and its sub-plans are intended to provide the Contractors with a framework to manage ESHS risks associated with the construction activities.

Efforts has been made to control the noise impacts at the source level. Following mitigation measures shall be adopted –

- Noise barrier helps in reduction of the noise level. Noise level reduction with the help of the barriers is depicted in Figure below. Noise barriers can reduce the noise level from 6-15 dB (A) (reference – FTA Guidelines for transit Noise and Vibration Impact Assessment). Noise barriers should be provided to minimize the noise levels at sensitive locations/residential areas/depot area. Noise barrier comprising of absorptive type metal panel and reflective type polycarbonate sheets can be located on edge of the viaducts to reduce the noise intensity to be generated due to metro movement. Height of these barriers can be kept 1.5-2.0 m above the top of rail. The barrier must be long enough to screen out a moving train along most of its visible path. Thus, length of the barrier shall be considered additional 1 m on both ends at proposed locations.



- Provision of anti-dumping floor and noise absorption material.
- Low speed compressor, blower and air conditioner.
- Ballast less track supported on two layers of rubber pads can be used to reduce track noise and ground vibrations.
- Trackside lubrication can be effective in avoiding wheel squeal, which often occurs as Metro rail vehicles traverses tight-radius curves. This installation automatically deposits a small

amount of biodegradable lubricant on the top of the rail and has effectively eliminated wheel squeal and associated complaints from nearby residents.

- To prevent development of surface irregularities on the rail, a fairly heavy rail section is to be used. Further, rail grinding at regular intervals by Rail grinding machine and also lubrication of rail by vehicle mounted lubricator have been contemplated.
- Rail shall be continuously welded and also shall be laid to fine tolerances so that any noise/vibration on account of irregular track geometry could be reduced. Rails should begrinded in regular basis to minimize the vibrations.

6.3 Impact due to Vibration during construction

During construction, some equipment may cause ground-borne vibration, most notably pile driving equipment. Construction equipment can produce vibration levels at 25 feet (7.62 m) that range from 58 VdB for a small bulldozer to 112 VdB for a pile driver. Operation of construction equipment causes ground vibrations which spread through the ground and diminish in strength with distance. Vibration source levels and the procedure proposed by Federal Transient Administration (FTA) of USA has been considered to evaluate the impact due to operation of equipment's during construction phase. The sensitive receptors were identified along the alignment. The impact of vibration due to operation of construction equipment's were analysed using the procedure proposed by Federal Transient Administration (FTA). List of sensitive locations is shown in Table.

Table 6.12 List of representative sensitive receptors along the alignment (within 50m either side of alignment)

S.no	Location	Distance from centreline
1.	St. Martin's Church (near JLN stadium station)	15m
2.	Guru Temple (near Alinchuvadu station)	20m
3.	St. Michael's Church (near Chembumukku station)	30m
4.	Special School (near Chembumukku station)	20m
5.	Malabar Church (near Vazhakkala station)	20m
6.	Ayurveda Hospital (near Padamughal station)	40m

After the detailed analysis it is concluded that Pile drivers (impact or sonic), clam shovel drop, and vibratory roller are among the most problematic equipment. The results shows that the annoyance level criteria were exceeded in all these locations while the damage criteria due to impact pile driver was exceeded at St. Martin's location.

A comprehensive report on impact & mitigation measures due to vibration during construction phase is attached in Appendix 6.2.

6.4 Impact due to Vibration during operation

In India, no criterion has been prescribed in "The Noise Pollution (Regulation and Control) Rules, 2000" regarding the limits of ground-borne vibrations and noise due to railway systems.

"Metro Rail Transit System. Guidelines for Noise and Vibrations" elaborated by CT-38 Track Design Directorate, Research Designs and Standards Organisation (RDSO), Ministry of Railways of India, analyses different worldwide vibration standards and conclude that all of them are more or less in agreement with FTA Manual provisions. Hence, in India FTA Manual provisions are adopted for railway induced ground-borne vibrations during infrastructure's operation phase as well as FTA Manual provisions regarding construction vibration impact.

Steps need to be followed to assess the vibration impact during the operational phase are the followings:

- Step 1: Employ FTA vibration screen procedures developed based on the land use and type of the vibration source to identify the sensitive locations to ground- borne vibration.

Table 6.13 List of representative sensitive receptors along the alignment (within 50m either side of alignment)

S.no	Location	Distance from centreline
1.	St. Martin's Church (near JLN stadium station)	15m
2.	Guru Temple (near Alinchuvadu station)	20m
3.	St. Michael's Church (near Chembumukku station)	30m
4.	Special School (near Chembumukku station)	20m
5.	Malabar Church (near Vazhakkala station)	20m
6.	Ayurveda Hospital (near Padamughal station)	40m

- Step 2: Select the base curve for ground surface vibration level.

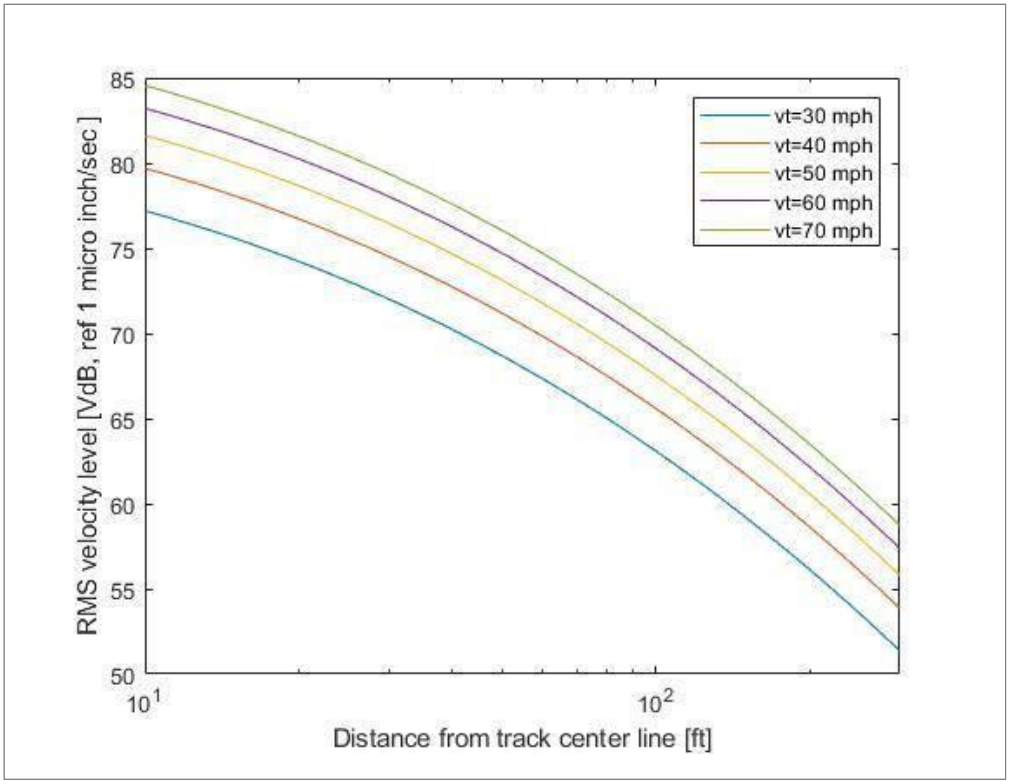


Figure 6.1. Vibration curves for different train speeds

- Step 3: Apply project-specific adjustments to the standard vibration curve including the adjustments in source, propagation, and receiver.
- Step 4: Compare the predicted vibration level after applying the adjustment with the vibration impact criteria to assess the vibration impact.
- Step 5: Proposing vibration abatement solutions if the predicted vibration exceeds the vibration criteria.

The methodology explained above (as proposed by FTA) has been used to predict the induced vibration due to train pass-by in elevated section for both design and scheduled speeds as a function of distance between the centre of track and receptor. The results are shown in figure 6.2.

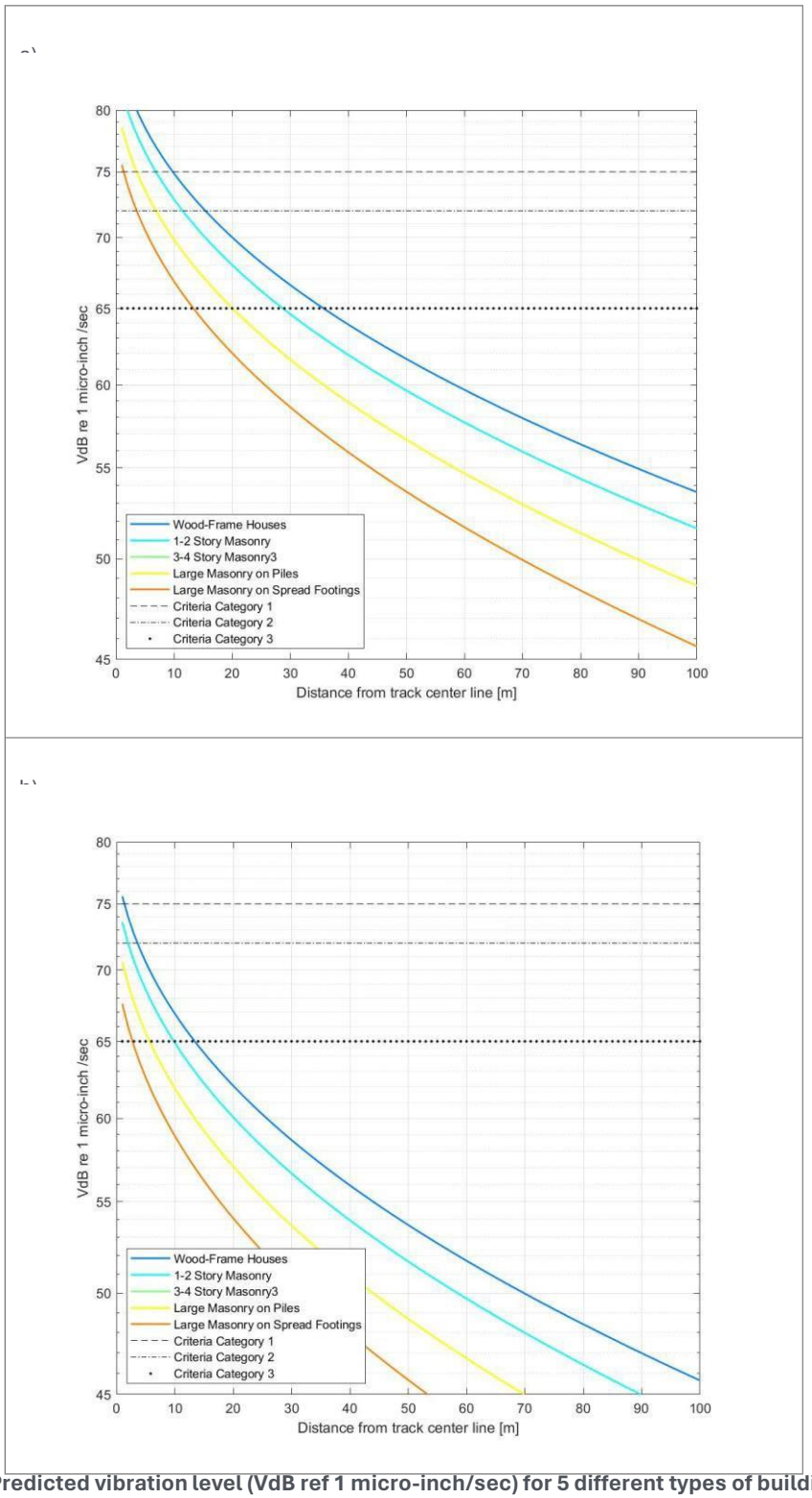


Figure 6.2. Predicted vibration level (VdB ref 1 micro-inch/sec) for 5 different types of buildings induced totrain pass-by in elevated sections with a) designed speed of 90 kmph and b) with scheduled speed of 34 kmph. Horizontal lines present the criteria impact for 3 different land use.

From the modelling results, it is concluded that no vibration levels higher than the criteria will be induced in the sensitive structures along the alignment.

A comprehensive report on impact & mitigation measures due to vibration during operation phase is attached in Appendix 6.2.

7 PUBLIC CONSULTATION AND STAKEHOLDER IDENTIFICATION

MDBs' policies require projects to carry out meaningful public consultation on an ongoing basis. Public consultation will: (i) begin early and carry on throughout the project cycle; (ii) provide timely disclosure of relevant information, understandable and accessible to people; (iii) ensure a free and un-intimidated atmosphere without coercion; (iv) ensure gender inclusiveness tailored to the needs of disadvantaged and vulnerable groups; and (v) enable the incorporation of all relevant views of affected people, and stakeholders into project decision making, mitigation measures, the sharing of development benefits and opportunities, and implementation issues.

Review of EIA & Identified gaps : During the EIA stage, there was no formal public consultation conducted. However, individual discussions were held with affected individuals to comprehend their perspectives on the project and the associated issues. The feedback received from the people was generally supportive of the project, and some suggestions provided were integrated into the Environmental Management Plan (EMP).

Due Diligence Covers: During the EDDR stage, group meetings were organized with individuals representing potential Project Affected Persons (PAPs) and other stakeholders within the community. The objective was to enhance public understanding about the project and address community concerns related to mitigating adverse impacts. These consultations took place at Vazhakkala, Edappally, and Kakkanad on October 19, 2023. Additionally, a consultation was held near the Cochin Sez station where piling work was in progress. Public consultations, conducted at various stages of the Social Impact Assessment (SIA), have also been integrated into the EDDR. The details of the public consultations are presented in Table 7.1.

Table 7.1 Summary of Public Consultations during SIA & EDDR stage

Place	Date	Number of participants
Edappally South	09.08.2018	10
Vazhakkala	10.08.2018	18
Palarivattom	03.03.2020	20
Kakkanad	13.07.2020	17
Kakkanad	25.05.2023	22

During public consultation, benefits due the project and issues related to construction and operation were discussed with the affected communities; their opinions, suggestions and apprehensions were recorded. The points raised during meeting are –

1) Time bound acquisition process will mitigate the impact.
2) The present level of Access to be resettled during and after the implementation of the project.
3) Community Properties like waiting sheds will be resettled.
4) Reasonable compensation will provide for land, property, and business loss.
5) Regular information will provide on progress of acquisition.
6) Alignment will re-examine and save buildings and structures as much possible.
7) Rehabilitation and Resettlement process will be well informed and ensure community participation and consultation.

The photograph of consultation is shown in Table 7.2.

During public consultation, benefits due the project and issues related to construction and operation were discussed with the affected communities. The participants highly appreciated the upcoming phase- 2 metro project as it will increase connectivity, reduce the traffic load, and reduce existing level of pollution.

Table 7.2 Photographs of Public Consultations

	
Public consultation during SIA at Kakkanad	Public consultation during SIA at Kakkanad
	
Public consultation during SIA at Vazhakkala	Public consultation during SIA at Vazhakkala
	
Consultation with PAPs at Palarivattom jn during Due Diligence	Consultation with PAPs at Vazhakkala during Due Diligence

	
Consultation with PAPs at Vazhakkala during Due Diligence	Consultation with PAPs at Edappally during Due Diligence
	
Consultation with PAPs at kakkanad during Due Diligence	Consultation with PAPs at Palarivattom jn during Due Diligence

7.1 Information Disclosure

All environmental documents are subject to public disclosure, and therefore, will be made available to the public. The EIA and the Executive Summary (in both English and Malayalam) will be disclosed on KMRL and AIIBs' websites. The hard copies of EIA will be made available at KMRL office as well as at other locations accessible to stakeholders. KMRL will ensure that meaningful public consultations, particularly with project affected persons are undertaken throughout the design, construction, and operation stages.

8 GRIEVANCE REDRESS MECHANISM

Grievance Redress Mechanism (GRM) is an integral and important mechanism for addressing/resolving the concern and grievances in a transparent and swift manner. Grievances related to the implementation of the project, particularly regarding the environmental management plan, rehabilitation and resettlement, compensation etc. will be acknowledged, evaluated, and responded to the complainant with corrective action proposed using understandable and transparent processes that are gender responsive, culturally appropriate, and readily accessible to all segments of the affected people.

Review of EIA & Identified gaps: The EIA report doesn't comprise the requirement of GRM and how the GRM will work during the implementation of Phase-II metro.

Due Diligence Covers: Due diligence study incorporate the GRM process for KMRL.

KMRL is committed to address the grievances of all the stakeholders of Kochi Metro. In its endeavour to ensure transparent and timely redressal of grievances, KMRL has devised the following grievance redressal mechanism.

(ix) KMRL website
(x) A toll-free helpline,
(xi) Written feedback forms (available at stations' customer cares),
(xii) An email,
(xiii) A WhatsApp chat bot,
(xiv) Social media channels,
(xv) Station controller mobiles,
(xvi) Metro Promo Center.

KMRL has an established escalation process for addressing complaints received from these channels.

8.1 Grievance Redressal Through Web Portal

The stakeholders can submit their grievances through the google form provided in the portal. The stakeholder will receive an acknowledgement from the administrator on the email or WhatsApp number shared in the form. If the stakeholder chooses to submit the grievance as 'anonymous', the Acknowledgement will be displayed on the screen. Once the grievance is furnished, it will be analysed by the concerned nodal officer at KMRL and KMRL will send the response which will contain the details of action taken/proposed to be taken/why action not to be taken by KMRL in a span of 7 working days. Responses will not be sent to stakeholders who have shared their feedbacks/suggestions as anonymous.

8.2 Grievance Redressal for Land Acquisition

The land acquisition for KMRL is completely undertaken by Government of Kerala as per the Right to Fair Compensation and Transparency in Land Acquisition, Rehabilitation and Resettlement Act, 2013 (RFCTLARR Act). The Act provides for addressing the grievances during various stages of the land acquisition process. The District Collector is the nodal officer for grievance redressal regarding land acquisition. Even though the District Collector is the nodal officer, the concerned stakeholder can submit the grievance through the google form provided in the portal. The stakeholder will receive an acknowledgement from the administrator on the email or WhatsApp number shared in the form. If the stakeholder chooses to submit the grievance as 'anonymous', the Acknowledgement will be displayed on the screen. All the grievances shared by stakeholders in this regard will be duly forwarded to the District Collector for onward action. The stakeholders may further contact the District Collector with the Acknowledgement from KMRL for further actions.

Records of grievances received, corrective actions taken, and their outcomes will be properly maintained and form part of the quarterly environmental monitoring report to MDBs.

8.3 Grievance Redressal During Project Execution

During execution of the project, there will be complaints/issues which from local communities, workers and the complaints for the gender-based violence, require immediate attention. In order to address such requirements, KMRL has set up a mechanism at the field level. The complaints will be registered in the complaint register kept at the field offices of KMRL and immediately looked into by a team formed by the following.

a) Deputy General Manager/Manager of KMRL in charge of the concerned area.

b) Senior Engineer of General Consultant

c) Project Manager/ Assistant Project Manager of the contractor.

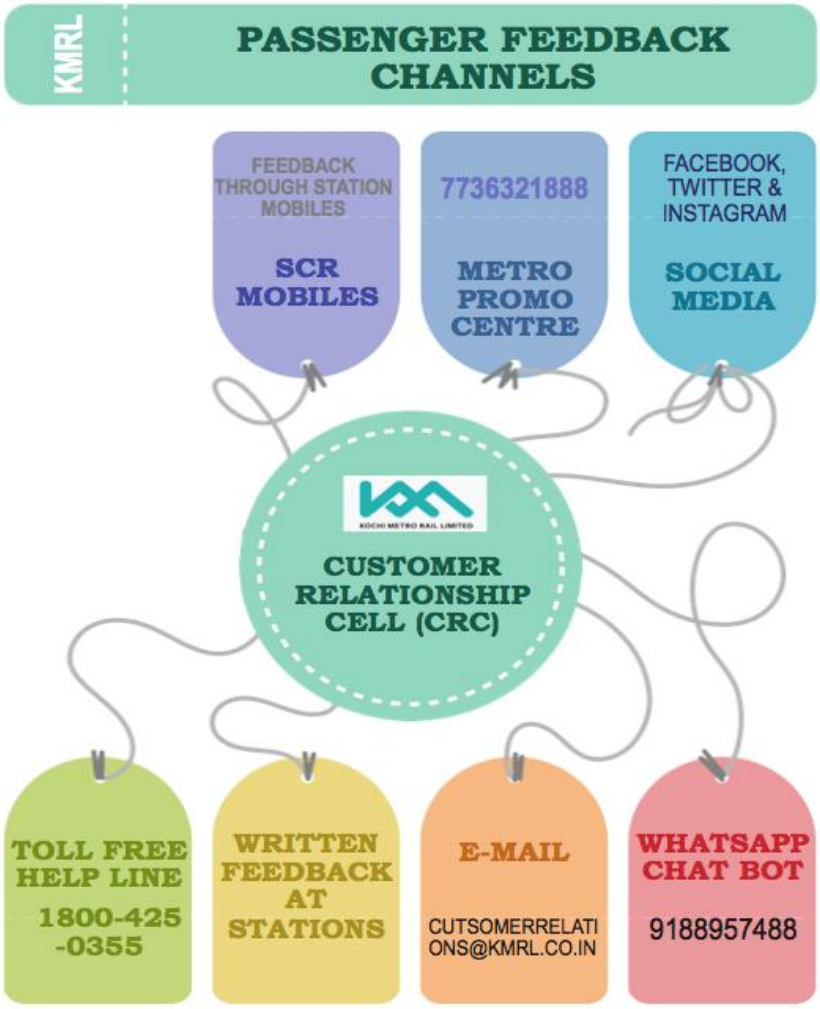
The team will examine the complaint and if the complaint is found to be under the purview of KMRL project and can be resolved immediately, then necessary actions from the field level will be taken to resolve the issue. If the complaint is resolved to the petitioner's satisfaction, then the complaint is marked as closed in the register. If the complaint is not resolved at field level within 7 working days, then the concerned stakeholder may report the issue through the portal.

8.4 Customer Relationship Cell (CRC)

Customer Relationship Cell is constituted at KMRL to be in constant touch with patrons for collecting their feedback on Kochi Metro travel experience and to inform them of various offers provided by KMRL. Customer Relationship Cell always ensures all complaints/suggestions/enquiry are dealt with in an equitable, objective, and unbiased manner. All queries raised by commuters related to metro system are addressed within stipulated time. Customer care boosts the overall customer experience by providing reply to common questions through the Emails, social media, WhatsApp chat-bots, or with customer care agents through toll free helpline.

Lost & Found – CRC helps the passengers to find their valuable lost items by coordinating with the OCC and station team on a real time basis. Moreover, we are also providing real time details of lost & found items in our websites.

8.5 Various Channels available for customers:

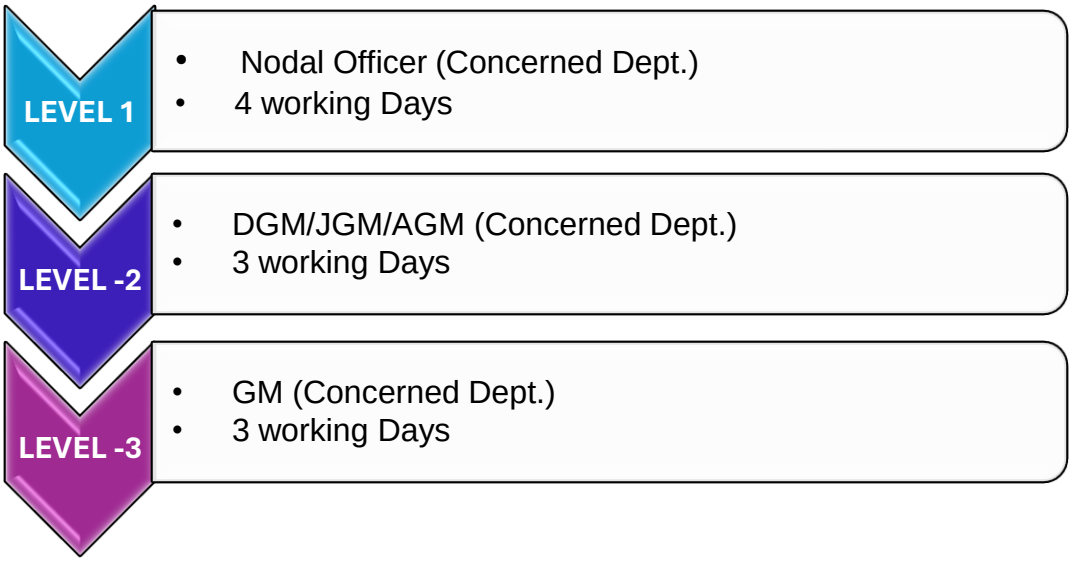


- Toll Free Helpline – 1800 425 0355
- Written Feedback forms available at station customer cares
- Email – customerrelations@kmrl.co.in
- WhatsApp Chat bot – 9188957488
- Feedback through various social media handles
- Feedback through Station Controller (SCR) Mobiles
- Feedback through Metro Promo Center.

8.6 The Escalation mechanism for complaint/suggestion redressal

- The public complaint addressed by different levels within the time period as stipulated in the escalation matrix.
- All the department nominate a nodal officer for coordinating and resolving the complaint in their department. All other staff shall support the nodal officer for resolution of public complaints.
- Concerned nodal officers ensures the complaint is acknowledged & resolution is planned within minimum (TAT).
- The escalation matrix of the public complaints of different levels & their minimum Turnaround Time (TAT) is provided below.

Escalation mechanism for complaint/suggestion redressal Respective department & Turn- around Time (TAT)



The flow chart of GRM is presented in Figure 8.1.

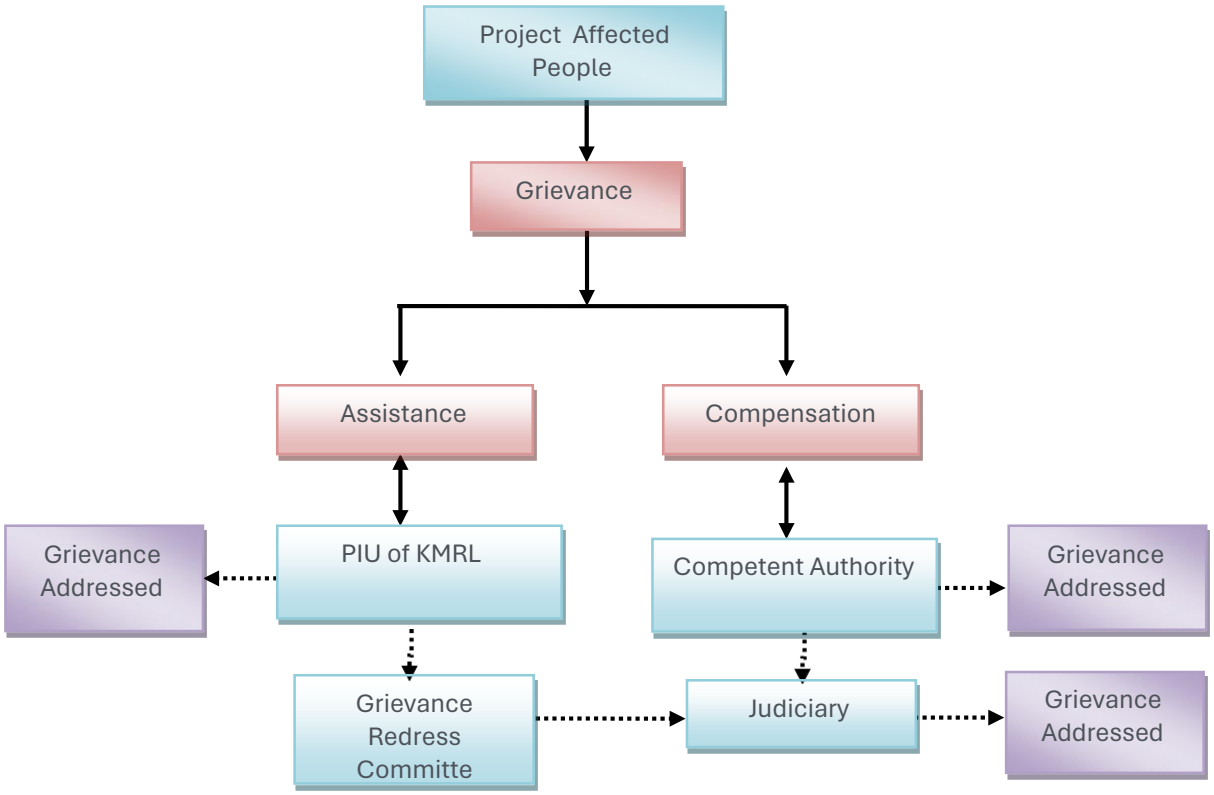


Figure 8.1: Grievance Redress Mechanism

The following process is followed for consideration of various cases by GRC:

- GRC function independently
- All grievances are received in written form by GRCs and a separate record of the same, including contact details, is maintained.
- A separate file / processing document is created for each case, based on its category (project, location etc.) and all observations and documents related to the case are maintained in such file.
- Cases related to environment pollution, noise, eligibility, entitlements, disputes etc. are promptly handled after consultation with relevant authorities.
- GRCs can seek necessary record / information (such as survey details, past written communication etc.)
- Written notices are sent to the aggrieved persons and respondents to appear for hearing along with documents, and further dates are provided in case of genuine inconvenience to the party about the appointed date.
- Multiple hearings are conducted as per the requirements of cases and aggrieved persons (including their representatives) and respondents are heard and are provided opportunities to submit further documents / proofs.
- Site visit documents submitted by the parties are verified from appropriate sources, as may be considered necessary.
- In normal circumstances (excluding those requiring information from external agencies) the entire process is carried out in a time bound manner (On an average, it takes about 1-2 months for disposal of each case in GRC)
- After due consideration of the cases, written and reasoned orders are passed under the signature of Head of concerned GRC.
- Any fatality accident should be reported to GRC and MDBs immediately.

9 ENVIRONMENTAL MANAGEMENT & MONITORING PLAN

Review of EIA & Identified gaps : The Environmental Management Plan (EMP) outlined in the EIA report for Kochi Metro Phase-II encompasses mitigation, monitoring, and institutional measures aimed at minimizing adverse environmental and social impacts while enhancing positive impacts. The plan delineates the actions necessary for the implementation of these measures. However, it is noteworthy that the EMP prepared during the EIA stage lacks provisions for Noise and Vibration Management during both the construction and operation phases.

Due Diligence covers:. The development of a Construction Environmental Management Plan (CEMP) by the contractor is essential to ensure the integration of environmental considerations into the construction stage of a project. The due diligence study explicitly outlines the comprehensive coverage of key elements of the CEMP, as addressed in the Environmental Management Plan (EMP), including the institutional arrangements for EMP implementation. To account for the costs associated with environmental mitigation, management, and monitoring, the environmental budget has been revised and updated.

9.1 Institutional Arrangement

Implementing Agency

For effective implementation of the proposed environmental management plan, it is necessary to have permanent organizational set up charged with the task of ensuring effective implementation of EMP and to monitor the implementation efficiency. KMRL is agency for planning, implementation and operating the project. The KMRL will be the Implementing Agency (IA) responsible for implementation of the metro rail project. Managing Director, KMRL will be in charge of the overall project activities. KMRL will be accountable to the GoK.

Project Implementation Unit (PIU), KMRL headed by the Project Director (PD) is responsible for the overall execution of the project and implementation of the EMP. The PIU will be assisted by General Consultant (GC). The safeguard role of GC is to assist KMRL in review of documentation and monitoring of implementation of EMP and monitoring plan during construction and operation by means of scheduled inspections, meetings and reports submitted to KMRL.

Implementation of EMP
KMRL: EMP will be committed by KMRL as part of its agreement with Multilateral Development Banks (MDBs). The responsibility to implement the EMP including Grievance Redressal rests with KMRL. Environment clearances related to locations and design of the project will be secured before start of construction. Permissions/certifications required during operation of the project and Environment monitoring during operation shall be the responsibility of KMRL.

Contractors: Permits required during construction and those directly related to construction. The EMP will be implemented by the contractors based on the contract agreement. The contractor environmental team will be headed by Project Manager assisted by qualified and trained safety professionals and environment engineers along with onsite junior field personnel. This team will be assisted by:

- electrical and mechanical engineers qualified in safety evaluation.
- environment engineer.
- traffic engineer; and
- professionals in occupational health and labour welfare.

KMRL and GC: Supervision and review of implementation will be the responsibility of GC. With assistance from GC, KMRL will also be responsible for reviewing and approving any specific documents/plans that have to be provided by contractors (traffic management plan, waste management plan, muck disposal plan etc.). Implementation of EMP will be continuously monitored by the ESHS team of GC and KMRL. The KMRL-GC team will be common for all sections of the project with a view to facilitate unified approach and knowledge enhancement.

The KMRL's ESHS team will head by senior Manager assisted by qualified and trained mid-level safety professionals, environment engineers, traffic engineer, labour welfare officer. The Manager ESHS for the project in KMRL will report directly to Director (Works) and Managing Director, KMRL.

GC will contribute,

- Specialists from fields of safety, environment, traffic engineering, occupational and community health, ecology, noise and vibration
- Onsite junior field personnel, at least one site each.
- The visits and review meetings will comprise:
  - Weekly site visits independently by KMRL and jointly with contractor.
  - Weekly review meetings by KMRL and contractor.
  - Quarterly monitoring reports to KMRL.
  - Semi-annual monitoring reports to MDBs.
- Orientation and training of KMRL team in implementation of EMP and environmental monitoring will be undertaken at the beginning of the project.

MDBs: Disclosure of all latest safeguard documents on their websites. Implementation of the EMP will be monitored half yearly by MDBs through their specialists.

The reporting line of all relevant parties is, Contractor → PIU → KMRL and GC → MDBs. The external monitor will conduct independent monitor to inform KMRL any remediation actions to ensure the safeguard compliance.

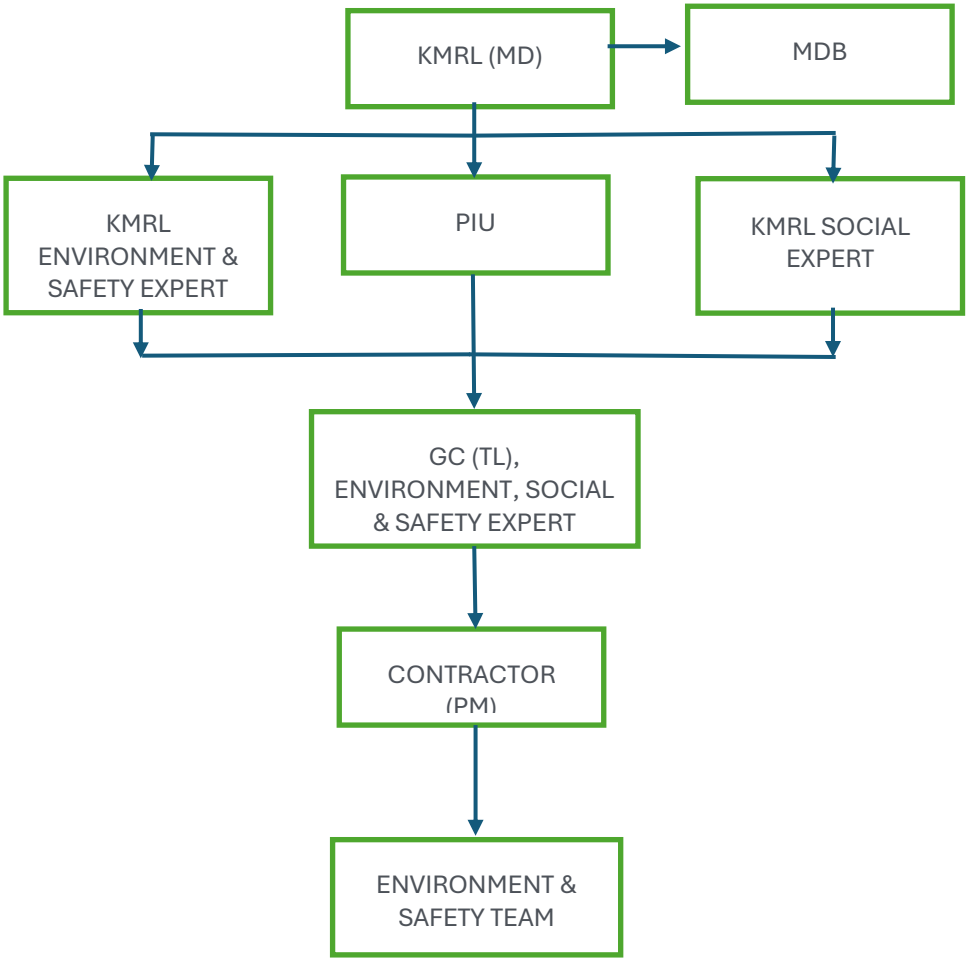


Figure 9.1 Implementation arrangement for EMP

An EMP Matrix is presented in Table 9.2 below.

9.2 Development and Implementation of subplans

Within the construction environmental management plan, contractors are required to formulate various subplans as outlined in the EMP and in accordance with the Environmental, Social, Health, and Safety (ESHS) system requirements specified in KMRL's Safety, Health, and Environment Manual. These plans are designed to adhere to good environmental management practices and function as guiding documents. The developed subplans will constitute part of the construction EMP, ensuring alignment with the contractor's Safety, Health, and Environment (SHE) plans, and will be incorporated into the bid documents. Table 9.1 outlines some of the key plans to be developed by the contractor, specifying the major responsible party for approval in consultation with KMRL/GC.

Table 9.1 Contractor's subplans and approvals

Plan	Description
1. Work plan for securing all permits and approvals	The plan will list all necessary permits, approvals and/ or consent including the responsible authorities and the timeframe of obtaining them.
2. Construction and labor camp Management Plan	The plan will provide a layout map of the construction sites and campsite and clearly show the access road, entry and exit and different facilities inside the camp. Facilities inside the camp may include contractor's office, residential quarters, toilets, health center, construction plants, storage areas etc. The plan will include information on waste management, supply of water for drinking and bathing, wastewater and drainage management, traffic movement routes etc.
3. Site and Camp Restoration Plan	Describes the clean-up and restoration operations to be implemented by the Contractor prior to demobilization including clearance of all temporary structures, disposal of all garbage, night soils and petroleum, oil and lubricants wastes and filling and sealing of all disposal pits or trenches.
4. Muck Disposal Plan	The plan shall describe sources of muck generation (piling work for viaducts etc), type and quantity of muck generated from various sources, use of muck generated, method collection and transportation, transportation routes, disposal site location and design, approvals required for disposal sites, and treatment method. Recommendations provided in the EIA must be considered.
5. Waste Management Plan	The plan shall describe waste streams and amounts, describe recycling/reuse methods for each material, identify the waste destinations and transport modes, including what materials are being segregated on site for reuse or recycling, specify responsibilities for managing and disposal of waste. Describe special measures for material use and handling. Describe communication and training to support and encourage participation from everyone on site.
6. Traffic Management Plan	The plan shall be designed to ensure that traffic congestion and traffic safety impacts due to construction activities and movement of construction vehicles, haulage trucks, and equipment is minimized. The plan shall be prepared in consultation with traffic officials. The plan shall identify traffic diversion and management issues, haul road network plan, traffic schedules, traffic arrangements showing all detours/lane diversions, modifications to signalling

		at intersections, necessary barricades, warning/advisory signs, road signs, lighting, and other provisions to ensure that adequate and safe access is provided to motorists and other road users in the affected areas. Pre-construction access road surveys will also form part of the TMP. The plan shall also include locations for pedestrian crossings and conditions for the management of these crossings, including the use of flagmen.
7.	Occupational and Community Health and Safety Plan	Consistent with international standards (e.g., World Bank Group Environmental, Health, and Safety Guidelines, 2007) and Labor Code of India. The Plan shall address health and safety hazards associated with construction activities, use of heavy equipment, transport of materials and other hazards associated with various construction activities and shall provide links to existing government health programs. The plan will include a Covid-19 response and management plan. The document to be read together with the Camp Management Plan. Recommendations provided in the EIA must be considered.
8.	Labor and Working Conditions Management Plan	This will include – policy/legal framework information (including labor and OHS requirements of national legislation, ESS of MDB's), workforce induction and information on rights, child and forced labor, equal opportunity, migrant workers, promotion of local employment opportunities, labor union, worker accommodation requirements, provision for retrenchment plans, workforce grievance mechanism, security personnel (Voluntary Principles on Security and Human Rights), etc. Contractor needs to ensure that the core labor requirements are cascaded down across the entire contracting chains, including sub-contractors and suppliers of core materials. The plan shall also be in compliance with IFC Guidance Note "Workers' accommodation: processes and standards".
9.	Code of Conduct	The Contractor shall prepare a Code of Conduct that outlines camp rules articulating acceptable behaviours of the workforce with local communities. Associated induction training will be provided to ensure rules are well understood and enforced.
10.	Emergency Response Plan	This plan shall prescribe measures to prevent, mitigate, respond to and recover from emergency events that could occur due to project activities such as accidents, spills of hazardous substances, fire, extreme weather events, and others; measures to prevent, mitigate, respond to and recover from emergency events that could occur due to project activities such as accidents during piling, spills of hazardous substances, fire, floods, and other events.
11.	Construction Vibration Management Plan	Detailing the procedures for vibration surveys, monitoring and control. Such details shall include; procedures to complete condition surveys, Measurement locations and methods; Method statements for works likely to induce vibrations, including programs of trial construction sections to determine the likely magnitude of vibrations at defined distances from the vibration source, in sufficient detail for the contractor to develop a final method for constructing the works without excessive vibration; Description of the instrumentation and equipment to be used; Copies of the instruction manuals and the laboratory calibration and test equipment certification; The resumes of the vibration monitoring technical support personnel, sufficient to define details of relevant experience; Procedures for data collection and analysis; Frequency of measurements; Means and methods of providing warnings when the specified construction vibration limits are reached; and Action plans to be implemented in the event the specified construction vibration limits are reached. The generalized plans of action shall comprise the positive measures by the Contractor to control vibrations using alternative construction methods.
12.	Construction Water	Plan to describe the water sources, required permits and ways to minimize

	Management Plan	water wastage
13.	Utility shifting and restoration plan	Plan to describe temporary or permanent diversions of utility services in order to secure that utility services remain operational during the entire construction period and after completion of project.

9.3 Environmental Monitoring and Reporting Program

EMoP contain parameters, location, sampling and analysis methods, frequency, and compared to standards or agreed actions that will indicate non-compliances and trigger necessary corrective actions. More specifically, the objectives of the EMoP are:

- Ensure that impacts do not exceed the established legal standards.
- Check the implementation of mitigation measures in the manner described in the EIA report.
- Monitor implementation of the EMP
- Check whether the proposed mitigation measures have been achieved the intended results, and or/ other environmental impacts occurred.

A monitoring plan defining all parameters to be monitored, with tentative location, project stages for measurements, implementation and institutional responsibility for different environmental components is prepared for all stages of project and presented in Table 9.3.

Formats specified in Appendix 1 of EMP is to ensure the effective reporting of environmental issues. This will not only ensure that the environmental provisions are addressed but also link the satisfactory compliance to environmental procedures.

Table 9.2 EMP Matrix

SN	Activity	Aspect /Parameter affected	Impact	Mitigation measures	Responsibility	
					Implementation	Supervision
Planning and Design Phase						
1.	Land Acquisition	Social	Total land required for the project is 29200 sqm out of which 11050 sqm is private land and 18150 sqm is Government land. As per DPR, 115usculo. 56 structures occupied by 45-50 families would be affected between JLN Station and Infopark. 21 commercial structures and 17 residential cum commercial structures will be affected due to the project development	1. Compensation and Resettlement benefits as well as livelihood restoration measures have been approved by KMRL. Based on The Right to Fair Compensation and Transparency in Land Acquisition, Rehabilitation and Resettlement Act, 2013. 2. Land Acquisition is being carried out as per the provision of GoK and GoI policies. The affected people will be compensated and assisted as per the provisions of Resettlement Action Plan (RAP).	KMRL	KMRL
2.	Change in Land use	Land	Land use will be slightly changed.	1. Temporary acquired areas like areas for casting yards & workshops etc. should be properly rehabilitated after completion of the construction phase and handed back to the owner. 2. Proper clearance/permission/consents will be sought from competent authority before construction.	Contractor / GC	KMRL

3.	Contractor Preparatory Works (Upon issuance of Notice to Proceed)	EHS	Non-compliance with contract conditions and regulatory requirements.	The Contractor shall complete the following activities no later than 30 days upon issuance of Notice to proceed, (a) appoint contractor's Safety, Health and Environmental Officer (SHEO); (b) SHEO will engage GC-Environment Specialist to discuss EMP, seek clarification and recommend corresponding revisions if necessary. (c) SHEO will agree with GC the monthly monitoring template and deadlines for submission. (d) SHEO will submit for GC's approval on work plan to secure all permits and approvals needed to be secured during construction stage which include but not limited to: i) operation of crushers and hot mix plants, ii) transport and storage of hazardous materials (e.g., fuel, lubricants, explosives), iii) waste disposal sites and disposal. Management plan, iv) temporary storage location, iv) water use, and v) emission compliance of all vehicles. (vi)Arrangements to link with government health programs on hygiene, sanitation, and prevention of communicable diseases will also be included in the action plan. (e) SHEO will submit for GC's approval of the construction camp layout and management plan before its establishment; and (f) SHEO will update EIA (in consultation with GC, in case of design changes) and prepare site-specific EMPs. Template of internal weekly environmental inspection, weekly audit by the contractor is placed in Appendix II of Environment Impact Assessment Report	Contractor / GC	KMRL

4.	Labour Management	Labour	Labour right	1. Compliance with GoI labor legislation, ratified International Labour Organization conventions. 2. Prohibition of child labor, including prohibition of persons under 18 years old from working in hazardous conditions (which includes construction activities) and from working at night; medical examinations required to determine that persons above 18 years old are fit to work. 3. Elimination of discrimination with respect to employment and occupation, to be defined as any distinction, exclusion, or preference based on race, gender, religion, political opinion, trade union affiliation, national extraction, or social origin. 4. Human resource policy or plans that establish (a) the rights and responsibilities of project company employees and any contractor employee working in the project regarding remuneration, working conditions, benefits, disciplinary and termination procedures, occupational safety and health, promotion procedures, and training and (b) the rights, responsibilities, and requirements in contractor or subcontractor agreements related to worker rights. 5. Grievance Redress Mechanism for workers should be established as early as possible to function no later than construction commencement. 6. There will be provision for group accidental insurance for the workers.	Contractor	GC / KMRL

		Health and Safety	Accidents	1. Make mandatory the use of safety gears (helmets, safety belts, masks, gloves, Ear plugs/ muffs and boot) by workers depending on nature of work. 2. Necessary planning and safety approach will be made for rescue during emergency. 3. Use of exhaust ventilation for dust control 4. Workers will be provided with first aid and health facilities at the site. 5. There should have facility to deal with medical aspects of HIV/AIDS treatment with specialized services.	Contractor	GC / KMRL
5.	Obtaining Clearance, Permission and Consents	Regulatory Compliance	Delay of obtaining forest clearance, Tree felling information, Consents to establish labour camps, pre-casting and material yards, depots, establish and operate hot mix plant, crushers, batching plant, DG sets etc. muck/waste disposal.	1. Consultation and coordination with relevant authorities to prepare the documents to obtain clearance, permission, and consents. 2. Conditions set in the clearance, permission, and consents to be incorporated into the site-specific EMPs, with dedicated officers to maintain the regulatory compliance tracker.	KMRL / Contractor	KMRL
6.	Site clearance and demolition	Tree felling	About 669 trees will be affected at alignments, & stations. This number will be updated again during site clearance. Additionally, in some areas, pruning will be required.	1. Adequate coordination with applicable government regulatory authorities. Compensatory plantation of 12 saplings for every tree felled will be done in sites to be identified. 2. Plan including sites for compensatory plantation and species and identification of trees to be transplanted will be identified by KMRL in consultation with Forest Department and Municipal Corporation. 3. KMRL Stakeholder communication to avoid or minimize public concerns or protests.	KMRL / Contractor	KMRL

				4. Definition of adequate budget and contingencies as well as financial resources to cover all related costs. This will be finalized before work on relevant section is commenced between KMRL and Contractor.		
		Noise	Noise will be generated the use of hand tools such as jackhammers, sledgehammers, and picks etc.	1. The procedure of demolition will be conducted as per the demolition plan prepared by the Contractor in consultation with KMRL. 2. The existing structures should be demolished one after another cautiously. Wherever possible demolition will be done manually.	Contractor	GC / KMRL
		Physical Cultural Resources	Historic and Cultural Value Loss	1. Contractor to conduct pre-construction structural integrity inspections if there are known or a significant likelihood of archaeological and/or culturally valuable sites or finds in the project's direct area of influence. Prepare a monitoring scheme prior to construction based on the above inspections, with a focus on pre-identified receptors comprising educational, medical, and physical cultural buildings located within recommended screening distance of 62m (for cat. 2) on either side of alignment or finds in the project's direct area of impact. 2. Prepare a monitoring scheme prior to construction based on the above inspections, with a focus on pre-identified culturally valuable sites if any near the alignment or finds in the project's direct area of impact. 3. Compliance with applicable legislation (permits and procedures) and good international practice. 4. Adaptive management in site-specific EMP during final design, including site locations	Contractor	GC / KMRL

				(stations and construction staging areas). 5. Chance finds procedure to be prepared by Contractor and reviewed by GC/KMRL before submitting to all lenders.		
7.	Severance of utilities	Social EHS	The proposed alignments will cross drains and utility services such as sewer, storm water drains, water and wastewater pipes, roadside lights, telephone cables, electricity power lines, electric poles, natural gas lines and traffic signals etc.	1. Assets and utilities will be maintained without affecting and damages by shifting temporary/ permanently where it is necessary. 2. In case gas pipelines are found during detailed utility survey prior to construction, Contractor will conduct the hazardous operation study to ensure the smooth and safe shifting. 3. Utility shifting plan will be developed by KMRL and Contractor in coordination with concern authorities and shifting of utilities will be done as per agreed utility shifting plan prior to construction commenced. The plan will include required EHS management measures, supervision and monitoring of implementation, and final report and confirmation that construction works will be properly closed (for example, all waste will be removed, or re-pavement will be completed as required). 4. In case public utilities are required to be shifted to private land in exceptional circumstances, then adequate compensation shall be made by KMRL to the property owner on the same principles as temporary land acquisition. Following completion of construction of metro, such utilities shall be rehabilitated on public land.	Contractor	GC/KMRL

9.	Noise and Vibration Impacts Related Design	Environ mental Nuisance	Noise and vibration from construction and train operation	1. The detailed noise and vibration analysis (mathematical modelling) at pre-identified receptors comprising educational, medical, and physical cultural buildings and other fragile buildings located project vicinity on either side of alignment based on final engineering designs is ongoing, based on which, a set of mitigations should be prepared and shared with all lenders for review, prior to commencement of construction. 2. Visual inspections of these buildings shall be done by the contractor to serve as baseline to monitor progression of building damage if any due to vibration. 3. Ballast less track structure is supported on two layers of rubber pads to reduce noise and vibrations. In addition, baffle wall as parapets will be constructed up to the rail level so as reduce sound levels. Noise at source will be controlled or reduced by incorporating suitable feature in the design of structures and layout of machines and by use of resilient mounting and dampers etc. 4. Noise barriers made of suitable polycarbonate as per tender document will be installed.	GC/KMRL	GC / KMRL
10.	Traffic Diversion	Land Occupational safety Community safety	Nuisance from traffic congestion	1. The Contractor shall develop detailed and robust traffic management plans consistent with the Indian Guidelines on Traffic Management in work zones (Indian Road Congress: SP:55-2014), prior to mobilization for respective sections with site- or station-specific plans and throughout the construction and operation periods. 2. At congested sections, the temporary traffic coordinators will be engaged by KMRL to	Contractor	GC/ KMRL/ Traffic Police

				facilitate the traffic management. 3. At the minimum, the traffic management plans will have the following components: construction traffic, ensuring access to properties, accommodating pedestrians, parking, access by construction vehicles, faulty traffic lights and problem interchanges, use of public roads, parking provision during construction, use of residential streets and traffic diversion due to temporary road closures, and construction and use of temporary access roads. 4. Strengthening impact and risk prevention measures, such as establishing construction site works to minimize the entrance and exit of vehicles at stations during peak traffic. 5. The logistics should be considered to manage transport materials from storage areas outside of the dense urban core to worksites and to return excavated soil and other materials to disposal locations. If needed, construction traffic may be confined to certain routes (based on infrastructure capacity) or restricted to certain off -peak hours (that is, to reduce noise pollution at night or to avoid commuting and school hours during the day). 6. Any diversions of traffic will cause considerable confusion for pedestrians and drivers as they rearrange their itineraries, hence, to minimize the effects of the diversion or reorganization, it is necessary to conduct communication campaigns and disseminate appropriate information to urban residents and taxi and bus drivers in advance of disruptions. Efforts will be given to divert traffic to roads		

				wide enough to accommodate extra traffic. 7. Compliance with scheduled deadlines for the detour is essential. If necessary, bus service and other public and private transport services in the area should be improved to meet residents' transportation needs. 8. The detailed route for traffic diversion is given in appendix 9.1.		
11.	Construction method, construction material and sites selection	Environment	Pollution and nuisance	1. Contractor is committed to use environmentally friendly construction methods and materials, including cement, sand, and aggregate. 2. Construction material shall be sourced from quarries approved by GoK and KMRL. Extraction from riverbeds is banned. 3. The contractor shall be responsible to ensure that the vendor adheres to the pollution mitigation measures. 4. during loading, transportation and unloading the material. 5. Energy saving technologies will be embedded into the Project design wherever possible. For instance, solar panels, rainwater harvesting. Bureau of Energy Efficiency (BEE) certified/ Energy efficient LED lights, automatic signalling, etc. 6. Procedures for minimizing waste segregation, reuse, 7. temporary storage, recycling, donation, and disposal. 8. Selection of waste disposal service providers (transport, recycling, and disposal) based on EHS criteria (including compliance with all	Contractor	GC / KMRL

				regulatory requirements, no documented EHS issues related to materials at operation or site facilities, and agreement to provide access for site visits to discuss EHS management).		
12.	Climate Designs	Health and Safety	Natural disasters generated health and safety accidents. Maintenance Cost	1. Disaster management plan will be prepared to adapt the disruption of road level access to stations due to rise in mean sea level. 2. Other climate adaptation designs will be embedded in the final design, such as (a) Increase in capacity of stormwater drainage will be made so as to deal with extreme flooding in addition to demand of future land use growth along this alignment. 3. Increased number of pits for rainwater harvesting from elevated metro to cater to flood waters and heavy rains. 4. Climate change mitigation measures will be considered, such as solar panels on station buildings and roofs to reduce the extensive use of grid-generated electricity supplied to the station for operation and maintenance.	Contractor / GC	KMRL
13.	Establishment of Grievance Redress Mechanism	EHS	Complaints not resolved in time	1. Grievance Redress Mechanism for workers and project affected people should be established as early as possible to function no later than groundwork commencement. 2. The Grievance Redress Mechanism information and focal should be disseminated to public.	KMRL	KMRL
14.	Community Liaison	Social	Complaints	1. To ensure that Grievance Redress Mechanism to function effectively for affected people on construction nuisance at ground level with grievance log well documented. 2. Contractor to develop a community communication plan as per the construction	Contractor	GC/ KMRL

				plan, including important measures to reduce community risk, such as fence and related protection around work sites (including strength and visual protection), education and awareness signs and information, and placement of safety risks (explosive and flammable materials, generators).		
Construction Phase						
15.	Construction Monitoring	EHS	Breach of legislation, EIA, EMP, Contracts Accidents	1. Contractor to collect and monitor the Ambient environmental data of air, water (surface and ground), noise& vibration, soil quality and submit monitoring reports to GC / KMRL on monthly basis. 2. GC / KMRL to review the data compared to baseline data and urge Contractor to take immediate actions over any project generated pollution / contamination. 3. GC to submit monitoring reports on quarterly basis to KMRL. 4. If any unanticipated EHS impacts arise during construction, implementation or operation of the Project that were not considered in the EIA / EMP, Contractor and GC to promptly inform KMRL of the occurrence of such risks or impacts, with detailed description of the event and proposed corrective action plan. KMRL will report to all lenders accordingly. 5. KMRL to engage qualified and experienced third-party monitor to verify information produced through the Project monitoring process and facilitate the carrying out of any verification activities by such third-party monitor. 6. KMRL to report all lenders any actual or potential breach of compliance with the	Contractor / GC	KMRL

				measures and requirements set forth in the EMP promptly after becoming aware of the breach.		
16.	Community Liaison	Social	Complaints	1. To ensure that ongoing timely consultations / communications with communities are provided on the progress of the project together with feedbacks on the environmental management performance of the project. 2. Grievance Redress Mechanism for affected people should function effectively with grievance log well documented. 3. Contractor will provide a minimum of two (2) weeks notification to directly affected residents, businesses, and other relevant groups of the intended construction commencement date. In providing a mechanism for communication between the contractor and the community and informing the public of construction details (timing, expected impacts), KMRL will undertake consultations. 4. Adaptive management that monitors, adjusts, or adds measures to reflect actual community risks. 5. Important measures to reduce community risk, such as fence and related protection around work sites (including strength and visual protection), education and awareness signs and information, and placement of safety risks (explosive and flammable materials, generators).	Contractor	GC/ KMRL

17.	Truck and Driver Management	Environment Social	Community disruption Accidents Reputational risk	1. Contractor's transport vehicles and other equipment shall conform to emission standards. 2. Control, inspection, and documentation of trucks prior to leaving site, including removal of soil on tires. Contractor will provide a wash pit or a wheel washing and/or vehicle cleaning facility at the exits from 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. 3. Definition of allowable routes, speeds, and times (day or week). 4. Driver requirements and controls, including prework medical (and blood tests) and physical inspections, ongoing monitoring (of visual and alcohol or drug use), driver training, daily total allowable work time, and allowable deviations. 5. Driver contracts with clearly specified requirements and remedies for noncompliance. 6. Procedure for truck maintenance, including selection of service providers considering environmental aspects, application of low-Sulphur fuel, no idling of trucks, routine maintenance (including assurance of proper engine operations related to emissions and noise), and disposal of used oil and other fluids, batteries, and tires etc.	Contractor	GC/KMRL
18.	Mechanical piling and Pier Construction	Air	Construction of Piles Piers will result into fugitive dust generation	1. Fugitive dust could be controlled using water sprinkling. Water sprinkling to be carried out by Contract at regular interval. 2. Every vehicle should be washed to remove any dusty materials from its body and wheels before leaving the construction sites.	Contractor	GC/ KMRL

				3. Imposition of speed controls for vehicles on unpaved site roads. Ten kilometres per hour is the recommended limit.		
		Noise	Construction of Piles Piers will result into noise generation	1. At sensitive locations, auger piling will be carried out in place of mechanical (by driven) piling which will generate less noise than mechanical piling (around 70-75 dB(A)). Also, 2m high barricade of GI sheet will be installed on all sides of piling operations. This could effectively cut down noise levels by 10-15 dB (A). Piling operations will be restricted during daytime hours only. 2. Efforts should be made to keep the noise levels under control by appropriate noise attenuation and adopting employee safety measures. 3. Use of low-noise equipment and ensuring good maintenance and trying to avoid using high-noise equipment simultaneously at the same section. 4. Information dissemination to local residents and shop owners about the nature and duration of intended activities including the construction method, probable effects, quality control measures and precautions prior to commencement and kept updated as to changes in the management and mitigation plan. 5. Enclose especially noisy activities if above the noise limits and employ transportable noise screens between noise sources and identified noise sensitive areas for the duration of noisy construction activities.	Contractor	GC/ KMRL

				6. Monitoring required during construction, including field observations and measurements.		
		Vibration	Pile driving for viaduct pier and buildings vibrations	1. Cast-in-situ piling will be deployed at locations with sensitive receptors so as to reduce vibration. 2. At locations where the alignment is close to sensitive receptors, the contractor shall implement the pre- construction structural integrity inspections. 3. Contractor to ensure that vibration levels at historically and culturally sensitive Structures, and Structures in poor state condition will not exceed 5.0 mm/s. 4. Information dissemination to local residents and shop owners about the nature and duration of intended activities including the construction method, probable effects, quality control measures and precautions prior to commencement and kept updated as to changes in the management and mitigation plan. 5. Monitoring during construction including field observations and measurements.	Contractor	GC/ KMRL
		Waste	Soil and surface/ground water pollution	1. Segregation and storage of different types of waste in different containers, skips or stockpiles to enhance reuse or recycling of materials and their proper disposal. 2. Nomination of an approved person, such as a site manager, to be responsible for good site practices, arrangements for collection and effective disposal to an appropriate facility, of all wastes generated at the site.	Contractor	GC/ KMRL

		Physical Cultural Resources	Historic and Cultural Value Loss Conflicts with community	1. Before start of piling, Contractor and KMRL will coordinate with Kerala State Department of Archaeology to reconfirm that there is presence of buried artifacts along the metro line alignment. No piling will be allowed unless cleared by the Archaeological Department. 2. Archaeological monitoring during construction stage, including specialists in field with authority to stop work. 3. All workers will undergo a briefing with the Archaeology Department to ensure safeguarding of heritage resource and cultural/religious practices. 4. The project will implement, where required, chance finds procedure contained in ESS8 of WBG ESF. It includes requirement to notify relevant authorities; to fence-off the area of finds or sites to avoid further disturbance; to conduct an assessment of found objects or sites by cultural heritage experts; to identify and implement actions consistent with the requirements of this ESS and national law; and to train project personnel and project workers on chance find procedures.	Contractor	GC/ KMRL
19.	Excavation	Air	Excavation will result into fugitive dust generation.	1. Fugitive dust could be controlled using water sprinkling. Water sprinkling to be carried out by Contract at regular interval. 2. Imposition of speed controls for vehicles on unpaved site roads. Ten kilometres per hour is the recommended limit. 3. Every vehicle should be washed to remove any dusty materials from its body and wheels before leaving the construction sites. 4. Excavation machinery will be topped up by low-Sulphur fuel. 5. Water for sprinkling and tire washing will be	Contractor	GC/ KMRL

				sourced from treated effluent from ETPs located nearby or seawater or surface runoff; use of municipal treated water shall be minimized.		
		Noise and Vibration	Nuisance	1. Efforts should be made to keep the noise levels under control by appropriate noise attenuation and adopting employee safety measures. 2. Use of low-noise equipment and ensuring good maintenance and trying to avoid using high-noise equipment simultaneously at the same section. 3. Wherever baseline noise already exceeds the standards, only 3dB of noise increase is allowed. If baseline noise is below the CPCB and IFC-EHS standards, the construction noise has to meet these standards that is, construction noise level has to be less than level prescribed in these standards. 4. Information dissemination to residents and shop owners about the nature and duration of intended activities including the construction method, probable effects, quality control measures and precautions prior to commencement and kept updated as to changes in the management and mitigation plan. 5. Enclose especially noisy activities if above the noise limits and employ transportable noise screens between noise sources and identified noise sensitive areas for the duration of noisy construction activities. 6. Monitoring required during construction, including field observations and measurements. 7. Contractor to ensure that vibration levels at	Contractor	GC/ KMRL

				receptors comprising educational, medical, and physical cultural buildings and other fragile buildings located within recommended screening distance of 62m (for cat. 2) on either side of alignment will not exceed 5.0 mm/s.		
		Surface water	Dumping of construction waste like concrete, bricks, waste material etc. cause surface water pollution.	1. Proper drainage systems using contour information will be constructed around active and & large construction sites. The wastewater should be discharged after sedimentation in tanks. 2. To avoid water pollution and soil erosion due to flooding, earthwork will be limited during monsoon season.	Contractor	GC/ KMRL
		Groundwater	Dewatering (if done) will adversely affect the groundwater regime.	1. Dewatering due to piling will be small in quantity. It will be done only when required Groundwater will be collected in sedimentation tanks and reused in non-potable uses. 2. As it is likely to be contaminated with chemicals on construction sites this water after precipitation, will be discharged into public sewers; it will be treated by municipal agencies to Environment Protection Rules (EPR) 1986 Schedule VI standards of discharge of general effluents into surface water. 3. Groundwater monitoring, including groundwater quality and aquifer status.	Contractor	GC/ KMRL
		Soil	Excavation will adversely affect the soil.	4. Soil erosion by runoff will be controlled by installing proper drainage systems using contour information It is suggested to avoid bringing soil from outside the project boundary and to use the excavated mounds for filling low lying area where it is necessary. 5. The topsoil should be preserved (by storing it at appropriate places) so that same can be restored after completion of work.	Contractor	GC/ KMRL

		Physical Cultural Resources	Historic and Cultural Value Loss Conflicts with community	1. Before start of piling, Contractor and KMRL will coordinate with Kerala State Department of Archaeology to reconfirm that there is presence of buried artifacts along the metro line alignment. No piling will be allowed unless cleared by the Archaeological Department. 2. Archaeological monitoring during construction stage, including specialists in field with authority to stop work. 3. All workers will undergo a briefing with the Archaeology Department to ensure safeguarding of heritage resource and cultural/religious practices. 4. The project will implement, where required, chance finds procedure contained in ESS8 of WBG ESF. It includes requirement to notify relevant authorities; to fence-off the area of finds or sites to avoid further disturbance; to conduct an assessment of found objects or sites by cultural heritage experts; to identify and implement actions consistent with the requirements of this ESS and national law; and to train project personnel and project workers on chance find procedures.	Contractor	GC/ KMRL
		Health and Safety	Accidents	1. To specify the number and length of shifts for each worker. 2. Where a site boundary adjoins roads, streets, or other areas accessible to the public, hoarding should be provided along the entire length except for a site entrance or exit.	Contractor	GC/ KMRL
		Aesthetics	Loss of aesthetics value due to excavation and related activities.	1. The excavation sites will be barricaded on all sides using GI sheets. Hauling will be carried out in non-peak hours. 2. Aesthetic value of the site will be restored after completion of the works.	Contractor	GC/ KMRL

20.	Hauling of excavated material	Air	During transportation of excavated material, fugitive dust will be generated from two sources, (1) from re-suspension of dust from road surface, (2) from the movement of air, against the excavated material being hauled	1. The traffic management plan will be stringently implemented with regular monitoring and inspections. 2. The trucks/dumpers carrying the excavated material will be covered using tarpaulin/similar covering materials. 3. Sprinkling of water should be carried out. 4. Truck tires will be washed to excess remove soil clinging to it. Contractor will provide a wash pit or a wheel washing and/or vehicle cleaning facility at the exits from 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. Used water shall be collected, subject to precipitation and re-used. 5. Water for sprinkling and tire washing will be sourced from surface runoff, wastewater from construction sites, construction yards and seawater; use of municipal treated water shall be minimized. 6. Haul roads will be kept in good state of maintenance.	Contractor	GC/ KMRL/Traffic Police
		Noise	Dumper trucks carrying excavated material will result into high noise. The adverse impacts of noise will be most intense in the residential / urban areas.	1. The routing, timing and logistics of the haul truck movement should be planned to have minimal impacts on noise level. 2. The route selection will avoid any sensitive receptors. 3. Efforts should be made to keep the noise levels under control by appropriate noise attenuation and adopting employee safety measures. 4. Wherever baseline noise already exceeds the standards, only 3dB of noise increase is allowed. If baseline noise is below the CPCB and IFC-EHS standards, the construction noise has to meet these standards that is,	Contractor	GC/ KMRL

				construction noise level has to be less than level prescribed in these standards. 5. Information dissemination to local residents and shop owners about the nature and duration of intended activities including the construction method, probable effects, quality control measures and precautions prior to commencement and kept updated as to changes in the management and mitigation plan. 6. Enclose especially noisy activities if above the noise limits and employ transportable noise screens between noise sources and identified noise sensitive areas for the duration of noisy construction activities. 7. Monitoring required during construction, including field observations and measurements.		
		Social	Incessant movement of trucks could create social issues. This will have higher occurrences near depots.	1. The local community has to be taken into confidence before the construction commences. Their advice must be taken and incorporated in decision making. 2. Grievance Redress Mechanism for affected people should function effectively with grievance log well documented.	Contractor	GC/ KMRL
		Health & Safety	The movement of trucks will increase the traffic risk of the commuters.	The routing, timing and logistics of the haul truck movement should be planned to have minimal impact on occupational and community health and safety.	Contractor	GC/ KMRL
21.	Dumping of excavated materials	Air	The dumping operation of excavated material will generate fugitive dust in the nearby areas	1. Site of dumping shall be selected by contractor in consultation with KMRL and authorities. 2. The disposal plan will be stringently implemented with site monitoring and inspections.	Contractor / GC	KMRL

				3. It will be located outside of urban habitation. 4. Sprinkling of water should be carried out. Water shall be sourced from surface runoff, wastewater from construction sites, construction yards and seawater. Use of municipal treated water shall be minimized. Groundwater extraction shall be avoided.		
		Soil	Dumping may increase the height of the land and affect the natural drainage pattern of the area	1. The dumping will be done in pre-designated low-lying areas identified KPCB, and KMRL for this specific purpose. 2. The disposal plan will be stringently implemented with regular monitoring and inspections. 3. Field inspections, monitoring, and documentation of dumping excavated materials.	Contractor	GC/ KMRL
22.	Traffic diversion	Air	The under-construction areas will be restricted for human and vehicular movements. This will result in detouring of vehicles and/or pedestrians, on the project line which passes through busy urban areas. This may also result into traffic congestion and air pollution from stagnated vehicles in urban areas. Primary pollutants will be NOx, CO, NMHC, and VOCs.	1. Permission from Traffic Police will be sought before commencement of work. Detours will be properly planned and enacted during non-peak hours only, if possible. Traffic marshals will be posted near such detours. Proper signage must be posted informing motorists about detours following IRC norms. 2. Adaptive management with field inspections and monitoring during plan implementation and adjustments, as needed, to reflect actual traffic congestion or related issues. 3. The Contractor will discuss and coordinate the implementation of the traffic re-routing scheme particularly at station area when it starts the cut and cover activities and the hauling and disposal of excavated materials to the project sites.	Contractor	GC/ KMRL/ Traffic Police

		Noise	Barricading & detouring may result into traffic congestion in the urban areas. This will result into (a) noise from vehicular movement and (b) honking noise due to congestion.	1. Permission from Traffic police will be sought before commencement of work. Detours will be properly planned and enacted during non-peak hours only, if possible. Traffic marshals could be posted near busy intersections, to oversee the smooth flow of traffic. 2. Detour route selection to avoid sensitive receptors to noise. 3. Adaptive management with field inspections and monitoring during plan implementation and adjustments, as needed, to reflect actual traffic congestion or related issues.	Contractor	GC/ KMRL
		Social	Traffic diversion (especially. for public transport) will create inconvenience	1. Implement the traffic management plan. Plans will be made to spare traffic diversion during peak hours (morning and evening peaks). Also, separate arrangements for bus, auto and taxi parking bays will be made. Street furniture for pedestrians will be provided wherever possible. 2. Real-time communication to public prior to site-specific work (for example, via signs, radio, and newspaper) and during key periods of traffic interference or peak traffic. 3. Adaptive management with field inspections and monitoring during plan implementation and adjustments, as needed, to reflect actual traffic congestion or related issues.	Contractor	GC/ KMRL
		Resource consumption	Detouring will increase the road length to be travelled by a car, thus, increasing the overall fuel consumption.	The detour will be planned to be optimum in terms of road length. The faster completion of works will also tend to reduce enhanced fuel consumption.	Contractor	GC/ KMRL

23.	Restricted pedestrian movement	Social	Restricted pedestrian movement will cause social uproar, esp. in people living near metro stations	1. Safe passage for pedestrians with proper sunshade / fall protection and signage will be planned. Public consensus will be built. Representatives of non-governmental organization and volunteers from local communities at respective sections of the project shall be invited to participate in meetings with KMRL, GC, and Traffic Police where joint decision on diversion measures will be arrived at. 2. Grievance Redress Mechanism for affected people should function effectively with grievance log well documented.	Contractor	GC/ KMRL
		Health & Safety	Movement though constricted space may cause potential health & safety issues amongst pedestrians	1. Safe passage for pedestrians with proper fall protection and signage will be planned.	Contractor	GC/ KMRL
24.	Muck generation & disposal	Surface water	Muck generated from drilling operations will drain with surface runoff and pollute nearby water bodies	1. Muck disposal plan will be stringently implemented with regular monitoring and inspections. 2. The construction sites will be provided with garland drains with intercepting pits to trap silt & muck. 3. Muck will be stored in lined tanks / ponds (if such area is available). Or mechanically dewatered if such area is unavailable. After screening & detention, supernatant liquid from such tanks should be discharged into drainage lines adhering to CPCB standards. Such tank/ ponds could be covered during monsoon to control runoff. 4. The temporary muck storage areas will be maintained by the Contractor at all times until the excavate is re-utilized for backfilling	Contractor	GC/ KMRL

				or disposed of as directed by Employer. Dust control activities will continue even during any work stoppage. 5. Transportation of muck will be scheduled by time and route to minimize air pollution in habitat areas.		
		Groundwater	Muck & drill fluids may settle down from pond / tanks and will affect groundwater	The tanks/ ponds holding muck will be lined to prevent infiltration into groundwater. It will be passed through precipitation chambers and discharged into public sewers; it will be treated by municipal agencies to EPR 1986 standards of discharge of general effluents into surface wate Groundwater quality monitoring.	Contractor	GC/ KMRL
		Aesthetics	Muck generation will create an aesthetic issue	The construction site will be covered from all sides to reduce visual impacts.	Contractor	GC/ KMRL
25.	Steel structure preparation	Soil	Steel structure preparation will create steel scraps	Steel scrap will be collected, sorted by diameter, and sold to scrap dealers on alter date.	Contractor	GC/ KMRL
		Health & safety	Bar bending & other activities (inc. working at heights) might pose a H&S threat to workers	1. Workers will be provided appropriate hand gloves and personal protective equipment (PPE). 2. Skilled workers working at height or doing hot work will be required to seek permission from site	Contractor	GC/ KMRL

26.	Stacking & warehousing of raw material	Surface water	Washed out raw material could pose serious threat to surface water bodies	Small dikes and garlanding drains along the periphery of the yard and ploy boundary could be constructed. This will control runoff and washing out of finer material.	Contractor	GC/ KMRL
		Soil	Spillage of materials / mix products on the ground could pollute soil	Proper care will be taken. Such spills will be cleared by scraping and disposing the products as road sub-grade material.	Contractor	GC/ KMRL
		Health & Safety	Fine products like cement/ silt/ sand could cause harm to respiratory system.	Cement and sand will be stacked under tarpaulin and secured by GI sheet barricading (working & wind break). Shorter work shift and daily medical check-ups of workers will be implemented. Dust filters atop cement silos, wet suppression for aggregate crushing and screening will be employed.	Contractor	GC/ KMRL
		Aesthetics	Stacking of raw material will cause aesthetic issues for residential areas located nearby	The height of walls between the residential area and RM yard / construction area will be raised using GI sheets.	Contractor	GC/ KMRL
27.	RCC pouring (using concrete pump)	Noise	RCC pouring using concrete pump will generate low frequency rumbling noise. This will be more perceived and irritating in residential areas.	1. RCC pumps will be covered from all sides. 2. Bends and excessive head will be avoided. 3. Wherever baseline noise already exceeds the standards, only 3dB of noise increase is allowed. If baseline noise is below the CPCB and IFC-EHS standards, the construction noise has to meet these standards that is, construction noise level has to be less than level prescribed in these standards.	Contractor	GC/ KMRL

		Soil	Spillage from concrete pouring may contaminate soil	The spoils from pouring concrete will be collected and reused as sub-grade material in road construction.	Contractor	GC/ KMRL
		Aesthetics	Spoils from concrete pouring will create unpleasant looking visuals	After each pouring cycle, the spoils will be manually collected and reused as sub-grade material in road construction.	Contractor	GC/ KMRL
28.	Setting of concrete (using needle vibrator)	Noise	Needle vibrators generate low frequency noise when dipped in concrete and high frequency noise when raised. Sound level vary between 82-93 dB (A).	1. If the consistency of concrete could be altered, the need for use of vibrator (esp. in low temperature & low thickness casting) could be reduced. Damping could be used to reduce high frequency noise, and thereby reducing the noise levels. Workers should be provided with suitable PPEs. 2. Wherever baseline noise already exceeds the standards, only 3dB of noise increase is allowed per IFC/WB guideline. If baseline noise is below the CPCB and IFC- EHS standards, the construction noise has to meet these standards that is, construction noise level has to be less than level prescribed in these standards.	Contractor	GC/ KMRL
		Soil	During setting, spillage from cast could take place.	The spoils from pouring concrete will be collected and reused as sub-grade material in road construction.	Contractor	GC/ KMRL

29.	Curing of concrete (use of water)	Surface water	Curing water will drain to the low lying areas and pollute water courses	1. Garland drainage is proposed to be constructed around the construction yard. This will intercept the runoff generated from site. Rainwater harvesting (as a compensatory measure) will be practiced. Curing needs will be met from municipal supply, water resulting from dewatering during piling and surface runoff water. 2. After precipitation it shall be discharged into public sewers; it will be treated by municipal agencies to EPR 1986 standards of discharge of general effluents into surface water.	Contractor	GC/ KMRL
		Groundwater	Curing water will drain to the low lying areas and pollute water courses	In view of low groundwater levels risk of saline water ingress due to proximity of seacoast, use of groundwater will not be resorted to.	Contractor	GC/ KMRL
		Aesthetics	Curing will create water impounding and may lead to vector propagation	Garlanding drain will be constructed around the construction area. The curing water impounded will be reused for curing.	Contractor	GC/ KMRL
30.	Construction of labour camp(s) and associated environmental issues	Surface water	Sewage from labour camps may be discharged into open slopes thus contaminating surface water	Labour camps will be constructed in semi urban / urban set-ups. It shall be discharged into public sewers; it will be treated by municipal agencies to EPR 1986 standards of discharge of general effluents into surface water.	Contractor	GC/ KMRL
		Groundwater	Surface water on flat terrain could percolate and contaminate groundwater.	1. Contractor to collect the groundwater baseline date prior to construction. 2. Disposal in compliance with applicable regulatory requirements. 3. Groundwater quality monitoring.as per EMoP 4. Water abstracted must be measured/ recorded periodically.	Contractor	GC/ KMRL

				5. After Construction, Contractor will conduct groundwater analysis and be obliged to reinstate the used sites no worse than the conditions of pre-construction.		
		Soil	Solid waste generated from the labour camps will cause soil pollution	1. Contractor to collect the soil baseline date prior to construction. 2. Municipal solid waste will be collected and taken away and disposed by municipality. 3. Solid waste will have to be disposed in compliance with Municipal Solid Waste (Management & Handling) Rules, 2000, as amended to date. 4. After Construction, Contractor will conduct soil analysis and be obliged to reinstate the used sites no worse than the conditions of pre-construction.	Contractor	GC/ KMRL
		Social	Influx of non-local labours will create a social issue	1. Mixing of skilled non-local labours with local unskilled people will reduce social frictions. 2. To avoid labor influx risk, sensitizing of local community and the non-local workers separately as well as jointly will be done regularly.	Contractor	GC/ KMRL
		Health & safety	Living in congested condition, make-shift temporary arrangement; the labours are prone to diseases.	1. Regular counselling, medical check-ups and treatment at separate clinics, coordination with local health authorities will be conducted. 2. Per Building & Other Construction Workers (BOCW Regulation of Employment and Conditions of Service) Act, 1996 the employer (contractor) is liable to arrange for sanitation, health care facilities of labours, free of charge. Labour camps will be in full compliance of BOCW Act.	Contractor	GC/ KMRL

		Resources	Labours will consume resources like wood for cooking	1. Liquid petroleum Gas cylinders will be made available free of cost to the labourers by the Contractor. 2. Labour camps are provided with canteen systems. They shall be provided with treated water for drinking, bathing and other needs.	Contractor	GC/ KMRL
31.	Loading/unloading of construction material	Air	Loading & unloading of construction material will generate fugitive dust	1. The traffic management plan will be stringently implemented with regular monitoring and inspections. 2. The trucks/dumpers carrying the material will be covered using tarpaulin/similar covering materials. 3. Fugitive dust could be controlled using water sprinkling. Contractors should carry out water sprinkling. 4. Truck tires will be washed to excess remove soil clinging to it. Contractor will provide a wash pit or a wheel washing and/or vehicle cleaning facility at the exits from 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. Used water shall be collected, subject to precipitation and re-used. 5. Water for sprinkling and tire washing will be sourced from surface runoff, wastewater from construction sites, construction yards and seawater.	Contractor	GC/ KMRL
		Noise	Loading & unloading of construction material will generate noise	1. The RM storage yard will be separately built and enclosed from all sides. This will reduce noise generation at site. 2. Concrete preparation will only take place in casting yards (away from habitation). 3. If baseline noise is below the CPCB and IFC-EHS standards, the construction noise has to meet these standards that is, construction noise level has to be less than level prescribed in these	Contractor	GC/ KMRL

				standards. 4. Information dissemination to local residents and shop owners about the nature and duration of intended activities including the construction method, probable effects, quality control measures and precautions prior to commencement and kept updated as to changes in the management and mitigation plan. 5. Enclose especially noisy activities if above the noise limits and employ transportable noise screens between noise sources and identified noise sensitive areas for the duration of noisy construction activities.		
		Health & safety	Fugitive dust and noise generation will have potential health & Safety implications.	1. Cement and sand will be stacked under tarpaulin and secured by GI sheet barricading (working & wind break). Shorter work shifts and regular health check-ups will be implemented. The RM storage yard will be separately built and enclosed from all sides. The worker will be provided with suitable PPEs. Also they will be trained and encouraged in using PPEs.	Contractor	GC/ KMRL
32.	Use of batching plant	Air	Loading & unloading of construction material into batching plant will generate fugitive dust	1. High GI sheet screens and water sprinkling will be employed. 2. Batching plant / casting yard shall be barricaded and made as a compulsory PPE zone. This will effectively reduce the fugitive dust generation.	Contractor	GC/ KMRL
		Noise	Operation of batching plant will generate noise	1. GI sheet barricading around batching area and worker PPE like earmuffs will be used. 2. Batching plant / casting yard shall be barricaded and made as a compulsory PPE zone. This will reduce the impacts of noise generation. 3. If baseline noise is below the CPCB and IFC-EHS standards, the construction noise has to	Contractor	GC/ KMRL

				meet these standards that is, construction noise level has to be less than level prescribed in these standards.		
		Soil and Groundwater	Runoff of waste can contaminate soil and groundwater	1. Contractor to collect baseline soil and groundwater quality data prior to operate the plants. 2. Municipal water will be used. In view of fragile groundwater status, extraction will be avoided. 3. The construction sites will be provided with drains with intercepting pits in which the cement and sand will settle. After screening & detention, liquid will be discharged into drainage lines. Disposal in compliance with applicable regulatory requirements. After precipitation, it shall be discharged into public sewers; it will be treated by municipal agencies to EPR 1986 standards of discharge of general effluents into surface water. 4. Soil and Groundwater quality monitoring. 5. After Construction, Contractor will conduct soil and groundwater analysis and be obliged to reinstate the used sites no worse than the conditions of pre- construction.	Contractor	GC/ KMRL
		Hazardous waste	Health impacts and soil and groundwater pollution from hazardous water at batching/casting yards	1. The use and storage of hazardous materials at the casting yard and batching plant should adhere to SPCB requirements. 2. The transport, handling and storage of hazardous waste will be done in accordance with the provisions of Hazardous Chemicals (Management & Handling) Rules. Hazardous wastes from construction activity and equipment are labelled, recorded, stored in	Contractor	GC/ KMRL

				impermeable containment and for periods not exceeding mandated periods and, in a manner, suitable for handling storage and transport. 3. The contractor shall maintain a record of sale, transfer, storage of hazardous waste and make these records available for inspection. 4. The contractor shall get Authorized Recyclers to transport and dispose Hazardous Waste. 5. Proper collection and storage facilities will be provided especially for hazardous waste.		
		Resources	If the batching plant will get its power from DG sets, substantial diesel will be consumed.	1. If power from the grid is used, permission from power supply company must be obtained by the Contractor. 2. DG sets, if used, should: (a) conform to height of stack norms as per CPCB rules; (b) conform to emission norms as per E (P) Act, 1986; (c) noise level at 1 m distance from enclosure should not be >75 dB(A). 3. The required permissions from local Environmental Authorities/Pollution Control Board/ or any other relevant Authority shall be obtained by the Contractor for using DG sets for power supply. 4. Diesel storage if done beyond threshold limit (1000 L) permission should be obtained. Diesel should be stored on pukka platforms and spillages should be avoided.	Contractor	GC/ KMRL
33.	Casting of segments	Groundwater	Casting will require use of water	1. Kerala Metropolitan Water Supply and Sewerage Board/ Municipal water will be used. In view of fragile groundwater status, extraction will be avoided. 2. The construction sites will be provided with drains with intercepting pits in which the	Contractor	GC/ KMRL

				cement and sand will settle. After screening & detention, liquid will be discharged into drainage lines. Disposal in compliance with applicable regulatory requirements. After precipitation, it shall be discharged into public sewers; it will be treated by municipal agencies to EPR 1986 standards of discharge of general effluents into surface water.		
		Resources	Casting (incl. operation of gantry and hydraulic pre-stressing units) will consume lot of energy	1. Pre-stressing and casting are basic requirements. However, most of the power should be drawn from approved lines, not from DG sets.	Contractor	GC/ KMRL
34.	Curing of segments	Groundwater	Curing will require a significant amount of water	2. Garland drainage is proposed to be constructed around the construction yard. This will intercept the runoff generated from site. Stagnation of water (and resultant vector propagation) should be avoided. 3. Groundwater quality monitoring. 4. After precipitation, it shall be discharged into public sewers; it will be treated by municipal agencies to EPR 1986 standards of discharge of general effluents into surface water. 5. Groundwater will not be used. Water will be sourced from municipal supply, surface runoff or dewater.	Contractor	GC/ KMRL
35.	Hauling of segments to site	Air	During transportation of segments, fugitive dust will be generated from re-suspension of dust from road surface. Plus, there will be air emission from trucks	1. The traffic management plan will be stringently implemented with regular monitoring and inspections. 2. The trucks/dumpers carrying the excavated material will be covered using tarpaulin/similar covering materials. 3. Sprinkling of water should be carried out. 4. Truck tires will be washed to excess remove soil clinging to it. Contractor will provide a wash pit or a wheel washing and/or vehicle cleaning facility at the exits from construction	Contractor	GC/ KMRL

				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. Used water shall be collected, subject to precipitation and re-used. 5. Water for sprinkling and tire washing will be sourced from surface runoff, wastewater from construction sites, construction yards and seawater.		
		Noise	Trucks carrying segments will result into high noise. The adverse impacts of noise will be most intense in the residential/urban areas.	1. The routing, timing and logistics of the haul truck movement should be planned to have minimal impacts on noise level. The route selection will avoid any sensitive receptors. 2. Efforts should be made to keep the noise levels under control by appropriate noise attenuation and adopting employee safety measures. 3. If baseline noise is below the CPCB and IFC-EHS standards, the construction noise has to meet these standards that is, construction noise level has to be less than level prescribed in these standards. 4. Information dissemination to local residents and shop owners about the nature and duration of intended activities including the construction method, probable effects, quality control measures and precautions prior to commencement and kept updated as to changes in the management and mitigation plan. 5. Enclose especially noisy activities if above the noise limits and employ transportable noise screens between noise sources and identified noise sensitive areas for the duration of noisy construction activities. 6. Monitoring required during construction, including field observations and measurements.	Contractor	GC/ KMRL

		Social	Incessant movement of trucks could create social issues	The local community has to be taken into confidence. Their advice has to be taken and incorporated in decision making.	Contractor	GC/ KMRL
		Health & safety	The movement of trucks will increase the traffic risk of the commuters	The routing, timing and logistics of the haul truck movement will be planned to have minimal impacts on occupational and community health and safety.	Contractor	GC/ KMRL
		Aesthetics	Movement of trucks will create an aesthetic problem	Proper housekeeping activities must be undertaken near the casting yard and nearby areas.	Contractor	GC/ KMRL
36.	Use of DG sets	Air	Emission of NOx, SOx, CO, PM10, PM2.5 from DG sets will create air pollution problems	1. Primary power source will be power distribution company, DG sets will be used only for power back-ups for stations. 2. The required permissions from local Environmental Authorities/Pollution Control Board/ or any other relevant Authority shall be obtained by the Contractor if using DG sets for power supply. DG sets compliant with CPCB norms will be used. Specification no. GSR 520(E) dt. 1-7-2003 for DG sets rating < 800 KW, and GSR 489(E) dt. 09-07-2002 for DG sets > 800 KW under E (P) Rules, 1986. 3. Stack height of DG sets will be as per CPCB requirement [stack ht. = 0.2*(rating in kVA)0.5] 4. Stack monitoring will be conducted monthly of the criteria pollutants. 5. Compliance monitoring will be done to the regularly and check the monitoring instruments. 6. Fuels used for DG will be High Speed Diesel with low- sulphur content.	Contractor	GC/ KMRL
		Noise & Vibration	Noise & vibration will be generated from the use of DG sets	1. DG sets compliant with CPCB norms will be used. 2. If baseline noise is below the CPCB and IFC-EHS standards, the construction noise has to meet these standards that is, construction noise level has to be less than level prescribed in these standards.	Contractor	GC/ KMRL

				3. Monitoring required during construction, including field observations and measurements. 4. Noise will be controlled using acoustic enclosure. 5. The DG sets will be mounted on damping skids, which will reduce the vibration generated from DG sets.		
		Resources	DG sets will consume Diesel	DG sets should always be use as a power back up, and not the primary sources of power. This should be made mandatory for all Contractors.	Contractor	GC/ KMRL
		Aesthetics	Operation of DG sets will cause an aesthetic issue	1. Enclosures will be used to keep them off from public views. 2. PM content of DG sets smoke will be as per the CPCB norms; thus the DG will emit dark smokes only during start-up & shut-down (b) Noise will be controlled using acoustic enclosure.	Contractor	GC/ KMRL
37.	All Construction Activities	Environment	Construction and Demolition (C&D) waste results from land clearing, excavation, construction, demolition, remodelling and repair of structures, roads and utilities.	1. Records of movement and loading/unloading of C&D waste and records of waste loaded by vendors. 2. C&D waste will be reused/recycled as it has the potential to save natural resources (stone, river sand, soil etc.) and energy. C&D waste generated from metro construction has potential use after processing and grading. 3. The contractor will segregate and temporarily store the C&D waste till the vendor takes it away for recycling and disposal at authorized facilities. 4. Contractor will adhere with the C&D Waste Management Rules.	Contractor	GC/ KMRL

		Occupational Health and Safety	Accidents All parties' reputation	1. Worker safety is important on all construction projects. It is important to consider the effects of staffing on worker safety and to provide appropriate training in safety awareness for all labor. 2. The use of hearing protection should be enforced actively when the equivalent sound level over 8 hours reaches 85 dB(A), the peak sound levels reach 140 dB(C), or the average maximum sound level reaches 110dB(A). Hearing protective devices provided should be capable of reducing sound levels at the ear to at least 85 dB(A).	Contractor	GC/ KMRL
38.	Storage of Diesel	Groundwater	Diesel spillage (from underground or above ground storage facility) will affect groundwater quality adversely	1. Before it percolates into the groundwater, contaminated runoff water can be run through adsorbents such as bentonite to remove the diesel. The diesel will be quickly collected into steel trays and disposed to authorized recyclers. 2. All bulk diesel tanks shall be properly supported in an elevated position to facilitate gravity discharge. They shall stand within a bund constructed to contain a volume of110% of the volume of the tank. There shall be no breaches in the bund wall, no material shall be stored within the bund and rainwater collecting in the bund shall be regularly removed to prevent build-up. 3. Spillage will be controlled using methods mentioned in the environmental contingency plan. 4. Groundwater quality monitoring.	Contractor	GC/ KMRL
		Health & safety	Storage of Diesel will attract the provisions of Hazardous Chemicals (Management & Handling) Rules and Petroleum Rules; as amended to date. It could cause serious damage to health & safety of workers /	1. Proper onsite emergency plan will be prepared and will be approved through KMRL. 2. If the diesel storage crosses the threshold limits permissions, proper fire protection norms have to be undertaken as per National Building Code, 2005 (if building)/ Oil Industry Safety Directorate Standard 117 (if installation).	Contractor	GC/ KMRL

			property if ignited			
39.	Cleanup Operations, Restoration, and Rehabilitation	Environment	Aesthetics	1. The clean-up and restoration operations are to be implemented by the Contractor prior to demobilization. 2. All spaces excavated and not occupied by the foundation or other permanent works shall be refilled with earth up to surface of surrounding ground.	Contractor	GC/ KMRL
Operational Phase						
40.	Operation of metro trains	Noise and Vibration	The most significant source of noise will be rolling noise from contact between wheel and rail including noise from contact between the brake pad and wheel, followed by engine noise and aerodynamic noise.	1. To minimize operation stage impacts measures such as Ballast less track structure is supported on two layers of rubber pads to reduce noise and vibrations. In addition, baffle wall as parapets will be constructed up to the rail level so as reduce sound levels. Noise at source will be controlled or reduced by incorporating suitable feature in the design of structures and layout of machines and by use of resilient mounting and dampers etc. 2. Since the rakes will be air conditioned and enclosed from all side, the impacts of noise on the travelers will be nominal. 3. Noise barriers will be installed at locations based on final design noise prediction analysis. 4. Wherever baseline noise already exceeds the standards, only 3dB of noise increase is allowed. If baseline noise is below the CPCB and IFC-EHS standards, the operation noise has to meet these standards that is, noise level has to be less than level prescribed in these standards. 5. The mitigations suggested based on the detailed noise and vibration analysis, should be strictly followed.	KMRL	KMRL

		Aesthetics	Metro rail will increase the aesthetics of KMRL.	A proper housekeeping routine will be followed to enhance the aesthetics of metro rail station.	KMRL	KMRL
		Health and Safety	Accidents Reputational risks	1. Detailed specification of equipment e.g., power cables, rectifiers, transformer, E&M equipment etc. shall be framed to reduce conducted or radiated emissions as per appropriate international standards. 2. The Metro system as a complete vehicle (trains, signaling & telecommunication, traction power supply, E&M system etc.) shall comply with the Electromagnetic compatibility (EMC) requirements of international standards viz. EN50121-3-1, EN50123, IEC61000 series etc. EMC requirements of international standards for whole railway system to the outside world shall comply with EN50121-2. 3. A standby silent type of DG set of adequate capacity will sustain the following: essential lighting, signaling, and telecommunications, fire-fighting system and lift operation. 4. Automatic Train Protection and Automatic Train Supervision sub-systems will be installed to provide a high level of safety. 5. CCTV system will be installed for local and centralized monitor of operation. 6. In view of the potential hazards from system failure resulting to accidents, both on- site and off-site emergency measures will be implemented. All trains will have public address systems to warn the passengers of any emergency. 7. Emergency team, ambulance, contact number and hospital should be available. Emergency response plan should be implemented during operation periods.	KMRL	KMRL

			Operating Personnel Health risks	1. Operating staff such as drivers and Control Centre staff shall be administered regular medical check-ups. 2. Well-designed workstations, lighting in Control Centre. 3. Emotional resilience training, counselling for recovery and rehabilitation.	KMRL	KMRL
			Severely contagious diseases such as COVID-19 can impact health of staff thereby affecting operations; can cause economic loss to the country and loss of reputation to the project.	Kochi Metro COVID-19 SOP shall be implemented; staff shall be trained; staff and commuters shall be informed of precautions such as social distancing, sanitizing; arrangements for stationary and hand-held thermal scanners; provision of sanitizer pedestals, vending machines of face masks and gloves etc. shall be provided in stations; site record of COVID-19 hospitals; daily disinfection of operating rooms, circulation spaces, equipment and vehicles; protected ambulances at stations.	KMRL	KMRL
41.	Track repair	Environment	Spill accidents	KMRL to ensure no illegal disposal of solid waste or wastewater.	KMRL	KMRL
42.	Use of DG sets	Air	Emission from DG sets will create air pollution problems	DG sets compliant with CPCB norms will be used.	KMRL	KMRL
		Noise	Noise & vibration will be generated from the use of DG sets	1. DG sets compliant with CPCB norms will be used. Monitoring of air quality shall be done as per CPCB norms. 2. Noise enclosures will be used. 3. Wherever baseline noise already exceeds the standards, only 3dB of noise increase is allowed. If baseline noise is below the CPCB and IFC-EHS standards, the operation noise has to meet these standards that is, noise level	KMRL	KMRL

				has to be less than level prescribed in these standards.		
		Groundwater	Diesel spillage (from underground or above ground storage facility) will affect groundwater quality adversely	1. Diesel should be stored in designated sites prior to final relocation. 2. Oil that is mixed in water will be removed in the ETP.	KMRL	KMRL
		Health & safety	Storage of Diesel will attract the provisions of Hazardous Chemicals (Management & Handling) Rules and Petroleum Rules; as amended to date. It could cause serious damage to health & safety of workers / property if ignited	1. Diesel should be stored in designated sites prior to final disposal. 2. Fire fighter is equipped at storage site. 3. Proper onsite emergency plan will be prepared by GC and will be approved through KMRL.	KMRL	KMRL
		Aesthetics	Operation of DG sets will cause an aesthetic issue	1. Enclosures will be used.	GC/ KMRL	KMRL
		Resources	DG sets will consume Diesel (and in effect reduce the levels of a non-renewable resource)	1. DG sets compliant with CPCB norms will be used only as backup.	KMRL	KMRL

43.	Development of feeder routes	Social	Along with Metro routes, metro feeder routes will be developed. This will have a positive impact in terms of enhanced connectivity and inclusion in the social mainstream	1. KMRL will work with bus operators to implement metro feeder routes along major arterial and sub-arterial routes to reduce travel time to the nearest station. Better quality coaches & comfortable rides should be planned to enhance acceptability.	GoK	GoK
		Aesthetics	Better designed coaches will enhance ride pleasure and aesthetics	1. The buses coaches should be properly maintained from time to time in order to enhance the aesthetic value.	GoK	GoK
		Health & safety	Better & frequent transport system will reduce risk of traffic accidents	The new feeder routes should (a) follow proper timetable b) should have frequent services during the morning & evening peak;(c) should have a limited carrying capacity. The feeder buses should arrive and depart from designated bus bays or similar structures. Proper arrangements for road crossing should be established. The appointed personnel should assist passengers to reach their destinations. An easily accessible grievance redressal system should be established by KMRL.	GoK	GoK
44.	Generation of employment	Social	The proposed project will result into generation of employment	The project will cause direct and indirect employment generation. Economic activity will be stimulated by easier movement of passengers thus leading to indirect employment generation.	GoK	GoK
45.	Ancillary development along metro route	Social	Ancillary development along the metro alignment will have positive effect on the social environment	There should be positive participation of the common people in the ancillary development process. An open, transparent & people-centric outlook has to be adopted.	GC/ KMRL	GoK

		Land	Ancillary developments will take place along with metro corridor	Provision for increased density of development along project corridor is available through existing byelaws as well as new ToD norms. Mixed land use of ToD tends to reduce non-work trip length and its higher density promotes increased use of metro for work trips on long distances.	GoK	GoK

Table 9.3: Environmental Monitoring Plan

Environmental Features	Aspect to be Monitored	Standard to be complied with	Time and Frequency of Monitoring	Location
Pre-Construction stage (By Contractor)				
Air	Emission of dust and particulate matter as PM2.5 and PM10, NOx and SOx, CO	GoI and WHO/IFC which ever stringent	Once, 24 hours continuously (13 locations)	Each station, batching plant and casting yard, Muck disposal site
Water (Surface and Ground)	DO, Turbidity, Conductivity, pH, Heavy metals, E. Coli, TSS, Oil and Grease, VOCs and Volatile Chlorinated Hydrocarbons (groundwater only) and TDS	GoI and WHO/IFC which ever stringent	Once, (6 locations for GW 3 locations for SW)	Groundwater at batching plant and casting yard, Muck disposal site and construction camps Surface water at wherever waterbody located within 100m from sites
Soil	pH, Sulphate (SO3), Chloride, ORP, water Soluble salts EC, Organic Matter (Oil), Heavy metals, Poly-Aromatic Hydrocarbons (PAH), Moisture Content	GoI and WHO/IFC which ever stringent	Once, (6 locations)	At batching plant and casting yard, Muck disposal site, construction camps and excavation sites

Noise & vibration	Noise levels in dB(A) Vibration PPV mm/s	GoI and WHO/IFC which ever stringent Federal Transit Administration (FTA) Guideline Standards or any other internally recognized standards	Once, Hourly basis for 24 hours (13 locations)	Each station (near sensitive receptors), batching plant and casting yard
Biodiversity	Number of nests, breeding sites population size for target species confirmed by Forest Department, Fisheries Department, GoK. If any of above found during site clearance, they will be transferred to a safe place as guided by the biodiversity expert and KFD/Wildlife/Fisheries.	GoI and IFC EHS Guideline and Guidance Note 6 or any internationally recognized guidelines which ever stringent	Once, prior to site clearance	Ecologically sensitive locations
Construction Stage				
Air	Emission of dust and particulate matter as PM2.5 and PM10, NOx and SOx, CO	GoI and WHO/IFC which ever stringent	24 hours continuously every month (no. of location varies as per the construction work progress)	For active construction site until civil works completed, batching plant and casting yard, Muck disposal site throughout
Water (Surface and Ground)	DO, Turbidity, Conductivity, pH, Heavy metals, TN, TP, E.Coli, TSS, Oil and Grease, VOCs (groundwater only) and TDS	GoI and WHO/IFC which ever stringent	Quarterly (6 locations for GW 3 locations for SW)	Groundwater at batching plant and casting yard, Muck disposal site, construction camps throughout construction phase, and excavation sites stations until civil works completed.

				Surface water at wherever waterbody located within 100 m from sites.
Soil	PH, Sulphate (SO3), Chloride, ORP, water Soluble salts EC, Organic Matter (Oil), Heavy metals, PAH, Moisture Content	GoI and WHO/IFC which ever stringent	Quarterly (6 locations)	At batching plant and casting yard, Muck disposal site, construction camps throughout construction phase and excavation sites.
a) Noise, b) Vibration c) Building Condition Survey	a) Noise levels in dB(A) b) Vibration PPV mm/s	GoI and WHO/IFC whichever stringent Federal Transit Administration (FTA) Guideline Standards or any other internally recognized standards	a) Monthly or when complaint is received. Hourly basis for 24 hrs (noise) b) Continuous monitoring during piling (vibration) (no. of location varies as per the construction work progress)	For active construction site until civil works completed, batching plant and casting yard
Occupational and Community Health and Safety	As specified in project ESHS plan prepared by Contractor	IFC General and Sector EHS Guidelines or any other international recognized guidelines, WHO and GoI guidelines on COVID-19	Weekly	Project Site
Operation Stage				

Air	Emission from DG sets (SPM, NOx and SOx), Odor	GoI and WHO/IFC whichever stringent	At least 2 times in a year for the first year, annually for another 2 years	DG sets of all stations
Groundwater	DO, Turbidity, Conductivity, pH, Heavy metals, TP, TN, E. Coli, TSS, Oil and Grease, VOCs and TDS	GoI and WHO/IFC whichever stringent	At least 2 times in a year for the first year, annually for another 2 years	Groundwater at Station locations
Noise	Noise levels in dB(A)	GoI and WHO/IFC whichever stringent	At least 2 times in a year for the first year, annually for another 2 years	Alignment, Stations
Vibration	PPV mm/s	Federal Transit Administration (FTA) Guideline Standards or any other internally recognized standards	At least 2 times in a year for the first year, annually for another 2 years	At key structure locations
Occupational Health and Safety	As specified in project EMP and SHE Manual	IFC General and Sector EHS Guidelines or any other international recognized guidelines	Monthly for 3 years	Stations

9.4 Training and Capacity Building Program

A training program is being proposed for environmental, health, and safety officials from KMRL, GC, and contractors, specifically focusing on the monitoring and reporting requirements outlined by AIIB. External monitors will facilitate training and capacity-building activities, and a designated budget has been allocated within the EMP to support these initiatives.

9.5 Environment Management Budget

The costs involved in Environmental mitigation, management, and monitoring on the account of present corridor of Kochi Metro is presented in Table 9.4.

Table 9.4 Cost of EMP and EMoP Implementation

Items	Cost INR (in millions)
Compensatory Afforestation	4.14
Noise Barrier along the corridor	45
Dust Suppression measures	3.6
Air, Noise, vibration, soil and Water quality monitoring	37.85
Ecological Monitoring	6.90
Environmental Division	38.57
Training	5.15
Total	**141.21**

10 CONCLUSION AND RECOMMENDATION

The Beijing headquartered Asian Infrastructure and Investment Bank has agreed to provide financial assistance to KMRL to support the execution of the project expansion works (Phase II). As per AIIBs requirement, an environmental due diligence has been conducted for the project. The Kochi Metro project has been classified as category 'A' as per the AIIB's project categorization.

The due diligence study conducted for the Kochi Metro Phase II project presents a comprehensive assessment of the environmental, social, and climate-related aspects associated with the proposed expansion. The project, aimed at enhancing urban connectivity and public transportation, has undergone thorough study in alignment with the requirements set by the Asian Infrastructure Investment Bank (AIIB).

The DPR for the phase-II corridor from JLN to Info Park of 11.2 km was carried out initially by M/S Rites Ltd in 2016. KMRL has approached the Urban Mass transit Company Ltd. (UMTC) to modify and update the Detailed Project Report of JLN to Info Park metro rail corridor under Phase II of Kochi Metro prepared by M/S RITES Ltd and the revised report was submitted in 2018. Environment impact assessment was carried out for the Phase II of Kochi metro Rail, i.e., from JLN Station to Info Park in the year 2019 forms the basis for the project's environmental considerations. The due diligence study identified gaps and discrepancies in the EIA, leading to a more detailed analysis during the Due Diligence stage.

- The EIA report covers the laws, regulations, policies, and guidelines which are applicable as well not applicable for the project. As per provisions of the Environmental Impact Assessment (EIA) Notification 2006 and its subsequent amendments by the Ministry of Environment, Forests and Climate Change (MoEF&CC), Metro Rail Projects are exempted from requirements of Environmental Clearance. For the MDB's requirement, the EIA report is in context with the WB operational policies, the due diligence study demonstrates alignment of the project safeguards with the requirements of AIIB.

- The baseline data collection for the Air, Water, Noise and Soil was done in June 2019 during the EIA stage, comprehensive approach was taken in baseline data collection for the EIA stage, as well as the additional monitoring conducted during the Due Diligence study. This enables a thorough comparison between the current state and the initial assessments, provides insights into any changes or potential impacts. Vibration monitoring was not included as part of the Environmental Impact Assessment (EIA) report, considering the significance of vibration impact due to a metro project, vibration monitoring was carried out during the due diligence study.

- The noise monitoring results of the Environmental Impact Assessment (EIA) study is within the permissible standards as prescribed by the CPCB. It is observed during the due diligence study monitoring results, both the daytime and night-time noise level are on higher sides and exceeds the CPCB Noise Standards limits at almost all locations except at locations near Palarivattom jn and KINFRA PARK station. Influence of commercial land use along the alignment and traffic congestion can be major source of noise pollution.

- EIA not comprehensively address risks associated with Noise & Vibration during the metro construction and operation phase. The detailed study for the Noise and Vibration Impact assessment has been conducted during EDDR stage.

- A comprehensive climate assessment was not part of the EIA study due diligence phase recognized the gap and a detailed assessment has been carried out to identify the physical climate risks that the proposed project and its components are exposed and to identify the adaptation measures to manage these risks. As per the climate risk screening exercise the overall climate risk of the project is medium. The likelihood of different natural hazards/risks such as flood, precipitation increase, water availability, wind speed and temperature increase are identified for the project. The government of Kerala launch comprehensive rebuild framework and emergency action plans following the flash flooding. The NMT Master Plan identifies a network for walking and cycling facilities along the phase – I metro corridor, with area improvement proposals to encourage active use of public spaces, walking, cycling and use of public transport systems. Following the similar vision for seamless transportation even during the flood situation, it is proposed that a NMT plan for the phase – II metro corridor be developed to help increase accessibility to the metro stations and thereby the overall mobility and user experience.

- As per the proceedings of social forestry, there are 402 nos of trees within ROW and 267 nos. of trees in proposed entry exit locations. As on date 614 number of trees are cut and 55 numbers to be cut in the station entry exit locations. Compensatory plantation will be done in a ratio of 10 saplings against each tree felled. For plantation of 6140 trees, app. 12.28 ha of the land will be required (500 tree/ha) the land shall be finalised during the construction stage by the KMRL in consultation with the local bodies.

- From the baseline study data, the ambient noise levels for day and night is exceeding the specified CPCB standards. Hence a slight increase in noise level induced due to operation of construction equipment's will cause some impacts to nearby residential, religious, and institutional structures. The induced impact will be of short-term during construction phase however, the mitigation measures are proposed for minimizing the noise levels.

- An attempt has been made to predict the rise in ambient noise level during the operation phase of metro system using mathematical Continuous Point Source Model The difference between the baseline values and the predicted cumulative values are not exceeding 3dB, hence the receptors can be categorised in no impact zone. However, to minimize the noise level due to metro train operation, measures shall be adopted. Height of these barriers can be kept 1.5-2.0 m above the top of rail and the noise barrier locations should be finalized during construction stage in consultation with the KMRL and stakeholders.

- Vibration source levels and the procedure proposed by Federal Transient Administration (FTA) of USA has been considered to evaluate the impact due to operation of equipment's during construction phase. The sensitive receptors were identified along the alignment. The impact of vibration due to operation of construction equipment's were analysed using the procedure proposed by Federal Transient Administration (FTA). From the modelling results, it is concluded that no vibration levels higher than the criteria will be induced in the sensitive structures along the alignment.

- No formal public consultation was done during EIA stage; however, one to one discussion was carried out with the affected people to understand their perspective about the project and the issues associated with the project. The people were in favour of the project with some suggestions that were incorporated in EMP. Public consultations at different stages of SIA were carried out at different locations.

- During the EDDR stage, meetings with groups of persons comprising likely PAPs and other stakeholders in the community were conducted in order to enhance public understanding about the project and address the concerns of the community pertaining to mitigation of adverse impacts. The consultations were done at Vazhakkala, Edappally and Kakkanad on 19.10.2023.

- The costs involved in Environmental mitigation, management and monitoring on the account of present corridor of Kochi Metro is reassessed as provided in EIA and finalized with some minor upgrades. The total cost shall be INR 141.21 million.

  Project Proponent, KMRL, shall focus on "No net loss" approach wherein Project-related biodiversity losses are balanced by gains resulting from measures taken to avoid and minimize these impacts, to undertake on-site restoration and finally, to offset significant residual impacts, if any, on an appropriate geographic scale.

- Best available technology and best management practices has been built-in to the project design. All project components will be implemented and monitored in line with the MDBs' applicable policies and standards. A semi-annual environmental and social monitoring report will be submitted to MDBs and will be disclosed publicly at the MDBs' websites.

- The establishment of an Environment Division within Kochi Metro Rail Limited (KMRL) and the incorporation of occupational risk mitigation measures ensure a robust approach to environmental management. Additionally, the emphasis on traffic management strategies, noise control, and waste management underscores the project's commitment to responsible construction practices.

- EMP will be implemented by the Contractor for which the EMP has been included in the Bid Document to make it mandatory for implementation. A Construction Environmental Management Plan (CEMP), that outlines the strategies and measures to be implemented during the construction phase of a project to minimize environmental impacts shall be developed by the contractor before project commencement for further implementation at site.

- It is recommended that contractor's CESMP should incorporate noise management plan including adherence to site rules and restrictions, making due allowance with detailed programme of works to be carried out at site.

- Contractor shall ensure briefing of management and operatives to ensure all restrictions are clearly noted with method statements. State the types of plant being used including manufacture literature to advise of the sound power level of the plant, and the proposed noise control methods.

- Contractor shall ensure that all fixed items of construction plant are electrical powered rather than diesel or petrol driven if possible. Where this is not practicable, suitable attenuation measures should be provided if necessary.

11 ENVIRONMENTAL CORRECTIVE ACTION PLAN

This Environmental Corrective Action Plan is created with a timeline based on the findings of the Environmental Due Diligence.

S.NO	CORRRECTIVE ACTIONS/RECOMMENDATIONS	RESPONSIBLE AGENCY	TIMELINE
1.	KMRL to establish an Environment Division The division shall have an Environmental Officer and an Environment Engineer who will monitor the environmental and social safeguards and EMP implementation for the project.	KMRL	During project preparation phase
2.	KMRL to include EMP and Environmental budget in the Tender and contract documents	KMRL	During project design stage
3.	Prepare Construction Environmental and Social Management Plan (CESMP) The contractor to develop and implement the CESMP which includes following subplans – a) Construction Air Quality and Dust Management plan b) Occupational Health & Safety Management Plan c) Disaster Risk Management Plan d) Construction Noise and Vibration Management plan e) Construction Water and Soil Management plan f) Construction Waste Management Plan g) Construction Traffic Management Plan	Contractor	Prior to commencement of construction
4.	The contractor to conduct baseline air quality, water quality, soil quality and noise monitoring as specified in EMP.	Contractor	Prior to commencement of construction and as per the approved monitoring plan during construction and operation phase
5.	Obtain required permission/approvals. a) Permission for ground water extraction from CGWA/State Water Resource Department b) Consent to Establish and Consent to operate for Batching Plant, Stations, Quarries, and Stone Crushers etc. c) Pollution Under Control Certificate d) Other permission form Centre/State/Local bodies for execution of works as required	Contractor	Prior to commencement of construction and to be renewed as per the requirement.
6.	Site for Compensatory plantation – A suitable location for compensatory plantation (1:10) will be identified by the KMRL/contractor in consultation with stakeholders and concerned forest officials.	KMRL/Contractor	Prior to commencement of construction
7.	The contractor shall develop and implement a grievance mechanism for workers. Workers' grievances should be handled by a Grievance Redressal Mechanism at the Contractor's level to be overseen by the General Consultant (GC) and unresolved matters to be brought to the notice of Metro PIU by GC and resolved by the Metro PIU. This	Contractor	Prior to commencement of construction

	arrangement to be incorporated in the Contractor's Environmental Management Plan. This workers Grievance Redress Committee to have representatives of workers and female workers.		
8.	The contractor to carry out noise monitoring prior to commencement of construction. The locations of noise barrier, if required, shall be identified by the contractor in consultation with KMRL, stakeholders and PAPs and the finalised locations shall be added in the CESMP (Construction Environment and Social Management Plan).	Contactor	Prior to commencement of construction
9.	Climate adaptation Measures KMRL should consistently monitor the performance of the project's infrastructure concerning climate resilience. This involves a comprehensive assessment of the applied adaptation measures. If deemed necessary, KMRL should propose and execute targeted corrective measures to effectively address identified climate risks.	KMRL/GC/Contractor	During Construction and Operation Phase
10.	KMRL to develop Operational Environment Management Plan in line with the EMP. Levels of noise and air quality to be measured at representative roadside receptors, at least semi-annually for a period of 2 years post construction	KMRL	During Operation

KOCHI METRO RAIL LIMITED

APPENDICES

SYSTRA

KOCHI METRO RAIL LIMITED

APPENDIX 1

Formats for Environmental Monitoring

SYSTRA

RF 1: CONSTRUCTION CAMP/ PLANT SITE MANAGEMENT PLAN

S.No	Description	Compliance
1	Name of the location	
2	Nearest site chainage.	
3	Name of the owner	
4	Area involved	
5	Arrangements with the owner (agreement with landowner, including the restoration aspects, should be attached as an Annexure)	
6	Existing land use	
7	Photographs depicting the present condition of the construction camp and access road.	
8	Land use of the area surrounding the site including a map	
9	Site layout plan of the construction camp	
10	Establishment and maintenance of demarcated and labelled different areas within the camp	
11	Number of trees to be removed, if any, along with compensation measures	
12	Proposed topsoil management	
13	Activities planned in the construction camp	
14	Machinery & equipment to be used on site	
15	Labour camp facilities onsite	
16	Health facilities	
17	Site drainage provisions	
18	Copy of the consents to establish and operate should be attached as an Annexure	
19	Conditions laid down in the clearance / licenses and plans	
20	Staff strength and details such as contractor staff vs sub contractors, women labour, migrant vs local labour and skilled & unskilled labour	
21	Access road condition and proposed maintenance	
22	Safety provision such as fire protection equipment and personal protective measure.	
23	Closure / completion plan	**Format RF: 1A**

RF 1A: CLOSURE PLAN CONSTRUCTION CAMP AND/ PLANT SITE

S. No	Description	Compliance
1	Name / identity of location	
2	Distance from the site	
3	Name of the owner	
4	Details of the Land i). Survey Number ii). Boundaries iii). Other Revenue Details	
5	Details of settlements, sensitive areas, water bodies, wells and bore wells within 500 m Population in Numbers Name of the Village Distance from the construction camp Details of water bodies/ sensitive areas/ wells/ bore wells	
6	Physical Details Number of Labour Stationed Number of Dwellings Constructed Number of toilets provided Were dwellings demolished Were the wastewater treatment facilities demolished and cleared? Was the solid waste generated cleared and disposed of properly, if yes specify the location and quantity? Whether any soil was contaminated with oils and waste oils was cleared and disposed safely, if yes specify the location and quantity. Was scrap generated while the construction removed, if yes specify the details such as where, when, to whom and quantity.	
7	Land Use before Establishment Proposed Use after completion of works	

RF2: CONSTRUCTION CAMP / PLANT AND ENVIRONMENTAL MANAGEMENT

S. No	Issue	Status
		Camp-1
1	Drainage System 1. Closed	
2	Disposal for Wastewater 1. Kitchen wastewater 2. Wastewater from water closets 3. Wastewater from bathrooms 4. Wastewater from the vehicular washings.	
3	Collection and Disposal of Solid Waste 1. Waste from the office 2. Waste from the kitchen 3. Waste from sweeping	

4	Drinking Water facility Source with quantity No of bore wells with capacity Location of the well and bore well Any treatment facility No of overheads tanks Test results of the Drinking water Any license obtained	
5	First Aid Facility	
6	Roads in Camp Site Type of road Dust suppression practicing or not, if the roads are not tarred. Condition of the road.	
7	Fuel Storage 1. Impervious Base 2. Spills and Wastewater will be collected in a sump 3. Number of drums where wastes are collected. 4. Number of drums disposed	
8	Garbage & Night Soil 1. Provision of Garbage Bins 2. Separation of Polythene materials 3. Records of solid waste removal from septic tanks	

RF 3: CONSTRUCTION PLANTS AND POLLUTION CONTROL

S. No.	Construction Plant	Locations	Capacity	Description of Pollution Control System/ Equipment	Remarks
1					
2					
3					
4					
5					
6					
7					

RF 4: MACHINERY/ VEHICLES AND POLLUTION CONTROL

S. No	Machinery/ vehicles with capacity	Diesel consumed during the month	Engine oil consumed during the month	PUC certificate no./validity	Machinery new/ old	Remarks
1						
2						
3						
4						

RF 5: DETAILS OF THE DG SETS WITH THE POLLUTION CONTROL EQUIPMENT

S. No	Capacity in KVA	Vertical Stack If provided height in m	Noise Control System	Remarks
Camp-1				
Crusher -I				
Plant Site -I				
Construction Works				

RF 6: DETAILS OF OIL STORAGE

S. No	Type of Product	Location	Number of Barrels	Capacity of barrels in Litres	Increase/ Decrease in Storage	Stored on Impervious base (Yes/No)	Remarks
1	Diesel						
2	Petrol						
3	Engine Oils						
4	Lubricants						

RF 7: DETAILS OF THE GROUND WATER EXTRACTION

S. No	Location	Capacity of Motor Installed in HP	Quantity of water drawn in Kilo litres			Ground water department Permission	Type of source
			During the month	Up to end of last month	Total		

RF 8: PERSONAL PROTECTIVE EQUIPMENT

S. No	Details of Equipment	Total Procured in No	Distributed in No	Available in Store in No	Remarks
1	Helmets				
2	Safety Shoes				
3	Safety Shoes				
4	Nose Masks				
5	Hand Gloves				
6	Goggles				
7	Safety Belts				

8	Ear Plugs				
9	Reflective Jackets				
10	Gum Boots				
11	Harness				

RF 9: IDENTIFICATION OF DISPOSAL SITE LOCATIONS

(To be filled by the Contractor)

Name of Corridor _____

Link No._____

(Give chainages and nearest settlements from both ends)

S. No	Criteria on which information for each site is to be collected	Site 1	Site 2	Site 3	Site 4
1	Existing Land Use				
2	Area covered (m2)				
3	Total Material that can be dumped within the site (m3)				
4	Depth to which dumping is feasible (m)				
5	Distance of nearest watercourse (m)				
6	Nearest Settlement (m)				
7	Date/s of Community Consultation/s				
8	Whether the community is agreeable to siting of dumping site (Y/N)				
9	Date of Permission from Villager/local community				
10	Proposed future use of the Site				
11	Selected Site (tick any one column only)				

Enclosures (Tick as appropriate)

Map of each location

Photographs

Each Disposal location

Each community consultation

Photocopy of Agreement (along with revenue record of the owner)

Remark

RF 10: FORMATS FOR GRIEVANCE REDRESSAL MECHANISM DURING CONSTRUCTION

A	PROJECT DETAILS	INFORMATION			
1	Name of the Project				
2	Name and address of the				
3	Contract Date and Duration				
B	**Details of Complaints Received**		**Site Name**		
Sl. No	**Date of Complaint**	**Name and Address of Person with Contact**	**Complaint**	**Action Taken with Date**	**Signature of Environmental representative of Contractor**
1					
2					
3					
4					

A Register in this format shall be maintained at each site office of the contractor.

RF 11: REPORTING FORMAT FOR WORK FORCE MANAGEMENT

A	PROJECT DETAILS		DATE OF REPORTING		
1	Name of the package and Corridor				
2	Name and Address of the contractor				
3	Contract date and duration				
4	Name of Work Site with Sl. No. in register of site				
B	**Status of work force**				
S. No	**Category of work force**	**Work force in the Previous Month (No)**	**Work Force added in the reporting month (No.)**	**Work Force left in the reporting month (No.)**	**Total Work Force in the reporting month (No.)**
1	Unskilled Labourers				
2	Skilled labourers				
3	Supervisors				
4	Engineers				
5	Office Staff				
6	Sub Total				
7	Grand Total				

C. Categorization of Work Force

S. No	Category of work Force	Male		Female		Employment Status		Residential Status		Accommodation Status	
		< 18 years	< 18 years	< 18 years	< 18 years	Regular	Temporary	Migrant	Local	Staying in Labour Camp/ Quarters	Others
1	Unskilled Labourers										
2	Skilled labourers										
3	Supervisors										
4	Engineers										
5	Office Staff										
	Sub Total										
	Grand Total										
D. Details of the non-working migrated people, living in the labour camps/Staff Quarters											

S. No	Category of work Force	Male	Female	Employment Status	Residential Status	Accommodation Status
as part of work force family						
No. of Children (0-6 years)		No. of Children (7-18 years)		No of Adults		Grand Total
E. Submission Details						
		Submitted by (Environmental Officer of the Contractor)		Approved By (Environmental Engineer of GC)		
Signature & Date						
Name						
Designation						
Remarks by						

RF-12: REPORTING FORMAT FOR OCCUPATIONAL HEALTH AND SAFETY MEASURES

A	Project Details		Date of reporting
1	Name of the package and Corridor:		
2	Name and Address of the contractor:		
3	Contract date and duration:		
4	Status of completion of the project:		
B	**Implementation Status of Health and Safety Measures**		
S. No	**Health and Safety Measures**	**Implementation Status (Yes/No)**	**Remarks**
1	Appointment of qualified Environment and Safety Engineer		
2	Approval for Construction Safety Management Plan by the Engineer		
3	Provision for flags and warning lights for potential hazards		
4	Provision of adequate stating, from work and access (ladders and handrail) for works at a height of more than 3.0m		
5	Provision of adequate Shorting/ bracing/barricading/lighting for all deep excavations of more than 3.0m depth		
6	Provision for enough lighting epically for night-time work		
7	Construction Workers Safety-Provision of personnel protective equipment		
	A. Helmets		
	B. Safety Shoes		
	C. Dust Masks		
	D. Hand Gloves		
	E. Safety Belts		
	F. Reflective Jackets		
	G. Ear Plugs for Labour		
8	Workers engaged in welding works shall be provided with welder protective shields		

A	Project Details		Date of reporting
9	All vehicles are provided with reverse horns		
10	All Scaffolds, ladders and other safety devices shall be maintained in as safe and sound condition		
11	Ensuring the sanitary conditions and all waste disposal procedures & methods in the camp		
12	Ensuring the sanitary conditions and all waste disposal procedures & methods in the		
13	Provisions for insurance coverage to the workers		
C	Submission Details		
	Submitted by (Environmental representative of the Contractor)	**Approved By (Environmental Specialist of GC)**	
Signature & Date			
Name			
Designation			
Remarks			

RF 13: FORMAT FOR REGISTERING OF ACCIDENTS AND ITS REPORTING

A	Project Details			Date of Reporting
1	Name of package and Corridor			
2	Name and address of the contractor			
3	Contract date and duration			
4	Status of completion of the Project			
B	**Details of Accident and People Involved in Accident**			
	Name of site where accident happened			
	Name and address of people involved in the accident			
	Whether Contractor's personal or General public			
	Details of Injury			
	Details of compensation given			
C	**Type of Accident ('1)**			
	Fall of person from a height			Explosion
	Slip,trip or fall on same level			Fire
	Struck against fixed objects			Contract with hot or corrosive substance
	Struck by flying or falling objects			Contract with poisonous gas or toxic substances.
	Struck be moving objects			Contract with poisonous gas or toxic substances.
	Struck/caught by cable			Hand tool accident
	Stepping on hall etc.			Vehicle/Mobile plant accident
	Handling without machinery			Machinery operation accident
	Crushing/burying			Other (please specify)
	Drowning or asphyxiation			
D	**Agent Involved in Accident ('1)**			
	Machinery			Stair edge
	portable power appliance			Excavation/undergrou nd working
	Vehicle or associated equipment / machinery			Ladder
	Material being handled, used or stored			Scaffolding/gondola
	Gas, vapour, dust, fume or oxygen			Construction formwork, shuttering and false work
	Hand tools			Electricity supply cable, wiring switchboard and associated equipment
	Floor edge			Nail, splinter or chipping
	Floor opening			Other (please specify)
	Left shaft			
E	**Unsafe Action Relevant to the Accident ('1)**			
	Operating without authority			Failure to use proper footwear

A	Project Details			Date of Reporting
	Failure to secure objects			Failure to use eye protector
	Making safety devices inoperative			Failure to use respirator
	Working on moving or dangerous equipment			Failure to use proper clothing
	Using un-safety equipment			Failure to use warn others or given proper signals
	Adopting unsafe position or posture			Horseplay
	Operating or working at unsafe speed			No unsafe action
	Unsafe loading, Placing, mixing et			Other (please specify)
	Failure to use helmet			
F	**Lack of Safety Measures Relevant to the Accident ('1)**			
	No protective gear			Unsafe layout of job, traffic etc.
	Defective protective gear			Unsafe process of Job methods
	Improper dress/footwear			Poor housekeeping
	Improper guarding			Lack of warning system
	Improve ventilation			Defective tool, machinery or material
	Improper illumination			No unsafe condition
	Improper procedure			Other (please specify)
G	**Personal Factor Relevant to the Accident ('1)**			
	Incorrect attitude/motive			No unsafe personal factor
	Unsafe act by another person			Other (please specify)
H	Details of Corrective and Prevention action taken			
1				
2				
3				
I	**Submission details**			
	Submitted by (Environment & Safety Engineer of Contractor)			**Approved by (Environment Specialist of GC)**
Signature & Date				
Name				
Designation				
Remarks				

KOCHI METRO RAIL LIMITED

APPENDIX 5.1

ANNEXURE F of IRC 6

SYSTRA

Annexure F

(IRC: 6 2017)

Sate-wise Higest Maximum and Lowest Minimum Temperature

(Source: Climatological Normals 1981-2010, IMD,Pune)

State	Station	Shade air Temperature (°C)	
		Max.	**Min.**
Andaman and Nicobar Island	Car-Nicobar	38.1	10.9
	Hut Bay	39.4	0.2
	Kondul	47.2	14
	Long Island	43.1	14.6
	Mayabandar	39	14
	Nancowry	39.2	13.9
	Port Blair	36.4	14.6
Andhra Pradesh	Anantapur	44.1	9.4
	Arogyavaram	40.6	8
	Bapatla	47.4	11.1
	Cuddapah	46.1	10
	Dolphine Nose/CDR Visakhapatnam	42.8	14.1
	Gannavaram (A)	48.8	8.5
	Kakinada	47.2	12
	Kalingapatanam	46.2	10.3
	Kavali	47.2	16.4
	Kurnool	45.6	6.7
	Masulipatnam	47.8	13.2
	Nandigama	47.1	9.3
	Nandyal	48.2	9.2
	Narsapur	46.1	14.6
	Nellore	46.7	11.1
	Nidadavolu	48.9	11.4
	Ongole	47.4	14
	Rentachintala	49.9	9.4

	Tirmalai	37.6	3.6
	Tirupathy	45.2	12.9
	Tuni	47.5	13.9
	Vishakhapatnam	45.4	10.5
	Vishakhapatnam (RS/RW)	42	15.8
Arunachal Pradesh	Pasighat	38.8	6
Assam	Dhubri (Rupsi) (A)	41.3	2.4
	Dibrugarh (Mohanbari) (A)	39.8	1
	Guwahati (Bhorjar) (A)	40.3	3
	North Lakhimpur	39	2.7
	Rangia	39.4	6
	Silchar	39.4	5
	Tezpur	45.7	5.6
Bihar	Bhagalpur	46.6	3.8
	Chaibasa	46.7	4.4
	Chapra	46.6	2.4
	Daltonganj	48.8	0
	Darbhanga	44.1	0
	Dehri	49.5	-1
	Dumka	48.5	1.9
	Gaya	49	1.2
	Hazaribagh	46.6	0.5
	Jamshedpur	47.7	3.9
	Jamshedpur (A)	46.6	4.4
	Motihari	44.4	0
	Muzaffarpur	44.5	2.2
	Patna (A)	46.6	1.4
	Purnea	43.9	-0.2
	Ranchi(A)	43.4	0.6
	Sabaur	46.1	0.6

Chattisgarh	Ambikapur	44.9	0.9
	Bailaldila	39.4	4.6
	Jagdalpur	46.1	2.8
	Pbo Raipur	47	6.6
	Raipur	47.9	3.9
	Raipur (Mana)	47.9	5.7
Daman & Diu	Diu	44	5
Goa	Dabolim (N.A.S.)	38.2	13.6
	Marmugao	38.4	12.2
	Panjim	39.8	3.4
Gujarat	Ahmedabad	47.8	2.2
	Amreli	46.2	1.6
	Balsar (Valsad)	43.1	5.8
	Baroda	46.7	-1.1
	Baroda (A)	46.2	2.8
	Bhavnagar (A)	47.3	0.6
	Bhuj (Rudramata) (A)	47.8	-0.2
	Deesa	49.4	2
	Dohad	47	0
	Dwarka	42.7	6.1
	Idar	48.5	4.8
	Keshod (A)	45.5	3.6
	Naliya	44.6	0.4
	New Kandla	47.1	4.4
	Okha	39.5	10
	Porbandar (A)	45.5	2
	Rajkot (A)	47.9	-0.6
	Surat	45.6	4.4
	Vallabh Vidyanagar	47.5	2
	Veraval	44.2	4.4
Haryana	Ambala	47.8	-1.3
	Bhiwani	46.8	0.4
	Gurgaon	49	-0.4
	Hissar	48.8	-3.9
	Karnal	49	-0.4
	Narnaul	48.4	-0.9
	Rohtak	47.2	-0.5

Himachal Pradesh	Bhuntar (A)	40	-5.2
	Dharamshala	42.7	-1.9
	Kalpa (GL)	32.4	-15.5
	Manali	35	-11.6
	Nahan	43	-7.9
	Nauni / Solan	39	-3.9
	Shimla	32.4	-12.2
	Sundernagar	42.1	-2.7
	Una	45.2	-5.8
Jammu and Kashmir	Badarwah	39.4	-10.8
	Banihal	36.3	-13.6
	Batote	36.6	-7.2
	Gulmarg	29.4	-19.8
	Jammu	47.4	0.6
	Kathua	48	-1.8
	Katra	46.2	-1
	Kukernag	34.9	-15.3
	Kupwara	37.6	-15.7
	Pehalgam	32.2	-18.6
	Quazigund	35.7	-16.7
	Srinagar	38..3	-20
Karnataka	Agumbe	38	3.2
	Bagalkote	42.8	7.8
	Balehonnur	39.2	6.7
	Bangaluru [Bangalore]	38.9	7.8
	Bangalore (A)	38.3	8.8
	Belgaum	41.9	6.7
	Belgaum (Sambre) (A)	40.2	6.4
	Bellary	44.7	7
	Bidar	44	6.2
	Bijapur	44.9	5.6
	Chickmagalur	37	10
	Chitradurga	41.7	8.3
	Gadag	41.7	9.8
	Gulbarga	46.1	5.6

	Hassan	37.8	5.6
	Honavar	38.6	13.5
	Karwar	39.6	11.6
	Kolar Gold Field	39.7	9.4
	Mandya	39.1	8
	Mangalore (Bajpe) (A)	39.8	15.9
	Mangalore (Panambur)	38.1	15.6
	Mercara	36.2	4.8
	Mysore	39.4	8.6
	Raichur	45.6	7.3
	Shimoga	44	6
	Shirali	38.9	14.3
	Tumkur	39	6
Kerala	Alleppy (Alappuzha)	39.9	13.8
	Calikote/Kozhicode	38.1	13.8
	Cannanore (Kannur)	38.3	16.4
	Cochin (N.A.S.)/ Kochi	36.5	16.3
	Karipur (Airport)	38.6	11.2
	Kottayam	38.5	16
	Palakkad (Palghat)	41.8	14
	Punalur	40.6	12.9
	Thiruvananth apuram (Trivandrum)	38.3	16
Lakshadweep Islands	Agatti(A)	38	22.1
	Amini Divi	38.3	16.6
	Minicoy	36.7	16.7
Madhya Pradesh	Alirajpur (Jhabua)	46.2	0
	Bagratawa	47.2	1.5
	Betul	48	-0.2
	Bhopal (Bairagarh)	46	0.6
	Chhindwara	47.6	1.1
	Damoh	49.8	1
	Datia	48.5	0
	Dhar	47.1	3
	Ginabahar	46.1	-6.1
	Guna	48	-2.2

	Gwalior	48.3	-1.1
	Hoshangabad	47.1	1
	Indore	46	-2.8
	Jabalpur	46.7	0
	Jashpurnagar	42.5	-1.3
	Kannod	47.6	1.1
	Khajuraho	48.4	0.6
	Khandwa	47.6	0.2
	Khargone	47.9	0.2
	Malanjkhand	45.5	0.6
	Mandla	46.8	0
	Narsinghpur	48.6	-1.4
	Nimach	46.7	-1.1
	Nowgong	48.8	-1.7
	Panna	47	-0.4
	Pendra Road	46.7	1.7
	Raisen	47.7	0
	Rajgarh	48.3	6.4
	Rajnandgaon	46.7	1.7
	Ratlam	45.5	2.5
	Rewa	46.8	0.6
	Sagar	46.4	1.1
	Satna	47.8	0.4
	Seoni	45.2	2.8
	Shajapur	47.2	-0.5
	Sheopur	48.8	-2.2
	Shivpuri	47.2	-4
	Sidhi	52.3	1
	Thikri	47.5	0.5
	Tikamgarh	47.5	-0.6
	Ujjain	46	0
	Umaria	48.7	0
	Vidisha	49.1	0
Maharashtra	Ahmednagar	48.2	2.2
	Akola	47.8	2.2
	Akola (A)	47.7	4.4
	Alibagh	40.1	9.4
	Amravati	48.3	1.5

	Aurangabad (Chikalthana) (A)	43.6	1.2
	Baramati	43.8	5
	Bhira	49	5.1
	Bir (Beed)	47	4
	Brahmapuri	48.3	0.8
	Buldhana	44.2	4.4
	Chandrapur (Chanda)	49.2	2.8
	Dahanu	40.6	8.3
	Devgad (Devgarh)	43.1	14.1
	Gondia	47.5	0.8
	Harnai	39.8	12.5
	Jalgaon	48.4	1.7
	Jeur	46.6	2.2
	Kolhapur	42.3	8.6
	Mahabaleshwar	38.2	3.9
	Malegaon	46.7	-0.6
	Miraj (Sangali)	43	6.5
	Mumbai (Colaba)	40.6	11.7
	Mumbai(Bombay) (Santa Cruz)	42.2	7.4
	Nagpur (Mayo-Hospital)	47.7	7.3
	Nagpur (Sonegaon)	47.8	3.9
	Nanded	46.7	3.6
	Osmanabad	45.1	8
	Ozar(A)	43.9	0.4
	Parbhani	46.6	4.4
	Pune	43.3	1.7
	Pusad	47.6	1.1
	Ratnagiri (PBO)	40.6	11.5
	Satara	42.6	4.8
	Sholapur	46	4.4
	Sironcha	48.2	4.5
	Vengurla	40	6.2
	Wardha	48.4	4.3
	Yeotmal	46.6	6.2

Manipur	Imphal/Tulihal(A)	36.1	-2.7
Meghalaya	Barapani	35.2	-3.4
	Cherrapunji	31.1	-1
	Shillong (C.S.O.)	30.2	-3.3
Mizoram	Aizwal	35.5	6.1
New Delhi	New Delhi Palam (A)	48.4	-2.2
	New Delhi (Safdarjang)	47.2	-0.6
	New Delhi C.H.O.	47.8	-0.4
Orissa	Angul	47.2	0
	Balasore	46.7	6.7
	Baripada	48.3	6.5
	Bhawani Patna	48.5	4.5
	Bhubaneshwar (A)	46.5	8.6
	Bolangir	49	1.6
	Chandbali	46.7	5.1
	Cuttack	47.7	5.8
	Gopalpur	44	9.6
	Jharsuguda	49.6	6
	Keonjhargarh	47.4	0.6
	Paradip Port	42.4	9.6
	Pulbani	44.6	-2.3
	Puri	44.2	7.5
	Sambalpur	49	3.6
	Sundergarh	47.6	1.6
	Titlagarh	50.1	4
Pondicherry	Pondicherry	45.5	15.1
	Pondicherry (M.O)	43.1	16.2
Punjab	Amritsar (Rajasansi)	47.8	-3.6
	Kapurthala	47.7	0
	Ludhiana	46.6	-1.7
	Ludhiana (P.A.U.)	46.6	-1.6
	Patiala	47	-0.9
	Patiala (Rs/Rw)	47	-0.1
Rajasthan	Abu	40.4	-7.4
	Ajmer	47.4	-2.8
	Alwar	50.6	-0.8
	Banswara	47.5	2.8

	Bharatpur	48.5	1.7
	Barmer	49.9	-1.7
	Bhilwara	47.8	-0.3
	Bikaner(P.B.O)	49.4	-4
	Chambal/(Rawat Bhatta Dam)	47.6	-1.1
	Chittorgarh	47.5	-0.1
	Churu	49.9	-4.6
	Dholpur	50	-4.3
	Ganganagar	50	-2.8
	Jaipur (Sanganer)	49	-2.2
	Jaisalmer	49.2	-5.9
	Jawai Bandh/ Erinpura	48.1	-3.1
	Jhalawar	49.3	-0.6
	Kota (A)	48.5	1.8
	Kota (PB-Micromet)	47.4	2.1
	Phalodi	49.6	-3.3
	Pilani	48.6	-4
	Sawai Madhopur	48	-1.2
	Sikar	49.7	-4.9
	Udaipur	44.6	0.4
	Udaipur (Dabok) (A)	46.4	-1.3
Sikkim	Gangtok	29.9	-2.2
	Tadong	32.6	0
Tamil Nadu	Adiramapatinam	43	15.6
	Ariyalur	49.6	13
	Chennai (Minambakkam) (A)	49.1	15.7
	Chennai (Nungambakkam)	45	13.9
	Coimbatore (Pilamedu)	42.6	12.2
	Coonoor	29.6	-0.5
	Cuddalore	43.3	8
	Dharmapuri	41.4	10.6
	Erode	42.8	13
	K. Paramathy	45.4	13.4
	Kanniyakumari	39.4	18.6

	Kodaikanal	29.3	0.6
	Karaikal	42	17.8
	Karaikudi	42.7	15.5
	Koradacherry	42.6	15
	Kudumiamalai	43.1	13.5
	Madurai	44.5	10.5
	Madurai (A)	43.4	14.6
	Mettur Dam	42.4	13.1
	Nagapattinam	42.8	15.6
	Octacamund	28.5	-2.1
	Palayamkottai	44.9	16.3
	Pamban	38.9	17
	Port Novo	43.5	13
	Salem	42.8	11.1
	Tanjavur	46.2	16.6
	Tiruchirapalli (A)	43.9	13.9
	Tiruchi	42.4	16
	Tiruppattur	46.3	10.2
	Tiruttani	48.6	10
	Tondi	40.4	15.7
	Tuticorin	41.1	15.3
	Vedaranniyam	40	14.8
	Vellore	45	8.4
Telangana	Bhadrachallam	49.4	8.4
	Hanamkonda	47.8	8.3
	Hyderabad (A)	45.5	6.1
	Khammam	47.2	9.4
	Mahbubnagar	45.3	9.1
	Medak	46.3	2.7
	Nalgonda	46.5	10.6
	Nizamabad	47.3	4.4
	Ramgundam	47.3	7.5
Tripura	Agartala (A)	42.2	2
	Kailashahar (A)	42.2	2.4
Uttar Pradesh	Agra	48.6	-2.2
	Aligarh	49.5	0
	Allahabad	48.8	-0.7
	Bahraich	47.6	0.3

	Ballia	48	0
	Banda	48.9	-0.8
	Barabanki	47	2
	Bareilly P.B.O.	47.3	-1.3
	Churk	49	-0.6
	Etawah	48.6	0.4
	Faizabad	47.4	0.8
	Fatehgarh	48.8	2.1
	Fatehpur	48.1	-1.7
	Gazipur	46.4	-0.5
	Gonda	49.9	0.1
	Gorakhpur (P.B.O)	49.4	1.7
	Hamirpur	48.2	-1
	Hardoi	48.3	0.7
	Jhansi	48.2	0
	Kanpur (A)	47.3	0.4
	Kheri-Lakhimpur	47.6	0.5
	Lucknow (Amausi)	47.7	-1
	Mainpuri	49.2	-1.7
	Mathura	47.6	0
	Meerut	46.1	0
	Moradabad	48.2	0
	Mukhim	36.3	-9
	Muzaffarnagar	45	-2.6
	Najibabad	45.2	-2.9
	Shahajahanpur	46.2	0.6
	Sultanpur (M.O.)	48	0
	Varanasi	47.2	1
	Varanasi (Babatpur)	48	0.3
Uttarakhand	Dehra Dun	43.9	-1.1
	Mukteswar (Kumaun)	31.5	-7.8
	Pantnagar	45.6	-2.2
	Roorkee	47.4	-2.2
West Bengal	Bagati	46.2	0.8
	Balurghat	43.4	4.1
	Bankura	47.4	0.8
	Bankura (M.O.)	46.4	6.2
	Berhampore	48.3	3.9

	Calcutta (Alipur)	43.9	6.7
	Calcutta (Dum Dum) (A)	43.7	5
	Canning	42.5	7.6
	Contai	43.8	7.7
	Cooch Behar (A)	41	3.3
	Darjeeling	28.5	-7.2
	Digha	42	7.6
	Diamond Harbour	43	8.2
	Haldia	40.9	9.1
	Jalpaiguri	40.9	2.2
	Kalimpong	34.1	-0.6
	Krishnanagar	46.1	0.9
	Malda	45	3.9
	Midnapore	47.2	0.6
	Purulia	46.3	3.8
	Sagar Island	40	7.2
	Sandheads	40.4	9.2
	Shanti-Niketan	47	5
	Ulberia	43.5	6.6

KOCHI METRO RAIL LIMITED

APPENDIX 5.2

Outline Design Specifications

SYSTRA

As per Clause-2.8.5 of IRS-Bridge Rules, in transverse / longitudinal seismic condition, only 50% of gross tractive effort/braking force will be considered.

Dispersion, of longitudinal forces is not allowed as per Clause-2.8.3.4 of IRS Bridge Rules except during checking of Rail stress.

6.4.5 Centrifugal Forces Due to Curvature of Superstructure

The horizontal centrifugal force due to moving load in curved superstructure is to be considered as per Clause 2.5 of IRS: BR.

$$C = \frac{Wv^2}{127R}$$

Where W is Live load reaction & C is Centrifugal force (unit of C & W shall be same), v is maximum design speed in km/h and R is radius of curvature in m. This force is assumed to act at a height of 1.830 m above rail top level on safer side.

Design Speed of Live load of 90 km/h will be considered for computation of centrifugal force for curvature up to 450m radius. For sharper curves, speed restrictions as per SOD shall be followed.

6.4.6 Racking Force

The horizontal transverse loading due to racking specified in IRS-Bridge Rules Clause-2.9 is applicable to design of lateral bracing and does not need to be taken into account in the global analysis of loads on the viaduct.

6.5 TEMPERATURE EFFECTS

6.5.1 A) Overall Temperature (OT)

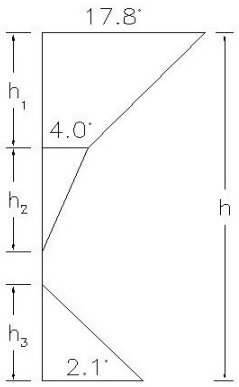
The loads shall be considered as per Clause-2.6 of IRS-Bridge Rules and Clause-215 of IRC: 6. Temperature variation of ±20°C will be considered details of which are given below

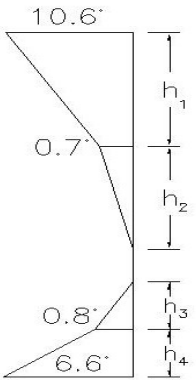
Maximum Temperature considered as per Annex. F of IRC 6: +36.5°C Minimum Temperature considered as per Annex. F of IRC 6: +16.3°C

Temperature variation as per clause 215.2 of IRC 6 will be =(36.5-(16.3))/2+10= ±20.1°C **say 20^{O}C.**

B) Differential Temperature (DT)

The provision given in Clause 215.4 of IRC 6, shall be considered to compute effect of differential temperature gradient in absence of any provisions in IRS code. The differential gradient of temperature along depth of superstructure has been reproduced below for ready reference. Short term modulus of elasticity as per Table given under clause 5.1 of ODS shall be used to calculate the effects.





Positive Temperature Difference

h1 = 0.3h < 0.15m

h2 = 0.3h > 0.1m

< 0.25m

h3 = 0.3h <0.15m

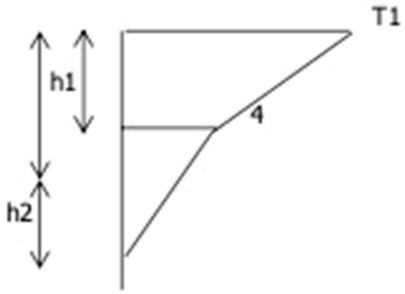
Negative Temperature Difference

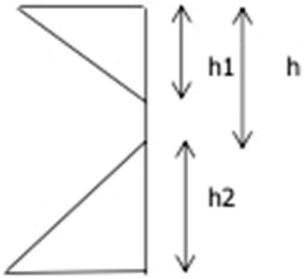
h1 =h4 =0.2h <0.25m

h2 = h3 = 0.25h < 0.25m

Note: For purpose of these calculations no reduction shall be made for presence of track plinths.

Temperature Difference for Concrete Bridge Decks





Positive Temperature Difference

h1 =0.6h

h2 =0.4m

H(m)	$T1^{o}c$
0.2	18
0.3	20.5

NegativeTemperature Difference

H(m)	$T1^{o}c$
0.2	4.4

Temperature Difference across Steel and Composite Section

Note: For purpose of these calculations no reduction shall be made for presence of track plinths.

6.5.2 Resistance to Movement of Elastomeric Bearings (BS)

Elastomeric bearing will resist movement/deformation of superstructure other than applied load i.e. due to variation of temperature/creep strain/shrinkage strain etc. The bearing resistance shall be calculated as per Clause-211.5.1.3 of IRC: 6 duly ensuring provisions given in IRS: Bridge Rules.

The bearing resistance will produce lateral force on the substructure and foundation. The bearing resistance shall be calculated as (VL *L - VR *R), where VL and VR are the shear rating of the left and right elastomeric bearings respectively and L and R are the deck movement at elastomeric bearing location. The above force will be zero when both side spans & supporting bearings are identical, in such case 10% of VL * L shall be considered for design of substructure and foundation.

6.5.3 Rail Structure Interaction (LWR Forces)

Guidelines vide BS Report No. 119 “RDSO Guidelines for carrying out Rail-Structure Interaction studies on Metro System (version-2)” shall be followed.

A rail structure interaction [RSI] analysis is required because the continuously welded running rails are continuous· over the deck expansion joints. The interaction occurs because the rails are directly connected to the decks by fastening system.

1. Rail structure interaction studies shall be done as per provisions of “RDSO Guidelines for carrying out Rail-Structure Interaction studies on Metro System (version-2)”. The following shall be adhered to:

a) Track resistance in loaded and unloaded conditions shall be obtained from cl. 3.2.6 Track Stiffness of “RDSO Guidelines for carrying out Rail-Structure Interaction studies on Metro System (version-2)”. As per the clause, the recommended values for track stiffness for ballasted tracks are 60kN/m and 20kN/m for loaded and unloaded track respectively and recommended values of track stiffness for ballast less tracks are 60kN/m and 40kN/m for loaded and unloaded tracks respectively. The elastic limit is 2 mm for ballasted tracks and 0.5 mm for ballast less tracks. No change in track stiffness is permitted on account of actual track behaviour.

b) The temperature variations, to be used for analysis, shall be taken as per provisions of cl. 3.2.8 Temperature Variations of “RDSO Guidelines for carrying out Rail- Structure Interaction studies on Metro System (version-2)”. The following shall be used for analysis:

-The temperature of the bridge does not deviate from the reference temperature by more than $\pm$ 33 ^{0}C

-The temperature of the rail does not deviate by more than ± 50^0C.
-The difference in temperature between deck and track does not exceed ± 20^0C.

-The reference temperature is the temperature of the deck and the rail when the rail is fixed.

c) Maximum additional stresses in rail in tension as well as compression on account of rail-structure interaction shall be within the permissible limits as prescribed in cl. 3.3.1 Additional Stresses in Rails of "RDSO Guidelines for carrying out Rail-Structure Interaction studies on Metro System (version-2)". The limit prescribed in the document shall be used as it is and no benefit on account of lesser axle load of actual rolling stock shall be permitted.

d) The provisions of cl. 3.3.2 Displacements of Bridge Elements of "RDSO Guidelines for carrying out Rail-Structure Interaction studies on Metro System (version-2)" shall be adhered to.

e) Checks must be performed for break in rail continuity due to unusual conditions such as fractures or for maintenance purposes. The provisions of cl. 4.8 "Rail Gap Analysis of RDSO Guidelines for carrying out Rail-Structure Interaction studies on Metro System (version-2)" shall be followed.

f) Minimum (unfactored) LWR force of 1.6t/m of span length shall be considered for design irrespective of number of tracks.

2. Software and general methodology to be used for carrying out Rail Structure interaction analysis must be validated before adopting the same. A well-established document such as UIC 774-3R may be used for validation.

3. Representative stretches must be chosen for carrying out Rail-Structure interaction which shall include special spans. The same shall be got approved from the engineer.

4. LWR forces shall be considered in appropriate load combinations as specified in cl. 7.0 Load Combinations (Ground IIIb) of the ODS.

6.6 WIND LOAD (WL)

The wind load shall be calculated as per Clause 2.11 of IRS: BR and IS: 875 (Part 3). As per cl. 5.3 of IS: 875 (Part 3)
Design Wind Speed, Vz = **Vb.k1.k2.k3.k4**
Where

Vb = Basic wind speed = 39 m/s for Kochi Zone (as per National Building code).

K1 = 1.08 for class IV type structure (table 1 of IS: 875 (Part 3)).
k2 = 1.07 for category 2 (table 2 of IS: 875 (Part 3)) for 20m Height.

k2 = 1.12 for category 2 (table 2 of IS: 875 (Part 3)) for 30m Height

KOCHI METRO RAIL LIMITED

APPENDIX 5.3

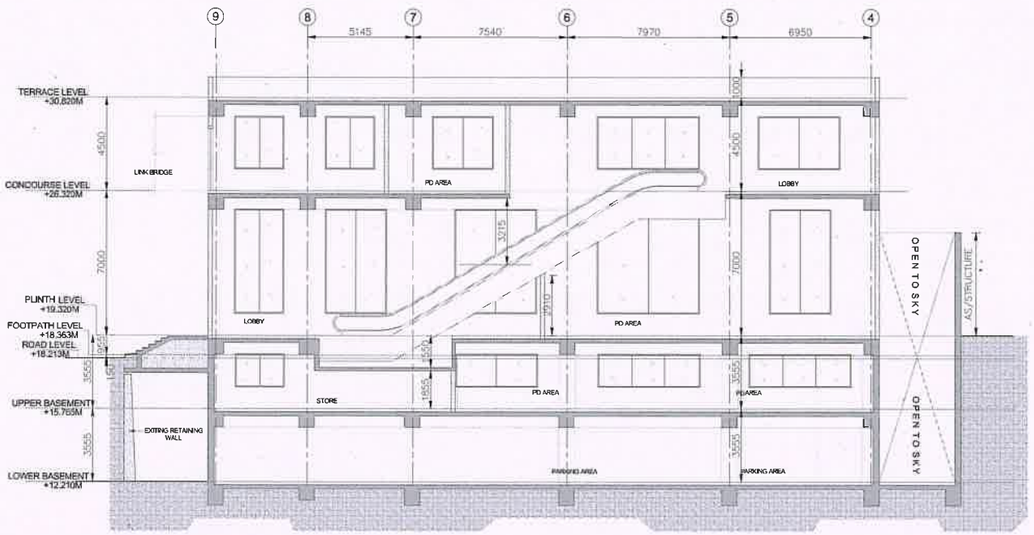
Entry/Exit Station Building Levels

SYSTRA

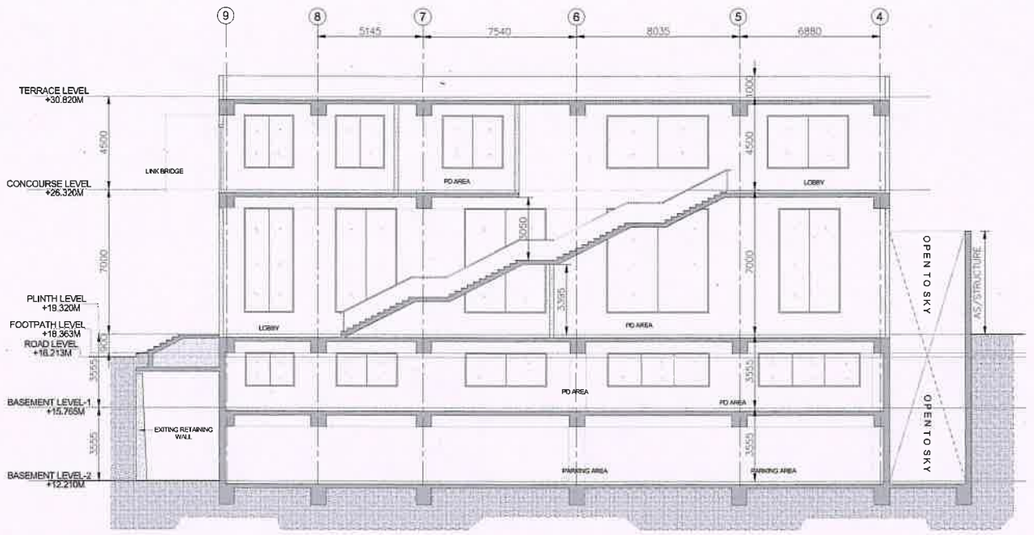
TOWARDS JLN STADIUM

KAKKANAD JUNCTION
CHAINAGE 5339.353 m OLD

TOWARDS INFOPARK



1 SECTION -4 (LHS-THROUGH ESCALATOR)
SCALE : 1/150



2 SECTION -5 (LHS-THROUGH STAIRCASE)
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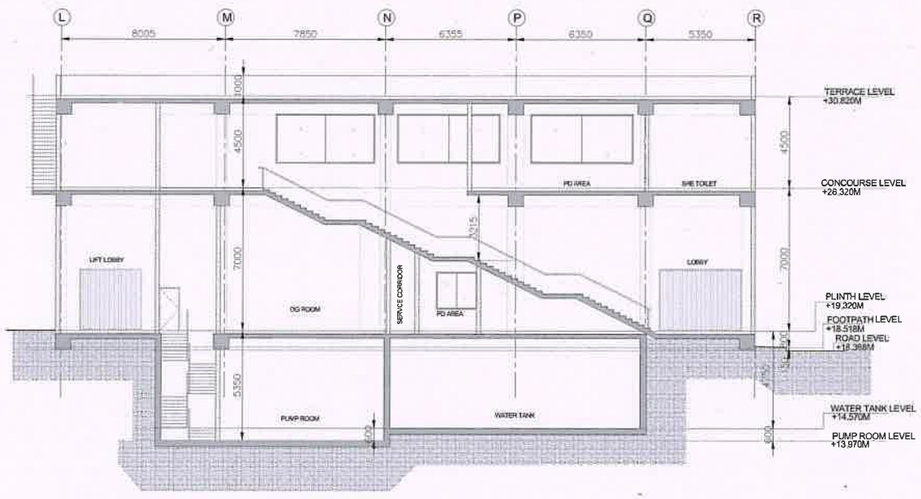

3 SECTION -6 (RHS-THROUGH STAIRCASE)
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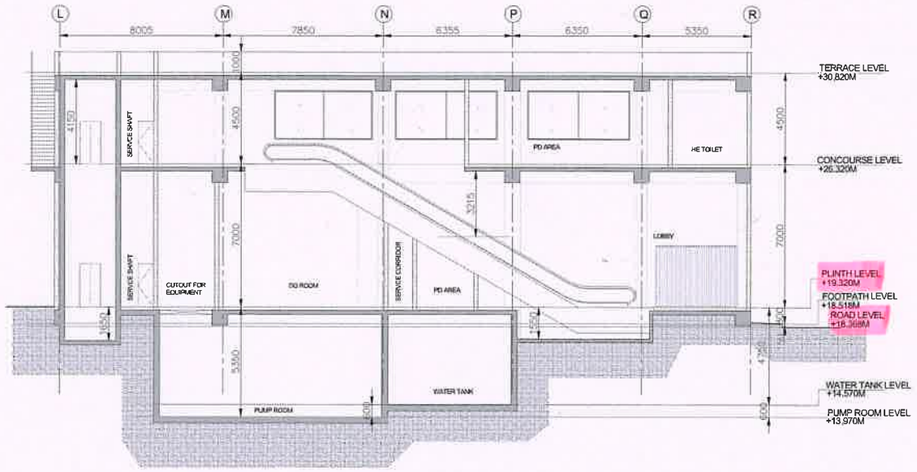

4 SECTION -7 (RHS-THROUGH ESCALATOR)
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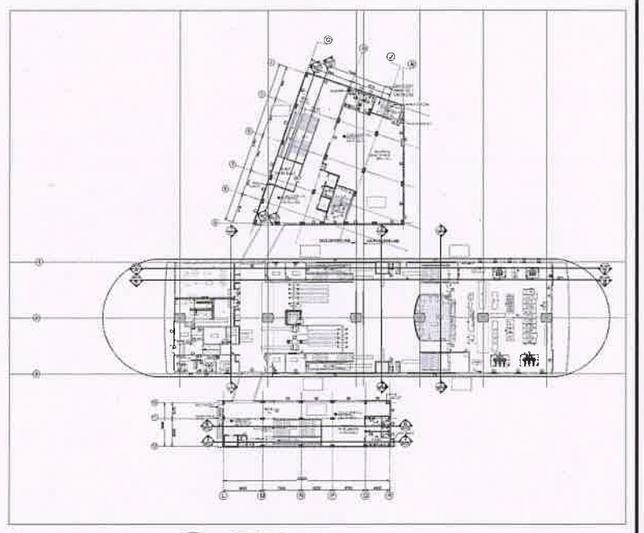


5 KEY PLAN

GENERAL NOTES:

1. ALL DIMENSIONS ARE IN MILLIMETERS, UNTILL OTHERWISE MENTIONED.
2. ALL DIMENSIONS ARE TO BE READ AND NOT MEASURED.
3. DIMENSIONS OF RCC WALLS IN THE SCHEDULE ARE INDICATIVE AND MAY VARY AS PER FINAL STRUCTURAL DESIGN.
4. GROUND LEVELS ARE INDICATIVE, CONTRACTOR TO VERIFY EXISTING LEVELS AT SITE PRIOR TO COMMENCEMENT
5. OF CONSTRUCTION.
6. CONTRACTOR TO VERIFY THE LEVELS FOR STAIRCASE AND LIFT/ESCALATORS PRIOR TO COMMENCEMENT OF
7. CONSTRUCTION.MINIMUM INTERNAL CLEARANCES ARE MANDATORY.
8. LOCATION AND NOS. OF MAIN COLUMNS SHALL BE AS PER STRUCTURAL DESIGN.
9. ACTUAL SIZES OF CUTOUTS AND OPENINGS IN STRUCTURAL SLABS AND WALLS SHALL BE AS PER SEM DRAWING.
10. WHEREVER INTERNAL PARTITION WALLS ARE INDICATED AS RCC WALLS, IT SHALL BE MANDATORY TO FOLLOW THE RCC WALL OF SPECIFIED THICKNESS.
11. FHC NICHE SHOULD BE MADE AS PER SIZE IF REQUIRED.
12. LOCATION AND SIZE OF TEMPORARY CUTOUT FOR EQUIPMENT LOWERING SHALL BE CONFIRMED BY SYSTEMWIDE CONTRACTOR.
13. FOR INTERNAL & EXTERNAL DRAINAGE SYSTEM LAYOUT REFER PLUMBING DRAWINGS.
14. CLEAR HEIGHTS GIVEN IN SECTIONS ARE SUBJECT TO STRUCTURAL DESIGNS.
15. ESCALATOR AND LIFT SIZES ARE INDICATIVE AND FINAL SIZES SHALL BE AS PER MANUFACTURER'S REQUIREMENT AS FINALIZED BY KMRL AND THEIR PIT DRAINAGE MANUFACTURER'S REQUIREMENT AS FINALIZED BY KMRL AND THEIR PIT DRAINAGE TO BE AS PER E&M DRAWINGS.
16. REFER VENDOR AND FABRICATOR DRAWING FOR ALL FINAL TERMINATION AND FIXING DETAIL.
17. STATION STRUCTURE ARE TENTATIVE WILL BE REVISED AS PER STRUCTURE DESIGN.

egis rail s.a. egis rail FOR APPROVAL

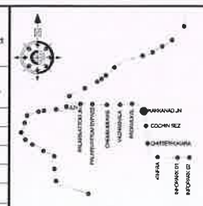
CLIENT
Kochi Metro Rail Limited,
(A joint venture company of Govt. of India & Govt. of Kerala)
KMRL, 4th Floor,
JLN Stadium Metro Station, Kaloor,
Ernakulam, Pin: 682 017
Phone: 0484-292 9700
Fax : 0484-236 0955
Email: contactus@kmrl.co.in

CONSULTANT:
egis rail

PROJECT NAME:
CONSULTANCY SERVICES FOR THE DETAILED DESIGN OF STATION COMPONENTS FOR PHASE II CORRIDOR OF KOCHI METRO RAIL PROJECT

QUALITY ASSURANCE -
The responsibility of control, check and verification of accuracy, correctness, completeness, integration and full compliance of contract provisions in respect of design analysis and drawings rests with the design consultants.

	NAME	SIGNATURE	DATE
DRAWN	M.B.		01/11/2023
DESIGNED	M.K.		01/11/2023
CHECKED BY	M.K.		01/11/2023
APPROVED	A.S.		01/11/2023
PM	S.M.		01/11/2023



APPROVALS BY KMRL

DGM (Arch)		DGM (E&M)		JGM (S&T)	
DGM (Design)		DGM (P&T)		GM (S&T)	
DGM (Track)		JGM (P&T)			
GM (Design)		ACE (RS & E)			
GM (Projects)					
CIVIL		E&M		S & T	

REVISIONS

NO.	DESCRIPTION	DATE	BY
R2	AS PER KMRL COMMENTS	01.11.23	MB
R1	AS PER KMRL COMMENTS	27.10.23	LP
R0	FIRST ISSUE	12.09.23	M.B

PRELIMINARY DESIGN

KOCHI METRO RAIL PROJECT

PHASE II | JLN STADIUM - INFOPARK

STATION : KAKKANAD JUNCTION

TITLE : ENTRY / EXIT SECTIONS

DRG NO : EIRA1KL002-KMRL-PRD-AR-KJS-06122

SCALE 1:200mm

DATE 01/11/2023

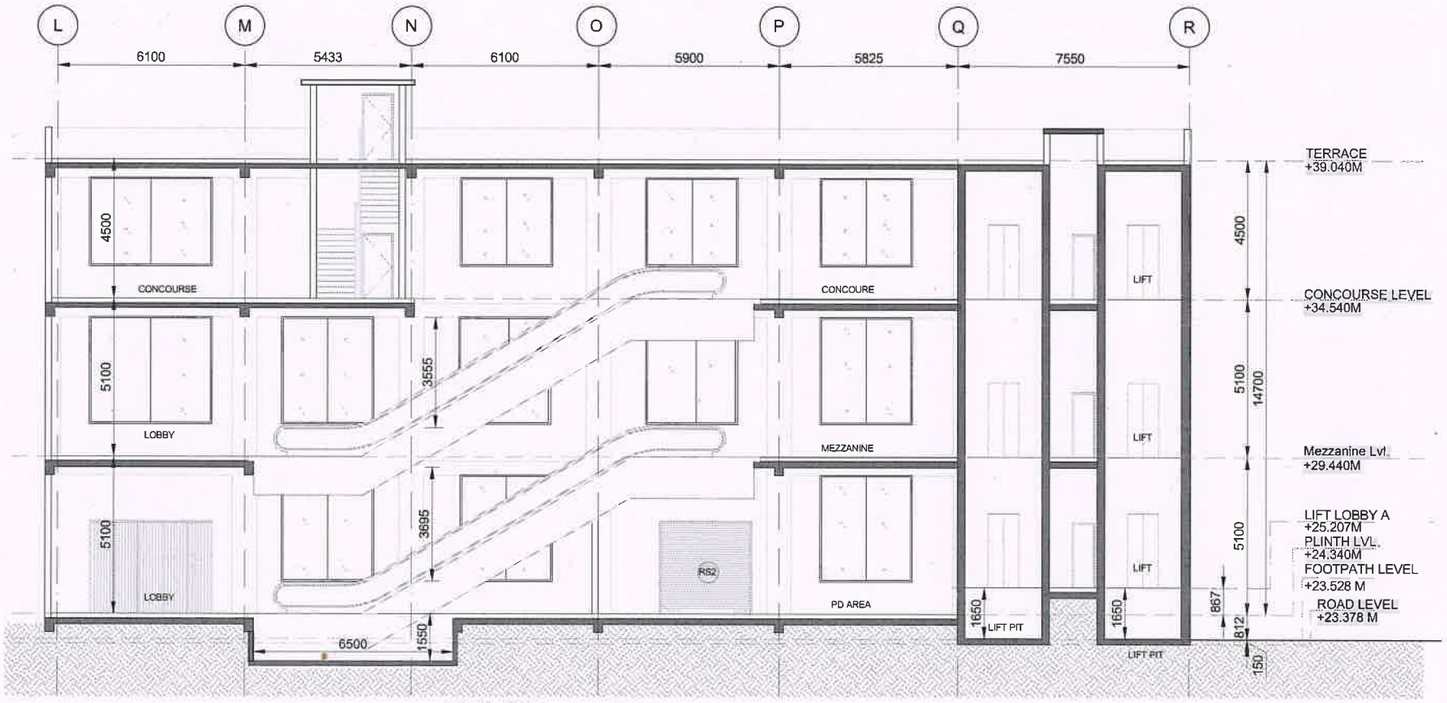
REV.- R2

SHEET- A1

TOWARDS JLN STADIUM

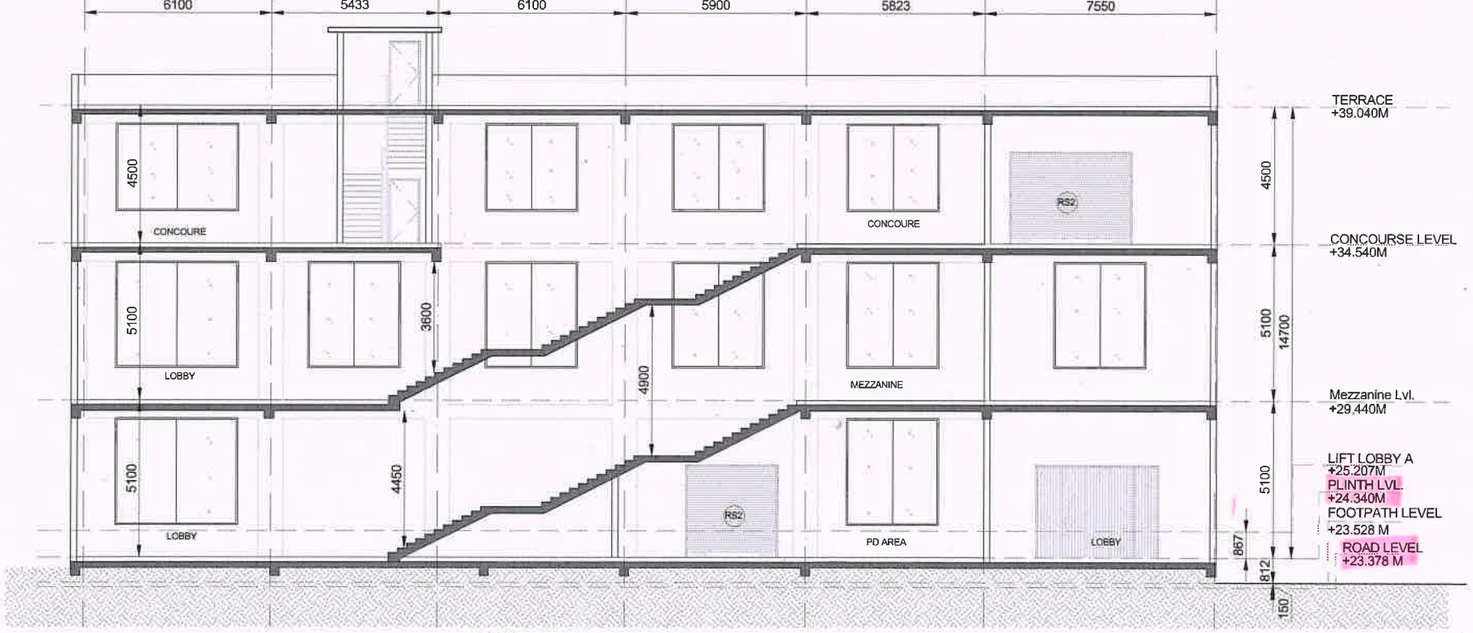
COCHIN SEZ CH : 6361.021

TOWARDS INFOPARK



6 SECTION 6-6 RHS

SCALE : 1/150



7 SECTION 7-7 RHS

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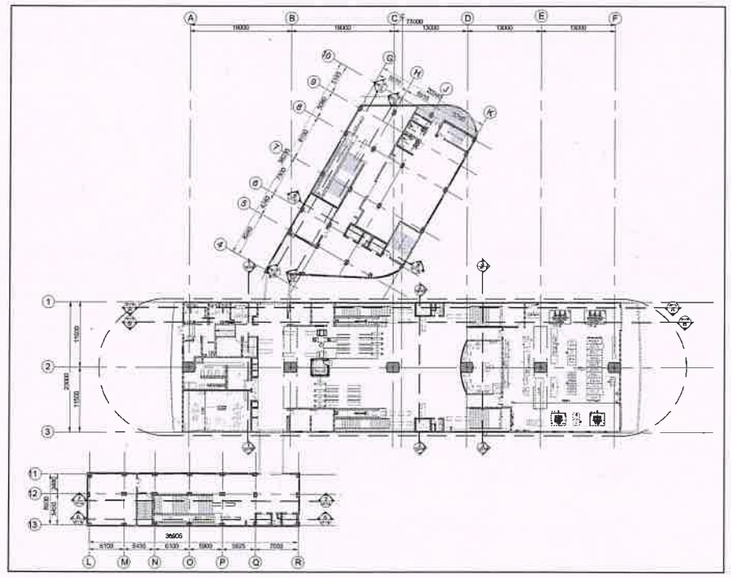

KEY PLAN

NOTE -
For beam and column we have refer the following structural drawings.
1 - LHS ENTRY - EIRA1KL002-KMRL-PRD-ST-CSS-07203
2 - RHS ENTRY- EIRA1KL002-KMRL-PRD-ST-CSS-07103

FOR APPROVAL

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Phone : 0484-282 8700
Fax : 0484-239 0665
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CONSULTANT:
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PROJECT NAME:
CONSULTANCY SERVICES FOR THE DETAILED DESIGN OF STATION COMPONENTS FOR PHASE II CORRIDOR OF KOCHI METRO RAIL PROJECT

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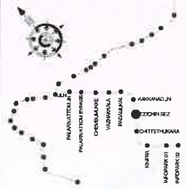
	NAME	SIGNATURE	DATE
DRAWN	A.K.		31.10.23
DESIGNED	M.K.		31.10.23
CHECKED BY	M.K.		31.10.23
APPROVED	A.S.		31.10.23
PM	S.M.		31.10.23



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DGM (Track)		JGM (P&T)			
GM (Design)		ACE (RS & E)			
GM (Projects)					
CIVIL		E&M		S & T	

REVISIONS

NO.	DESCRIPTION	DATE	BY
R2	REVISED AS PER KMRL COMMENTS	31.10.23	AK
R1	AS / COMMENTS RECEIVE FROM CLIENT	14.09.23	AK
R0	FIRST ISSUE	31.08.23	AK

PRELIMINARY DESIGN

KOCHI METRO RAIL PROJECT

PHASE II | JLN STADIUM - INFOPARK

STATION : COCHIN SEZ

TITLE : SECTIONS ENTRY / EXIT LHS AND RHS

DRG NO : EIRA1KL002-KMRL-CRD-AR-CSS-07118

SCALE 1:100mm

DATE 31.10.2023

REV.- R2

SHEET- A1

KOCHI METRO RAIL LIMITED

APPENDIX 6.1

Tree Cutting Permission

SYSTRA

എറണാകുളം സോഷ്യൽ ഫോറസ്ട്രി അസിസ്റ്റന്റ് ഫോറസ്റ്റ് കൺസർവേറ്ററുടെ നടപടി ഉത്തരവ്

ഹാജർ : അനസ് എം.എ.

വിഷയം: പൊതുസ്ഥലങ്ങളിൽ സ്ഥിതിചെയ്യുന്ന മരങ്ങൾ മുറിച്ചു നീക്കുന്നത് - സംബന്ധിച്ച്.

സൂചന: 1)ജനറൽ മാനേജർ(പ്രൊജക്റ്റ്സ്), കൊച്ചി മെട്രോ റെയിൽ ലിമിറ്റഡ്, കൊച്ചി-682011-ന്റ് 01.07.19ലെ KMRL/PH-IIRWIDE/279/3201 നമ്പർ അപേക്ഷ.
2)04.10.19ലെ ട്രീകമ്മറ്റി സംയുക്ത പരിശോധന റിപ്പോർട്ട്.
3)എറണാകുളം റെയിഞ്ച് ഫോറസ്റ്റാഫീസറുടെ 16.08.19ലെ എസ്.എഫ്.ആർ.14/2019 നമ്പർ റിപ്പോർട്ട്.

ഉത്തരവ് നമ്പർ ഇ3-2368/19 തീയതി 22.10.19.

കൊച്ചി മെട്രോ റെയിലിന്റെ രണ്ടാംഘട്ട നിർമ്മാണ പ്രവർത്തനങ്ങളുടെ ഭാഗമായി കാക്കനാട് സിഗ്നൽ ജംഗ്ഷൻ മുതൽ സീപോർട്ട്-എയർപോർട്ട് റോഡിലെ ഇൻഫോപാർക്ക് വരെയുള്ള റോഡിന് വീതി കൂട്ടുന്ന പ്രവൃത്തിക്ക് തടസ്സമായി നിൽക്കുന്ന മരങ്ങൾ മുറിച്ചു നീക്കം ചെയ്യണമെന്ന് ആവശ്യപ്പെട്ടുകൊണ്ട് സൂചന(1) പ്രകാരം അപേക്ഷ ലഭിച്ചിട്ടുണ്ട്.

പൊതുസ്ഥലങ്ങളിൽ സ്ഥിതി ചെയ്യുന്ന മരങ്ങൾ പരിശോധിക്കുന്നതിന് രൂപീകരിക്കപ്പെട്ട കമ്മറ്റി സ്ഥലത്ത് പോയി പരിശോധിച്ചതിൽ അപേക്ഷയിൽ പറയുന്ന മരങ്ങളിൽ വികസന പ്രവർത്തനത്തിന് തടസ്സമായി നിൽക്കുന്ന 402 മരങ്ങൾ മുറിച്ചു മാറ്റുവാൻ, മുറിച്ചു മാറ്റുന്ന 402 മരങ്ങൾക്ക് പകരം പത്തിരട്ടി മരങ്ങൾ വച്ച് പിടിപ്പിക്കണമെന്ന വ്യവസ്ഥയിൽ അനുവാദം നൽകാവുന്നതാണ് എന്ന് തീരുമാനിക്കുകയുണ്ടായി.

മേൽ സാഹചര്യത്തിൽ കൊച്ചി മെട്രോ റെയിലിന്റെ രണ്ടാംഘട്ട നിർമ്മാണ പ്രവർത്തനങ്ങളുടെ ഭാഗമായി കാക്കനാട് സിഗ്നൽ ജംഗ്ഷൻ മുതൽ സീപോർട്ട്-എയർപോർട്ട് റോഡിലെ ഇൻഫോപാർക്ക് വരെയുള്ള റോഡിന് വീതി കൂട്ടുന്ന പ്രവൃത്തിക്ക് തടസ്സമായി നിൽക്കുന്ന 402 മരങ്ങൾ മുറിച്ചു മാറ്റുവാൻ അനുമതി നൽകിക്കൊണ്ട് ഉത്തരവാകുന്നു. പ്രസ്തുത മരങ്ങളിൽ നിന്നും ലഭിക്കാവുന്ന തടിയുടെയും വിറകിന്റെയും വില റെയിഞ്ച് ഫോറസ്റ്റാഫീസർ കണക്കാക്കിയത് ഇതോടൊപ്പം ഉള്ളടക്കം ചെയ്യുന്നു.

മരങ്ങൾ വിറ്റുകിട്ടുന്ന നികുതി ഉൾപ്പെടെയുള്ള ആകെ തുകയുടെ 5% വനവികസന ഫണ്ടിലേക്ക് ഇതോടൊപ്പമുള്ള ചെലാനിൽ രേഖപ്പെടുത്തി ട്രഷറിയിൽ അടച്ച് അസ്സൽ രശീതി ഈ ഓഫീസിൽ ലഭ്യമാക്കേണ്ടതാണ്. G.O(Rt)No.172/2010/F&WLD dt.21.04.2010 പ്രകാരം മുറിച്ചു മാറ്റിയ മരങ്ങൾക്ക് പകരമായി പത്തിരട്ടി മരങ്ങൾ നട്ടുപിടിപ്പിക്കേണ്ടതാണ് എന്ന നിബന്ധന കർശനമായും പാലിക്കേണ്ടതാണ്.

അസിസ്റ്റന്റ് ഫോറസ്റ്റ് കൺസർവേറ്റർ
സോഷ്യൽ ഫോറസ്ട്രി, എറണാകുളം

സ്വീകർത്താവ്: ജനറൽ മാനേജർ (പ്രൊജക്റ്റ്സ്), കൊച്ചി മെട്രോ റെയിൽ ലിമിറ്റഡ്, കൊച്ചി- 682011-ചലാൻ സഹിതം അയക്കുന്നു.

പകർപ്പ് : എറണാകുളം ജില്ലാപഞ്ചായത്ത് പ്രസിഡണ്ടിന് അറിവിനായി അയയ്ക്കുന്നു.
:എറണാകുളം സോഷ്യൽ ഫോറസ്ട്രി റെയിഞ്ച് ഓഫീസർക്ക്. മുറിച്ച് മാറ്റുന്ന മരങ്ങൾക്കു പകരമായി പത്തിരട്ടി മരങ്ങൾ നട്ടു പിടിപ്പിക്കുന്നുണ്ടന്ന് ഉറപ്പുവരുത്തേണ്ടതാണ്.
: വൃക്ഷകമ്മിറ്റി അംഗങ്ങൾക്ക്.
: സ്റ്റോക്ക് ഫയലിലേക്ക്.

			Timber			Fire Wood				
Sl.No	Speices	GBH in cm	Volume	Rate	Amount	Volume	Rate	Amount	Total	Remark
1	Vatta	50.00			0.00	0.10	1770	88.50	88.50	
2	Vatta	40.00			0.00	0.10	1770	88.50	88.50	
3	Kalasham	40.00			0.00	0.1	1770	88.50	88.50	Chittiyathukara
4	Kalasham	40.00			0.00	0.10	1770	88.50	88.50	Station
5	Vatta	40.00			0.00	0.10	1770	88.50	88.50	
6	Vatta	40.00			0.00	0.10	1770	88.50	88.50	
7	Vatta	40.00			0.00	0.10	1770	88.50	88.50	
8	Mazha Maram	70.00			0.00	0.10	1770	88.50	88.50	
9	Mazha Maram	60.00			0.00	0.10	1770	88.50	88.50	
10	Vatta	50.00			0.00	0.10	1770	88.50	88.50	
11	Vatta	45.00			0.00	0.10	1770	88.50	88.50	
12	Vatta	50.00			0.00	0.10	1770	88.50	88.50	
13	Vatta	40.00			0.00	0.10	1770	88.50	88.50	
14	Vatta	40.00			0.00	0.10	1770	88.50	88.50	
15	Vatta	35.00			0.00	0.10	1770	88.50	88.50	
16	Vatta	65.00			0.00	0.10	1770	88.50	88.50	
17	Vatta	70.00			0.00	0.10	1770	88.50	88.50	
18	Pana	110.00			0.00		150	150.00	150.00	
19	Vatta	60.00			0.00	0.10	1770	88.50	88.50	
20	Vatta	50.00			0.00	0.10	1770	88.50	88.50	
21	Vatta	45.00			0.00	0.10	1770	88.50	88.50	
22	Vatta	60.00			0.00	0.10	1770	88.50	88.50	
23	Vatta	50.00			0.00	0.10	1770	88.50	88.50	
24	Vatta	50.00			0.00	0.10	1770	88.50	88.50	
25	Vatta	60.00			0.00	0.10	1770	88.50	88.50	
26	Vatta	50.00			0.00	0.10	1770	88.50	88.50	
27	Vatta	75.00			0.00	0.10	1770	88.50	88.50	
28	Vatta	70.00			0.00	0.10	1770	88.50	88.50	
29	Vatta	60.00			0.00	0.10	1770	88.50	88.50	
30	Vatta	60.00			0.00	0.10	1770	88.50	88.50	
31	Vatta	60.00			0.00	0.10	1770	88.50	88.50	
32	Vatta	110.00	0.396	1800	712.80	0.10	1770	88.50	801.30	
33	Vatta	60.00			0.00	0.10	1770	88.50	88.50	
34	Vatta	50.00			0.00	0.10	1770	88.50	88.50	
35	Vatta	50.00			0.00	0.10	1770	88.50	88.50	
36	Vatta	50.00			0.00	0.10	1770	88.50	88.50	
37	Vatta	50.00			0.00	0.10	1770	88.50	88.50	
38	Povaka	110.00	0.396	1650	653.40	0.17	1770	150.45	803.85	
39	Vatta	50.00			0.00	0.10	1770	88.50	88.50	
40	Vatta	50.00			0.00	0.10	1770	88.50	88.50	
41	Vatta	40.00			0.00	0.10	1770	88.50	88.50	
42	Almaram	50.00			0.00	0.10	1770	88.50	88.50	
43	Vatta	50.00			0.00	0.10	1770	88.50	88.50	
44	Vatta	100.00	0.257	1800	462.60	0.07	1770	61.95	524.55	
45	Vatta	130.00	0.708	9500	6726.00	0.33	1770	291.17	7017.17	
46	Badam	120.00	0.547		0.00	0.28	1770	487.00	487.00	

47	Vatta	60.00			0.00	0.10	1770	88.50	88.50	
48	Vatta	80.00	0.115	1800	207.00	0.10	1770	88.50	295.50	
49	Vatta	150.00	0.932	1623	1512.64	0.75	680	253.98	1766.62	
50	AQUASIA	145.00	0.932	1623	1512.64	0.75	1770	661.10	2173.73	
51	Vatta	100.00	0.322	1800	579.60	0.39	1770	344.27	923.87	
52	Pala	200.00	1.659	7400	12276.60	1.83	1770	1620.44	13897.04	
53	Vatta	65.00			0.00	0.10	1770	88.50	88.50	
54	Vatta	60.00			0.00	0.10	1770	88.50	88.50	
55	Nelli	40.00			0.00	0.10	1770	88.50	88.50	
56	Vatta	60.00			0.00	0.10	1770	88.50	88.50	
54	Vatta	60.00			0.00	0.10	1770	88.50	88.50	
55	Nelli	40.00			0.00	0.10	1770	88.50	88.50	
56	Vatta	60.00			0.00	0.10	1770	88.50	88.50	
57	Vatta	50.00			0.00	0.10	1770	88.50	88.50	
58	Vatta	50.00			0.00	0.10	1770	88.50	88.50	
59	Vatta	40.00			0.00	0.10	1770	88.50	88.50	
60	Mazha Maram	115.00	0.547	2970	1624.59	0.28	1770	246.92	1871.51	
61	Vatta	55.00			0.00	0.10	1770	88.50	88.50	
62	Vatta	65.00			0.00	0.10	1770	88.50	88.50	
63	Vatta	60.00			0.00	0.10	1770	88.50	88.50	
64	Vatta	60.00			0.00	0.10	1770	88.50	88.50	
65	Vatta	60.00			0.00	0.10	1770	88.50	88.50	
66	Vatta	50.00			0.00	0.10	1770	88.50	88.50	
67	Vatta	80.00			0.00	0.10	1770	88.50	88.50	
68	Ngaval	80.00	0.13	1463	190.19	0.10	1770	88.50	278.69	
69	Kani Konna	90.00	0.13		0.00	0.10	1770	88.50	88.50	
70	Vatta	50.00			0.00	0.10	1770	88.50	88.50	
71	Vatta	60.00			0.00	0.10	1770	88.50	88.50	
72	Vatta	50.00			0.00	0.10	1770	88.50	88.50	
73	Vatta	90.00	0.218	1800	392.40	0.39	1770	344.27	736.67	
74	Vatta	130.00	0.674	1800	1213.20	0.83	1770	730.13	1943.33	
75	Vatta	80.00	0.218	1800	392.40	0.10	1770	88.50	480.90	
76	Vatta	40.00			0.00	0.10	1770	88.50	88.50	
77	Mahogany	70.00			0.00	0.10	1770	88.50	88.50	
78	Mazha Maram	120.00	0.567	2970	1683.99	0.28	1770	246.92	1930.91	
79	Kani Konna	60.00			0.00	0.10	1770	88.50	88.50	
80	Vatta	70.00			0.00	0.10	1770	88.50	88.50	
81	Vatta	70.00			0.00	0.10	1770	88.50	88.50	
82	Mazha Maram	145.00	1.061	3630	3851.43	0.79	1770	698.27	4549.70	
83	Mazha Maram	160.00	1.247	3630	4526.61	0.87	1770	769.95	5296.56	
84	Mazha Maram	190.00	1.889	3630	6857.07	1.47	1770	1300.07	8157.14	
85	Vatta	100.00	0.322	1800	579.60	0.29	1770	255.77	835.37	
86	Kalasham	70.00			0.00	0.10	1770	88.50	88.50	
87	Mazha Maram	60.00			0.00	0.10	1770	88.50	88.50	
88	Mazha Maram	70.00			0.00	0.10	1770	88.50	88.50	
89	Vatta	30.00			0.00	0.10	1770	88.50	88.50	
90	Vatta	45.00			0.00	0.10	1770	88.50	88.50	
91	Vatta	60.00			0.00	0.10	1770	88.50	88.50	
92	Vatta	50.00			0.00	0.10	1770	88.50	88.50	
93	Mahogany	50.00			0.00	0.10	1770	88.50	88.50	

94	Vatta	93.00	0.322	1800	579.60	0.10	1770	88.50	668.10	
95	Vatta	90.00	0.218	1800	392.40	0.10	1770	88.50	480.90	
96	Mazha Maram	150.00	1.061	3630	3851.43	0.70	1770	623.04	4474.47	
97	Vatta	50.00			0.00	0.10	1770	88.50	88.50	
98	Vatta	40.00			0.00	0.10	1770	88.50	88.50	
99	Vatta	75.00			0.00	0.10	1770	88.50	88.50	
100	Mazha Maram	60.00			0.00	0.10	1770	88.50	88.50	
101	Mazha Maram	45.00			0.00	0.10	1770	88.50	88.50	
102	Vatta	60.00			0.00	0.10	1770	88.50	88.50	
103	Mazha Maram	30.00			0.00	0.10	1770	88.50	88.50	
104	Mazha Maram	60.00			0.00	0.10	1770	88.50	88.50	
105	Vatta	50.00			0.00	0.10	1770	88.50	88.50	
106	Vatta	65.00			0.00	0.10	1770	88.50	88.50	
107	Vatta	30.00			0.00	0.10	1770	88.50	88.50	
108	Vatta	60.00			0.00	0.10	1770	88.50	88.50	
109	Vatta	80.00	0.115	1800	207.00	0.10	1770	88.50	295.50	
110	Vatta	75.00	0.115	1800	207.00	0.10	1770	88.50	295.50	
111	Vatta	40.00			0.00	0.10	1770	88.50	88.50	
112	Vatta	50.00			0.00	0.10	1770	88.50	88.50	
113	Vatta	60.00			0.00	0.10	1770	88.50	88.50	
114	Mahogany	100.00	0.287	15430	4428.41	0.07	1770	61.95	4490.36	
115	Vatta	90.00	0.218	1800	392.40	0.10	1770	88.50	480.90	
116	Vatta	90.00	0.218	1800	392.40	0.10	1770	88.50	480.90	
117	Vatta	90.00	0.218	1800	392.40	0.10	1770	88.50	480.90	
118	Vatta	70.00			0.00	0.10	1770	88.50	88.50	
119	Vatta	70.00			0.00	0.10	1770	88.50	88.50	
120	Vatta	60.00			0.00	0.10	1770	88.50	88.50	
121	Vatta	110.00	0.424	1800	763.20	0.10	1770	88.50	851.70	
122	Vatta	90.00	0.218	1800	392.40	0.10	1770	88.50	480.90	
123	Vatta	100.00	0.218	1800	392.40	0.10	1770	88.50	480.90	
124	Vatta	90.00	0.218	1800	392.40	0.10	1770	88.50	480.90	
125	Mahogany	95.00	0.257	15430	3965.51	0.07	1770	62.84	4028.35	
126	Vatta	145.00	0.912	1800	1641.60	0.75	1770	661.10	2302.70	
127	Pachani	160.00	1.247		0.00	0.87	1770	1213.00	1213.00	
128	Badam	90.00	0.13		0.00	0.10	1770	136.00	136.00	
129	Badam	45.00			0.00	0.10	1770	88.50	88.50	
130	Badam	130.00	0.708		0.00	0.33	1770	616.00	616.00	
131	Badam	50.00			0.00	0.10	1770	88.50	88.50	
132	Badam	40.00			0.00	0.10	1770	88.50	88.50	
133	Mazha Maram	155.00	1.247	3630	4526.61	0.87	1770	769.95	5296.56	
134	Mazha Maram	185.00	1.889	3630	6857.07	1.47	1770	1300.07	8157.14	
135	Mazha Maram	150.00	1.061	3630	3851.43	0.70	1770	623.04	4474.47	
136	Kalasham	110.00	0.396	7780	3080.88	0.17	1770	150.45	3231.33	
137	Mahogany	60.00			0.00	0.10	1770	88.50	88.50	
138	Mazha Maram	74.00			0.00	0.10	1770	88.50	88.50	
139	Mazha Maram	115.00	0.547	2930	1602.71	0.28	1770	246.92	1849.63	
140	Plavu	80.00	0.117	11400	1333.80	0.26	1770	228.33	1562.13	
141	Mave	60.00			0.00	0.10	1770	88.50	88.50	
142	Almaram	310.00	5.338		0.00		1770	5870.00	5870.00	
143	Puvaka	165.00	1.449	2930	4245.57	1.10	1770	973.50	5219.07	

144	Plum Tree	20 nos			0.00	0.98	1770	867.30	867.30	
165	Kalasham	70.00			0.00	0.10	1770	88.50	88.50	
166	Vatta	165.00	1.062	1800	1911.60	1.09	1770	964.65	2876.25	
167	Teak	80.00	0.207	39630	8203.41	0.12	1770	104.43	8307.84	
168	Vatta	215.00	1.98	1800	3564.00	2.46	1770	2177.10	5741.10	
169	Povaka	145.00	1.061	2830	3002.63	0.70	1770	623.04	3625.67	
170	Mahogany	50.00			0.00	0.10	1770	88.50	88.50	
171	Vatta	180.00	1.352	9500	12844.00	1.39	1770	1230.15	14074.15	
172	Vatta	120.00	0.552	1800	993.60	0.44	1770	392.06	1385.66	
173	Mazha Maram	70.00			0.00	0.10	1770	88.50	88.50	
174	Badam	50.00			0.00	0.10	1770	88.50	88.50	
175	Vatta	125.00	0.675	1800	1215.00	0.52	1770	455.78	1670.78	
176	Mave	290.00	3.547	21856	77523.23	3.66	1770	3239.10	80762.33	
177	Mazha Maram	200.00	2.116	3630	7681.08	1.72	1770	1517.78	9198.86	
178	Vatta	90.00	0.218	1800	392.40	0.16	1770	141.60	534.00	
179	Vatta	135.00	0.8	9500	7600.00	0.62	1770	546.93	8146.93	
180	Pala	90.00	0.257	7400	1901.80	0.10	1770	88.50	1990.30	
181	Vatta	175.00	1.352	9500	12844.00	1.31	1770	1158.47	14002.47	
182	Pala	95.00	0.257	7400	1901.80	0.10	1770	88.50	1990.30	
183	Vatta	205.00	1.802	9500	17119.00	2.14	1770	1890.36	19009.36	
184	Pala	100.00	0.257	7400	1901.80	0.10	1770	88.50	1990.30	
185	Vatta	205.00	1.065	9500	10117.50	0.90	1770	798.27	10915.77	
186	Pala	100.00	0.257	7400	1901.80	0.10	1770	88.50	1990.30	
187	Vatta	95.00	0.322	1800	579.60	0.39	1770	344.27	923.87	
188	Vatta	100.00	0.322	1800	579.60	0.39	1770	345.15	924.75	
189	Pala	100.00	0.257	7400	1901.80	0.10	1770	88.50	1990.30	
190	Vatta	125.00	0.674	9500	6403.00	0.52	1770	455.78	6858.78	
191	Mahogany	60.00			0.00	0.10	1770	88.50	88.50	
192	Mazha Maram	50.00			0.00	0.10	1770	88.50	88.50	
193	Vatta	100.00	0.322	1800	579.60	0.39	1770	344.27	923.87	
194	Vatta	265.00	2.89	9500	27455.00	4.57	1770	4042.68	31497.68	
195	Kalasham	40.00			0.00	0.10	1770	88.50	88.50	
196	Mave	50.00			0.00	0.10	1770	88.50	88.50	
197	Pambazham	110.00	0.396	2300	910.80	0.10	1770	88.50	999.30	
198	Badam	75.00			0.00	0.10	1770	88.50	88.50	
199	Vatta	185.00	1.523	9500	14468.50	1.55	1770	1375.29	15843.79	
200	Vatta	100.00	0.257	1800	462.60	0.10	1770	88.50	551.10	
201	Aval	110.00	0.547	1513	827.61	0.28	1770	246.92	1074.53	
202	Vatta	140.00	0.8	9500	7600.00	0.62	1770	546.93	8146.93	
203	Vatta	50.00			0.00	0.10	1770	88.50	88.50	
204	Vatta	140.00	0.8	9500	7600.00	0.62	1770	546.93	8146.93	
205	Mazha Maram	90.00	0.237	2920	692.04	0.10	1770	88.50	780.54	
206	Mazha Maram	145.00	1.061	3630	3851.43	0.70	1770	623.04	4474.47	
207	Pala	100.00	0.257	7400	1901.80	0.10	1770	88.50	1990.30	
208	Mazha Maram	110.00	0.326	2570	837.82	0.10	1770	88.50	926.32	
209	Mazha Maram	95.00	0.257	2970	763.29	0.10	1770	88.50	851.79	
210	Mazha Maram	160.00	1.247	3630	4526.61	0.57	1770	504.45	5031.06	
211	Ngaval	120.00	0.547	1463	800.26	0.24	1770	211.52	1011.78	
212	Mazha Maram	95.00	0.257	2970	763.29	0.10	1770	88.50	851.79	
213	Mazha Maram	125.00	0.708	2970	2102.76	0.33	1770	291.17	2393.93	

214	Naval	70.00			0.00	0.10	1770	88.50	88.50	
215	Mazha Maram	120.00	0.547	2970	1624.59	0.28	1770	246.92	1871.51	
216	Mazha Maram	85.00	0.13	2970	386.10	0.10	1770	88.50	474.60	
217	Mazha Maram	95.00	0.218	2970	647.46	0.10	1770	88.50	735.96	
218	Vatta	90.00	0.218	1800	392.40	0.10	1770	88.50	480.90	
219	Mahogany	90.00	0.257	15430	3965.51	0.10	1770	88.50	4054.01	
220	Povaka	80.00			0.00	0.10	1770	88.50	88.50	
221	Mazha Maram	95.00	0.257	2970	763.29	0.10	1770	88.50	851.79	
222	Vatta	90.00	0.218	1800	392.40	0.10	1770	88.50	480.90	
223	Vatta	90.00	0.208	1800	374.40	0.10	1770	88.50	462.90	
224	Mazha Maram	85.00	0.13	2970	386.10	0.10	1770	88.50	474.60	
225	Mahogany	140.00	0.879	35091	30844.99	0.55	1770	484.98	31329.97	
226	Povaka	170.00	0.449	2830	1270.67	1.06	1770	936.33	2207.00	
227	Povaka	130.00	0.708	2830	2003.64	0.33	1770	291.17	2294.81	
228	Komil	100.00	0.257	4963	1275.49	0.10	1770	88.50	1363.99	
229	Pana	40.00			0.00		1770	0.00	0.00	
230	Pana	40.00			0.00		1770	0.00	0.00	
231	Povaka	150.00	1.061	2830	3002.63	0.70	1770	623.04	3625.67	
232	Povaka	95.00	0.144	12530	1804.32	0.55	1770	483.21	2287.53	
233	Mazha Maram	30.00			0.00	0.10	1770	88.50	88.50	
234	Povaka	150.00	1.061	2830	3002.63	0.70	1770	623.04	3625.67	
235	Kattadi	150.00	1.061	1013	1074.79	0.70	1770	623.04	1697.83	
236	Pomaram	90.00	0.13	1650	214.50	0.11	1770	97.35	311.85	
237	Kattadi	100.00	0.257	1013	260.34	0.07	1770	61.95	322.29	
238	Pomaram	120.00	0.547	1650	902.55	0.24	1770	211.52	1114.07	
239	Pala	240.00	3.243	7400	23998.20	2.79	1770	2471.81	26470.01	
240	Pana	160.00			0.00		100	100.00	100.00	
241	Pana	150.00			0.00		100	100.00	100.00	
242	Pala	140.00	0.879	7400	6504.60	0.55	1770	484.98	6989.58	
243	Pala	150.00	1.061	7400	7851.40	0.70	1770	623.04	8474.44	
244	AQUASIA	200.00	2.06	16253	33481.18	1.72	680	583.10	34064.28	
245	Vatta	110.00	0.434	1800	781.20	0.40	1770	354.89	1136.09	
246	Pala	280.00	3.068	7480	22948.64	4.08	1770	3610.80	26559.44	
247	Vatta	110.00	0.434	1800	781.20	0.40	1770	354.89	1136.09	
248	Vatta	90.00	0.218	1800	392.40	0.10	1770	88.50	480.90	
249	Plavu	80.00	0.124	11480	1423.52	0.93	1770	823.94	2247.46	
250	Vatta	60.00			0.00	0.10	1770	88.50	88.50	
251	Vatta	160.00	1.865	9500	17717.50	0.90	1770	798.27	18515.77	
252	Vatta	110.00	0.434	1800	781.20	0.10	1770	88.50	869.70	
253	Kalasham	160.00	1.247	7780	9701.66	0.87	1770	769.95	10471.61	
254	Mahogany	120.00	0.543	15430	8378.49	0.27	1770	242.49	8620.98	
255	Mahogany	100.00	0.257	15430	3965.51	0.10	1770	88.50	4054.01	
256	Vatta	90.00	0.218	1800	392.40	0.10	1770	88.50	480.90	
257	Vatta	150.00	0.932	9500	8854.00	0.75	1770	661.10	9515.10	
258	Angily	90.00	0.144	12570	1810.08	0.55	1770	483.21	2293.29	Media Acadam
259	Vatta	110.00	0.414	1800	745.20	0.10	1770	88.50	833.70	
260	Vatta	110.00	0.434	1800	781.20	0.10	1770	88.50	869.70	
261	Matti	200.00	1.659	5500	9124.50	1.83	1770	1619.55	10744.05	
262	Matti	120.00	0.552	5500	3036.00	0.44	1770	392.06	3428.06	
263	Mazha Maram	170.00	1.449	3630	5259.87	1.06	1770	936.33	6196.20	

264	Mazha Maram	180.00	1.661	3630	6029.43	1.26	1770	1117.76	7147.19	
265	Mazha Maram	70.00			0.00	0.10	1770	88.50	88.50	
266	Mazha Maram	70.00			0.00	0.10	1770	88.50	88.50	
267	Mazha Maram	70.00			0.00	0.10	1770	88.50	88.50	
268	Mazha Maram	220.00	2.605	3630	9456.15	2.22	1770	1963.82	11419.97	
269	Mazha Maram	70.00			0.00	0.10	1770	88.50	88.50	

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Office of the Assistant Conservator of Forests ★ Social Forestry Division ★ ERNAKULAM-682 024

Sreelath. G (Forest Range Officer)
Ernakulam Section

			Timber			Fire Wood				
Sl.No	Speices	GBH in cm	Volume	Rate	Amount	Volume	Rate	Amount	Total	Remark
1	Puvaka	100.00	0.257	1650	424.05	0.07	1770	62.84	486.89	**Signal**
2	Mazha Maram	170.00	1.661	3630	6029.43	1.26	1770	1115.99	7145.42	
3	Vatta	90.00	0.257	1800	462.60	0.07	1770	62.84	525.44	
4	Povaka	115.00	0.547	1650	902.55	0.28	1770	246.92	1149.47	
5	Mazha Maram	165.00	1.449	3630	5259.87	1.06	1770	936.33	6196.20	
6	Marotti	60.00			0.00	0.10	1770	88.50	88.50	
7	Ngaval	110.00	0.396	1463	579.35	0.17	1770	150.45	729.80	
8	Aval	120.00	0.547	1513	827.61	0.28	1770	246.92	1074.53	
9	Badam	70.00			0.00	0.10	1770	88.50	88.50	
10	Badam	88.00	0.13		0.00	0.10	1770	88.50	131.00	
11	Mazha Maram	138.00	0.879	3630	3190.77	0.55	1770	484.98	3675.75	
12	Badam	70.00			0.00	0.10	1770	88.50	88.50	
13	Badam	110.00	0.396		0.00	0.17	1770	150.45	676.00	
14	Nelli	65.00			0.00	0.10	1770	88.50	88.50	
15	Mazha Maram	170.00	1.449	3630	5259.87	1.06	1770	936.33	6196.20	
16	Mazha Maram	140.00	0.879	3630	3190.77	0.55	1770	485.87	3676.64	
17	Mazha Maram	130.00	0.708	3630	2570.04	0.33	1770	291.17	2861.21	
18	Mazha Maram	125.00	0.708	3630	2570.04	0.33	1770	291.17	2861.21	
19	Mazha Maram	170.00	1.449	3630	5259.87	1.06	1770	936.33	6196.20	
20	Mahogany	130.00	0.708	15430	2570.00	0.33	1770	291.17	2861.17	
21	Mazha Maram	175.00	1.661	3630	6029.43	1.26	1770	1115.99	7145.42	
22	Mazha Maram	190.00	1.889	3630	6857.07	1.47	1770	1300.07	8157.14	
23	Vatta	70.00			0.00	0.10	1770	88.50	88.50	
24	Vatta	70.00			0.00	0.10	1770	88.50	88.50	
25	Mazha Maram	120.00	0.547	3630	1985.61	0.28	1770	246.92	2232.53	
26	Vatta	50.00			0.00	0.10	1770	88.50	88.50	
27	Vatta	180.00	1.661	9500	15779.50	1.26	1770	1115.99	16895.49	
29	Mazha Maram	118.00	0.547	3630	1985.61	0.28	1770	246.92	2232.53	
30	Vatta	100.00	0.257	1800	462.60	0.07	1770	62.84	525.44	
31	Mazha Maram	117.00	0.547	3630	1985.61	0.28	1770	246.92	2232.53	
32	Vatta	50.00			0.00	0.10	1770	88.50	88.50	
33	Mazha Maram	170.00	1.449	3630	5259.87	1.06	1770	936.33	6196.20	
34	Mazha Maram	110.00	0.396	2970	1176.12	0.17	1770	150.45	1326.57	
35	Mazha Maram	100.00	0.257	2970	763.29	0.07	1770	62.84	826.13	
36	Mahogany	80.00	0.13	15430	2005.90	0.10	1770	88.50	2094.40	
37	Mazha Maram	180.00	1.661	3630	6029.43	1.26	1770	1115.99	7145.42	
38	Mahogany	60.00			0.00	0.10	1770	88.50	88.50	**Infront of DLF**
39	Mazha Maram	200.00	2.116	3630	7681.08	1.72	1770	1517.78	9198.86	
40	Poovaka	82.00	0.13	1650	214.50	0.10	1770	88.50	303.00	
42	Vatta	100.00	0.257	1800	462.60	0.07	1770	62.84	525.44	
43	Vatta	85.00	0.13	1800	234.00	0.10	1770	88.50	322.50	
44	Vatta	100.00	0.257	1800	462.60	0.07	1770	62.84	525.44	
45	Vatta	85.00	0.13	1800	234.00	0.10	1770	88.50	322.50	
46	Vatta	95.00	0.257	1800	462.60	0.07	1770	62.84	525.44	
47	Nelli	50.00			0.00	0.10	1770	88.50	88.50	
48	Nelli	40.00			0.00	0.10	1770	88.50	88.50	
49	Vatta	60.00			0.00	0.10	1770	88.50	88.50	

50	Va	130.00	0.708	9500	6726.00	0.33	1770	291.17	7017.17	
51	Vatta	140.00	0.879	9500	8350.50	0.55	1770	484.98	8835.48	
52	Mazha Maram	230.00	2.869	3630	10414.47	2.50	1770	2211.62	12626.09	
53	AQUASIA	70.00			0.00	0.10	680	34.00	34.00	
54	Povaka	150.00	1.061	2830	3002.63	0.70	1770	623.04	3625.67	
55	Mazha Maram	140.00	0.879	2830	2487.57	0.55	1770	484.98	2972.55	
56	Mazha Maram	60.00			0.00	0.10	1770	88.50	88.50	
57	Povaka	140.00	0.879	3630	3190.77	0.55	1770	484.98	3675.75	
58	Mazha Maram	45.00			0.00	0.10	1770	88.50	88.50	
59	Vatta	50.00			0.00	0.10	1770	88.50	88.50	
60	Mazha Maram	170.00	1.449	3630	5259.87	1.06	1770	936.33	6196.20	
61	Mazha Maram	100.00	0.257	2970	1020.00	0.07	1770	62.84	1082.84	
62	Mahogany	70.00			0.00	0.10	1770	88.50	88.50	
63	Marotti	60.00			0.00	0.10	1770	88.50	88.50	
64	Mazha Maram	70.00			0.00	0.10	1770	88.50	88.50	
65	Ngaval	100.00	0.257	1463	375.99	0.07	1770	62.84	438.83	
66	Mazha Maram	70.00			0.00	0.10	1770	88.50	88.50	
67	Mazha Maram	60.00			0.00	0.10	1770	88.50	88.50	
68	Mazha Maram	210.00	2.36	3630	8566.80	1.96	1770	1737.26	10304.06	
69	Povaka	90.00	0.13	1650	214.50	0.10	1770	88.50	303.00	
70	Vatta	100.00	0.257	1800	462.60	0.07	1770	62.84	525.44	
71	Badam	100.00	0.257		0.00	0.07	1770	404.00	404.00	
72	Vatta	85.00	0.13	1800	234.00	0.10	1770	88.50	322.50	
73	Vatta	75.00			0.00	0.10	1770	88.50	88.50	
74	Vatta	70.00			0.00	0.10	1770	88.50	88.50	
75	AQUASIA	90.00	0.13	16063	2088.19	0.10	680	34.00	2122.19	
76	Vatta	80.00	0.13	1800	234.00	0.10	1770	88.50	322.50	
77	Vatta	85.00	0.13	1800	234.00	0.10	1770	88.50	322.50	
78	AQUASIA	50.00	0.13	1800	234.00	0.10	680	34.00	268.00	
79	Mazha Maram	100.00	0.257	2970	763.29	0.10	1770	88.50	851.79	
80	Mazha Maram	130.00	0.708	3630	2570.04	0.33	1770	291.17	2861.21	
81	Mazha Maram	185.00	1.889	3630	6857.07	1.47	1770	1300.07	8157.14	
82	Teema	135.00	0.879		0.00	0.55	1770	1068.00	1068.00	
83	Badam	80.00			0.00	0.10	1770	88.50	88.50	
84	Badam	60.00			0.00	0.10	1770	88.50	88.50	
85	Badam	65.00			0.00	0.10	1770	88.50	88.50	
86	Badam	65.00			0.00	0.10	1770	88.50	88.50	
87	Badam	130.00	0.708		0.00	0.33	1770	616.00	616.00	
88	Badam	100.00	0.257		0.00	0.07	1770	202.00	202.00	
89	Teema	105.00	0.396		0.00	0.17	1770	676.00	676.00	
90	Nelli	75.00			0.00	0.10	1770	88.50	88.50	
91	Mazha Maram	130.00	0.708	3630	2570.04	0.33	1770	291.17	2861.21	
92	Mazha Maram	80.00	0.136	2970	403.92	0.10	1770	88.50	492.42	
93	Mazha Maram	100.00	0.257	2970	763.29	0.02	1770	15.05	778.34	
94	Mazha Maram	60.00			0.00	0.10	1770	88.50	88.50	
95	Mahogany	90.00	0.13	15430	2005.90	0.10	1770	88.50	2094.40	
96	Ngaval	95.00	0.257	1463	375.99	0.07	1770	62.84	438.83	**Infront of Jail**
97	Mazha Maram	130.00	0.708	3630	2570.04	0.33	1770	291.17	2861.21	
98	Mahogany	75.00			0.00	0.10	1770	88.50	88.50	
99	Teema	75.00			0.00	0.10	1770	88.50	88.50	

100	[illegible] Maram	170.00	1.449	3630	5259.87	1.06	1770	936.33	6196.20	
101	Mahogany	70.00			0.00	0.10	1770	88.50	88.50	
102	Mazha Maram	160.00	1.447	3630	5252.61	1.06	1770	936.33	6188.94	
103	Mahogany	60.00			0.00	0.10	1770	88.50	88.50	
104	Mazha Maram	180.00	1.661	3630	6029.43	1.26	1770	1115.99	7145.42	
105	Pangi Maram	110.00	0.396		0.00	0.17	1770	676.00	676.00	
106	Pangi Maram	140.00	0.8		0.00	0.82	1770	579.00	579.00	
107	Mazha Maram	270.00	4.026	3630	14614.38	3.76	1770	3326.72	17941.10	
108	Mazha Maram	210.00	2.36	3630	8566.80	1.96	1770	1737.26	10304.06	
109	Mazha Maram	60.00			0.00	0.10	1770	88.50	88.50	
110	Mazha Maram	215.00	2.609	3630	9470.67	2.22	1770	1963.82	11434.49	
111	Badam	65.00			0.00	0.10	1770	88.50	88.50	
112	Mazha Maram	150.00	1.061	3630	3851.43	0.70	1770	623.04	4474.47	
	Kakkanade Station									
113	Mazha Maram	45.00			0.00	0.10	1770	88.50	88.50	
114	Vatta	50.00			0.00	0.10	1770	88.50	88.50	
115	Vatta	40.00			0.00	0.10	1770	88.50	88.50	
116	Vatta	75.00			0.00	0.10	1770	88.50	88.50	
117	Vatta	65.00			0.00	0.10	1770	88.50	88.50	
118	Pana	75.00			0.00		1770	0.00	100.00	
119	Palla	140.00	0.879	7400	6504.60	0.55	1770	484.98	6989.58	
120	Vatta	60.00			0.00	0.10	1770	88.50	88.50	
121	Vatta	50.00			0.00	0.10	1770	88.50	88.50	
122	Vatta	50.00			0.00	0.10	1770	88.50	88.50	
123	Mazha Maram	45.00			0.00	0.10	1770	88.50	88.50	

Grand Total **276368.00**

Sreelekha. G Ki. Nambiar

Total No of Trees to be Cut(LHS) 269 +
RHS 123
Palmyras 10
402

Office of the Assistant Conservator of Forests ★ Social Forestry Division ★ ERNAKULAM-682 024

എറണാകുളം സോഷ്യൽ ഫോറസ്ട്രി അസിസ്റ്റന്റ് ഫോറസ്റ്റ് കൺസർവേറ്ററുടെ നടപടി ഉത്തരവ്

ഹാജർ : എ. ജയമാധവൻ

വിഷയം: പൊതുസ്ഥലങ്ങളിൽ സ്ഥിതിചെയ്യുന്ന മരങ്ങൾ മുറിച്ചു നീക്കുന്നത് - സംബന്ധിച്ച്.

സൂചന: 1)ജനറൽ മാനേജർ(പ്രൊജക്റ്റ്സ്), കൊച്ചി മെട്രോ റെയിൽ ലിമിറ്റഡ്, ജെ.എൽ.എൻ. മെട്രോ സ്റ്റേഷൻ, 4th ഫ്ളോർ, കലൂർ-682 017- ന്റെ 10.08.20ലെ KMRLPRJ/JIC-PRE/185/2014/725 നമ്പർ അപേക്ഷ.
2)28.09.20 ലെ ട്രീകമ്മറ്റി സംയുക്ത പരിശോധന റിപ്പോർട്ട്.
3)21.10.20 ലെ ട്രീകമ്മറ്റി സംയുക്ത പരിശോധന റിപ്പോർട്ട്.
3)എറണാകുളം റെയിഞ്ച് ഫോറസ്റ്റാഫീസറുടെ 07.09.20ലെ എസ്.എഫ്.ആർ.14/2020 നമ്പർ റിപ്പോർട്ട്.

ഉത്തരവ് നമ്പർ ഇ3-1545/20 തീയതി 04.01.2021.

കൊച്ചി മെട്രോ റെയിൽ പദ്ധതിയുടെ രണ്ടാംഘട്ട പ്രവർത്തനങ്ങളുടെ ഭാഗമായി കലൂർ ജവഹർലാൽ നെഹ്റു സ്റ്റേഡിയം മുതൽ കാക്കനാട് സിഗ്നൽ വരെ മെട്രോ ലൈനുകൾ സ്ഥാപിക്കുന്നതിനും, സ്റ്റേഷനുകൾ സ്ഥാപിക്കുന്നതിനും തടസ്സമായി നിൽക്കുന്ന മരങ്ങൾ മുറിച്ചു നീക്കം ചെയ്യണമെന്ന് ആവശ്യപ്പെട്ടുകൊണ്ട് സൂചന(1) പ്രകാരം അപേക്ഷ ലഭിച്ചിട്ടുണ്ട്.

പൊതുസ്ഥലങ്ങളിൽ സ്ഥിതി ചെയ്യുന്ന അപകടാവസ്ഥയിൽ നിൽക്കുന്നതും വികസനാവശ്യങ്ങൾക്ക് തടസ്സമായി നിൽക്കുന്നതുമായ മരങ്ങൾ മുറിക്കുന്നതുമായി ബന്ധപ്പെട്ട് രൂപീകരിക്കപ്പെട്ട കമ്മറ്റി സ്ഥലത്ത് പോയി പരിശോധിച്ചതിൽ ജവഹർലാൽ നെഹ്റു സ്റ്റേഡിയം മുതൽ ചെമ്പുമുക്ക് വരെയുള്ള സ്ഥലത്ത് നിൽക്കുന്ന വിവിധഇനം 175 മരങ്ങളും, ചെമ്പുമുക്ക് മുതൽ കാക്കനാട് ജംഗ്ഷൻ വരെയുള്ള 92 മരങ്ങളും മുറിച്ചു മാറ്റുവാൻ തീരുമാനിക്കുകയുണ്ടായി. മുറിച്ചു മാറ്റുന്ന ഒരു മരത്തിനു പകരം 10 എണ്ണം എന്ന നിലയിൽ മരങ്ങൾ വച്ചുപിടിപ്പിച്ച് പരിപാലിക്കണമെന്ന നിലയിൽ വനംവകുപ്പും കൊച്ചി മെട്രോ റെയിൽ ലിമിറ്റഡുമായി എഗ്രിമെന്റ് എഴുതണമെന്ന വ്യവസ്ഥയിൽ അനുവാദം നൽകാവുന്നതാണ് എന്നും തീരുമാനിക്കുകയുണ്ടായി.

മേൽ സാഹചര്യത്തിൽ കൊച്ചി മെട്രോ റെയിൽ പദ്ധതിയുടെ രണ്ടാംഘട്ട പ്രവർത്തനങ്ങളുടെ ഭാഗമായി കലൂർ ജവഹർലാൽ നെഹ്റു സ്റ്റേഡിയം മുതൽ ചെമ്പുമുക്ക് വരെയുള്ള സ്ഥലത്ത് നിൽക്കുന്ന വിവിധഇനം 175 മരങ്ങളും, ചെമ്പുമുക്ക് മുതൽ കാക്കനാട് ജംഗ്ഷൻ വരെയുള്ള 92 മരങ്ങളും മുറിച്ചു മാറ്റുന്നതിന് അനുമതി നൽകിക്കൊണ്ട് ഉത്തരവാകുന്നു. പ്രസ്തുത മരങ്ങളിൽ നിന്നും ലഭിക്കാവുന്ന തടിയുടെയും വിറകിന്റെയും വില റെയിഞ്ച് ഫോറസ്റ്റാഫീസർ കണക്കാക്കിയത് ഇതോടൊപ്പം ഉള്ളടക്കം ചെയ്യുന്നു.

മരങ്ങൾ വിറ്റുകിട്ടുന്ന നികുതി ഉൾപ്പെടെയുള്ള ആകെ തുകയുടെ 5% വനവികസന ഫണ്ടിലേക്ക് 0406-01-101-96 FDT എന്ന ഹെഡിൽ എറണാകുളം അഡീഷണൽ സബ് ട്രഷറിയിൽ തന്നെ അടച്ച് അസ്സൽ രശീതി ഈ ഓഫീസിൽ ലഭ്യമാക്കേണ്ടതാണ്. G.O(Rt)No.172/2010/F&WLD dt.21.04.2010 പ്രകാരം മുറിച്ചു മാറ്റിയ മരങ്ങൾക്ക് പകരമായി പത്തിരട്ടി മരങ്ങൾ നട്ടുപിടിപ്പിക്കേണ്ടതാണ് എന്ന നിബന്ധന കർശനമായും പാലിക്കേണ്ടതാണ്.

അസിസ്റ്റന്റ് ഫോറസ്റ്റ് കൺസർവേറ്റർ
സോഷ്യൽ ഫോറസ്ട്രി, എറണാകുളം

സ്വീകർത്താവ്: ജനറൽ മാനേജർ(പ്രൊജക്റ്റ്സ്), കൊച്ചി മെട്രോ റെയിൽ ലിമിറ്റഡ്, ജെ.എൽ.എൻ. മെട്രോ സ്റ്റേഷൻ, 4th ഫ്ളോർ, കലൂർ-682 017-അയക്കുന്നു.
തൈ ഒന്നിന് 24/-രൂപ നിരക്കിൽ എറണാകുളം സോഷ്യൽ ഫോറസ്ട്രി റെയിഞ്ചാഫീസിൽ നിന്ന് ലഭ്യമാക്കാവുന്നതാണ്.

പകർപ്പ് : മേയർ, കൊച്ചിൻ കോർപ്പറേഷന് അറിവിനായി അയയ്ക്കുന്നു.
: എറണാകുളം സോഷ്യൽ ഫോറസ്ട്രി റെയിഞ്ച് ഓഫീസർക്ക്. മുറിച്ച് മാറ്റുന്ന മരങ്ങൾക്കു പകരമായി പത്തിരട്ടി മരങ്ങൾ നട്ടു പിടിപ്പിക്കുന്നുണ്ടെന്ന് ഉറപ്പുവരുത്തേണ്ടതാണ്.
: വൃക്ഷകമ്മിറ്റി അംഗങ്ങൾക്ക്.
: സ്റ്റോക്ക് ഫയലിലേക്ക്.

LIST OF STANDING TREE FROM JLN STADIUM - CHEMBUMUKKU

S.No	Tree no.	Tree name	GBH (Cm)	TIMBER WOOD			FIREWOOD			Total	Remark
				Volume (cu.m)	Rate	Amount	Volume (MT)	Rate	Amount		
1	1A	Rain tree	315	3.895	3630	14,138.85	1.695	1770	3,000.15	17,139.00	RHS
2	1B		195	1.659	3630	6,022.17	0.916	1770	1,621.32	7,643.49	RHS
3	2	Mango tree	95	0.302	1673	505.25	0.195	1770	345.15	850.40	RHS kuzhimanthi hotel
4	3	Arana	40			-	0.100	1770	177.00	177.00	
5	4	Arana	55			-	0.100	1770	177.00	177.00	
6	5	Arana	45			-	0.100	1770	177.00	177.00	
7	6	Mango tree	185	1.503	4293	6,452.38	0.777	1770	1,375.29	7,827.67	
8	7	Rain tree	195	1.659	3630	6,022.17	0.916	1770	1,621.32	7,643.49	LHS
9	8	Coconut						150	150.00	150.00	LHS
10	9	Coconut						150	150.00	150.00	LHS
11	10	Rain tree	50			-	0.100	1770	177.00	177.00	LHS
12	11	Coconut						150	150.00	150.00	LHS
13	12	Coconut						150	150.00	150.00	LHS
14	13	Pooparuthi	125	0.674	16063	10,826.46	0.258	1770	456.66	11,283.12	LHS
15	14	Cotton tree	205	1.82	7400	13,468.00	1.068	1770	1,890.36	15,358.36	LHS
16	15	Arana	145	0.932	1650	1,537.80	0.375	1770	663.75	2,201.55	LHS
17	16	Badam	90			-	0.533	1770	943.41	943.41	LHS
18	17	Pooparuthi	95	0.322	16063	5,172.29	0.195	1770	345.15	5,517.44	LHS
19	18 A	Poovaka	130	0.674	2830	1,907.42	0.258	1770	456.66	2,364.08	RHS
20	18 B	Poovaka	100	0.434	1650	716.10	0.200	1770	354.00	1,070.10	RHS
21	19	Edana	110	0.552	2710	1,495.92	0.222	1770	392.94	1,888.86	LHS
22	20	Teak	105	0.434	11710	5,082.14	0.200	8925	1,785.00	6,867.14	LHS
23	21	Edana	40			-	0.100	1770	177.00	177.00	LHS
24	22	Mango tree	40			-	0.100	1770	177.00	177.00	LHS
25	23	Poovaka	190	1.659	2830	4,694.97	0.916	1770	1,621.32	6,316.29	RHS
26	24A	Poovaka	175	1.356	2830	3,837.48	0.655	1770	1,159.35	4,996.83	RHS
27	24B	Poovaka	115	0.552	1650	910.80	0.222	1770	392.94	1,303.74	RHS
28	25	Poovaka	205	1.82	2830	5,150.60	1.068	1770	1,890.36	7,040.96	RHS
29	26	Jack tree	145	0.932	2830	2,637.56	0.375	1770	663.75	3,301.31	LHS
30	27	Mango tree	95	0.322	1673	538.71	0.195	1770	345.15	883.86	LHS
31	28	Mango tree	270	3.068	4293	13,170.92	2.540	1770	4,495.80	17,666.72	LHS
32	29A	Poovaka	170	1.352	2830	3,826.16	0.655	1770	1,159.35	4,985.51	RHS
33	29B	Poovaka	205	1.82	2830	5,150.60	1.068	1770	1,890.36	7,040.96	RHS
34	30A	Poovaka	100	0.322	1650	531.30	0.195	1770	345.15	876.45	RHS
35	30B	Poovaka	100	0.434	2830	1,228.22	0.200	1770	354.00	1,582.22	
36	30C	Poovaka	90	0.322	1650	531.30	0.195	1770	345.15	876.45	
37	30D	Poovaka	150	1.065	2830	3,013.95	0.451	1770	798.27	3,812.22	
38	31A	Poovaka	115	0.552	1650	910.80	0.222	1770	392.94	1,303.74	
39	31B	Poovaka	95	0.322	1650	531.30	0.195	1770	345.15	876.45	
40	32	Mango tree	130	0.8	4293	3,434.40	0.309	1770	546.93	3,981.33	LHS
41	33	Poovaka	185	1.503	2830	4,253.49	0.777	1770	1,375.29	5,628.78	
42	34	Poovaka	165	1.062	2830	3,005.46	0.545	1770	964.65	3,970.11	
43	35A	Poovaka	200	1.82	2830	5,150.60	1.068	1770	1,890.36	7,040.96	
44	35B	Poovaka	140	0.932	2830	2,637.56	0.374	1770	661.98	3,299.54	
45	36	Poovaka	180	1.503	2830	4,253.49	0.777	1770	1,375.29	5,628.78	
46	37	Badam	55			-	0.100	1770	177.00	177.00	
47	38	Poovaka	145	0.932	2830	2,637.56	0.375	1770	663.75	3,301.31	
48	39	Poovaka	115	0.552	1650	910.80	0.222	1770	392.94	1,303.74	
49	40	Poovaka	185	1.503	2830	4,253.49	0.777	1770	1,375.29	5,628.78	
50	41A	Rain tree	180	1.503	3630	5,455.89	0.777	1770	1,375.29	6,831.18	
51	41B	Rain tree	155	1.065	3630	3,865.95	0.451	1770	798.27	4,664.22	
52	41C	Rain tree	75	0.115	1970	226.55	0.195	1770	345.15	571.70	
53	42	Rain tree	165	1.062	3630	3,855.06	0.545	1770	964.65	4,819.71	
54	43	Rain tree	155	1.065	3630	3,865.95	0.451	1770	798.27	4,664.22	
55	44	Rain tree	150	1.065	3630	3,865.95	0.451	1770	798.27	4,664.22	
56	45A	Rain tree	185	1.503	3630	5,455.89	0.777	1770	1,375.29	6,831.18	
57	45B	Rain tree	130	0.8	3630	2,904.00	0.309	1770	546.93	3,450.93	
58	46	Mango tree	155	1.065	4293	4,572.05	0.451	1770	798.27	5,370.32	

59	47	Arana	50			-	0.100	1770	177.00	177.00	
60	48	Arana	50			-	0.100	1770	177.00	177.00	
61	49	Arana	50			-	0.100	1770	177.00	177.00	
62	50	Arana	50			-	0.100	1770	177.00	177.00	
63	51	Arana	50			-	0.100	1770	177.00	177.00	
64	52	Arana	50			-	0.100	1770	177.00	177.00	
65	53	Arana	50			-	0.100	1770	177.00	177.00	
66	54	Arana	95	0.322	1650	531.30	0.195	1770	345.15	876.45	
67	55	Arana	90	0.322	1650	531.30	0.195	1770	345.15	876.45	
68	56	Pala	125	0.674	7400	4,987.60	0.256	1770	453.12	5,440.72	
69	57	Rain tree	185	1.503	3630	5,455.89	0.777	1770	1,375.29	6,831.18	
70	58	Arana	40			-	0.100	1770	177.00	177.00	RHS
71	59	Arana	45			-	0.100	1770	177.00	177.00	RHS
72	60	Arana	40			-	0.100	1770	177.00	177.00	RHS
73	61	Arana	40			-	0.100	1770	177.00	177.00	RHS
74	62	Arana	40			-	0.100	1770	177.00	177.00	RHS
75	63	Arana	45			-	0.100	1770	177.00	177.00	RHS
76	64	Arana	40			-	0.100	1770	177.00	177.00	RHS
77	65	Arana	40			-	0.100	1770	177.00	177.00	RHS
78	66	Arana	40			-	0.100	1770	177.00	177.00	RHS
79	67	Arana	40			-	0.100	1770	177.00	177.00	RHS
80	68	Arana	40			-	0.100	1770	177.00	177.00	RHS
81	69	Arana	40			-	0.100	1770	177.00	177.00	RHS
82	70	Arana	40			-	0.100	1770	177.00	177.00	RHS
83	71	Arana	45			-	0.100	1770	177.00	177.00	RHS
84	72	Arana	35			-	0.100	1770	177.00	177.00	RHS
85	73	Arana	35			-	0.100	1770	177.00	177.00	RHS
86	74	Arana	30			-	0.100	1770	177.00	177.00	RHS
87	75	Arana	35			-	0.100	1770	177.00	177.00	RHS
88	76	Arana	30			-	0.100	1770	177.00	177.00	RHS
89	77	Arana	35			-	0.100	1770	177.00	177.00	RHS
90	78A	Poovaka	85	0.218	1650	359.70	0.195	1770	345.15	704.85	RHS
91	78B	Poovaka	165	1.082	2830	3,062.06	0.545	1770	964.65	4,026.71	RHS
92	78C	Poovaka	125	0.674	2830	1,907.42	0.250	1770	442.50	2,349.92	RHS
93	79	Poovaka	155	1.065	2830	3,013.95	0.452	1770	800.04	3,813.99	RHS
94	80	Poovaka	170	1.082	2830	3,062.06	0.545	1770	964.65	4,026.71	RHS
95	81	Poovaka	185	1.503	2830	4,253.49	0.777	1770	1,375.29	5,628.78	RHS
96	82	Poovaka	95	0.322	1650	531.30	0.195	1770	345.15	876.45	RHS
97	83A	Poovaka	100	0.434	1650	716.10	0.200	1770	354.00	1,070.10	RHS
98	83B	Poovaka	165	1.082	2830	3,062.06	0.545	1770	964.65	4,026.71	RHS
99	84A	Poovaka	145	0.972	2830	2,750.76	0.374	1770	661.98	3,412.74	RHS
100	84B	Poovaka	185	1.503	2830	4,253.49	0.772	1770	1,366.44	5,619.93	RHS
101	84C	Poovaka	105	0.434	1650	716.10	0.201	1770	355.77	1,071.87	RHS
102	85	Rain tree	300	3.681	3630	13,362.03	3.381	1770	5,984.37	19,346.40	LHS
103	86	Rain tree	265	2.88	3630	10,454.40	3.284	1770	5,812.68	16,267.08	RHS PIPE LINE ROAD
104	87	Poovaka	75	0.115	1650	189.75	0.195	1770	345.15	534.90	RHS
105	88A	Poovaka	125	0.674	2830	1,907.42	0.257	1770	454.89	2,362.31	
106	88B	Poovaka	110	0.434	1650	716.10	0.201	1770	355.77	1,071.87	
107	89	Poovaka	155	1.065	2850	3,035.25	0.457	1770	808.89	3,844.14	
108	90	Pala	70	0.115	7400	851.00	0.195	1770	345.15	1,196.15	
109	91	Poovaka	170	0.674	2830	1,907.42	0.257	1770	454.89	2,362.31	
110	92	Aaal	160			-	1.614	1770	2,856.78	2,856.78	
111	93	Badam	95			-	0.533	1770	943.41	943.41	
112	94	Poovaka	230	2.325	2830	6,579.75	1.608	1770	2,846.16	9,425.91	
113	95	Poovaka	235	2.325	2830	6,579.75	1.608	1770	2,846.16	9,425.91	
114	96	Poovaka	125	0.674	2830	1,907.42	0.257	1770	454.89	2,362.31	
115	97	Jack tree	75	0.115	11480	1,320.20	0.195	1770	345.15	1,665.35	
116	98	Mango tree	175	1.352	4293	5,804.14	0.655	1770	1,159.35	6,963.49	
117	99	Rain tree Pain	125	0.674	3653	2,462.12	0.258	1770	456.66	2,918.78	
118	100	Rain tree Pain	150	1.065	3653	3,890.45	0.457	1770	808.89	4,699.34	
119	101	Rain tree Pain	130	0.8	3653	2,922.40	0.364	1770	644.28	3,566.68	
120	102	Poovaka	145	0.932	2830	2,637.56	0.374	1770	661.98	3,299.54	
121	103	Poovaka	230	2.325	2830	6,579.75	1.608	1770	2,846.16	9,425.91	
122	104	Poovaka	220	2.15	2830	6,084.50	1.412	1770	2,499.24	8,583.74	
123	105A	Poovaka	105	0.434	1650	716.10	0.201	1770	355.77	1,071.87	
124	105B	Poovaka	120	0.674	1650	1,112.10	0.258	1770	456.66	1,568.76	

125	105C	Poovaka	155	1.065	2830	3,013.95	0.451	1770	798.27	3,812.22	
126	106	Poovaka	125	0.674	2830	1,907.42	0.257	1770	454.89	2,362.31	
127	107	Poovaka	180	1.503	2830	4,253.49	0.777	1770	1,375.29	5,628.78	
128	108	Poovaka	180	1.503	2830	4,253.49	0.777	1770	1,375.29	5,628.78	
129	109	Mahagani	45			-	0.100	1770	177.00	177.00	
130	110	Neem	45			-	0.100	1770	177.00	177.00	
131	111	Neem	40			-	0.100	1770	177.00	177.00	
132	112	Neem	40			-	0.100	1770	177.00	177.00	
133	113	Coconut						150	150.00	150.00	
134	114	Arana	55			-	0.100	1770	177.00	177.00	
135	115	Arana	50			-	0.100	1770	177.00	177.00	
136	116	Arana	50			-	0.100	1770	177.00	177.00	
137	117	Coconut						150	150.00	150.00	
138	118	Manjun	165	1.062	16253	17,260.69	0.545	680	370.60	17,631.29	
139	119	Coconut						150	150.00	150.00	
140	120	Jack tree	120	0.674	11480	7,737.52	0.257	1770	454.89	8,192.41	
141	121	Subabul	50				0.100	1770	177.00	177.00	
142	122	Mango tree	85	0.218	1673	364.71	0.195	1770	345.15	709.86	
143	123	Pana						150	150.00	150.00	
144	124	Coconut						150	150.00	150.00	
145	125	Coconut						150	150.00	150.00	
146	126	Coconut						150	150.00	150.00	
147	127	Aanjili	145	0.932	26830	25,005.56	0.375	1770	663.75	25,669.31	
148	128	Coconut						150	150.00	150.00	
149	129	Coconut						150	150.00	150.00	
150	130	Mango tree	115	0.552	1673	923.50	0.222	1770	392.94	1,316.44	RHS
151	131	Mango tree	255	2.69	4293	11,548.17	2.046	1770	3,621.42	15,169.59	LHS SBI
152	132	Poovaka	205	1.82	2830	5,150.60	1.068	1770	1,890.36	7,040.96	
153	133A	Poovaka	140	0.932	2830	2,637.56	0.375	1770	663.75	3,301.31	
154	133B	Poovaka	85	0.218	1650	359.70	0.195	1770	345.15	704.85	
155	134	Poovaka	240	2.563	2830	7,253.29	1.819	1770	3,219.63	10,472.92	
156	135	Poovaka	240	2.503	2830	7,083.49	1.819	1770	3,219.63	10,303.12	
157	136	Coconut						150	150.00	150.00	
158	137	Coconut						150	150.00	150.00	
159	138	Poovaka	90	0.322	8560	2,756.32	0.195	1770	345.15	3,101.47	
160	139	Arana	75	0.115	1650	189.75	0.195	1770	345.15	534.90	
161	140	Mango tree	125	0.674	4293	2,893.48	0.258	1770	456.66	3,350.14	
162	141	Mango tree	75	0.115	1673	192.40	0.195	1770	345.15	537.55	
163	142	Mango tree	78	0.115	1673	192.40	0.195	1770	345.15	537.55	
164	143	Poovaka	145	0.932	2830	2,637.56	0.375	1770	663.75	3,301.31	
165	144	Poovaka	150	1.065	2830	3,013.95	0.451	1770	798.27	3,812.22	
166	145	Kalan	68			-	0.100	1770	177.00	177.00	RHS
167	146	Kalan	100	0.434	1650	716.10	0.201	1770	355.77	1,071.87	
168	147	Kalan	105	0.434	1650	716.10	0.201	1770	355.77	1,071.87	
169	148	Kalan	80			-	0.456	1770	807.12	807.12	
170	149	S	70			-	0.200	1770	354.00	354.00	
171	150	Rain tree	380	5.512	3630	20,008.56	6.266	1770	11,090.82	31,099.38	
172	151	Kudapali	120	0.674	1620	1,091.88	0.218	1770	385.86	1,477.74	
173	152	Kudapali	215	1.98	1620	3,207.60	1.230	1770	2,177.10	5,384.70	
174	153	Kudapali	175	1.352	1620	2,190.24	0.655	1770	1,159.35	3,349.59	
175	154	Coconut	95					150	150.00	150.00	
TOTAL						**443,389.40**			**143,886.46**	**587,125.86**	

19/8/2021
Sreelekha. G. Nair
SFO Ernakulam.

RANGE FOREST OFFICER
SOCIAL FORESTRY
ERNAKULAM

LIST OF STANDING TREE FROM CHEMBUMUKKU - KAKKANAD JUNCTION

S.No	Tree no.	Tree name	GBH (Cm)	TIMBER WOOD			FRIRE WOOD			Total	Remark
				Volume (cu.m)	Rate	Amount	Volume (MT)	Rate	Amount		
1	1	Coconut				-		150	150.00	150.00	Proposed LHS chembumukku Meto station
2	2	Coconut				-		150	150.00	150.00	
3	3	Coconut				-		150	150.00	150.00	
4	4	Coconut				-		150	150.00	150.00	
5	5	Coconut				-		150	150.00	150.00	
6	6	Coconut				-		150	150.00	150.00	
7	7	Coconut				-		150	150.00	150.00	
8	8	Coconut				-		150	150.00	150.00	
9	9	Coconut				-		150	150.00	150.00	
10	10	Coconut				-		150	150.00	150.00	
11	11	Coconut				-		150	150.00	150.00	
12	12	Coconut				-		150	150.00	150.00	
13	13	Coconut				-		150	150.00	150.00	
14	14	Coconut				-		150	150.00	150.00	
15	15	Coconut				-		150	150.00	150.00	
16	16	Coconut				-		150	150.00	150.00	
17	17	Coconut				-		150	150.00	150.00	
18	18	Coconut				-		150	150.00	150.00	
19	19	Pongilyum	115	0.552	5500	3,036.00	0.222	1770	392.94	3,428.94	
20	20	Coconut	85			-		150	150.00	150.00	
21	21	Cashew nut	45			-	0.100	1770	177.00	177.00	
22	22	Cashew nut	85			-	0.456	1770	807.12	807.12	
23	23	Cashew nut	75			-	0.456	1770	807.12	807.12	
24	24A	Cashew nut	140			-	1.262	1770	2,233.74	2,233.74	
25	24B	Cashew nut	90			-	0.534	1770	945.18	945.18	
26	25	Coconut				-		150	150.00	150.00	
27	26	Coconut				-		150	150.00	150.00	
28	27	Cashew nut				-	0.456	1770	807.12	807.12	
29	28	Coconut				-		150	150.00	150.00	
30	29	Coconut				-		150	150.00	150.00	
31	30	Coconut				-		150	150.00	150.00	
32	31	Coconut				-		150	150.00	150.00	
33	32	Coconut				-		150	150.00	150.00	
34	33	Coconut				-		150	150.00	150.00	
35	34	Coconut				-		150	150.00	150.00	
36	35	Coconut				-		150	150.00	150.00	
37	36	Cashew nut	65			-	0.100	1770	177.00	177.00	
38	37	Badarn	85			-	0.455	1770	805.35	805.35	PBQ
39	38	Teak	120	0.674	28640	19,303.36	0.258	5925	1,528.65	20,832.01	TATA show room
40	39	Teak	95	0.322	19900	6,407.80	0.195	5925	1,155.38	7,563.18	
41	40	Teak	125	0.674	28640	19,303.36	0.258	5925	1,528.65	20,832.01	
42	41	Rain tree	157	1.065	3630	3,865.95	0.452	1770	800.04	4,665.99	
43	42	Rain tree	235	2.325	3630	8,439.75	1.608	1770	2,846.16	11,285.91	
44	43	Arana	50			-	0.100	1770	177.00	177.00	
45	44	Arana	75	0.115	1650	189.75	0.195	1770	345.15	534.90	
46	45	S	40			-	0.100	1770	177.00	177.00	
47	46	S	40			-	0.100	1770	177.00	177.00	
48	47	Aanjali	95	0.322	12570	4,047.54	0.195	1770	345.15	4,392.69	
49	48	Coconut				-		150	150.00	150.00	
50	49	Coconut				-		150	150.00	150.00	
51	50	Badam	105			-	0.626	1770	1,108.02	1,108.02	
52	51	Rain tree	315	3.895	3630	14,138.85	3.695	1770	6,540.15	20,679.00	
53	52	Poovaka	105	0.434	1650	716.10	0.201	1770	355.77	1,071.87	
54	53	Rain tree	145	0.932	3630	3,383.16	0.375	1770	663.75	4,046.91	
55	54	Arana	75	0.115	1650	189.75	0.195	1770	345.15	534.90	
56	55	Rain tree	120	0.674	2970	2,001.78	0.258	1770	456.66	2,458.44	
57	56	Teak	100	0.434	28640	12,429.76	0.201	5925	1,190.93	13,620.69	
58	57	Teak	80	0.218	19900	4,338.20	0.195	5925	1,155.38	5,493.58	
59	58	Rain tree	250	2.69	3630	9,764.70	2.046	1770	3,621.42	13,386.12	

60	59	pala	250	2.69	7400	19,906.00	2.046	1770	3,621.42	23,527.42	
61	60	Badam	85			-	0.455	1770	805.35	805.35	
62	61	Poovaka	150	1.065	2830	3,013.95	0.451	1770	798.27	3,812.22	
63	62	Cashew nut	115	0.552	1650	910.80	0.222	1770	392.94	1,303.74	
64	63	Rain tree	255	2.69	3630	9,764.70	2.046	1770	3,621.42	13,386.12	
65	64	Kadaplavu	65			-	0.200	1770	354.00	354.00	
66	65	Poovaka	120	0.674	1650	1,112.10	0.258	1770	456.66	1,568.76	
67	66	Poovaka	130	0.8	2830	2,264.00	0.314	1770	555.78	2,819.78	
68	67	vatta	110	0.552	9500	5,244.00	0.222	1770	392.94	5,636.94	
69	68A	pala	360	5.029	7400	37,214.60	5.464	1770	9,671.28	46,885.88	
70	68B	pala	175	1.352	7400	10,004.80	0.655	1770	1,159.35	11,164.15	
71	69	vatta	40			-	0.100	1770	177.00	177.00	CPWD
72	70	vatta	50			-	0.100	1770	177.00	177.00	
73	71	Poovaka	135	0.8	2830	2,264.00	0.314	1770	555.78	2,819.78	
74	72	kalan	120			-	0.894	1770	1,582.38	1,582.38	
75	73	Poovaka	50			-	0.100	1770	177.00	177.00	
76	74	vatta	180	1.503	9500	14,278.50	0.777	1770	1,375.29	15,653.79	
77	75	pala	180	1.503	7400	11,122.20	0.777	1770	1,375.29	12,497.49	
78	76A	vatta	180	1.03	9500	9,785.00	0.777	1770	1,375.29	11,160.29	Legal Metrology
79	76B	vatta	65			-	0.200	1770	354.00	354.00	
80	77	vatta	130	0.8	9500	7,600.00	0.314	1770	555.78	8,155.78	
81	78	vatta	95	0.322	9500	3,059.00	0.195	1770	345.15	3,404.15	
82	79	vatta	120	0.674	9500	6,403.00	0.258	1770	456.66	6,859.66	
83	80	Kadaplavu	90	0.322	2730	879.06	0.195	1770	345.15	1,224.21	
84	81A	pala	120	1.352	7400	10,004.80	0.655	1770	1,159.35	11,164.15	
85	81B	pala	80	0.218	7400	1,613.20	0.195	1770	345.15	1,958.35	
86	82	pala	75	0.115	7400	851.00	0.195	1770	345.15	1,196.15	
87	83	vatta	98	0.322	9500	3,059.00	0.195	1770	345.15	3,404.15	
88	84	pala	120	0.674	7400	4,987.60	0.258	1770	456.66	5,444.26	
89	85	pala	140	0.932	7400	6,896.80	0.374	1770	661.98	7,558.78	
90	86	vatta	65			-	0.200	1770	354.00	354.00	
91	87	pana				-		150	150.00	150.00	
92	88	Kadaplavu	120	0.674	2730	1,840.02	0.258	1770	456.66	2,296.68	
		TOTAL				**285,633.94**			**71,275.25**	**356,909.19**	

RANGE FOREST OFFICER
SOCIAL FORESTRY
ERNAKULAM

KOCHI METRO RAIL LIMITED

APPENDIX 6.2

Report on Vibrational Impacts and Mitigation Measures During Construction and Operational Phase

SYSTRA

VIBRATION IMPACT ASSESSMENT

1. Introduction

1.1. Background of the Project

Kochi is the most densely populated city in the state and is part of an extended metropolitan region, which is the largest urban agglomeration in Kerala. Kochi city is also a part of the Greater Cochin region. Kochi consists of mainland Ernakulam; the islands of Willingdon, Bolghatty and Gundu in the harbour; Fort Kochi and Mattancherry on the southern peninsula and Vypeen Island, north of Fort Kochi.

Rapid urbanization and intense commercial developments in the recent past have resulted in steep rise in travel demand putting Kochi's transport infrastructure to stress.

In effort to improve the transportation system of the Kochi city and to move towards the cleaner and sustainable mode of transportation, Government of Kerala intends to develop metro rail network (elevated) system for the entire city with the financial aid from Asian Infrastructure Investment Bank (AIIB). A Special Purpose Vehicle (SPV), i.e., Kochi Metro Rail Limited (KMRL), has been formed by the Government of Kerala for implementation, operation, and maintenance of the Metro projects. KMRL has already constructed Phase I of the Kochi Metro Rail from Aluva to Petta is operational. Subsequently, it was expanded from Petta to S N Junction (currently operational) and from S N Junction to Thrippunithura (currently under construction). Now KMRL has planned to develop Phase II from JLN to Info Park. This phase-II corridor of 11.2 km of elevated section will relate to the Phase-I at JLN Stadium Metro station to ensure integration of Phase I. Figure 1.1 shows the key plan of the alignment.

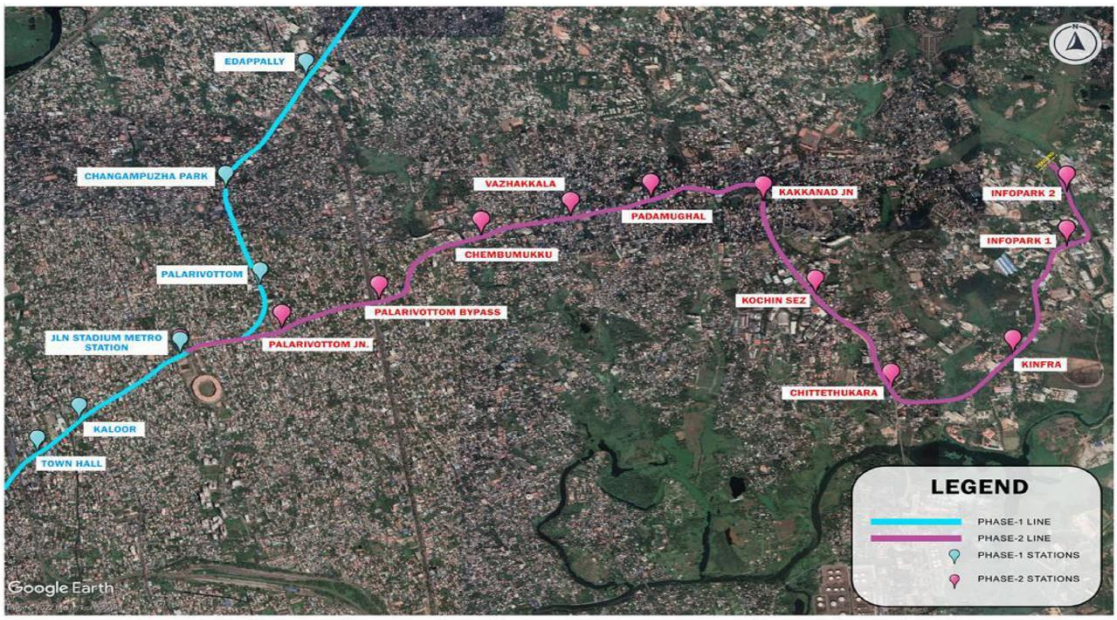

Fig. 1.1 key plan of the alignment

Train operation plan for Kochi Metro Phase-II corridors considers running of services for 19 hours a day, from 5 AM to midnight, with a station dwell time of 30 seconds and a scheduled speed of 34 km/h.
The train operation plan is envisaged with 3 car rake composition on the proposed Kochi Metro Phase-II corridor from JLN Stadium to Info Park with passenger interchange at JLN stadium station of Kochi Metro Phase-I. The trains for Phase-II are proposed to utilize the maintenance facilities at Muttom Depot.
To meet the projected traffic demand, running trains of 3-car consists with varying headways during peak hours and non-peak hours, has been examined. The traffic capacity and demand have been matched by suitable regulation of headways.

Linear infrastructures such as a railway lines or urban metro networks causes different impacts, some of them negative but others positive. The positive impacts include employment opportunities, benefits to economy, faster and safety mobility and air pollution reduction. But negative impacts also exist, and they include project affected people, soil erosion, risk to existing buildings specially during construction phase and noise and vibration caused primarily by construction work but also during operation phase.

As per RDSO (Research Designs and Standards Organization) Guidelines 2015, vibration studies must be conducted along the corridors to determine the extent of impacts. Pile driving for piers and tunnel driving generate vibrations. Apart from distance from the alignment, age, and condition of buildings adjacent to the alignment determines extent of damage to such buildings due to vibration. Continuous effect of vibration on the buildings can cause damage to buildings. As a rule of thumb, buildings subjected to the vibration of more than 150 VdB might be subjected to structural damage. If significant impacts are expected, mitigation measures must be implemented and building condition survey must be conducted before and during construction phase. Cost of such building condition survey can be estimated after vibration study is conducted and structures falling within likely corridor of impacts are identified.

2. Purpose of the Report

The purpose of this report is to carry out predictive calculation of ground-borne vibration induced into 6 locations during the construction phase as well as during the operational phase of this corridor.
Existing vibration levels at these locations before corridor's construction and operation are also assessed, based on results from a previous study.

3. Scope of the Work

The scope of the work is divided in three main categories:

1) Baseline vibration assessment: Vibration measurements were carried out in the frame of collecting baseline data for EIA report at 6 locations. These locations were selected considering covering different scenarios. Peak Particle Velocity (PPV) were measured and calculated as it is the indicator that is widely used to evaluate the strength of vibration.

2) Vibration induced during the construction phase: A quantitative assessment is required as a prolonged annoyance is expected during the construction phase. This assessment is carried out based on the methodology proposed by the Federal Transient Administration of USA in Transit Noise and Vibration Impact Assessment Manual [1].

3) Vibration induced during the operational phase: Also, USA Federal Transient Administration's methodology is used to create a ground-borne vibration prediction model to assess metro operation related vibration into buildings.

4. Mandatory Regulations

In India, no criterion has been prescribed in "The Noise Pollution (Regulation and Control) Rules, 2000" regarding the limits of ground-borne vibrations and noise due to railway systems.

"Metro Rail Transit System. Guidelines for Noise and Vibrations" elaborated by CT-38 Track Design Directorate, Research Designs and Standards Organisation (RDSO), Ministry of Railways of India, analyses different worldwide vibration standards and conclude that all of them are more or less in agreement with FTA Manual provisions. Hence, in India FTA Manual provisions are adopted for railway induced ground-borne vibrations during infrastructure's operation phase as well as FTA Manual provisions regarding construction vibration impact.
Vibration limits are presented in Table 4.1 and Table 4.2 for Kochi Metro operation phase, and in Table 4.3 as construction vibration damage criteria for Kochi Metro construction phase.

Table 4.1 Vibration limits into Buildings

Land use category	Ground-borne vibration limit (VdB ref = 25.4 μmm/s)
Category 1	
Buildings where vibration would interfere with interior operations	65 VdB
Category 2	
Residences and buildings where people normally sleep	72 VdB
Category 3	
Institutional land uses with primarily day-time use	75 VdB

Table 4.2 Recommended criteria for ground-borne vibration into special buildings

Land use category	Ground-borne vibration limit (VdB ref = 25.4 μmm/s)
Concert Halls	65 VdB

TV Studios	65 VdB
Recording Studios	65 VdB
Auditoriums	72 VdB
Theatres	72 VdB

Table 4.3 Construction vibration damage criteria

Building/Structural category	PPV (in/sec)	Approximate Lv* (VdB)
I. Reinforced-concrete, steel, or timber (no plaster)	0.5	102
II. Engineered concrete and masonry (no plaster)	0.3	98
III. Non-engineered timber and masonry buildings	0.2	94
IV. Buildings extremely susceptible to vibration damage	0.12	90

5. Infrastructure Description

5.1. Alignment

Kochi metro phase-II alignment starts from JLN metro station and will end at Infopark. The Route Start from JLN station and after the station, alignment takes right turn on the MKK Nair Road/civil lines road. JLN station is common station for both Phase I and II. Palarivattom junction station is planned at 890 m from JLN station after junction of MKK Nair road and Mahakavi Vailloppalli Road. After Palarivattom junction station, the alignment traverses on the Civil lines road and follows the road alignment on the mid of the road up to the NH 47 where Palarivattom Bypass station is proposed on the junction of Civil lines road and NH 47 at chainage 1/622, at a distance of 732m from previous station and kept on the straight and level section. After this the alignment takes left turn and due to site conditions, alignment deviates from the road and some private properties are required to be acquired in this section. The Chembumukku station has been proposed at Chainage 2/790 near Roman Catholic Church. Due to site constraints the station has been kept partially on canal to minimize property acquisition. After Chembumukku station alignment continues to run along the civil lines road and reaches near Jama Masjid area where Vazhakkala station has been proposed at Chainage 3/580, at a distance of 790 m from the previous station. After Vazhakkala station the alignment continues to run on the middle of the civil lines road except from Chainage 4/552 to 4/635 where it deviates from C/L of ROW. The alignment takes right turn just after NGO junction. The next station “Padamughal station” has been proposed near Hidhayatullsmal Madrasa at chainage 4/218. Due to site constraints, this location is selected at a short distance of 638m from the previous station. This is the nearest location to serve Metro city locality. After the Padamughal station alignment follows the civil lines road up to Kakkanad junction. Kakkanad Junction station is proposed at Chainage 5/312 at a distance of 1094m from previous station. After Kakkanad station, alignment traverses along the Seaport – Airport Road up to Chittethukara. Kochi SEZ station is planned at Chainage 6/366 at a distance of 1054m from previous station. Alignment after Kochin SEZ station continues to run along the Seaport – Airport Road and reaches near to info Park Junction where Chittethukara station is proposed at Chainage 7/457 just before the Info Park junction at a distance of 1091m from previous station. After the Chittethukara station, alignment to reach to info

park area, leaves the seaport - airport road and turns left towards Info Park area to traverse along Info Park expressway. After this the road is in curve and accordingly to keep the alignment on the middle of existing road, has to turn left again. Then after a small Cross junction of the road, KINFRA Station is planned at chainage 8/735 near Vastugram at a distance of 1278m from previous station. After KINFRA station alignment runs along the Info Park Express way and reaches terminal station Infopark 1.

5.2. Locations for Vibration Study

The locations considered for this study is represented in table 5.1.

Table 5.1 List of locations to be studied.

S.no	Location	Distance from centreline
1.	St. Martin's Church (near JLN stadium station)	15m
2.	Guru Temple (near Palarivattom bypass station)	20m
3.	St. Michael's Church (near Chembumukku station)	30m
4.	Special School (near Chembumukku station)	20m
5.	Malabar Church (near Vazhakalla station)	20m
6.	Ayurveda Hospital (near Padamughal station)	40m

5.3. Railway Superstructure

The choice of superstructure has to be made keeping in view the ease of constructability and the maximum standardization of the formwork for a wide span range. The following types of superstructures have been considered -

i. Precast segmental box girder using external un-bonded tendon.
ii. Precast segmental U-Channel superstructure with internal pre-stressing.

5.4. Track structure

The track structure selected for Metro systems should be long lasting and would require minimum maintenance and at the same time, ensure highest level of safety, reliability and comfort, with minimum noise and vibrations. The track structure has been proposed keeping the above philosophy in view. The track on main line will have Head hardened UIC-60 (60 kg/m) rail section to IRS T-12-2009 specifications. The ballast less track is recommended on the viaduct as the regular cleaning and replacement of ballast is extremely difficult/not possible on main line.

5.5. Rolling Stock

The broad features of Rolling Stock which are proposed to be followed are indicated in table below:

Table 5.2 Broad features of Rolling Stock

S.no	Parameter	Description
1.	Basic Unit	Two Driving Motor cars (DMC) and one Trailer car (TC). Every coach should be fully interchangeable with any other coach of same type.
2.	3-car train composition	DMC-TC-DMC
3.	Coach body material	Light weight stainless steel or aluminium body, provided with fire retarding material
4.	Maximum tare weight	DMC – 39 T, TC – 38 T
5.	Axle load	16 T
6.	Propulsion system	3 phase drive system with VVVF control
7.	Traction type	750 V dc Third Rail

Figure 5.1 shows the simplified velocity – time operation curve to achieve the desired schedule.

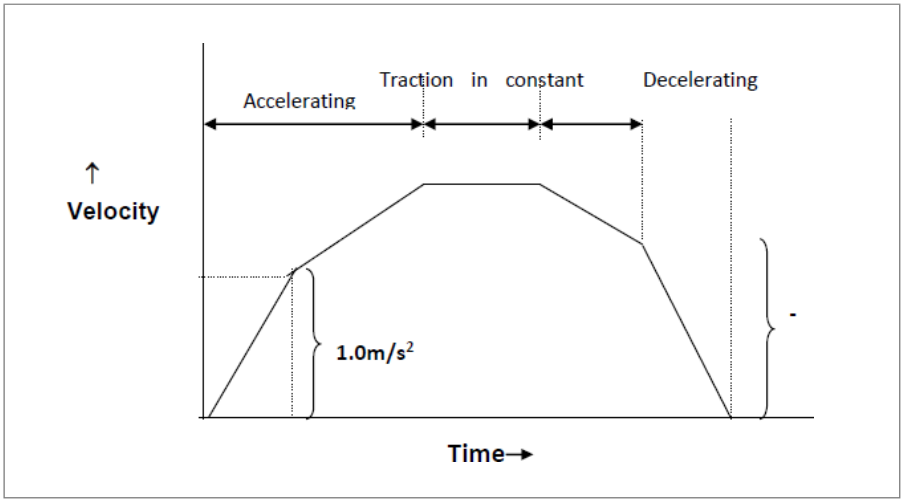

Fig. 5.1 Simplified velocity – time operation curve

5.6. Traffic Demand

Train operation plan for Phase II corridors has been formulated considering PHPDT for different sections of corridors. The PHPDT considered for the preparation of train operation plan is given in Table 5.3.

Table 5.3 Peak Hour Peak Direction Traffic (PHPDT) for Horizon Years

PHPDT					
Year 2023	Year 2028	Year 2033	Year 2038	Year 2043	Year 2048
7340	8464	9745	11597	14029	16263

The train operation plan is envisaged with 3 car rake composition on the proposed Kochi Metro Phase-II corridor from JLN Stadium to Info Park with passenger interchange at JLN stadium station

of Kochi Metro Phase-I. The trains for Phase-II are proposed to utilize the maintenance facilities at Muttom Depot. To meet the projected traffic demand, running trains of 3-car consists with varying headways during peak hours and non-peak hours, has been examined. The traffic capacity and demand have been matched by suitable regulation of headways.

Train operation plan for the corridor in year 2023-2024 is planned with 7.5 minutes' headway during peak period. The planned peak hour peak direction traffic (PHPDT) capacity is 6128 @ 6 passengers/m^2 of standee area (Capacity of 7800 @ 8 passengers/m^2 of standee area under dense loading conditions). The planned capacity is less than the PHPDT demand of 7340 to 6336 passengers from Palarivattom Bypass to Kakkanad Jn. station and Kinfra to Info Park 1 station.
However, demand on these sections can be met by carrying standees @ 8 passengers/m^2, meeting the demand for next few years. This arrangement will help in optimum utilization of Rolling Stock and empty running of trains will be considerably reduced.

5.7. Geology

Geology of Kochi indicates that the area is located on a thick sedimentary pile consisting of alternating layers of clay and sand. This thick pile of sediments is resting on a westerly slopping basement. Most part of Kochi area forms part of the extensive Vembanad wetland system with its ample water saturated sub-stratum. The geological succession of Kochi is as follows:

- Recent sediments (Alluvium, Teri's, Brown sands etc.), Mud banks, Laterite.
- Archaean-Basic Dykes, Charnockites, Gneisses.
- The entire western part is covered by recent sediments.

Based on morphological features and physico-chemical properties, the soils of the Ernakulam district are classified as Lateritic, Hydromorphic saline, Brown hydromorphic, Riverine alluvium and Coastal alluvium.
Lateritic soil is the most predominant soil type of the district. These soils are well drained, low in organic matter and plant nutrients. The major crops grown are coconut, tapioca, rubber, areacanut, pepper, cashew, and spices.
Brown hydromorphic soil is the second most prevalent soil type of the district, and they are encountered in valley bottoms. The soil is enriched in clay content and plant nutrients. The soil is suited for paddy cultivation. Small patches of hydromorphic saline soil are encountered in the coastal tracts of the district in Kanayannur and Kochin taluk. The tidal backwaters contribute to the salinity of the soil. Coconut is grown in these soils.
Riverine alluvium is restricted to the banks of rivers and their tributaries. They are composed of sandy to clayey loam and are enriched in plant nutrients. It is suited for a large variety of crops like coconut, paddy arecanut, pepper, vegetables etc. In Kochi taluk and the western parts of Paravur and Aluva taluk coastal alluvium is encountered and is composed of sand and clay. Coconut is the major crop in these soils.

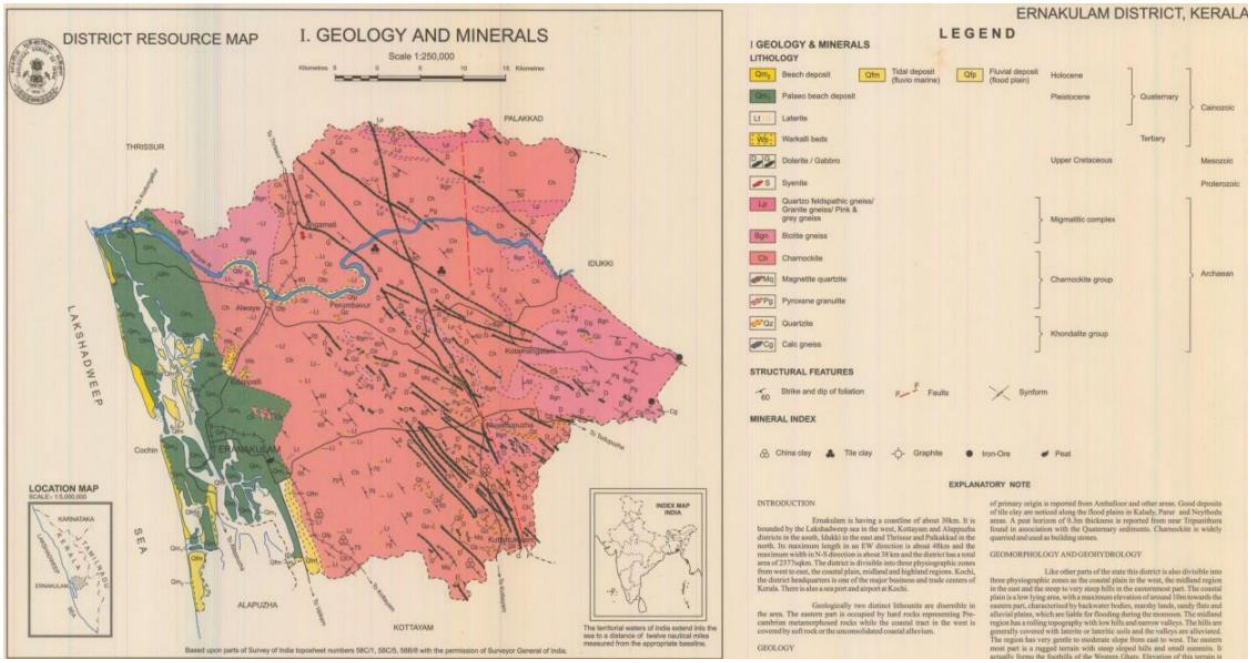

Fig 5.2 Geology of Ernakulam

6. Prediction Methodology

6.1. Construction Phase

Varying degrees of ground-borne vibration may be induced in the construction phase considering the type of the equipment and methods used in this phase. The induced vibrations propagate through the soil and its strength reduces with distance.

The first step in construction vibration assessment is to determine level of assessment required for the project. In this regard, first. vibration source levels from typical construction equipment and operations are introduced and then procedures on how to estimate construction vibration for damage and annoyance are provided. Noteworthy, both vibration source levels and theprocedure are the ones proposed by Federal Transient Administration (FTA) of USA.

Table 6.1 presents average source levels at 25 ft in terms of PPV and RMS velocity in decibels (L_v), for various types of construction equipment measured under a wide variety of construction activities. Note that although the table gives one level for each piece of equipment, there might be considerable variation in reported ground vibration levels from construction activities. The data in Table 6.1 provide a reasonable estimate for a wide range of soil conditions.

Table 6.1 Vibration source levels for construction equipment at 25ft

Equipment	PPV (in/sec)	Lv at 25ft (VdB re 1 micro - in/sec)
Impact Pile Driver: Upper range/Typical range	1.518/0.644	112/104
Sonic Pile Driver: Upper range/Typical range	0.734/0.17	105/93
Clam shovels drop	0.202	94
Hydromill: in soil/ in rock	0.008/0.017	66/75

Vibratory Roller	0210	94
Hoe Ram	0.089	87
Large bulldozer	0.089	87
Caisson drilling	0.089	87
Loaded trucks	0.076	86
Jackhammer	0.035	79
Small bulldozer	0.003	58

Assessment for building damage and for annoyance for each piece of equipment needs to be carried out.

6.1.1. Building Damage Assessment

Construction vibration is generally assessed in terms of peak particle velocity (PPV). In this regard, first, the vibration source level (PPVref) for each piece of equipment at a reference distance of 25 ft is determined using Table 6.1, then Eq. 6.1 is used to apply adjustment to the source reference level to account for the distance from the equipment to the receiver,

$$PPV_{equip} = PPV_{ref} \times (25/D)^{1.5} \qquad (6.1)$$

where $PPVequip$ is the peak particle velocity of the equipment, $PPVref$ is the source reference vibration level at 25 ft (Table 6.1) and D is the distance from the equipment to the receiver.
The predicted vibration levels obtained using this quantitative construction vibration assessment is compared with the impact criteria introduced Section 4.- to assess the construction vibration damage impact.

6.1.2. Annoyance Assessment

Ground-borne vibration related to human annoyance is related to RMS velocity levels, expressed in VdB (L_v). In this regard, first, the vibration source level ($L_{v,ref}$) for each piece of equipment at a reference distance of 25 ft is determined using Table 6.1, then Eq. 6.2 is used to apply adjustment to the source reference level to account for the distance from the equipment to the receiver,

$$L_{v,distance} = L_{v,ref} - 30log(D/25) \qquad (6.2)$$

where $L_{v,\,distance}$ is the RMS velocity level adjusted for distance (in VdB), $L_{v,ref}$ is the source reference vibration level at 25 ft (in VdB) as proposed by FTA in Table 6.1 and D is the distance from the equipment to the receiver.
The predicted vibration levels obtained using this quantitative assessment is compared with the impact criteria introduced in Section 4- for annoyance assessment during the construction phase.

6.2. Operational Phase

Steps need to be followed to assess the vibration impact during the operational phase are the followings:

- Step 1: Employ FTA vibration screen procedures developed based on the land use and type of the vibration source to identify the sensitive locations to ground- borne vibration.
- Step 2: Select the base curve for ground surface vibration level.
- Step 3: Apply project-specific adjustments to the standard vibration curve including the adjustments in source, propagation, and receiver.
- Step 4: Compare the predicted vibration level after applying the adjustment with the vibration impact criteria to assess the vibration impact.
- Step 5: Proposing vibration abatement solutions if the predicted vibration exceeds the vibration criteria.

6.2.1. Identify Locations

Identifying the sensitive receptors are mainly defined using two main criteria, type ofthe project (or type of the source) and land use category; based on which the screeningdistances for vibration assessments, as shown, is defined.

Type of Project	Critical Distance for Land Use Categories* Distance from ROW or Property Line, ft		
	Land Use Cat. 1	Land Use Cat. 2	Land Use Cat. 3
Conventional Commuter Railroad	600	200	120
RRT	600	200	120
LRT and Streetcars	450	150	100
ICT	200	100	50
Bus Projects (if not previously screened out)	100	50	--

*For the Vibration Screening Procedure, evaluate special buildings as follows: Category 1 - concert halls and TV studios, Category 2 - theaters and auditoriums

The locations considered for this study is represented in table 6.2.

Table 6.1 List of locations to be studied

S.no	Location	Distance from centreline
1.	St. Martin's Church (near JLN stadium station)	15m
2.	Guru Temple (near Palarivattom bypass station)	20m
3.	St. Michael's Church (near Chembumukku station)	30m
4.	Special School (near Chembumukku station)	20m
5.	Malabar Church (near Vazhakalla station)	20m
6.	Ayurveda Hospital (near Padamughal station)	40m

6.2.2. Base Curve

Three base curves are proposed by FTA guidelines. These based lines categorize the induced vibration level as a function of distance between the source and the receptor for three different types of sources, locomotive-powered passenger or freight curve, rapid transit or light rail vehicles curve and rubber-tired vehicles curve. Considering the type of the characteristics of the rolling stocks used, rapid transit or light rail vehicles curve is used in this study as a base curve for ground surface vibration level. Noteworthy, the main base curve proposed by FTA is for the reference train speed of $vtref$ = 50 mph, however, it is expressed that vibration level is approximately proportional to $20log(vt/vtref)$. for Figure 6.1 shows the base ground surface vibration curves for five different train speeds, it can be observed that the faster the train is, the higher induced vibration will be. The prediction is carried out for both design speed of 55.9 mph (90 kmph) and scheduled speed of 21.1 mph (34 kmph).

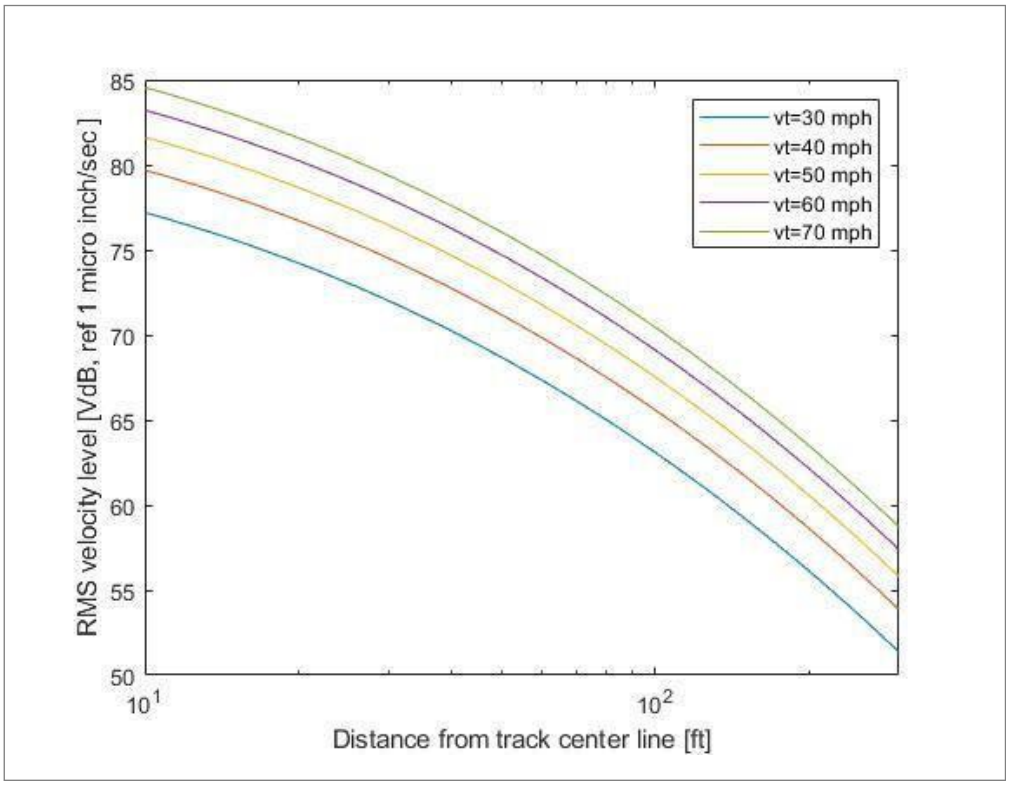

Fig 6.1 Ground surface vibration curves for different train speeds

6.2.3. Project Specific Adjustments

Once the base curve has been selected, the adjustments in can be used to develop vibration projections for specific receiver positions inside buildings. All the adjustments are given as single numbers to be added to, or subtracted from, the base level. The adjustment parameters can be categorized in three groups: adjustment factor for source adjustment factor for propagation path and adjustment factor receiver.

The main adjustment parameters for the source include worn wheels or wheels with flats, track worn or corrugated track, special track work within 200 ft and jointed track. Wheel flats or wheels that are

unevenly worn can cause high vibration levels. Corrugated track is a common problem. Mill scale on new rail can cause higher vibration levels until the rail has been in use for some time. If there are adjustments for vehicle parameters and the track is worn or corrugated, only include one adjustment. Wheel impacts at special trackwork will greatly increase vibration levels up to 10 VdB. The increase will be less at greater distances from the track. If the trackwork is more than 200 ft away from the receptor, no adjustment factor is needed. Jointed track can cause higher vibration levels than welded track.

In this study it has been considered that neither wheel nor track have special defects that can affect the induced ground- borne vibration. Moreover, it is assumed that all special track works including turnouts and crossovers are more than 200 ft away from the receptors.

The most important adjustment factors for the propagation path consist of type of transit structure, geologic conditions and coupling to building foundation. In general, the heavier the structure, the lower the vibration levels; and the heavier the building construction, the greater the coupling loss. The geological condition near the sensitive receptors shows that the soil type can be associated with efficient vibration propagation. As proposed by FTA guidelines, a conservative approach would be to use for efficient propagation for areas where efficient propagation is likely. This approach is followed in this study.

Regarding the receptor adjustment factors, there are floor-to-floor attenuation factor and amplification factor due the resonances of floors, walls, and ceilings. The former factor accounts for dispersion and attenuation of the vibration energy as it propagates through a building starting with the first suspended floor. In this study, the prediction is carried out only for the first floor where the highest vibration level will be perceived.

6.2.4. Vibration Impact Criteria

The criteria for ground-borne vibration land use categories 1-3 are presented in Table 4.1. Impact will occur if these levels are exceeded. Criteria for ground- borne vibration are expressed in terms of rms velocity levels in VdB. The criteria for ground-borne vibration and noise for special land uses are presented in Table 4.2.

6.2.5. Vibration Mitigation Measures

The purpose of vibration mitigation is to minimize the adverse effects that the project ground-borne vibration will have on sensitive land uses if the predicted vibration level exceeds the criteria limits. Targeting the mechanisms of ground-borne vibration generation to reduce transmitted forces by the vehicle to the track would be the most efficient approach. Due to high cost of the maintenance actions, countermeasures are necessary to address railway-induced ground-borne vibration problem at a more reasonable cost. Several solutions have been proposed to address the problem of ground-borne vibration induced by railways. The mitigation measures can be categorized according to the location at where they are applied: i) the source; ii) the receiver and iii) the propagation path.

Mitigation measures at the source mainly target the track and its resiliency to reduce vibration transmission into the ground. An effective measure to reduce the vibration at the point of the emission is using floating-slab and high-resilience fasteners. Damping treatments, localized

stiffening or mass addition are some mitigation measures at receivers, that can be used to reduce the post-construction vibration.

The countermeasures applied at the propagation path are all based on the same idea of interrupting the propagation of waves through the soil. Wave-impeding blocks (WIP) subgrade stiffening, and wave barriers are the most common mitigation measures in the category.

It should be recognized that the effectiveness of these mitigation measures is strongly dependent on the frequency spectrum of the vibration source and the frequency dependence of the vibration propagation. In this study the effect of using floating slab system and high-resilience fasteners in reducing the ground-borne railway-induced vibration are evaluated as there are adjustment factors associated to these mitigation measures in FTA guidelines.

7. Results

In this section, the methodology explained previously is used to obtain a general overview on vibration level induced during construction and operation phases regarding distance between the source and receptors. Then, the methodology is employed to predict the vibration level during construction and operation phases at sensitive receptors.

7.1. General Vibration Impact Assessment

7.1.1. Construction Phase – Damage Impact Assessment

The equation (6.1) has been used to predict the induced vibration during the construction phase for different equipment as a function of distance between construction zone and receptor. The results are shown in Figure 6.1. Moreover, the damage criteria have been shown in this figure. Noteworthy, four damage criteria (PPV in inch/sec) proposed by FTA guidelines based on the structure of the receptors:

- Criteria structure type 1 presents reinforced-concrete, steel, or timber (no plaster) with PPV=0.5 inch/sec.
- Criteria structure type 2 presents engineered concrete and masonry (no plaster)with PPV=0.3 inch/sec
- Criteria structure type 3 presents non-engineered timber and masonry buildingswith PPV=0.2 inch/sec
- Criteria structure type 4 presents buildings extremely susceptible to vibrationdamage with PPV=0.2 inch/sec.

In this figure, all the construction equipment defined by FTA guidelines has been presented regardless of its application in the present project. According to FTA guidelines, different pile drive methods could result in different vibration. Therefore, the upper range is proposed for pile drive. Noteworthy, it can be observed from Figure 7.1 that pile drivers, either impact or sonic, along with clam shovel drop and vibratory roller are among the most problematic equipment. To clarify the

effect of this equipment, the distance up to which the equipment can induce the vibration levels higher than the damage criteria are presented Table 7.1.

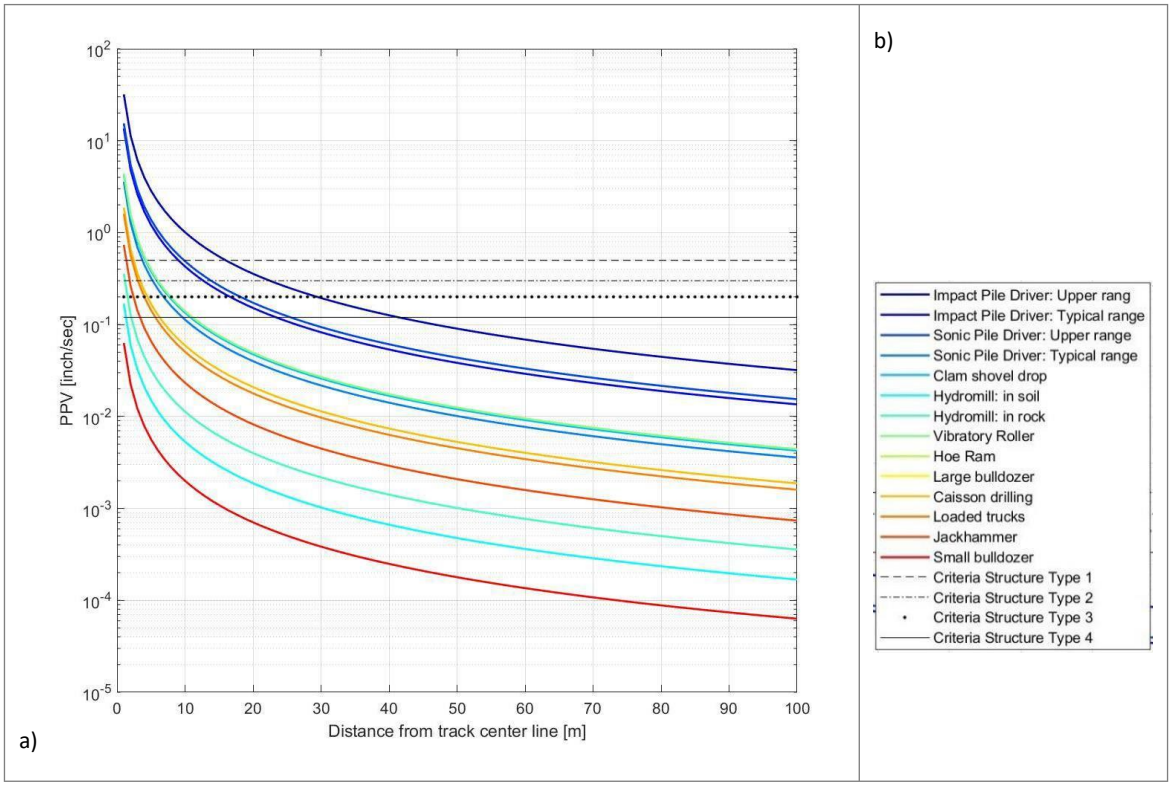

Figure 7.1. a) Predicted vibration level (PPV in inch/sec) for eleven type of construction equipment and impact criteria for four different types of structures and b) figure legend.

Table 7.1 Affected area in construction phase due to five use of five most problematic equipment. Categorized based on four different criteria impact of four type of structures.

Construction Equipment	Affected area distance from construction zone (m)			
	Structure Type 1 (0.5 in/sec)	Structure Type 2 (0.3 in/sec)	Structure Type 3 (0.2 in/sec)	Structure Type 4 (0.12 in/sec)
Impact pile drive (upper range)	16 m	23 m	30 m	41 m
Sonic pile drive (upper range)	10 m	14 m	19 m	25 m
Impact pile drive (typical range)	9 m	12 m	16 m	23 m
Clam shovel drop	4 m	6 m	8 m	11 m
Vibratory roller	4 m	6 m	8 m	11 m
Sonic pile drive (typical range)	4 m	6 m	6 m	9 m

7.1.2. Construction Phase – Annoyance Impact Assessment

The equation (6.2) has been used to predict the induced vibration during the construction phase for different equipment as a function of distance between construction zone and receptor. The results are shown in Figure 7.2. Moreover, the annoyance criteria have been shown in this figure. Three criteria proposed by FTA guidelines based on the land use, as explained in Section 4.-, are shown in the figure as well. Noteworthy, here it is considered that the use of construction equipment is considered as a frequent event (used more than 12 event per day). If the frequency event is less between 5 to 12 events per day, the criteria category 1 will not change, but, the criteria categories 2 and 3 will increase 3 dB. In addition, if the frequency event is less than 5 event per day, the criteria category 1 will not change, but, the criteria categories 2 and 3 will increase 8 dB. In this section, the conservative approach, assuming the frequent events, has been considered.

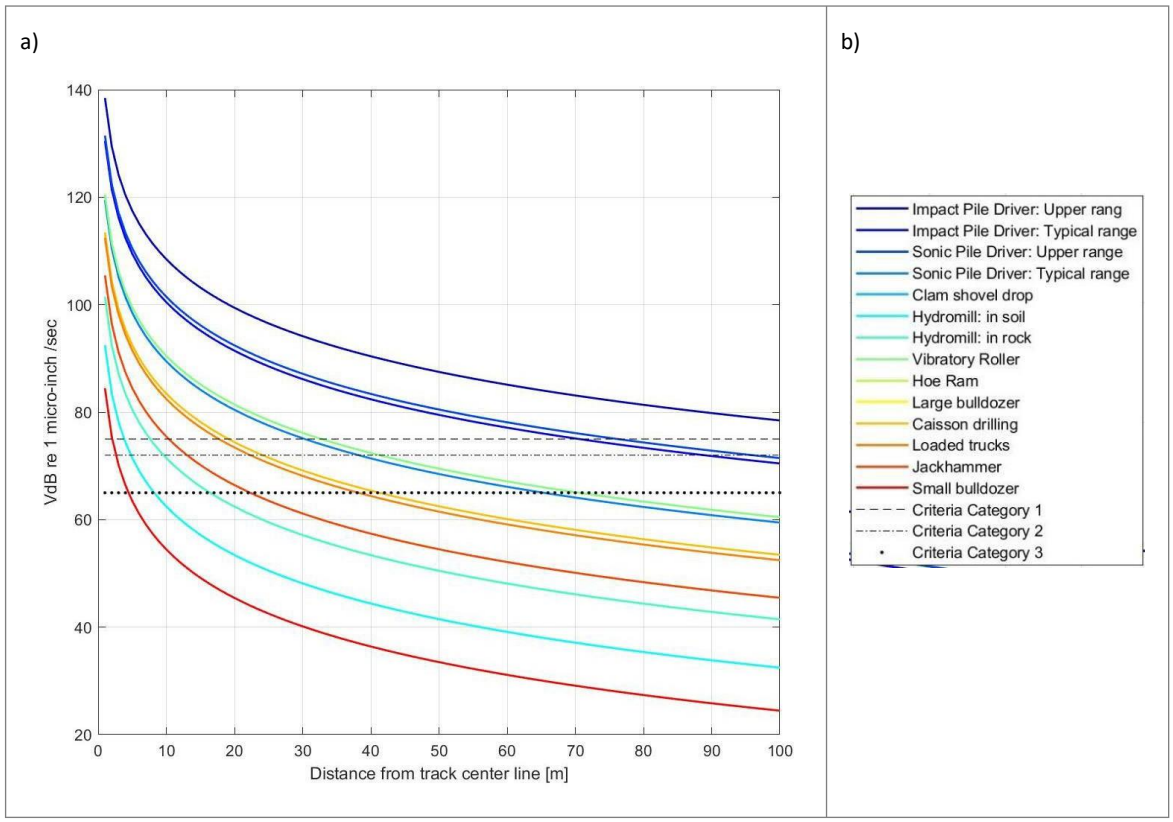

Figure 7.2. Predicted vibration level (VdB ref 1 micro-inch/sec) for eleven type of construction equipment and impact criteria for three different type of land use and b) figure legend.

To clarify the effect of most problematic equipment, the distance up to which the equipment can induce the vibration levels higher than the annoyance criteria arepresented in Table 7.2.

Table 7.2. Affected area due to t construction phase due to five uses of five most problematic. Categorized based on three different criteria impact of three land use category and the type of the building structure.

	Affected area distance from construction zone (m)

Building Structure	Category 1 (65VdB)	Category 2 (72 VdB)	Category 3 (75 VdB)
Impact pile drive (upper range)	100 m	100 m	100 m
Sonic pile drive (upper range)	100 m	93 m	76 m
Impact pile drive (typical range)	100 m	89 m	70 m
Clam shovel drop	69 m	41 m	32 m
Vibratory roller	69 m	41 m	32 m
Sonic pile drive (typical range)	64 m	37 m	30 m

7.1.3. Operation Phase

The methodology explained in Section 6.2.- has been used to predict the induced vibration due to train pass-by in elevated section for both design and scheduled speeds as a function of distance between the centre of track and receptor. The results are shown in Figure 6.4. Like before, the annoyance criteria have been shown in thisfigure. To clarify the effect of the type of the building foundation and the train speed,the distance up to which the train pass-by can induce the vibration levels higher than the annoyance criteria are presented in Table 6.5 and Table 6.6 for design and schedule speeds, respectively.

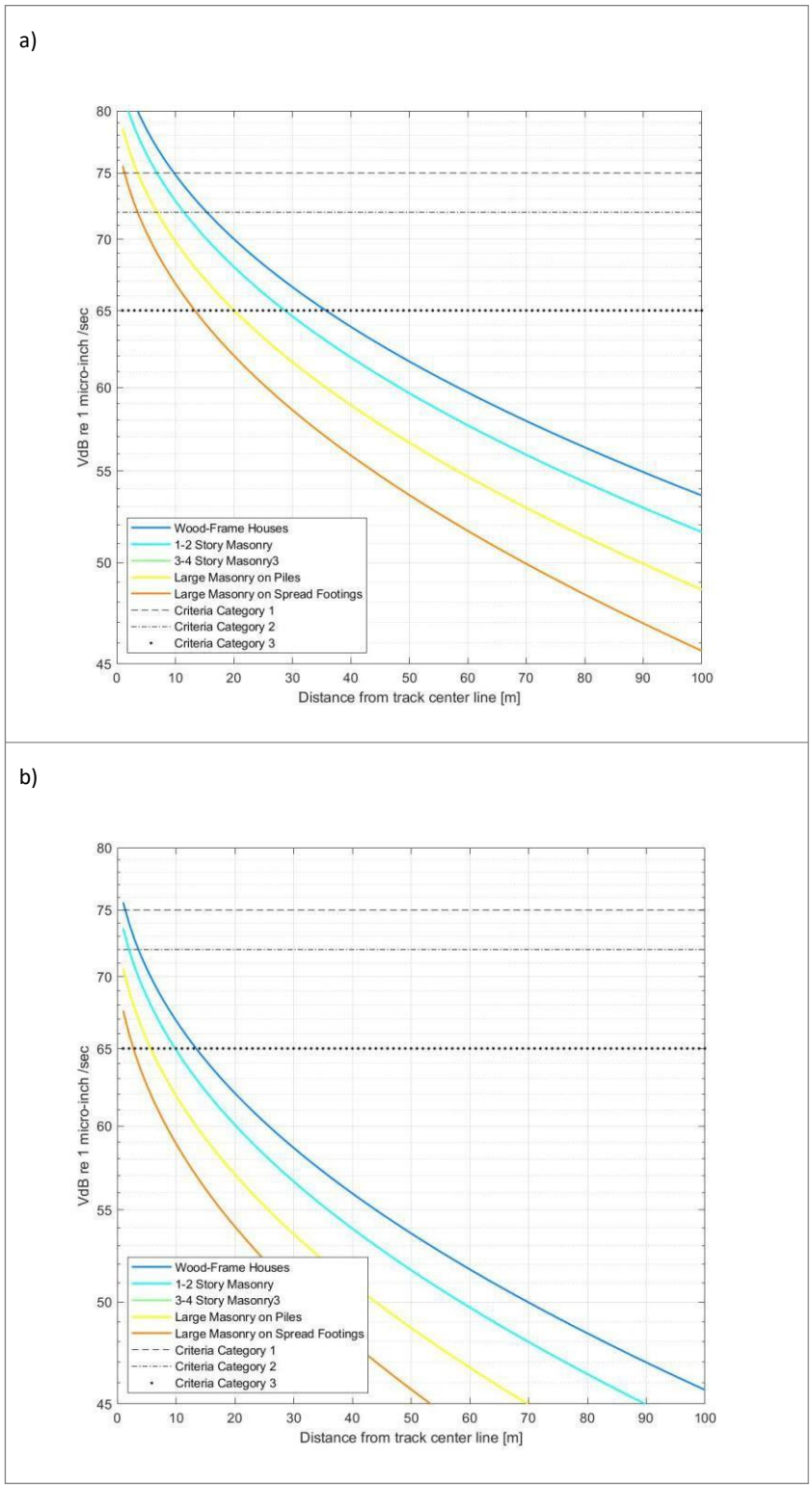

Figure 7.3. Predicted vibration level (VdB ref 1 micro-inch/sec) for 5 different types of buildings induced totrain pass-by in elevated sections with a) designed speed of 90 kmph and b) with scheduled speed of 34 kmph. Horizontal lines present the criteria impact for 3 different land use.

Design speed 90 kmph

Table 7.3. Affected area due to train-pass by in elevated section with designed speed of 80 kmph. Categorized based on three different criteria impact of three land use category and the type of the building structure.

Building Structure	Affected area distance from construction zone (m)		
	Category 1 (65VdB)	Category 2 (72 VdB)	Category 3 (75 VdB)
Wood-Frame Houses	36 m	16 m	10 m
1-2 Story Masonry	29 m	12 m	7 m
3-4 Story Masonry/ Large Masonry on Piles	20 m	7 m	4 m
Large Masonry on Spread Footings	13 m	3 m	2 m

Scheduled speed 34 kmph

Table 7.4. Affected area due to train-pass by in elevated section with scheduled speed of 34 kmph. Categorized based on three different criteria impact of three land use category and the type of the building structure.

Building Structure	Affected area distance from construction zone (m)		
	Category 1 (65VdB)	Category 2 (72 VdB)	Category 3 (75 VdB)
Wood-Frame Houses	14 m	4 m	--
1-2 Story Masonry	10 m	2 m	--
3-4 Story Masonry/ Large Masonry on Piles	5 m	--	--
Large Masonry on Spread Footings	3 m	--	--

7.2. Vibration Impact Assessment at Specific Locations

The vibration impact during the operation phase at specific sensitive locations has been presented in this section. As explained previously, the buildingstructure, its foundation, land use and frequency of events are important parameters to define the criteria for assessing the vibration impact either in construction phase or operation phase. However, there are some receptors which the type of foundation is not clearly defined. Therefore, the following approach has been followed for the criteria:

- For damage assessment during construction phase. if there is uncertainty about the receptor structure, four damage criteria for four different types of structures (St1/St2/St3/St4) as explained in Section 4 - are considered.
- For annoyance assessment during construction phase, if there is uncertainty about the frequency of the events, three annoyance criteria associated with frequent event, occasional even and infrequent even (as explained in Section 7.1.2.-) are considered.
- For annoyance assessment during construction phase, if there is uncertainty about the land use three annoyance criteria associated with three different landuse (Cat1/Cat2/Cat3) are presented.
- For annoyance assessment during operation phase, if there is uncertainty about the building foundation, several predicted results have been obtained.

St. Martin's Church

Table 7.5 Prediction results for construction phase

St. Martin's church	Construction Phase Damage assessment		Construction Phase Annoyance assessment	
	Predicted (in/sec)	Criteria (St1/St2/St3/St4)	Predicted (VdB)	Criteria (VdB re 1 μ in/sec)
Impact Pile Driver: Upper range	0.55	0.5/0.3/0.2/0.12	103.18	Frequent Event: 65/72/75 Occasional Event: 65/75/78 Infrequent Event: 65/80/83
Impact Pile Driver: Typical range	0.23		95.18	
Sonic Pile Driver: Upper range	0.27		96.18	
Sonic Pile Driver: Typical range	0.06		84.18	
Clam shovels drop	0.07		85.18	
Hydromill: in soil	0.00		57.18	
Hydromill: in rock	0.01		66.18	
Vibratory Roller	0.08		85.18	
Hoe Ram	0.03		78.18	
Large bulldozer	0.03		78.18	
Caisson drilling	0.03		78.18	
Loaded trucks	0.03		77.18	
Jackhammer	0.01		70.18	
Small bulldozer	0.00		49.18	

Table 7.6 Prediction results for operation phase

St. Martin's Church	Operation Phase	
	Predicted (VdB re 1 μ in/sec) Design/Scheduled Speed	Criteria (VdB re 1 μ in/sec) Cat1/Cat2/Cat3

1-2 Story Masonry	59.7/51.8	75
3-4 Story Masonry/ Large Masonry on Piles	62.1/54.2	75

Guru Temple

Table 7.7 Prediction results for construction phase

Guru Temple	Construction Phase Damage assessment		Construction Phase Annoyance assessment	
	Predicted (in/sec)	Criteria (St1/St2/St3/St4)	Predicted (VdB)	Criteria (VdB re 1 μ in/sec)
Impact Pile Driver: Upper range	0.36	0.5/0.3/0.2/0.12	99.43	Frequent Event: 65/72/75 Occasional Event: 65/75/78 Infrequent Event: 65/80/83
Impact Pile Driver: Typical range	0.15		91.43	
Sonic Pile Driver: Upper range	0.17		92.43	
Sonic Pile Driver: Typical range	0.04		80.43	
Clam shovel drop	0.05		81.43	
Hydromill: in soil	0.00		53.43	
Hydromill: in rock	0.00		62.43	
Vibratory Roller	0.05		81.43	
Hoe Ram	0.02		74.43	
Large bulldozer	0.02		74.43	
Caisson drilling	0.02		74.43	
Loaded trucks	0.02		73.43	
Jackhammer	0.01		66.43	
Small bulldozer	0.00		45.43	

Table 7.8 Prediction results for operation phase

Guru Temple	Operation Phase	
	Predicted (VdB re 1 μ in/sec) Design/Scheduled Speed	Criteria (VdB re 1 μ in/sec) Cat1/Cat2/Cat3
1-2 Story Masonry	66.2/58.2	75
3-4 Story Masonry/ Large Masonry on Piles	63.2/55.2	75

St. Michael's Church

Table 7.9 Prediction results for construction phase

St. Michaels's Church	Construction Phase Damage assessment	Construction Phase Annoyance assessment

	Predicted (in/sec)	Criteria (St1/St2/St3/St4)	Predicted (VdB)	Criteria (VdB re 1 μ in/sec)
Impact Pile Driver: Upper range	0.19	0.5/0.3/0.2/0.12	94.14	Frequent Event: 65/72/75 Occasional Event: 65/75/78 Infrequent Event: 65/80/83
Impact Pile Driver: Typical range	0.08		86.14	
Sonic Pile Driver: Upper range	0.09		87.14	
Sonic Pile Driver: Typical range	0.02		75.14	
Clam shovel drop	0.03		76.14	
Hydromill: in soil	0.00		48.14	
Hydromill: in rock	0.00		57.14	
Vibratory Roller	0.03		76.14	
Hoe Ram	0.01		69.14	
Large bulldozer	0.01		69.14	
Caisson drilling	0.01		69.14	
Loaded trucks	0.01		68.14	
Jackhammer	0.00		61.14	
Small bulldozer	0.00		40.14	

Table 7.10 Prediction results for operation phase

St. Michael's Church	Operation Phase	
	Predicted (VdB re 1 μ in/sec) Design/Scheduled Speed	Criteria (VdB re 1 μ in/sec) Cat1/Cat2/Cat3
1-2 Story Masonry	58.5/50.6	75
3-4 Story Masonry/ Large Masonry on Piles	55.5/47.6	75

Special School

Table 7.11 Prediction results for construction phase

Special School	Construction Phase Damage assessment		Construction Phase Annoyance assessment	
	Predicted (in/sec)	Criteria (St1/St2/St3/St4)	Predicted (VdB)	Criteria (VdB re 1 μ in/sec)
Impact Pile Driver: Upper range	0.36	0.5/0.3/0.2/0.12	99.43	Frequent Event: 65/72/75 Occasional Event: 65/75/78 Infrequent Event: 65/80/83
Impact Pile Driver: Typical range	0.15		91.43	
Sonic Pile Driver: Upper range	0.17		92.43	
Sonic Pile Driver: Typical range	0.04		80.43	
Clam shovels drop	0.05		81.43	
Hydromill: in soil	0.00		53.43	

Hydromill: in rock	0.00		62.43	
Vibratory Roller	0.05		81.43	
Hoe Ram	0.02		74.43	
Large bulldozer	0.02		74.43	
Caisson drilling	0.02		74.43	
Loaded trucks	0.02		73.43	
Jackhammer	0.01		66.43	
Small bulldozer	0.00		45.43	

Table 7.12 Prediction results for operation phase

Special School	Operation Phase	
	Predicted (VdB re 1 μ in/sec) Design/Scheduled Speed	Criteria (VdB re 1 μ in/sec) Cat1/Cat2/Cat3
1-2 Story Masonry	66.2/58.2	75
3-4 Story Masonry/ Large Masonry on Piles	63.2/55.2	75

Malabar Church

Table 7.13 Prediction results for construction phase

Malabar Church	Construction Phase Damage assessment		Construction Phase Annoyance assessment	
	Predicted (in/sec)	Criteria (St1/St2/St3/St4)	Predicted (VdB)	Criteria (VdB re 1 μ in/sec)
Impact Pile Driver: Upper range	0.36	0.5/0.3/0.2/0.12	99.43	Frequent Event: 65/72/75 Occasional Event: 65/75/78 Infrequent Event: 65/80/83
Impact Pile Driver: Typical range	0.15		91.43	
Sonic Pile Driver: Upper range	0.17		92.43	
Sonic Pile Driver: Typical range	0.04		80.43	
Clam shovels drop	0.05		81.43	
Hydromill: in soil	0.00		53.43	
Hydromill: in rock	0.00		62.43	
Vibratory Roller	0.05		81.43	
Hoe Ram	0.02		74.43	
Large bulldozer	0.02		74.43	
Caisson drilling	0.02		74.43	
Loaded trucks	0.02		73.43	
Jackhammer	0.01		66.43	
Small bulldozer	0.00		45.43	

Table 7.14 Prediction results for operation phase

Malabar Church	Operation Phase	
	Predicted (VdB re 1 μ in/sec) Design/Scheduled Speed	Criteria (VdB re 1 μ in/sec) Cat1/Cat2/Cat3
1-2 Story Masonry	66.2/58.2	75
3-4 Story Masonry/ Large Masonry on Piles	63.2/55.2	75

Ayurveda Hospital

Table 7.15 Prediction results for construction phase

Ayurveda Hospital	Construction Phase Damage assessment		Construction Phase Annoyance assessment	
	Predicted (in/sec)	Criteria (St1/St2/St3/St4)	Predicted (VdB)	Criteria (VdB re 1 μ in/sec) Category 1
Impact Pile Driver: Upper range	0.13	0.5/0.3/0.2/0.12	90.40	Frequent Event: 65 Occasional Event: 65 Infrequent Event: 65
Impact Pile Driver: Typical range	0.05		82.40	
Sonic Pile Driver: Upper range	0.06		83.40	
Sonic Pile Driver: Typical range	0.01		71.40	
Clam shovels drop	0.02		72.40	
Hydromill: in soil	0.00		44.40	
Hydromill: in rock	0.00		53.40	
Vibratory Roller	0.02		72.40	
Hoe Ram	0.01		65.40	
Large bulldozer	0.01		65.40	
Caisson drilling	0.01		65.40	
Loaded trucks	0.01		64.40	
Jackhammer	0.00		57.40	
Small bulldozer	0.00		36.40	

Table 7.16 Prediction results for operation phase

Ayurveda Hospital	Operation Phase	
	Predicted (VdB re 1 μ in/sec) Design/Scheduled Speed	Criteria (VdB re 1 μ in/sec) Cat1/Cat2/Cat3
1-2 Story Masonry	57.3/49.4	65

3-4 Story Masonry/ Large Masonry on Piles	54.5/46.1	65

8. Conclusion and Recommendation

The conclusions after the assessment of vibration levels to be induced along the alignment during the constructions phase as well as during operation phase of Kochi Metro Phase II are summarized below:

1. FTA Manual provisions are adopted for railway induced ground-borne vibrations during infrastructure's operation phase as well as regarding construction vibration impact.

2. FTA Manual prediction methodology is implemented to assess the vibration levels induced during construction phase as well as during its operation phase.

3. Regarding the construction phase:
    a. Pile drivers (impact or sonic) is the most problematic equipment.
    b. Distance up to which this equipment can induce vibration levels higher than the damage criteria are presented in Table 7.1. Depending on the building structure type, impact pile driving can affect up to 40 m distance.
    c. And distance up to which this equipment can induce vibration levels higher than the annoyance criteria are presented in Table 7.2. Depending on the land use category, impact pile driving can affect up to 100 m distance.
4. Regarding operation phase:
    a. Induced vibration due to train pass-by in underground and elevated sections for both design and scheduled speeds as a function of distancebetween the centre of track and receptor has been assessed.
    b. A maximum distance of 36 m will be affected if 90kmph design speed and masonry building structure are considered. Thisdistance will be reduced to 14 m if 34 kmph scheduled speed is considered.
5. The assessment of the vibration level into six (6) specific buildings carefully selected due to its sensitive use, leads to the following results:
    a. Typical range impact pile driving during construction will induce vibration levels higher than damage criteria in 1 out of 6 sensitive locations, while this equipment will cause vibration levels higher than annoyance criteria in 6 out of 6 sensitive locations.

b. No effective abatement solutions can be installed or applied to the construction phase, but a continuous vibration monitoring survey can be design and implemented to control the evolution of the vibration levels induced during the construction phase. This continuous vibration monitoring survey will be complemented with in situ examination of all affected buildings prior the commencement, during and after the completion of the construction phase, to detect possible damages due to the construction phase.

c. Metro Rail operation phase will not induce vibration levels higher than vibration limits into buildings in any of the six sensitive buildings.

d. There are two main possible and world-wide used vibration abatement solutions to reduce ground-borne vibration into the affected sensitive buildings: floating slabs and high-resilient fastening systems. These two solutions can reduce vibration levels up to 10 VdB and 5 VdB, respectively.

6. Building damage from construction vibration is only anticipated from pile driving at very close distances to buildings (Approx 7 -8 m). If piling is more than 7-8 m from buildings, or if alternative methods such as push piling or augur piling can be used, damage from construction vibration is not expected to occur. Other sources of construction vibration do not generate high enough vibration levels for damage to occur.

9. References

I. FTA VA-90-1003-06. Transit noise and vibration impact assessment, Federal Transit Administration, Office of Planning and Environment, Washington (USA), 2018.

II. Comprehensive Detailed Project Report for Kochi Metro Phase-II.

III. Comprehensive EIA Report for Kochi Metro Phase – II.

KOCHI METRO RAIL LIMITED

APPENDIX 9.1

Route for Traffic Diversion

SYSTRA

Alternate Routes for Traffic arrangements during Kochi Metro Rail Phase II Construction

The proposed Metro Rail alignment starts from JLN metro station and proceeds along MKK Nair Road- Civil Line Road to reach Kakkanad signal junction and by taking a right turn travel along sea port airport road for 2.5 Km and after Chittethukara and takes a left turn to Info Park expressway to end at Info Park. The following traffic arrangements are proposed to ensure smooth flow of traffic and avoid congestion.

Bus service will continue on the Civil Lane Road.

Eranakulam to Kakkanad Side

Vehicles coming from Eranakulam Side to Kakkanad and Sea Port-Airport Road can use the following roads by following vehicle type restrictions provided.

- NH 544-Old Kalamssery Road-HMT Junction-Sea Port Airport road (All vehicles Permitted)
- Edapally-Pookattupady Road from Edapally toll junction to Sea Port Airport Road (All vehicles permitted).
- NH 66 Edapally service road -Marottichodu Junction-Kennedy Mukku-NGO Quarters- Bharath Matha collage (Only LMV, Three-Wheeler, Two-Wheeler Permitted).
- NH 66 Edapally service road- Marottichodu Junction-Kennedy Mukku-NGO Quarters – Olimugal signal Junction. (Only LMV, Three-Wheeler, Two-Wheeler Permitted).
- NH Bypass – Pipe Line-Kennedy Mukku -Desiya Mukku-NGO Quarters Junction –Bharath matha college-seaport Airport Road (Only LMV, Three Wheeler, Two Wheeler Permitted).
- NH Bypass – Pipe Line-Kennedy Mukku- -Desiya Mukku-NGO Quarters Junction – Olimugal signal Junction. (Only LMV, Three-Wheeler, Two-Wheeler Permitted).

Kaloor, Kathrikkadaavu to Kakkanad, Chittethukara Side

LMV, Three-Wheeler and Two-Wheeler Vehicles coming from Kaloor, Kathrikkadavu side to Kakkanad, Seaport-Airport Road can access NH- 66 through Thammanam and Puthiya road.

LMV, Three-Wheeler and Two-Wheeler Vehicles LMV, Three-Wheeler and Two Wheeler Vehicles coming on NH 66 may take any of the following routes to Kakkanad, Chittethukara and Sea Port- Airport Road

- Puthiya Road-Palachuvadu-Eachamukku-Seaport Airport Road
- Puthiya Road-Palachuvadu-Adarsha nagar-Chitttethukara- Sea port Airport Road
- Puthiya Road-Palachuvadu-Bhavan's Arts and Commerce College Road - Seaport Airport Road (opposite District Jail).
- Sreekala Road-Lenin Centre-V Guard Junction- Palachuvadu- Eachamukku-Seaport Airport Road.
- Chakkraparambu-Vennala High School Road-Thuthiyoor Road- Seaport Airport Road.

Vyttila to Kakkanad Side

Vehicles travelling from Vyttila to kakkanad side can take Vyttila- Eroor- Irumapanam road to reach Kakkanad area (only for LMV, Three-Wheeler and Two-Wheeler Vehicles)

Kundanoor Junction to Kakkanad Side

All category of vehicles travelling coming from the following destinations to Chittethukara, Kakkanad side can take the below mentioned roads via Kundanoor Junction, Karingachira to seaport airport road.

- Aroor side via NH 66 - Kundanoor Junction - Mini Bypass Junction- Petta - Karingachira -Irumpanam
- Cochin Shipyard side - Thevara-. Thevara Ferry Junction- Kundanoor Junction- Mini Bypass Junction- Petta - Karingachira -Irumpanam
- Thoppumpady side- COPT Avenue Walkway road - Kundanoor junction- Mini Bypass Junction- Petta - Irumpanam

Kakkanad to Ernakulam Side

Vehicles coming from Kakkanad and seaport airport road to Ernakulam side can use the following roads by following vehicle type restrictions provided.

- Sea Port Airport road- HMT Junction- -Old Kalamssery Road- NH 544 (All vehicles Permitted)
- Sea Port Airport Road- Edapally toll junction Via Edapally- Pookattupady road (All vehicles permitted).
- Seaport Airport Road- Bharath Matha college- NGO Quarters Junction- Desiya Mukku-–Kennedy Mukku - Marottichodu Junction- NH 66 Edapally service road (Only LMV, Three-Wheeler, Two Wheeler Permitted).
- Seaport Airport Road- Olimugal Signal Junction - NGO Quarters Junction- Desiya Mukku-–Kennedy Mukku -Marottichodu Junction- NH 66 Edapally service road (Only LMV, Three-Wheeler, Two Wheeler Permitted).
- Seaport Airport Road- Bharath Matha college- NGO Quarters Junction- Desiya Mukku-–Kennedy Mukku – Pipe Line road - NH By Pass (Only LMV, Three Wheeler, Two Wheeler Permitted).
- Seaport Airport Road – Olimugal signal Junction- NGO Quarters Junction – Desiya Mukku- Kennedy Mukku – Pipe Line road - NH ByPass (Only LMV, Three Wheeler, Two Wheeler Permitted).

Kakkanad, Chittethukata to Kaloor, Kathrikkadavu, NH 66

LMV, Three Wheeler and Two Wheeler Vehicles coming from Kakkanad, Chittethukara, Seaport-Airport Road to Kaloor, Kathrikkadavu side can access NH- 66 by taking any of the following roads and proceed through Puthiya road and Thammanam.

- Seaport Airport Road- Eachamukku- Palachuvadu- Puthiya Road
- Sea port Airport Road- Chitttethukara (Near Infopark Gate) - Adarsha Nagar—Palachuvadu- Puthiya Road
- Seaport Airport Road (opposite District Jail)- Bhavan’s Arts and Commerce College Road -. Palachuvadu- Puthiya Road
- Seaport Airport Road- Eachamukku- Palachuvadu- V Guard Junction- Lenin Centre- Sreekala Road
- Seaport Airport Road- Thuthiyoor Road- Vennala High School Road- Chakkraparambu

Kakkanad to Vytilla Side

Vehicles travelling from Kakkanad to Vyttila side can take Irumpanam- Eroor- Vyttila route (only for LMV, Three Wheeler and Two Wheeler Vehicles)

Kakkanad to Kundanoor junction and beyond.

All category of vehicles travelling on seaport airport road can take the Irumpanam - Petta-Mini Bypass Junction-Kundannur Junction and take the following roads to respective destinations.

- Kundanoor Junction to Aroor side via NH 66
- Kundanoor Junction – Thevara Ferry Junction-Thevara-Cochin Shipyard side.
- Kundanoor junction- COPT Avenue Walkway Road towards Thoppumpady side.


KAKKANAD ALTERNATE ROUTE MAP
FOR KOCHI METRO PHASE II CONSTRUCTION
N
HMT Junction
KALAMASSERY
കളമശ്ശേരി
NH66
Pipeline Jn
Seaport - Airport Rd
Toll Junction
Edappally - Pukkattupady Rd
THRIKKAKARA
തൃക്കാക്കര
Bharat Matha Junction
Edappally Junction
Marotichodu Junction
NGO Quarters Junction
Olimugal Junction
വാഴക്കാല
Pipeline road
Civil Line Rd
Kakkanad
കാക്കനാട്
ELAMAKKARA
ഏളമക്കര
PADAMUGHAL
പടമുഗൾ
Eachamukku
Pipeline Junction
Opp. District Jail
Sreekala road
Thuthiyoor Rd
Infopark Gate
Chittethukara
Puthiya road
Chakkaraparambu
Adarsh Nagar
KALOOR
കലൂർ
Thammanam Junction
Kathrikadavu Junction
NH66
Mathoor Jn
Vyttila
Irumpanam
Eroor
KADAVANTHRA
കടവന്ത്ര
KARINGACHIRA
കരിങ്ങാച്ചിറ
THRIPPUNITHURA
തൃപ്പൂണിത്തുറ
Karingachira Junction
Mini Bypass Junction
East fort gate Jn.
THEVARA
തേവര
To shipyard via Thevara Ferry Jn
Kundannur Junction
To Aroor
NETTOOR
നെട്ടൂർ
To Willington island - Thoppumpady Side
LEGEND:
- Main Road
- Phase II alignment for metro rail
- Light motor vehicle/ 3 wheeler/ 2 wheeler
- All vehicles